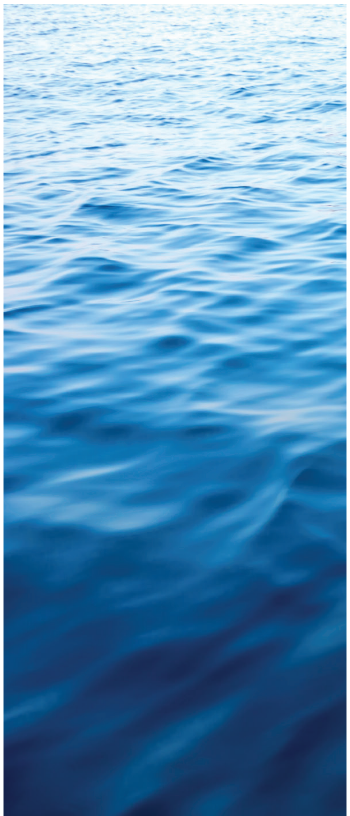

Environmental Impact Assessment

Payara Development Project

Esso Exploration and Production Guyana Limited

Volume I

ERM

GSEC GROUND STRUCTURES ENGINEERING CONSULTANTS INC.

EMC

August 2019

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Volume I of this Environmental Impact Assessment is hereby submitted by Esso Exploration and Production Guyana Limited (EEPGL).

EEPGL Country Manager	Rod O Henson	27 AUG 2019
	Rod Henson	Date

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Acronym	Definition
°	degree
%	percent
%BFROC	percentage of base fluid retained on cuttings
°C	degrees Celsius
°F	degrees Fahrenheit
µg/g	micrograms per gram
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
µmol/kg	micromoles per kilogram
µPa	micro pascal
3D	three dimensional
4D	four dimensional
AASM	Airgun Array Source Model
ADCP	Acoustic Doppler Current Profiler
AIDS	acquired immunodeficiency syndrome
AOI	Area of Influence
Application	Application for Environmental Authorisation
AQS	air quality standard
AUV	automated underwater vehicle
BAT	best available technology
bbl	barrel(s)
BDL	below detection limit
BETX	benzene, toulene, ethylbenzene, and xylenes
BOP	blowout preventer
BOPD	barrels of oil per day
BPD	barrels per day
BSEE	U.S. Bureau of Safety and Environmental Enforcement
CALM	catenary anchor leg mooring
CAPEX	capital expenditure
CARICOM	Caribbean Community
CARITRANS	Caribbean Transportation Consultancy Services Company Limited
CCR	central control room
CDC	Community Development Council
CGM	Conservation International
CI	
CIA	cumulative impact assessment
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CJIA	Cheddi Jagan International Airport
CLBD	Centre for Local Business Development

Acronym	Definition
cm	centimeter
cm/s	centimeter per second
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COD	chemical oxygen demand
Consultants	Environmental Resources Management (ERM), Environmental Management Consultants (EMC), and Ground Structures Engineering Consultants Ltd. (GSEC)
CPI	Carbon preference index
CR	Critically Endangered (IUCN)
CTD	conductivity, temperature, and depth
dB	decibel
DD	Data Deficient
DE	Department of Energy
DNA	deoxyribonucleic acid
DP	Dynamic Positioning
DWBC	Deep Western Boundary Current
EAB	Environmental Assessment Board
EBS	environmental baseline survey
EBSA	Ecologically or Biologically Significant Area
ECIA	Eugene F. Correira International Airport
eDNA	environmental DNA
EEPGL	Esso Exploration and Production Guyana Limited
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EHS	environmental, health, and safety
EITI	Extractive Industries Transparency Initiative
EMC	Environmental Management Consultants
EMP	environmental management plan
EN	Endangered (IUCN)
EPA	Guyana Environmental Protection Agency
ERL	Effect Range Low
ERM	Environmental Resources Management
ERM	Effects Range Median
ESMP	Environmental and Socioeconomic Management Plan
ESS	ecosystem services
EUNIS	European Nature Information System
FLET	flowline end termination

Acronym	Definition
FOC	fiber optic cable
FPSO	Floating Production, Storage, and Offloading (vessel)
FSO	Floating Storage and Offloading (vessel)
ft^2	square feet
Fugro	Fugro Marine Geoservices, Inc.
FWRAM	Full Waveform Range-dependent Acoustic Model
g	gravity
g/m^2	grams per square meter
gal	gallon
GCM	Community Grievance Mechanism
GDP	gross domestic product
GEA	Guyana Energy Agency
GEMSS	Generalized Environmental Modeling System for Surfacewaters
GGMC	Guyana Geology and Mines Commission
GHG	greenhouse gas
GHP	Global Health Practice
GI	gas [re]injection
GIOFP	Good International Oil Field Practice
GLSC	Guyana Lands and Surveys and Land Commission
GMPHOM	Guide to Manufacturing and Purchasing Hoses for Offshore Moorings
GSDS	Green State Development Strategy
GSEC	Ground Structures Engineering Consultants Ltd.
GSI	Gemini Solutions
GWI	Guyana Water Inc.
GYD	Guyanese dollar
H_2S	hydrogen sulfide
Handbook	Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets
HIV	human immunodeficiency virus
HP	high pressure
HSF	hard seafloor feature
HYCOM	Hybrid Coordinate Ocean Model
Hz	hertz
IBA	Important Bird Area
IBH	Important Bird Habitat
ICSS	Integrated Control and Safety System
ICZM	Integrated Coastal Zone Management

Acronym	Definition
IDB	Inter-American Development Bank
IFC	International Finance Corporation
ILO	International Labour Organization
IMO	International Maritime Organization
IOGP	International Oil and Gas Producers
IP	intermediate pressure
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
kg	kilogram
kHz	kilohertz
km	kilometer
km^2	square kilometer
LADCP	Lowered Acoustic Doppler Current Profiler
lb	pound
LC	Least Concern (IUCN)
LCDS	Low Carbon Development Strategy
LDAR	leak detection and repair
LFC	Low-frequency cetacean
LME	Large Marine Ecosystem
LOS	Level of Service
LP	low pressure
m	meter
m^2	square meter
MARAD	Maritime Administration Department
MARPOL 73/78	International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978
MFC	Mid-frequency cetaceans
mg/L	milligrams per liter
mi^2	square miles
MICS	Multiple Indicator Cluster Survey
MJ	megajoule
mm	millimeter
MMO	Marine Mammal Observer
MMscfd	million standard cubic feet per day
MOC	North Atlantic Meridional Overturning Circulation
MONM	Marine Operations Noise Model
MoNRE	Ministry of Natural Resources and Environment
MPa	megapascal
n	number
NA	not applicable
NABF	non-aqueous base fluid
NADF	non-aqueous drilling fluid
NBC	North Brazil Current
NBSAP	National Biodiversity Strategy and Action Plan
ND	no data
NDC	Neighbourhood Democratic Councils
NDS	National Development Strategy
NEAP	National Environmental Action Plan
NEBA	Net Environmental Benefit Analysis
NECC	North Equatorial Counter Current
ng/L	nanograms per liter
NGO	non-governmental organization
NO_2	nitrogen dioxide
NOAA	U.S. National Oceanic and Atmospheric Administration
NORM	naturally occurring radioactive material
NOx	nitrogen oxides
NPD	naphthalene, phenanthrene, anthracene, and dibenzothiophene
NR	not rated
NS	not sampled
NT	Near Threatened (IUCN)
NV	no value
NW-NNW	northwest-north-northwest
OCIMF	Oil Companies International Marine Forum
OIMS	Operations Integrity Management System
OSRP	Oil Spill Response Plan
OUT	operational taxonomic unit
PA	Petroleum Agreement
PAC	Project-Affected Communities
PAH	polycyclic aromatic hydrocarbons
PAM	passive acoustic monitoring
PBPA	Portland Bight Protected Area
PC	Project Contribution
PCS	Process Control System
PDA	Project Development Area
PEC	Predicted Environmental Concentration
PK	Peak Sound Pressure Level
$PM_{2.5}$	particulate matter with aerodynamic diameter of less than 2.5 micrometers
PM_{10}	particulate matter with an aerodynamic diameter of less than 10 micrometers
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million

Acronym	Definition
ppt	parts per thousand
Pr/Ph Ratio	Ratio of pristane to phytane
Project	Liza Phase 2 Development Project
PS	Performance Standard
PSC	Private Sector Commission
PSO	Protected Species Observer
PTS	Permanent Threshold Shift
R95%	Maximum distance from the source at which the given sound threshold is predicted in the modeled maximum-over-depth sound field over all azimuths, after the 5 percent of the threshold-exceeding area farthest from the source is excluded
R_{max}	maximum distance from the source at which the given sound threshold is predicted in the modeled maximum-over-depth sound field over all azimuths
RDC	Regional Democratic Council
redox	oxidation-reduction
ROV	remotely operated vehicle
s	second
SBPA	Shell Beach Protected Area
SD	standard deviation
SDU	Subsea Distribution Unit
SEL	sound exposure level
SEL_{24h}	24-hour sound exposure level
SEP	Stakeholder Engagement Plan
SGSCS	Suriname-Guyana Submarine Cable System
SHC	saturated and aliphatic hydrocarbons
SIS	Safety Instrumented System
SO_2	sulfur dioxide
SOLAS	International Convention for the Safety of Life at Sea
SPL	sound pressure level
SQG	sediment quality guideline
SQuiRT	Screening Quick Reference Table
SRU	Sulfate Removal Unit
SSH	sea surface height
SSHE	Safety, Security, Health, and Environment
SSS	side-scan sonar
SURF	Subsea, Umbilicals, Risers, and Flowlines
SWF	Sovereign Wealth Fund
TB	tuberculosis
TC	Town Council
TDS	total dissolved solids

Acronym	Definition
TED	turtle excluder device
THC	total hydrocarbons
TOC	total organic carbon
ToR	Terms of Reference
TSS	total suspended solids
UCM	Unresolved complex mixture
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISDR	United Nations International Strategy for Disaster Reduction
USD	U.S. dollars
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
USOS	Upper Slope and Outer Shelf
VEC	Valued Environmental and Social Component
VIR	Vertical Infrared Thermal Unit
VOC	volatile organic compounds
VSP	Vertical Seismic Profile
VU	Vulnerable (IUCN)
WBDF	water-based drilling fluids
WCD	worst case discharge
WG2	Protected Species Observer
WHO	World Health Organization
WHRU	waste heat recovery unit
WI	water injection
wt%	weight percent
WMP	Waste Management Plan

GLOSSARY

Term	Definition
anthropogenic	Made by humans or attributable to human activity.
barrel	The basic unit for measuring volume of oil or other liquids in the oil and gas industry. A barrel is equal to 42 U.S. gallons.
biogenic	Made by living organisms or attributable to the activity of living organisms.
biomagnification	Increasing concentration of a persistent substance, usually a pollutant or toxin, in the tissues of organisms at successively higher levels in a food chain.
borehole (or wellbore)	A deep hole drilled in the earth for the purpose of extracting a core, releasing gas, oil, water, etc.
casing	Steel pipe inserted into an oil or gas well to prevent the wall of the borehole from caving in, to prevent movement of fluids from one formation to another, and to improve the efficiency of extracting petroleum (for producing wells).
circumtropical	Distributed throughout the world's tropical latitudes.
congregatory	Tending to gather in large groups on a cyclical or otherwise regular and/or predictable basis.
crude oil	Liquid petroleum as it comes out of the ground. The properties of crude oil, such as color, gravity, and viscosity, can vary.
cumulative impact	Impacts that result from the successive, incremental, and/or combined effects of an action, project, or activity added to effects from other existing, planned, and/or reasonably certain actions, projects, or activities.
cuttings (or drill cuttings)	Broken bits of solid material produced as the drill bit advances through the borehole in the rock or soil. Cuttings are usually carried to the surface by the drilling fluid circulating up from the drill bit, and can be separated from the drilling fluid using a variety of treatment methods (e.g., centrifuge).
development well	A well drilled in a proven area in a field for the purposes of producing hydrocarbons.
drill center	Defined as a group of wells (including production, water injection, and/or gas re-injection wells) clustered around one or more manifolds. Each drill center incorporates separate manifolds that are designed for production or injection.
drill ship	A self-propelled floating offshore drilling unit that is a ship constructed to allow a well to be drilled from it. Drill ships are generally the preferred option for drilling wells in deep, remote waters.
drilling fluids	Specially formulated fluids that are typically a mixture of barite, clay, water, and other chemical additives. Drilling fluids are circulated into the borehole to lubricate and cool the rotary drill bit, to lift the cuttings out of the borehole and to the surface, and to help maintain well control.
ecosystem services	The benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities, and provide cultural fulfilment.
embedded control	Physical or procedural controls that are planned as part of the Project design (i.e., not added solely based on a mitigation need identified by the impact significance assignment process). These are considered from the very start of the impact assessment process as part of the Project, and are factored in to the pre-mitigation impact significance rating.
eutrophication	Over-enrichment of a waterbody with minerals and nutrients that can induce excessive growth of plants (including phytoplankton) or algae.

Term	Definition
exploration	A term in the oil and gas industry referring to activities related to the search for oil and gas resources. Exploration operations can include aerial surveys, geophysical surveys, geological studies, core testing, and the drilling of test wells.
flare (or flaring)	In the oil and gas industry, a system of piping and burners used to dispose (by burning) of surplus gas or vapors produced with the oil and gas.
Floating Production Storage and Offloading (FPSO) vessel	A floating vessel that is used for offshore oil and gas operations and is designed to process hydrocarbons and store oil until the oil can be offloaded onto a tanker ship. The processing equipment (or topsides) is located on the FPSO's deck, while the oil storage is below the deck within the hull of the vessel.
flowline	The pipe through which oil travels from a production well to processing equipment or to storage.
freehold property	Property owned by the land user, not leased.
hawser	A taut line connecting the FPSO to tankers during offloading. The hawser helps the offloading tanker maintain a safe distance from the FPSO.
hydrostatic test	A way in which facilities such as pipelines, plumbing, gas cylinders, boilers, pressure vessels, and fuel tanks can be tested for strength and leaks. The test involves filling the vessel or pipe system with a liquid, usually water, which may be dyed to aid in visual leak detection, and pressurizing the vessel or pipe system to the specified test point. Pressure tightness can be tested by shutting off the supply valve and observing whether there is a pressure loss.
hypoxia	Deficiency in dissolved oxygen concentrations.
ichthyoplankton	Fish eggs and larvae that drift with the ocean currents, usually near the surface, prior to developing directional swimming ability.
injection well	A well in which fluids, such as gas or water, are injected to increase pressure in the reservoir and drive the oil remaining in the reservoir to the vicinity of production wells.
Lagrangian	A type of model in which particles or parcels are moved under the influence of external forcing (winds, currents, buoyancy, turbulence, etc.) based on its individual location. The term is often used to differentiate such models from Eulerian models, where a field is established representing properties of interest (mass, concentration, etc.) in a discrete gridded space, and external forcing is applied to the entire property of that grid.
laydown area	An area that has been cleared for the storage of equipment and supplies. Laydown areas are usually covered with rock and/or gravel to ensure accessibility and safe maneuverability for transport and offloading vehicles.
manifolds	Gathering points or central connections made up of valves, hubs, piping, sensors, and control modules.
marine safety exclusion zone	A specific area of water where persons, vessels, and other activities are prohibited as the area has been designated for exclusive use by an activity; a form of safety control measure used to keep unauthorized persons and vessels away from a higher risk activity/event.
natural gas	A highly compressible, highly expansible mixture of hydrocarbons, which at atmospheric conditions of temperatures and pressure are in a gaseous phase.
oil-equivalent barrels	A unit of energy based on the approximate energy released by burning one barrel of crude oil. Quantities of natural gas and natural gas liquids are often translated into oil-equivalent barrels. The energy content of 6,000 cubic feet of natural gas is roughly equivalent to the energy in one barrel of oil (i.e., one oil-equivalent barrel).
photo-oxidation	The process of chemical breakdown caused by exposure to sunlight.

Term	Definition
pig	A specially designed device that is placed in the flowline at a launcher at one end and pushed by pressure until it reaches a receiving trap or catcher at the other end. Pigging is performed to aid in the maintenance, operations, cleaning, and/or inspection of flowlines and pipelines.
plugging and abandonment	When used in reference to a well after its productive life, the sealing of the well casing with materials (e.g., cement and/or mud) and removal of the wellhead.
produced water	Water that comes up a well with the oil and gas. Produced water is usually high in salinity. After leaving the well, the produced water is separated from the oil and gas. Can also be referred to as formation water, saltwater, or oilfield brine.
production well	A well that is used to retrieve petroleum or gas from an underground deposit.
reservoir	In the oil and gas industry, a porous and permeable sedimentary rock containing commercial quantities of oil and gas.
risers	The pipe and special fittings used on floating offshore drilling rigs to establish a seal between the top of the wellbore, which is on the ocean floor, and the drilling equipment, located above the surface of the water. A riser pipe serves as a guide for the drill stem from the drilling vessel to the wellhead and as a conductor of drilling fluid from the well to the vessel. The riser consists of several sections of pipe and includes special devices to compensate for any movement of the drilling rig caused by waves. Risers are also used to carry production fluids to the FPSO from the seabed and carry injection fluids (water and gas) from the FPSO to the seabed.
shorebase	A land-based facility that provides logistical and material support for offshore activities and facilities.
spread mooring system	A group of mooring lines distributed from the bow and stern of a vessel (FPSO) to anchors on the seafloor. The vessel is positioned in a fixed heading, which is determined by the sea and weather conditions. The symmetrical arrangement of anchors helps to keep the vessel on its fixed heading location. The spread mooring system does not allow the vessel to weathervane, which means to rotate in the horizontal plane due to wind, waves, or current.
structural casing	The outer layer of large-diameter, heavy-wall pipe installed in wells drilled from floating installations to isolate very shallow sediments from subsequent drilling, resist the bending moments imposed by the marine riser, and help support the wellhead installed on the conductor casing.
umbilical	A cable and/or hose that provides the electrical, hydraulic, chemical, and communications connections needed to provide power and control between the FPSO and subsea equipment.
wellhead	A structure that is installed at the top of a natural oil or gas well. Its main function is to ensure a safe operation and manage the flow of oil or gas from the well into the gathering-system. It is a system composed of valves, spools, and assorted adapters that control the pressure of the production well. It acts as an interface between the surface facilities and the casing-strings in the wellbore.
wellhead tree	An assembly of valves, spools, pressure gauges, and chokes fitted to the wellhead of a completed well to control production.

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ENVIRONMENTAL IMPACT STATEMENT

EXECUTIVE SUMMARY

In 2015, oil was discovered in the Liza field within the Stabroek Block, approximately 190 kilometers (120 miles) offshore from Georgetown in waters approximately 1,500 to 1,900 meters (932 to 1,180 feet) deep. Based on exploration and assessment activities to date, Esso Exploration and Production Guyana Limited (EEPGL) has estimated that the Stabroek Block contains more than 6 billion barrels of oil-equivalent recoverable resource.

EEPGL (45 percent) and its co-venturers Hess Guyana Exploration Limited (30 percent) and CNOOC Petroleum Guyana Limited (25 percent) are parties to a Petroleum Agreement with the Government of Guyana.

EEPGL, on behalf of itself and its co-venturers, and in accordance with the Guyana Environmental Protection Act, is seeking an environmental authorization from the Guyana Environmental Protection Agency (EPA) for a third project development in the eastern half of the Stabroek Block (hereafter referred to as the Payara Development Project, or “the Project”); the area that will be developed as part of the Project is located approximately 207 kilometers (approximately 128 miles) northeast of the coastline of Georgetown, Guyana. As part of its regulatory role, the EPA, considering recommendations from the Environmental Advisory Board and other government entities, is responsible for deciding whether and under what conditions to grant EEPGL’s Application for Environmental Authorisation (Application), which was filed with the EPA on 3 December 2018. Based on an initial assessment of the Application, the EPA determined that an Environmental Impact Assessment (EIA) was required in support of the Application.

The purpose of the EIA is to provide the factual and technical basis required by the EPA to make an informed decision on EEPGL’s Application to permit the Project. EEPGL conducted a robust public consultation program to both inform the public about the Project and to understand community and stakeholder concerns so this feedback could be incorporated and addressed in the EIA, as applicable.

The Project will consist of the drilling of up to 45 development wells (including production, water injection, and gas re-injection wells); installation and operation of Subsea, Umbilicals, Risers, and Flowlines equipment; installation and operation of a Floating Production, Storage, and Offloading (FPSO) vessel in the eastern half of the Stabroek Block; and—ultimately—Project decommissioning. Onshore logistical support facilities and marine/aviation services will be used to support each stage of the Project. EEPGL will use proven and industry-accepted standards and has incorporated many embedded controls into the overall Project design to reduce environmental and socioeconomic impacts. It could take up to 5 years to drill the wells, with drilling beginning in 2020. The initial production is expected to begin by early 2023, with operations continuing for at least 20 years. The Project is expected to employ up to 600 persons during development well drilling, approximately 600 persons at the peak of the installation stage, and up to about 140 persons during production operations.

The planned activities of the Project are predicted to have negligible residual impacts on most physical resources (air quality, marine geology and sediments, and marine water quality)—with potential moderate residual impacts on climate, no impacts on coastal biological resources, negligible to minor residual impacts on most marine biological resources (with potential moderate residual impacts on marine mammals), and negligible to minor residual impacts on socioeconomic resources—with largely positive impacts on socioeconomic conditions. These predictions are based on the fact that the bulk of the Project activity will occur approximately 207 kilometers (approximately 128 miles) offshore; and the Project will capture and re-inject produced natural gas (that which is not used as fuel on the FPSO) back into the targeted Project reservoirs, treat all required wastewater streams prior to discharge to the sea, have a very small physical footprint (e.g., infrastructure construction disturbs only about 0.8 square kilometers [0.3 square miles] of benthic habitat), and use Marine Mammal Observers and "soft starts" during selected activities to reduce the potential for auditory injury to marine mammals.

Unplanned events, such as a potential oil spill, are considered unlikely to occur because of the extensive preventative measures employed by EEPGL. Nevertheless, EEPGL has conducted oil spill modeling to evaluate the range of likely spill trajectories and rates of travel in the unlikely event of a spill. The location of the Project 207 kilometers (approximately 128 miles) offshore, prevailing northwest currents, the medium nature of the Payara field crude oil, and the region's warm waters would all help reduce the severity of a spill. A type of modeling known as stochastic modeling was performed for a number of spill scenarios. Stochastic modeling accounts for the variability in conditions such as winds and ocean currents by simulating hundreds of individual spills (theoretically occurring at different times and under different wind/current conditions) and generating a map that is a *composite* of all of the trajectories and provides a *probability footprint* showing the most likely path that a spill would follow. Stochastic modeling of an unmitigated subsea release of crude oil from a loss-of-well-control event indicates only a 5 to 20 percent probability of oil reaching the Guyana coast, without taking into consideration the effectiveness of any oil spill response, and the low likelihood that such a spill would occur.

Although the probability of an oil spill reaching the Guyana coast is very low, a subsea release of crude oil from a loss-of-well-control event would impact marine water quality and marine biological resources found near the well. Marine turtles and marine mammals would be particularly susceptible to impacts from an oil spill due to the need to surface to breathe and the resulting inhalation risks. Baleen whales feed near the surface where oil would be entrained, so an oil spill could foul their baleen plates and expose them to ingestion of oil as well as inhalation of volatized hydrocarbons. Should spilled oil reach the coast in Region 1, the risks of oiling nesting beaches could pose inter-generational risks to marine turtles. Other physical and biological resources such as air quality, seabirds, marine fish, and marine benthos could also be impacted, although current speeds in the Project Development Area regularly exceed 1 meter (3.3 feet) per second and, as the deterministic modeling discussed in EIA Section 9.1.5, Oil Spill

Modeling Results, demonstrates, spilled oil would travel rapidly to the north and/or west, depending on the season. Most of the biological resources listed are mobile and would be capable of at least some measure of avoidance of the higher hydrocarbon concentrations. This means that with the exception of immobile organisms in the immediate vicinity of the affected well, most physical and biological resources would likely experience impacts on the order of a few days at most.

Systemic ecological and food-web-related impacts could last longer depending on the extent of the acute impacts experienced from a spill event. Most species in the open ocean are at least somewhat mobile. This means that following initial detection of the oil, they would tend to avoid the affected area for the duration of the spill and return once the event is over, response activities are complete, and food resources recover. Given the likelihood that direct exposure to the effects of a spill would be short-term for most of these species, it is unlikely that an oil spill would cause widespread mortality and/or inter-generational impacts. The marine food web is based on planktonic organisms, many of which (with the exception of some fishes and a few macrobenthic species) would be expected to recover within a few weeks or months of the event. Even long-lived species with planktonic early life-stages would be expected to lose at most one year-class of recruits, and recover through emigration from unaffected areas within a few years of the event.

A spill could potentially impact Guyanese fisherfolk if commercial fish and shrimp resources were impacted. The magnitude of this impact would depend on the volume and duration of the release as well as the time of year at which the release were to occur (e.g., whether a spill would coincide with the time of year when these species are more abundant in the Project Development Area). Based on the results of the studies, fish diversity and abundance generally increase in the nearshore zone in the rainy season, marine turtle presence shows little variation over the seasons in terms of their abundance offshore, and marine mammals are more abundant in autumn and winter. Marine turtles are relatively abundant offshore Region 1 during the nesting season, but less common at other times of year. Regardless of seasonal trends in abundance or spatial distribution among the major taxonomic groups, effective implementation of the Oil Spill Response Plan (OSRP) would reduce this risk by reducing the ocean surface area impacted by a spill and thereby reducing potential exposure of these species to oil.

Oil spill modeling indicates that transboundary impacts could potentially occur for the largest spill scenarios considered (2,500-barrel release from an FPSO offloading spill and 20,000 barrels of oil per day to 202,192 barrels of oil per day release from a loss-of-well-control event) assuming no mitigation measures were implemented. The unmitigated modeling results for these scenarios indicate there is the potential for oil to reach portions of a number of countries in the Caribbean. Potential impacts on resources and receptors in these other countries would be similar to those for Guyana. Further, there are some additional resources that could potentially be affected (e.g., corals), which recent marine surveys have documented are sparsely distributed across the middle and outer continental shelf and continental slope.

Additional unplanned events, also considered unlikely to occur because of the preventative measures employed by EEPGL, could include collisions between Project vessels and third-party vessels; Project vessel strikes of marine mammals, marine turtles, riverine mammals, or rafting seabirds; collisions between Project vehicles and third-party vehicles; Project helicopter strikes with seabirds; and discharge of untreated wastewater from the Project FPSO. The extent of the impacts from these types of events would depend on the exact nature of the event. However, in addition to reducing the likelihood of occurrence, the embedded controls that will be put in place by EEPGL (e.g., training of vessel operators to recognize and avoid marine mammals, riverine mammals, and marine turtles; adherence to international and local marine navigation procedures; adherence to a Road Safety Management Procedure) would also serve to reduce the likely extent of impact, were such an event to occur.

Although a large marine oil spill is considered unlikely and the probability of reaching the Guyana coast is very low, given the sensitivity of many of the resources that could be potentially impacted by a spill (e.g., Shell Beach Protected Area, marine mammals, critically endangered and endangered marine turtles, coastal Guyanese and Amerindian communities reliant on ecosystem services for sustenance and their livelihood), preparation for spill response is warranted. Therefore, EEPGL will implement from time to time regular oil spill response drills, simulations, and exercises. EEPGL will involve appropriate Guyanese authorities and stakeholders in these activities and document the availability of appropriate response equipment on board the FPSO as well as offsite equipment required to be mobilized for a timely response.

With respect to potential transboundary impacts from an oil spill, implementation of EEPGL's OSRP would help to significantly reduce potential transboundary impacts just as it would reduce impacts within the Guyana Exclusive Economic Zone, as demonstrated by oil spill modeling that considers OSRP implementation (i.e., mitigated scenarios). In particular, EEPGL has put in place an interim solution that will facilitate installation of a capping stack on well location within 9 days in certain circumstances (e.g., where there is no debris that prevents or delays installation of the capping stack). Mitigated scenario modeling demonstrates that this, in combination with other response measures (e.g., dispersant application), would significantly reduce the extent of transboundary impacts. Additionally, EEPGL has committed to work with the Government of Guyana for the coordination of applicable activities with representatives of the respective countries that could be potentially impacted by a large oil spill.

It is recommended that all of EEPGL's planned embedded controls, as well as the mitigation measures described herein, and appropriate Environmental and Socioeconomic Management Plan components, including an OSRP, be adopted. With the adoption of such controls, mitigation measures, and management plans, and requirements for emergency response preparedness, the Project is expected to pose only minor risks to the environmental and socioeconomic resources of Guyana, while potentially offering significant economic benefits to the residents of Guyana.

1. INTRODUCTION

This Environmental Impact Statement (EIS) was prepared for the Payara Development Project (Project) in accordance with the Guyana Environmental Protection Act (as amended in 2005), the Environmental Protection (Authorisation) Regulations (2000), the Environmental Impact Assessment Guidelines—Volume 1, Version 5 (EPA 2004), the Environmental Impact Assessment Guidelines—Volume 2, Version 4 (EPA/EAB 2000), international good practice, Esso Exploration and Production Guyana Limited's (EEPGL's) standards, and the Project's Final Terms and Scope (24 June 2019) for the Project Environmental Impact Assessment (EIA).

The EIA was prepared by a team of consultants including Environmental Resources Management (ERM), an international environmental and social consulting firm with a local registration in Guyana and extensive experience in the preparation of EIAs for offshore oil and gas development projects, and the Guyanese consultancies Environmental Management Consultants (EMC) and Ground Structures Engineering Consultants Ltd. (GSEC). ERM, EMC, and GSEC are collectively referred to herein as "the Consultants." Appendix B provides the curriculum vitae of the key members of the EIA team.

1.1. PROJECT SPONSOR

EEPGL is the designated Operator of the Stabroek Block and is seeking authorization for the Project on behalf of itself and Hess Guyana Exploration Limited and CNOOC Petroleum Guyana Limited (EEPGL's "co-venturers"). EEPGL will be the operator of the Project, and is used in this EIA to represent the joint venture. EEPGL is an indirectly owned affiliate of Exxon Mobil Corporation.

1.2. PROJECT CONTEXT

EEPGL (with the co-venturers) holds an offshore Petroleum Prospecting Licence for the Stabroek Block from the Government of Guyana. In 2015, oil was discovered in the Liza field within the eastern half of the Stabroek Block approximately 207 kilometers (approximately 128 miles) northeast of the coastline of Georgetown in waters approximately 1,500 to 1,900 meters (approximately 4,900 to 6,233 feet) deep (Figure EIS-1). Based on exploration and assessment activities to date, EEPGL has identified the presence of multiple reservoirs of crude oil with an estimated recoverable resource in excess of 6 billion barrels of oil-equivalent resource in the eastern half of the Stabroek Block. The Project described herein represents EEGPL's third project development in the eastern half of the Stabroek Block, in the Payara, Pacora, Liza Deep, and northern area of the Liza fields. EEPGL and its co-venturers are parties to a Petroleum Agreement with the Government of Guyana.

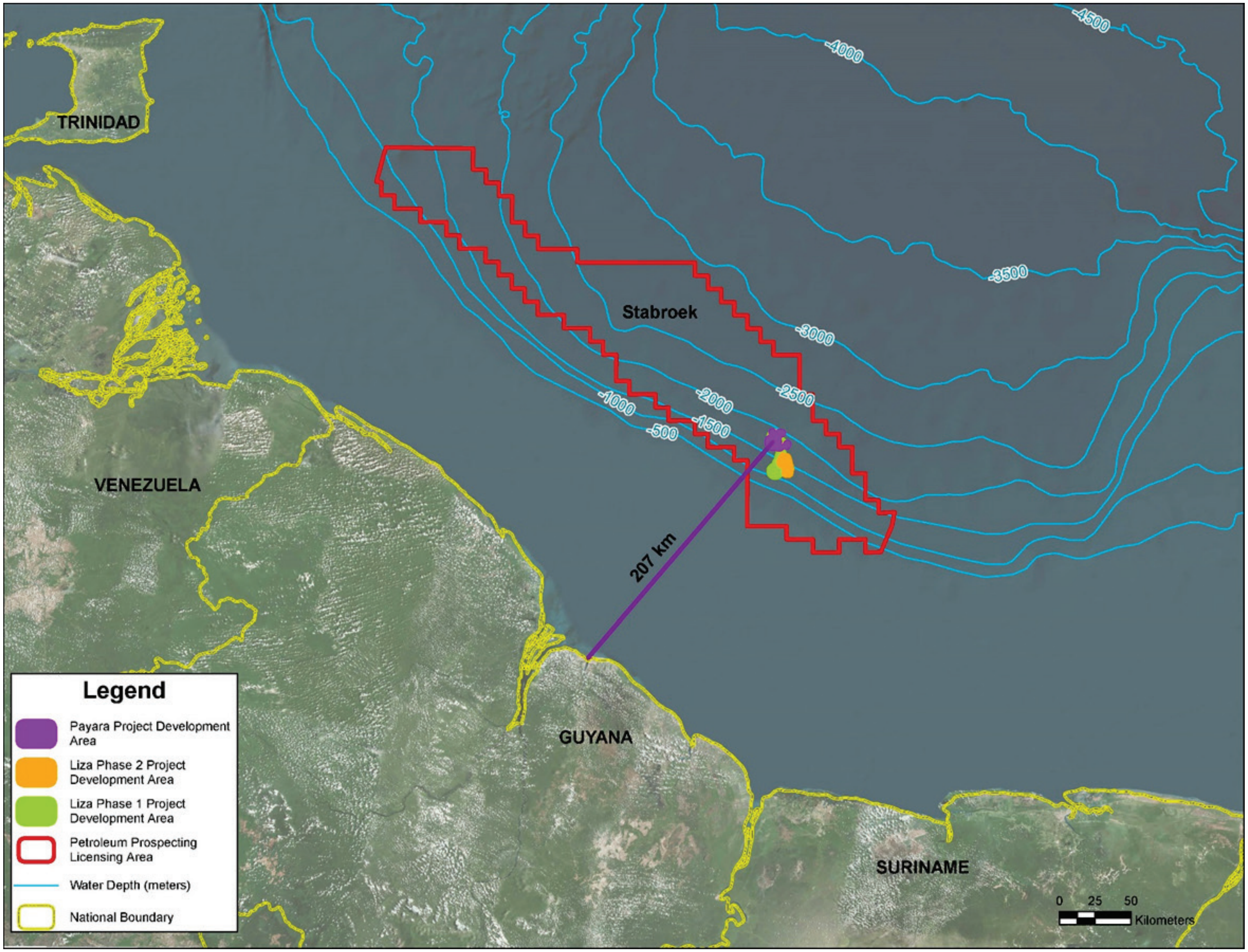

Figure EIS-1: Location of the Payara Project Development Area within Stabroek Block

1.3. PURPOSE OF THE PROJECT

The purpose of the Project is to achieve safe and efficient production of hydrocarbons from the Payara, Pacora, Liza Deep, and northern area of the Liza fields.

1.4. REGULATORY FRAMEWORK AND PURPOSE OF THIS EIA

To develop the Project, EEPGL has applied for a Project Environmental Authorisation from the Guyana Environmental Protection Agency (EPA) in accordance with the Guyana Environmental Protection Act (as amended in 2005). To that end, EEPGL filed its application with the EPA on 3 December 2018 (Application). As part of its regulatory role, the EPA, taking into consideration recommendations from the Environmental Advisory Board and other government entities, is responsible for deciding whether and under what conditions to approve EEPGL's Application. Based on an initial assessment of the Project, the EPA determined that an EIA is required. The purpose of the EIA is to provide the factual and technical basis required by EPA to make an informed decision on EEPGL's Application.

2. PROJECT DESCRIPTION

The Project will develop the offshore resource by drilling up to 45 development wells (including production, water injection, and gas re-injection wells) and using a Floating Production, Storage, and Offloading (FPSO) vessel to process, store, and offload the recovered oil. The FPSO will be connected to the wells via associated equipment, collectively referred to as Subsea, Umbilicals, Risers, and Flowlines (SURF), to transmit produced fluids (i.e., oil, gas, and produced water) from production wells to the FPSO, as well as treated gas and water from the FPSO to the injection wells. The combined extent of the area affected by both surface and subsea components and activities is referred to as the Project Development Area (PDA). The exact locations of the Payara development wells have not yet been finalized; however, the wells will be drilled from ten drill centers. During drilling and installation of the FPSO/SURF facilities, work may be performed in a subsea area within the PDA that could potentially cover an estimated 7,800 hectares. This area is referred to as the Subsea PDA. During the production operations stage, work performed on the surface of the ocean could potentially cover an estimated 5,000 to 5,500 hectares. This area is referred to as the Surface PDA. The PDA is located approximately 207 kilometers (approximately 128 miles) offshore (Figure EIS-2). The Project will also involve use of onshore shorebases and other support facilities and marine/aviation services to support development drilling, SURF and FPSO installation, production operations, and, ultimately, decommissioning.

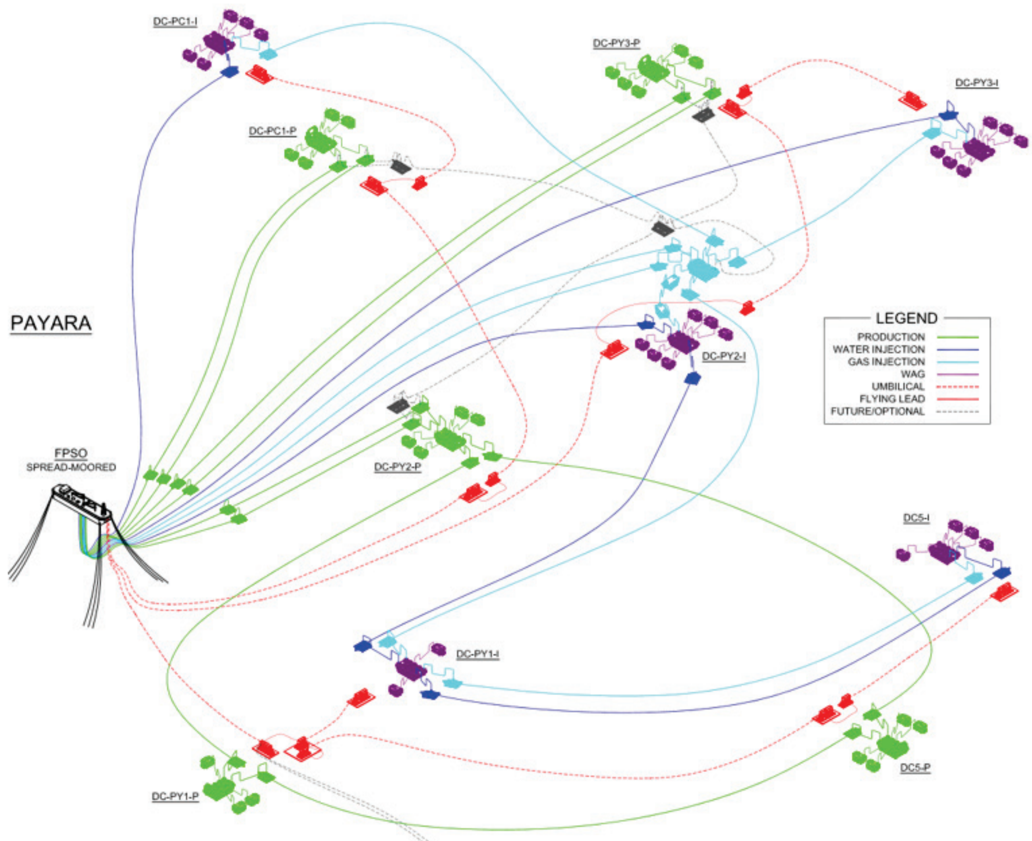

Figure EIS-2: Preliminary Payara Field Layout

Natural gas will be produced in association with the produced oil. EEPGL will use some of the recovered gas as fuel on the FPSO, and proposes to re-inject the remaining gas back into the reservoir, which will assist in optimizing management of the reservoir. Alternative uses of gas for future phases are being studied and any such uses would be addressed in a separate environmental authorization.

The Project will consist of three stages: (1) Drilling and Installation, (2) Production Operations, and (3) Decommissioning. Each of these stages is described briefly below.

2.1. DRILLING AND SURF/FPSO INSTALLATION

The Project will use several drill ships similar to that shown on Figure EIS-3 to drill the development wells. The number of drill ships required will be determined during the design development process based primarily on the number of wells required for initial oil production. For the purposes of environmental assessment, two full-time drill ships working concurrently on Project development wells will be the basis of analysis. Additional drill ships may be used to accelerate the drilling schedule, as allowed by simultaneous operations. The wellheads will be clustered around ten drill centers rather than being distributed over the seabed above the producing reservoirs. For safety reasons, a 500-meter (approximately 1,640-foot) marine safety exclusion zone around the drill ships and major installation vessels will be established to avoid interactions with unauthorized vessels.

For each well, the initial section (i.e., structural casing section) will feature a pipe inserted into the borehole and cemented in place. This section will be drilled using water based drilling fluids, and drill cuttings from this section will be discharged to the seafloor near the well. Subsequent (lower) sections of the wells will be drilled using low-toxicity non-aqueous drilling fluids (NADF) with low to negligible aromatic content. The used cuttings from the lower sections will be directed to the drill ship, where the drilling fluids will be recovered for reuse to the extent practicable and the cuttings will be treated to limit the percentage of fluid retained on the cuttings. After treatment, the cuttings will be discharged to the sea. As each well is drilled, a wellhead and tree will be installed and the well will be connected to a manifold, which will be connected to a production or injection flowline. The flowlines will be laid on the seafloor, and risers will connect the seafloor infrastructure to the FPSO. The flowlines and risers will be hydrostatically tested with treated seawater to ensure no leakage. After the testing, the hydrostatic water used to test the water and gas injection flowlines will be discharged near the seafloor, and the fluid used to test the production flowlines will be recovered and treated prior to discharging overboard.

The FPSO (Figure EIS-4) will be new-built with double-hull protection, with the capacity to store 2 million barrels of stabilized crude oil. The FPSO will be secured to the seafloor by a 20-point spread mooring anchor system. The FPSO and the mooring system will be designed to remain in place for at least 20 years and accommodate extreme (100-year return period) environmental conditions (associated wind, waves, and current). The FPSO will also provide living quarters and associated utilities for approximately 160 personnel. For safety reasons, the FPSO will have a 2-nautical mile exclusion zone during offloading to avoid interactions with unauthorized vessels.

Figure EIS-3: Typical Drill Ship

Figure EIS-4: Typical FPSO

2.2. PRODUCTION OPERATIONS

The FPSO will be designed to separate the recovered reservoir fluids into its oil, water, and gas phases (Table EIS-1). The oil will be treated to remove impurities (e.g., sulfate and other salts) and then sent to storage tanks in the hull. The water from the reservoir (referred to as produced water) will be treated to remove hydrocarbons and will then be discharged to the sea. The FPSO will dehydrate, compress, and re-inject the produced natural gas into the targeted Project reservoirs, although some of the gas will be used as fuel on the FPSO, and some gas may be occasionally flared on a temporary basis. The FPSO will also have the capacity to treat (by filtration, deaeration, and sulfate removal) seawater for injection into the reservoir to maintain reservoir pressure (and offset the withdrawal of reservoir fluids) to enhance oil production.

Table EIS-1: FPSO Key Design Rates

Service	Design Rate [a,b]
Oil production	220,000 BOPD
Produced water	215,000 BPD
Total liquids	270,000 BPD
Produced gas	395 MMscfd
Gas injection	365 MMscfd (assumes 30 MMscfd of produced gas will be used as fuel gas for the FPSO)
Water injection	250,000 BPD

BPD = barrels per day; BOPD = barrels of oil per day; MMscfd = million standard cubic feet per day
[a] All design rates are presented as the peak annual average.
[b] For the purposes of the EIA, 264,000 BOPD will be used as the conservative basis to assess potential impacts from the Project.

The FPSO will offload produced crude oil to conventional oil tankers on a regular basis. The tanker, under the guidance of a Mooring Master, will maneuver to within approximately 120 meters (390 feet) of the FPSO and hold position with the aid of up to three tugboats (Figure EIS-5). Crude oil will be pumped from the FPSO storage tanks to the offloading tanker using a floating hose at a rate of approximately one million barrels of oil in approximately 28 hours.

Figure EIS-5: General Offloading Configuration

2.3. DECOMMISSIONING

In advance of the completion of the Payara production operations stage, EEPGL will prepare a decommissioning plan for the facility. EEPGL will perform comparative assessments of facilities components where there may be multiple decommissioning options. Wells will be permanently plugged and abandoned by restoring suitable cap rock to prevent escape of hydrocarbons to the environment. Plugging and abandonment barriers will be installed in the wellbore, of adequate length to contain reservoir fluids, and deep enough to resist being bypassed by fracturing. It is expected that the risers, flowlines, umbilicals, subsea equipment, FPSO mooring lines, and anchor piles will be disconnected and abandoned in place on the seafloor, unless an alternative strategy is selected based on the results of the comparative assessments. The FPSO will be disconnected from its mooring system, removed from the production location, and towed to a new location for re-use or decommissioning.

2.4. Onshore, Marine, and Aviation Support

Shorebases, laydown areas, pipe yards, fabrication/maintenance facilities, warehouses, fuel supply, heliport, and waste management facilities are planned to support development drilling, FPSO/SURF installation, production operations, and ultimately, decommissioning. EEPGL plans to use an existing Guyana shorebase located on the east side of the Demerara River as the primary shorebase supporting the Project. All onshore support facilities will be owned/operated by others and will not be dedicated to the Project.

Marine support will include various supply vessels with an average of approximately 12 to 15 round-trips per week to the Stabroek Block (combined for Liza Phase 1, Liza Phase 2, and Payara) during development drilling and FPSO/SURF installation and approximately 5 to 10 round-trips per week (combined for Liza Phase 1, Liza Phase 2, and Payara) during production operations. The vessels will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad. Aviation support is expected to average at peak about 45 to 55 round-trip flights per week during drilling and installation (combined for Liza Phase 1, Liza Phase 2, and Payara) and an estimated maximum of 20 to 30 round-trip flights per week during production operations and continued development-drilling activities (combined for Liza Phase 1, Liza Phase 2, and Payara).

2.5. Project Workforce

EEPGL estimates it will require a workforce of approximately 600 persons at the peak of the development well drilling, approximately 600 persons at the peak of the installation stage, approximately 150 shorebase and marine logistical support onshore staff (some of whom will be Project-dedicated while others will be shared resources) at the peak of installation and drilling activities, approximately 100 to 140 persons at peak of production operations, and approximately 60 persons at the peak of decommissioning.

2.6. Project Schedule

It could take up to 5 years to drill the approximately 45 wells, with drilling planned to begin in late 2020. Installation of the SURF and FPSO is planned to be initiated in 2021 to be ready for initial production by early 2023, with operations continuing for at least 20 years (Figure EIS-6).

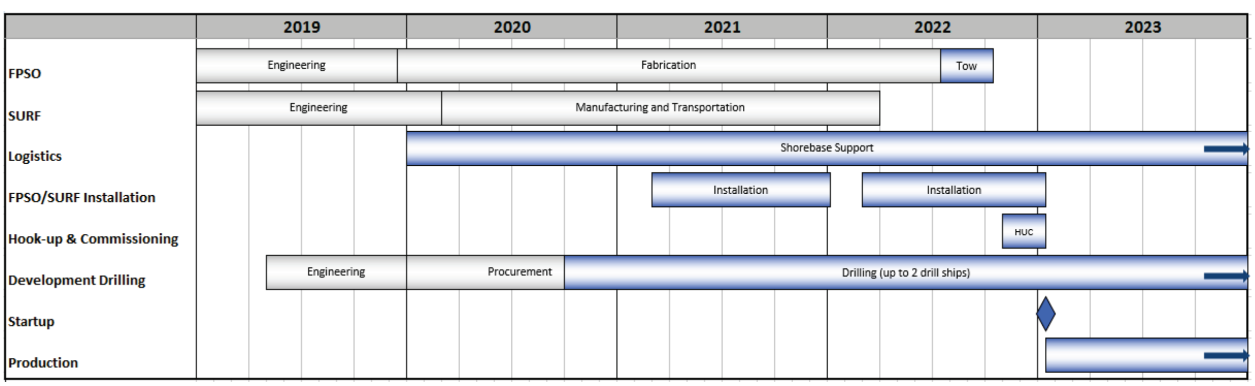

Figure EIS-6: Preliminary Project Schedule

2.7. PUBLIC CONSULTATION

EEPGL and the Consultants have conducted a robust public consultation program to both inform the public about the Project and understand stakeholder concerns so they could be incorporated into the EIA, as appropriate. The different stages of the Project each require stakeholder engagement that is tailored in terms of its objectives and intensity, as well as the forms of engagement used. The various engagements completed or planned specific to the EIA stage are summarized below.

- EEPGL has held a number of engagements and workshops on specific topics with the government and agencies related to the offshore oil and gas exploration and development in general and the Payara Development Project specifically, including but not limited to the Department of Energy (DE) (which falls under the Ministry of Presidency and recently took over responsibility for petroleum operations from the Ministry of Natural Resources), Guyana Geology and Mines Commission, and EPA.
- During scoping and the EIA development, EEPGL and/or the Consultants:
  - Held meetings and key informant interviews with and/or gathered relevant data from more than 15 Guyana government agencies, commissions, professional or business associations, non-governmental organizations, and elected officials and regional administrators; and
  - Held focus group meetings with more than 440 members of coastal communities and over 80 artisanal and commercial fisherfolk in Regions 1 to 6.

A Notice to the Public concerning the submission of the Application for the Project was published in the Stabroek News on 15 December 2018, and was posted on the EPA's website, initiating the 28-day public comment period. During this period, five public consultation meetings with the public were held.

These meetings are documented in the Stakeholder Engagement Plan and information received from these engagements was incorporated into the existing conditions and impact assessment components of the EIA, as appropriate.

2.8. ALTERNATIVES

The EIA considered a range of potential Project alternatives, as summarized below:

- Location Alternatives. The location of the offshore Project infrastructure, particularly the development wells and SURF hardware, is primarily driven by the location of the resource to be recovered. However, within the proximity of the resource, there is some flexibility in selecting the location of the FPSO and associated mooring system within the PDA. The locations/orientations of FPSO, SURF equipment, and drill centers were selected to reduce to the extent practicable the potential impacts on the environment and to optimize the recovery of resources. A key consideration in FPSO location is to minimize interference and facilitate efficient four-dimensional seismic operations in the Stabroek Block. Another consideration for the FPSO location is to avoid positioning FPSO anchor piles in areas that could create geotechnical challenges. Routing of flowlines/pipelines/risers between the manifolds and FPSO primarily seeks to minimize overall length while also avoiding clashing (e.g., between risers, umbilicals, and mooring lines). Minimizing length not only reduces Project cost, but also Project footprint (and impact). The FPSO and subsea equipment locations were chosen so that initial projects can be operated, including the marine operations associated with oil offloading, while subsequent projects are in the drilling or offshore installation phases. With respect to onshore components of the Project, the preferred alternative from an environmental perspective is to use existing shorebases in Georgetown with sufficient capacity to meet Project needs. If additional shorebases are developed in the future by third parties through separate permitting processes, EEPGL will consider the potential benefits (environmental, technical, and economic) of using these shorebases in addition to or in lieu of the shorebases that currently exist.

- Development Concept Alternatives
  - Drilling Facility Type: The primary alternatives considered for development well drilling facilities included a drill ship and a semi-submersible drilling rig. Drill ships allow for more efficient development operations as compared to semi-submersibles, given their increased variable deck load—which is critical due to multi-well drilling and completion equipment requirements. Drill ships also allow for faster transit speeds between drill centers, resulting in significant time-savings due to frequency of well movements during batch operations.
  - Production Facility Type: Several different types of production facility alternatives were evaluated during the early stages of the design process. Given the water depth and distance to shore of the Liza field, the development alternatives for the Project are primarily limited to floating production systems (e.g., FPSO, semi-submersible, tension leg platforms). Regardless of the structure, the chosen facility for the Project would need to process the same volumes of oil, gas, and water. As such, topsides facilities are similar between an FPSO and a semi-submersible. The real distinction is the need for oil storage. An FPSO has storage integrated into its facilities. A semi-submersible would require an additional floating, storage, and offloading (FSO) facility to allow for the oil storage. The FSO adds cost above the FPSO design and a semi-submersible with an FSO would also require additional moorings as compared to an FPSO. The use of an FSO would thus significantly increase the Project offshore infrastructure, which would increase potential Project impacts on air quality (e.g., increased air emissions), marine water quality (e.g., additional wastewater effluent discharges), marine benthos (e.g., increased disturbance of the seafloor for the FSO mooring system), and marine use and transportation (e.g., additional marine safety exclusion zones for additional marine vessels). For these reasons, an FPSO was selected as the preferred production facility alternative for the Project.

  - Crude Oil Commercialization: The principal alternatives for an offshore development are: (1) transmission to shore via subsea pipeline infrastructure to an onshore refining facility; and (2) offloading to export tankers for transport to onshore refining facilities located further from the resource than can be feasibly connected via pipeline infrastructure. As there are no existing petroleum refineries in Guyana or existing regional offshore pipeline infrastructure in close proximity, the only feasible alternative is offloading to export tankers for sale to existing refining facilities around the world.
  - Associated Gas Management: Three primary alternatives were considered for addressing associated gas produced during Project operations: gas re-injection, continuous flaring, and gas export. Gas re-injection was determined to be feasible for the Project, and it also provides benefits in terms of reservoir management by helping to maintain pressure in the reservoir (thereby increasing the amount of crude oil that can be recovered over time) and reduced air emissions (as compared to continuous flaring). Under this alternative, produced gas not used as fuel gas on the FPSO will be re-injected under normal operations. Continuous flaring of gas on a routine basis is not preferred, primarily due to the associated air emissions. Gas export alternatives for future development continue to be evaluated, with due consideration of the challenges related to commercialization of associated gas. Any proposal for implementation of gas export would be addressed under a separate environmental authorization process, and is therefore outside the scope of this EIA.

- Technology Alternatives. EEPGL is using the most appropriate industry-proven technologies in developing the Project, in terms of well drilling, drilling fluids, equipment selection, development concepts, and environmental management. EEPGL's parent company Exxon Mobil Corporation, its affiliates, and their contractors have extensive experience in delivering offshore deepwater development projects around the world, particularly with FPSO and SURF components, and are applying that knowledge, experience, and technology in the development of this Project. EEPGL evaluated the best available technology decisions for the following technology aspects: drill cuttings, gas processing, injection compressors, power generation, produced water, and sulfate removal.
- No Action Alternative. If this alternative is selected, the existing conditions described in EIA Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8 Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, would remain unaffected by the Project and the potential positive and negative impacts assessed in these chapters would not be realized. Therefore, evaluating the no action alternative means evaluating the tradeoff between positive and negative impacts.

Overall, the proposed Project reflects optimized locational siting, appropriate development concept, use of industry-proven technology, and selection of the environmentally preferred action alternative.

3. PROJECT IMPACTS

This section summarizes the predicted environmental and socioeconomic impacts of the Project resulting from planned activities and potential risks resulting from unplanned events, as well the Project's contributions to cumulative impacts on resources and receptors. The resources/receptors considered in this analysis are listed in Table EIS-2. The impacts of the Project were evaluated against the conditions of the existing environment, as described in Chapters 6, 7, and 8 of the EIA.

Table EIS-2: Resources and Receptors Considered in this EIA

Physical Resources	Biological Resources	Socioeconomic Resources
Air Quality and Climate	Protected Areas and Special Status Species	Socioeconomic Conditions
Sound	Coastal Habitats	Employment and Livelihoods
Marine Geology and Sediments	Coastal Wildlife	Community Health and Wellbeing
Marine Water Quality	Seabirds	Marine Use and Transportation
	Marine Mammals	Social Infrastructure and Services
	Riverine Mammals	Cultural Heritage
	Marine Turtles	Waste Management Infrastructure Capacity
	Marine Fish	Land Use
	Marine Benthos	Ecosystem Services
	Ecological Balance and Ecosystems	Indigenous Peoples

3.1. PLANNED ACTIVITIES

The Project is an offshore oil development and all drilling, installation, production operations, and decommissioning activities will occur over 207 kilometers (approximately 128 miles) off the coast of Guyana. The planned Project activities will not disturb any natural onshore habitats. There will be a negligible increase in traffic congestion due to Project-related vehicle movements. The Project will generate benefits for the citizens of Guyana through revenue sharing with the Government of Guyana, a minor increase in employment, and select Project purchasing from Guyanese businesses. The resources with the potential to incur meaningful impacts from planned Project activities are the physical resources water quality and climate, some marine-oriented biological resources, and some socioeconomic resources. These resources and their residual significance ratings (after mitigation measures are considered) are discussed briefly below. Additionally, while the EIA concludes that air quality will not incur any meaningful adverse impacts from planned Project activities, this resource is also discussed briefly below, due to the level of interest in this resource identified during consultation for the EIA.

3.1.1. Air Quality and Climate

Emissions generated by the Project generally emanate from two source categories: (1) specific point sources such as the power-generating units and diesel engines on drill ships and on the FPSO, non-routine flaring used to combust produced gas when not consumed as fuel gas on the FPSO or injected back into the reservoir, and vents; and (2) general area sources such as marine support vessels, installation vessels, and helicopters. Such emissions contribute to increases in the ambient air concentrations of certain pollutants.

The CALPUFF model was used to assess the dispersion of air pollutants and the potential impact for onshore human receptors. For all modeled constituents, the maximum onshore concentrations predicted to result from Project activities are negligible relative to World Health Organization guidelines (the highest predicted onshore concentration being less than 1.7 percent of the World Health Organization guideline), indicating a **Negligible** residual impact on onshore air quality from the Project.

The Project will also emit greenhouse gases (GHGs) throughout its predicted life cycle (at least 20 years), with peak emissions during steady-state production operations estimated to be approximately 1,355 kilotonnes of carbon dioxide-equivalents (CO_2e) per year. There are no applicable regulatory criteria against which these GHG emissions can be compared, but these emissions will be disclosed in accordance with good international practice to aid in managing GHG emissions at a national and international level. EEPGL proposes to re-inject recovered natural gas (that which is not used as fuel on the FPSO) back into the targeted Project reservoirs for reservoir pressure management, which contributes to a significant reduction in potential GHG emissions versus that which would result from continuous gas flaring. Guyana's 2012-reported annual GHG emissions were approximately 2 million tonnes of CO_2e, with total annual removals of approximately 60 million tonnes of CO_2e (resulting in net annual removals of approximately 58 million tonnes of CO_2e). Accordingly, although the overall emissions at a country level would be increased measurably by Project GHG emissions, net removals would decrease only slightly (i.e., approximately 2.5 percent). Further, the Project has applied technologies aligned with Good International Oil Field Practice to reduce GHG emissions, and the 1,355 kilotonnes of CO_2e per year rate represents an 82 percent reduction from projected GHG emissions without the application of these technologies. With these technologies, the Project's GHG performance factor is significantly better than the global industry average. Balancing these factors with the fact that climate change is an issue of global importance, a residual significance rating of **Moderate** is applied for the production operations stage of the Project.

3.1.2. Marine Water Quality

The Project will impact marine water quality in a localized manner via planned discharges during well drilling, hydrostatic testing of the flowlines and risers following installation, and production operations stages. Planned discharges of drill cuttings and fluids may have a localized impact on marine water quality as a result of increased total suspended solids (TSS) concentrations in the water column. Cuttings and fluids released at the seafloor during jetting and drilling of the initial sections of the well will increase TSS concentrations around the well near the seafloor. Cuttings discharged overboard from the drill ships will increase TSS concentrations in the photic zone (the upper level of the water column through which sunlight can penetrate). Modeling predicts that TSS concentrations above a threshold of 35 milligrams per liter will occur during drilling of the initial well sections only, and these instances are confined to within a relatively small area around the well locations, near the seafloor. The area impacted will be localized and impacts will occur over a short time period; however, a small fraction of the overall benthic community (sponges living on the hard seafloor features in the PDA) would have an elevated sensitivity to elevated TSS, so the residual impacts on marine water quality from TSS increases resulting from drill cuttings discharge are considered **Minor.**

During installation, the subsea flowlines and risers must be hydrostatically tested to confirm there are no leaks. Treated seawater is used for this purpose to prevent biofouling. A hydrate-inhibiting substance, such as methanol or ethylene glycol, will also be used to prevent formation of hydrates during commissioning of the production and gas injection lines. After testing is completed, the hydrostatic test water from the water injection and gas injection lines, and the hydrate inhibitor from the gas injection lines will be released at the seafloor. The hydrostatic test water and hydrate inhibitor from the production lines will be returned to the FPSO, treated, and discharged from the overboard water line. These discharges would be a one-time, short-term impact, and the treated seawater and hydrate inhibitor would be quickly diluted within the water column, resulting in a **Negligible** residual impact.

During production operations, the FPSO will discharge five primary effluent streams to the ocean (Table EIS-3) as permitted discharges. The FPSO systems associated with these discharges will be designed to ensure applicable discharge criteria are met, which may require treatment in some cases. Modeling indicates that concentrations of chemical constituents would be reduced to insignificant levels and temperature increases from cooling water and produced water discharges will be less than 3°C within approximately 100 meters (approximately 328 feet) of the discharge point, resulting in a **Negligible** residual impact.

Table EIS-3: Summary of Production Operations Discharges

Discharges	Source	Potential Contaminants	Discharge Rate	Comments
Cooling Water	Process water to dissipate heat from FPSO systems, no hydrocarbon contact	Temperature, residual chlorine	≤ 1,600,000 BPD	Discharge will meet internationally recognized standards limiting increases in ambient water temperature. Discharge meets applicable international residual chlorine standards without treatment.
Produced Water	Water separated from reservoir fluids	Oil and grease, temperature, residual production and water treatment chemicals	≤ 300,000 BPD	Will be treated to meet internationally recognized limits on oil and grease content. Discharge will meet internationally recognized standards limiting increases in ambient water temperature.

Discharges	Source	Potential Contaminants	Discharge Rate	Comments
Sulfate Removal and Potable Water Processing Brines	Removal of sulfates from seawater prior to injection; potable water processing	Biocide, chlorine, oxygen scavenger, Scale inhibitor	≤ 265,000 BPD	Discharge meets applicable standards without treatment.
Domestic and Sanitary Wastewater	Personnel black water and food wastes (treated); gray water (untreated)	Nutrients, chlorine, bacteria	360 BPD	Will be treated in accordance with internationally recognized standards prior to discharge, as required.
Offloading Tanker Ballast Water	Offloading tanker will discharge ballast water as it loads oil from the FPSO	None anticipated	≤ 1,200,000 barrels total (at each tanker loading)	Discharge will be conducted in accordance with internationally recognized standards.

BPD = barrels per day

3.1.3. Marine Geology/Sediments and Marine Benthos

The drilling of wells and the placement of flowlines and other subsea equipment will physically disturb approximately 0.8 km^2 (0.3 mi^2) of the sea bottom. After the initial structural casing section is installed, the remaining NADF drill cuttings will be returned to the drill ships for treatment to remove associated drilling fluids prior to discharge to the sea in order to meet acceptable discharge thresholds. The planned discharge of NADF drill cuttings will result in a localized accumulation of cuttings on the seafloor, primarily around the drill center locations, with the distribution of deposition determined by oceanographic conditions. Modeling has indicated that the discharge of these cuttings will not significantly impact sediment quality because of the relatively low toxicity and expected dispersion. Overall, the Project impact on marine sediments will be negligible.

Marine benthos (organisms living on the seafloor) could also be impacted by Project-related seafloor disturbance by potential smothering from the drill cuttings. The most sensitive component of the benthic community to elevated TSS concentrations is sponges living on the hard seafloor features in the PDA. Due to their immobile adult life form, sponges located on a relatively small portion the hard seafloor features that will be impacted by the elevated TSS concentrations will be unable to relocate to avoid impacts. While, this community accounts for a small proportion of the seafloor within the Subsea PDA, a small fraction of the overall benthic community would have an elevated sensitivity to elevated TSS, so the overall residual significance to benthic communities will be **Minor**.

3.1.4. Seabirds (including Special Status Species)

Seabirds have the potential to be impacted by planned Project activities through attraction- and disturbance-related effects or collision with a Project vessel or helicopter. It was determined that the significance of these residual impacts range from **Negligible** to **Minor** (for seabirds as a whole and special status seabirds, respectively) for the reasons explained below.

The EEPGL-commissioned marine bird survey completed from 2017 through 2019 indicated that the seabird community offshore Guyana is moderately diverse, but the abundance of birds is low compared with other areas in the greater Caribbean and tropical Western Atlantic region. The Project could impact seabirds by acting as an attractant to seabirds because of its lighting; or exposing them to disorientation, collision risks, additional energy expenditure, and compromised navigation for night-migrating birds. The Project lighting will be downcast when feasible to minimize its attraction potential. Potential benefits from the Project to seabirds are use of the FPSO, drill ship, and installation vessels for rest or shelter during adverse weather conditions or during long migrations and, if such vessels act as consistent attractants for seabird prey, providing a reliable food resource for seabirds.

Two special status species, Leach's Storm-Petrel (*Oceanodroma leucorhoa*) and Black-capped Petrel (*Pterodroma hasitata*) are known to occur in the Project Area of Influence (AOI), although only Leach's Storm-Petrel was observed during marine bird surveys conducted from 2017 through 2019. These species will have the same exposure to potential impacts as non-special status seabirds because their habitat use, behavior patterns, and biology are similar; accordingly, the impact ratings for special status species seabirds were not changed from those used for non-special status seabirds.

3.1.5. Marine Fish (including Special Status Species)

Marine fish survey conducted between 2017 and 2019 indicates that deepwater fish diversity is poor in the vicinity of the PDA and the pelagic fish community is typical of the region. The data suggest that offshore pelagic fish may be slightly more abundant in the latter half of the year, while nearshore fish are more abundant and diverse during the rainy season when freshwater inputs to the estuaries are greatest. The Project could impact marine fish by deterioration of water quality from the discharges described above and the potential to entrain (suck in) fish at the cooling water intake. Modeling indicates that water quality will return to near background conditions within 100 meters (approximately 328 feet) of the FPSO, so the area impacted will be very small, and fish are mobile and are known to avoid areas with degraded water quality. Water intakes will be designed to minimize the entrainment of fish. Several special status marine fish species are known or thought to occur in the Project AOI. While the magnitude of potential impacts on marine fish would be **Negligible** to **Small**, the significance of potential residual impacts on some species was considered to be **Minor**.

3.1.6. Marine Mammals (including Special Status Species)

Marine mammals have the potential to be impacted by the planned Project activities, primarily as a result of exposure to underwater sound, and it was determined that the significance of these potential residual impacts ranges from **Negligible** to **Moderate**. Marine mammal observations recorded during surveys in and around the Stabroek Block since 2015 indicate that the marine mammal community in the Stabroek Block consists primarily of small cetaceans, and that large cetaceans (i.e., whales) rarely occur south of the Stabroek Block on the relatively shallow continental shelf. Marine mammals have the potential to be impacted by two types of sound from planned Project activities: continuous sound from vessels and machinery operating in the PDA;

and comparatively louder, shorter-duration impulse sound from Vertical Seismic Profiling (VSP) and pile driving. Both the continuous sound and impulse sound sources would be loud enough to cause injury in the immediate vicinity of the source, but would attenuate to non-injurious levels within approximately 10 meters (approximately 33 feet) from the vessels, approximately 75 meters (approximately 246 feet) from the VSP, and approximately 1,400 meters (approximately 4,600 feet) from the driven piles (at depths of more than 1,500 meters [approximately 4,920 feet]).

Modeling results indicate sound levels from vessels and the VSP are insignificant compared to the predicted sound levels from impact pile driving. The distances from Project underwater sound sources to injury thresholds are largest for pile driving. Based on the premise that marine mammals will actively avoid physical discomfort associated with Project-related sound, if impact-driven piles are used, mid-frequency cetaceans (MFCs) would be expected to generally avoid the portion of the water column within at least approximately 700 meters (2,297 feet) from the location where pile driving is taking place, and low-frequency cetaceans (LFCs) would be expected to generally avoid the portion of the water column within at least approximately 1,400 meters (approximately 4,600 feet) of the activity. Both categories of cetaceans would be expected to avoid these areas for the duration of the pile-driving activity. LFC species, including many of the larger baleen whales and dolphins, and some MFC species, including toothed whales, will naturally remain outside of the area of potential effect because it will be deeper than their deepest recorded dive depths. Some MFC species, such as sperm whales, dive much deeper than LFC species (approximately 1,200 meters [approximately 4,000 feet] in tropical and subtropical latitudes), but most species do not dive deep enough or remain at depths long enough that they could potentially be exposed to injurious sound levels within the PDA.

3.1.7. Riverine Mammals (including Special Status Species)

Two species of riverine mammals—the West Indian manatee (*Trichechus manatus*) and the neotropical otter (*Lontra longicaudis*)—have the potential to be impacted by planned Project activities as a result of increased Project vessel traffic within the Demerara Harbour. Manatees and neotropical otters occur in low numbers in the brackish/intertidal waters of the Demerara Harbour and lower Demerara River, but resident riverine mammals of the harbor are expected to be habituated to the constantly changing and human-influenced environments of the harbor. The slight increase in overall marine vessel traffic in Georgetown Harbour that will occur as a result of the Project (1 to 4 percent increase) may result in a slight incremental increase in temporary avoidance behavior and displacement from the vessel transport route, which itself represents a small portion of the available riverine habitat within the harbor, but it was determined that the significance of this potential residual impact was **Minor**.

3.1.8. Marine Turtles

Marine turtles have the potential to be impacted by planned Project activities, but it was determined that the significance of these potential residual impacts is **Negligible**. Marine turtles are generally considered to be less sensitive to marine sound than marine mammals, so underwater sound from Project activities would not have the same potential to impact marine turtles as marine mammals. Marine turtles have been detected at a much lower rate than marine mammals offshore Guyana during surveys conducted from 2015–2019, which suggests that the density of marine turtles offshore is comparatively low. Preliminary tracking data from a marine turtle telemetry study initiated as part of the Liza Phase 1 Development Project indicate that individual turtles may nest multiple times a season at Shell Beach and that during the period between nesting events, they generally remain close to the nesting beaches, which would reduce the probability of their being disturbed by Project vessel traffic moving within the PDA or between the PDA and shorebases in Guyana.

3.1.9. Ecological Balance and Ecosystems

All planned Project activities that could affect the physical or biological attributes of the Project AOI are broadly relevant to basic ecosystem functions such as nutrient cycling, gene flow, and maintenance of biodiversity. The significance of potential residual impacts on ecological balance and ecosystems was concluded to range from **Negligible** to **Minor**. Changes in water quality could affect the planktonic base of the marine food web, but based on the negligible significance of water quality impacts and the very small portion of the North Brazil Shelf Large Marine Ecosystem that will be exposed to these impacts, the Project is predicted to have little if any measureable ecosystem-level impacts on nutrient cycling. The Project is not expected to create any significant obstacles to migration, breeding, or dispersal/colonization, so Project-related residual impacts on gene flow are expected to be **Negligible**. Ballast water exchange during the production operations stage is predicted to have potential impacts on biodiversity due to the potential for introduction of exotic or invasive species, but embedded controls will limit the potential for this impact (and the extent of the impact if it were to occur) and it is not expected to lead to the loss of any species or other long-lasting biological effects within the North Brazil Shelf Large Marine Ecosystem. Therefore, the Project's residual impacts on maintenance of biodiversity are expected to be **Minor**.

3.1.10. Employment and Livelihoods

As discussed above, the Project will generate a variety of marine vessel trips throughout the Project life (at least 20 years) and these will potentially impact open-ocean shipping in the vicinity of the PDA, the limited commercial fishing activity that occurs as far out as the PDA, and commercial and subsistence fishing activity within the portion of the Direct AOI that connects the PDA to Georgetown Harbour. In addition to the potential impacts on commercial and subsistence fishing vessels navigation, there may be potential impacts on livelihoods of artisanal fisherfolk nearshore and industrial fishing vessel operators in remote offshore areas as a result of navigation impacts. While commercial fishing vessels offshore will lose access to some fishing areas that are currently available to them as far out as the PDA, the significance of this potential residual impact on commercial fishing livelihoods was assessed as **Negligible** considering the small number of operators that currently participate in deep-sea fishing (no more than 12 vessels), the small footprint that will be impacted in the PDA, and the ability to provide information in advance about EEPGL's operations and marine safety exclusion zones. The highest potential for Project interactions with fisherfolk may be encounters with support vessels transiting between the PDA and shorebases in Georgetown. This could result in some limited and temporary disruption to mostly artisanal fishing activity in these areas. Artisanal fisherfolk engaging in fishing on the Guyanese coast have a limited ability to adapt to potential disruption to subsistence fishing activities, and since many do not carry radios, use remote ports, and/or may not receive notices of increased vessel activity, the significance of this potential residual adverse impact on artisanal fishing livelihoods was assessed as **Minor**. Overall, the potential impacts on employment and livelihoods that will result from Project employment, procurement, and worker spending are considered to be **Positive**.

3.1.11. Community Health and Wellbeing

The key potential impacts on community health and wellbeing as a result of planned Project activities are increased risk of communicable disease transmission, decreased public safety as a result of the presence of Project workers, increased public anxiety concerning the oil and gas industry as a whole, and decreased availability of emergency medical and health services. Given the small size of the Project workforce in comparison with the receiving community (less than 1 percent of the population of Georgetown), the Project workers' limited and occasional onshore presence, and the embedded health controls in place to further reduce risk, the significance of potential residual impacts related to both communicable disease transmission and public safety are considered **Negligible**. The residual significance of public anxiety over oil and gas sector risks, especially among the more vulnerable populations along the coastal areas in Region 1, is assessed to be **Minor**. In Georgetown, where there are higher levels of literacy and multiple means of accessing information on the Project and the country's developing oil and gas sector on a continual basis, anxiety and misconceptions about Project risks are considered to be **Negligible**. The potential for reduced access to emergency and health services as a result of Project activities, even considering a Project-dedicated onshore medical provider and ambulance, is assessed to have a **Minor** residual significance, principally in relation to the population in Georgetown and the vicinity, considering existing health system gaps.

3.1.12. Marine Use and Transportation

The Project will generate a variety of marine vessel trips throughout the Project life (at least 20 years), including maritime transport of Project materials, supplies, and personnel as well as the presence of the FPSO, drill ships, and major installation vessels. These marine activities will potentially impact vessel traffic into and out of Georgetown Harbour, open-ocean shipping in the vicinity of the PDA, the limited commercial fishing activity that occurs as far out as the PDA and commercial and subsistence fishing activity within the portion of the Direct AOI that connects the PDA to Georgetown Harbour. Project-related traffic is expected in both the active commercial port and in international waters and commercial vessels are expected to be able to safely navigate around other vessels. Therefore, the significance of potential residual impacts on commercial cargo vessels in Georgetown Harbour and in the vicinity of the PDA is considered to be **Negligible**. Commercial fishing vessels offshore will lose access to some fishing areas that are currently available to them, and will have to avoid Project-related vessel traffic where none currently exists. Subsistence fishing vessels will not lose access to existing fishing areas, as subsistence fishing does not occur as far out to sea as the PDA. Subsistence fishing vessels could experience interference due to movements of Project-related vessel traffic. While Notices to Mariners will be provided to mitigate potential interference with commercial and subsistence fishing vessel navigation, there are limitations—in particular for subsistence vessels—to the effectiveness of these notices. Accordingly, the significance of potential residual impacts on commercial and subsistence fishing vessels navigation as a result of increased marine traffic is assessed as **Minor**.

3.1.13. Social Infrastructure and Services

The planned Project activities with the potential to impact social infrastructure and services include Project worker presence (with the potential to impact availability of lodging and the availability and/or cost of housing and utilities) and ground and air transportation (with the potential to increase traffic congestion). Although the Project will have limited onshore planned activities, the presence of Project workers and of those seeking Project-related work has the potential to increase demand for housing and utilities in the Georgetown area, where current shortfalls of housing and appropriate utilities infrastructure already exist. While the anticipated number of Project workers is insignificant (less than 1 percent) compared to the Georgetown population, the significance of the potential residual impact (decreased availability/increased cost of housing and utilities) is assessed as **Minor** during the drilling and installation stages—when the workforce is at its peak. Due to smaller numbers of Project workers anticipated during the production operations stage, the residual impact significance is assessed as **Negligible** for this stage.

The presence of Project workers also has the potential to increase demand for lodging in the Georgetown area, which may lead to reduced availability and/or increased cost. While an assessment of available lodging in Georgetown indicates minimal chance for capacity constraints, due to the anticipated number of Project workers requiring lodging, the potential residual impact is assessed as **Minor** during the drilling and installation stages—when the workforce requiring lodging is at its peak. Due to smaller numbers of Project workers anticipated during the production operations stage, the residual impact significance is assessed as **Negligible**.

Planned Project activities will generate additional vehicular traffic around Georgetown as a result of EEPGL-related personnel movements and non-personnel (e.g., equipment, supplies, etc.) movements. Traffic impact modeling confirmed that the additional EEPGL-related vehicle trip counts in 2021, 2023, and 2025 will not meaningfully change traffic congestion levels on the road segments across Georgetown anticipated to potentially be among the more heavily used by EEPGL-related vehicle movements. On this basis, the significance of potential residual impacts on ground transportation as a result of planned Project activities is considered to be **Negligible**.

3.1.14. Waste Management Infrastructure Capacity

The planned Project activities have the potential to impact waste management infrastructure capacity for current users of Georgetown-based hazardous waste treatment facilities (primarily other oil and gas operators) and non-hazardous waste landfills (primarily the general community) due to increased burden of Project wastes on the capacity of these facilities. Based on an assessment of Georgetown-based hazardous waste treatment facilities, it was concluded that, without modifications, the infrastructure capacity of the hazardous waste treatment facilities would likely be unable to treat all of EEPGL's hazardous solids and waste oil liquids by late 2020. A separate assessment by the operator of the Georgetown-based non-hazardous waste landfill concluded that the capacity of the landfill, without opening a new cell, will be exhausted by the end of 2019.

The projected Project waste generation represents a significant portion of the total demand for Georgetown-based hazardous waste treatment facilities, but less than 2 percent of the total current demand at Georgetown non-hazardous waste landfill facilities.

Although the Project itself is not considered a receptor for the purpose of the EIA, the viability of its operations depends on reliable access to waste management infrastructure of a sufficient quality and with sufficient capacity. In view of this need to ensure Project viability, and in recognition of the potential future capacity constraints and potential impacts on non-Project users of Georgetown-based waste management infrastructure, the Project has initiated the following mitigation measures:

- Enable increases to existing Georgetown-based waste management capacity for hazardous wastes, explore use of new Georgetown-based hazardous waste treatment facility or facilities, or identify suitable alternative regional solutions; and
- Monitor the Ministry of Communities' planned construction of Cell 2 at the Haags Bosch landfill, or (if approved by the EPA) construction of an alternative landfill site in Georgetown, or identify suitable alternative regional solutions for non-hazardous waste disposal.

In addition to these mitigation measures, EEPGL will implement a number of waste management-related embedded controls, which are summarized in the Waste Management Plan provided as an appendix to the Environmental and Socioeconomic Management Plan (ESMP). Implementation of these mitigation measures and embedded controls will reduce the effects of Project-related demands on waste management infrastructure capacity, particularly related to hazardous waste management, resulting in a residual impact significance rating of **Negligible** for this aspect. However, in view of the fact that capacity expansions for the Georgetown-based landfill facilities are not under EEPGL's control, the significance rating for potential residual impacts on Georgetown-based landfill capacity is maintained at a level of **Minor**.

3.2. Unplanned Events

An unplanned event is defined as an event that is not planned to occur as part of the Project (e.g., oil spills, accidents), but that could potentially occur. Since these events are not planned, they are evaluated using methods different from those used for planned events, specifically taking into consideration the likelihood that an unplanned event will occur. For purposes of the Project, five types of unplanned events were identified and considered: hydrocarbon spill, discharge of untreated wastewater from the FPSO, vessel strike of a marine mammal, marine turtle, riverine mammals, or seabird; seabird collision with the FPSO flare tower, flare, or radiant heat plume; vessel collision; and onshore vehicular accident.

3.2.1. Vessel Collisions or Vehicular Accidents

While a vessel collision or vehicular accident could result in injuries, the potential for a vessel collision that led to significant injury or fatality would be expected to be low considering the robust controls incorporated into the Project, and the likely vessel and vehicle speeds in areas where risk of collisions would be highest. Based on consideration of the likelihood of occurrence and the likely range of severity given these factors, vessel collisions and vehicular accidents (i.e., related to the community health and wellbeing resource) are considered to have a residual risk level of **Minor** to **Moderate**.

3.2.2. Vessel Strikes of Marine Mammals, Marine Turtles, or Riverine Mammals

While marine mammals possess acute senses of hearing that they can use to detect approaching vessels, and they have the necessary swimming speed capability to avoid collisions, they are vulnerable to vessel strikes when they surface to breathe or to feed. This vulnerability increases in shallow nearshore areas where opportunities to maneuver are reduced.

Marine turtles tend to spend most of their time at sea at or near the sea surface, and do not possess the acute sense of hearing or the swimming speed that cetaceans use to avoid collisions. Marine turtles are inherently more vulnerable to vessel strikes in the shallow nearshore areas, where they congregate prior to coming ashore to nest, than they are in the open ocean. This increased vulnerability is caused by higher concentrations of turtles in the shallow nearshore areas.

Riverine mammals likely to be present within the nearshore and riverine zone of the PDA are vulnerable to vessel collision when they surface to breathe or to feed. This vulnerability increases in shallow areas, where there are fewer opportunities to maneuver compared to the open ocean. The West Indian manatee, in particular, would be susceptible to vessel collision within the lower Demerara River. It is well documented that manatees are highly vulnerable to vessel collision, and vessel collision is listed by the International Union for Conservation of Nature (IUCN) as one of the key threats to this subpopulation of manatees.

Most Project activities will take place in deep waters, and vessel speeds within the PDA will be low, reducing the potential for collisions. The only planned nearshore activities will be supply vessels entering/exiting shorebases, but even at the peak of drilling and installation, the incremental increase in traffic near shorebases will represent a small increase in overall risk to marine mammals and marine turtles. There is very little potential for collisions to occur within the PDA, but the potential remains for individual marine mammals or marine turtles to collide with vessels transiting between the PDA and shorebases. With respect to risk to marine turtles, the planned shorebases are all located more than 100 kilometers (62.1 miles) away from the nearest portion of the Shell Beach Protected Area, where most marine-turtle nesting in Guyana occurs (and where turtles may aggregate pre- and post-nesting as suggested by tagging data).

With respect to riverine mammals, collision between a Project vessel and a West Indian manatee could cause injury or mortality to the affected individual or temporary behavioral changes, but manatees in this area are accustomed to the presence of vessels and are therefore expected to exhibit some level of avoidance behavior when vessels are passing through. Very few manatees are expected to occur in the lower Demerara River, so vessel collision with a manatee, if it were to occur, would be very infrequent.

EEPGL will provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and riverine mammals at the sea surface, and will issue standing instructions to Project-dedicated vessel masters on what to do if they encounter marine mammals, marine turtles, or riverine mammals while in transit (i.e., reduce vessel speed or deviate from course, when possible, to lower the probability of a collision). While these measures will serve to reduce the residual risk, a vessel collision is considered to be **Moderate** for marine mammals and marine turtles and **Minor** for riverine mammals.

3.2.3. Discharge of Untreated Wastewater from FPSO

The FPSO will be equipped with an onboard sewage treating system, which will treat black water prior to discharge overboard. While there will be a number of controls to prevent a discharge of untreated black water to the ocean, an upset to this treatment system lasting for an extended period could result in untreated black water being discharged overboard for a short period of time. While there are a number of controls that would prevent this scenario from occurring, modeling of the scenario was conducted to assess the risk associated with such an event. Modeling results show that the short-term release of untreated wastewater will result in a plume of limited extent, with dilution of almost 99.9 percent within 100 meters (approximately 328 feet) of the discharge point, yielding a residual risk rating of **Minor** for all potentially affected resources.

3.2.4. Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume

The FPSO will have a flare system for the collection and safe disposition of produced hydrocarbon gases resulting from unplanned, non-routine maintenance or repairs, or emergency shutdown events. Should flaring occur, the flame and radiant heat plume will emanate from a flare tower located on top of the FPSO. While individual seabirds could be significantly impacted through contact with the FPSO flare tower, its flame, or its radiant heat plume, the likelihood of a seabird colliding with the tower or being present in the heat zone when temporary, non-routine flaring is occurring is extremely low. To date, marine bird surveys conducted on behalf of EEPGL since 2017 have not documented flocking birds in the Stabroek Block. While this does not preclude the possibility of a flock to occur, it is considered relatively rare and any such flocks would likely be small. Even during migration, most individuals are solitary or flying in loose groups (spread out spatially). Accordingly, in the circumstance that such an event occurred, it would likely only impact a single individual, yielding a risk rating of **Minor**.

3.2.5. Oil Spill

The Project will be producing, processing, storing, and offloading oil as its core activity, so the risk of an oil spill would be present. EEPGL has identified 15 spill scenarios, including spills of different types of hydrocarbons (e.g., crude oil, marine diesel, fuel oil, lubricating oil, NADF), with several being applicable for spills at the shorebases and on vessels in the Demerara River estuary (e.g., from a supply vessel) or in the Atlantic Ocean (e.g., from a well, drillship, supply vessel, tanker, FPSO). The largest of these scenarios considered a loss-of-well-control incident at the seafloor. For these scenarios, EEPGL worked with third-party specialists to model two worst-case discharge (WCD) scenarios for a loss-of-well-control event.

The WCD scenarios were developed based on a request from the DE regarding the Liza Phase 2 Project Development Plan. In accordance with the DE's request, EEPGL commissioned a third party to develop WCD calculations for the reservoirs to be developed as part of the Project in accordance with the U.S. Bureau of Safety and Environmental Enforcement's (BSEE's) guidelines published in the U.S. Department of Interior BSEE Worst Case Discharge Analysis (Volume I, February 2016). As stated in the BSEE guidelines document, although WCD modeling results "present an extremely dire representation of the potential for contact between the discharged oil and the environment, they do provide a working baseline of datum that will be useful for further analysis" (BSEE 2016).

The U.S. Bureau of Ocean Energy Management defines the WCD as the single highest daily flow rate of liquid hydrocarbon during an uncontrolled wellbore flow event (i.e., the average daily flow rate on the day that the highest rate occurs, under worst-case conditions). The WCD values represent an open well condition in which *no flow restrictions or well control technologies* such as blow out preventers are in operation. The WCD is neither the total volume spilled over the duration of the event, nor the maximum possible flow rate that would result from high-side reservoir parameters. It is a single value for the expected flow rate calculated under worst-case wellbore conditions using expected reservoir properties. The main purpose of a WCD calculation is to support oil spill response planning. The duration of the WCD release is typically 30 days unless shutting in the well with a capping stack or other technology is expected to occur earlier.

The third-party specialist incorporated information for the six reservoirs to be developed as part of the Project into its WCD simulation program and calculated six reservoir-specific WCDs ranging from 25,151 to 202,192 barrels of oil per day (BOPD). In consultation with EEPGL's oil spill modeling contractor, EEPGL identified two WCD scenarios to model a potential Project well-control scenario with loss of containment. EEPGL's standard scenario for a loss-of-well-control event (20,000 BOPD, developed by EEPGL based on its worldwide experience conducting similar analysis) is very close to the lowest of the calculated WCD rates (and therefore would be expected to produce similar modeling results), so this scenario was modeled as the "Most Credible WCD." Additionally, the highest of the calculated WCD rates was modeled as the "Maximum WCD." Although modeling of the Maximum WCD scenario supports oil spill response planning, the scenario represents an operational condition that is highly unlikely to be encountered during drilling operations. In a more representative scenario, apart from blowout preventers on the wellhead, there would be drill string, tubing, and/or other equipment that would be in the wellbore during a well-control event, which would partially constrain and restrict flow from the reservoir.

EEPGL's well-control philosophy is focused on blowout prevention using safety and risk management systems, management of change procedures, global standards, and trained experienced personnel. EEPGL has a mature program that emphasizes attention to safety, well control, and environmental protection. This includes proper preparation for wells (e.g., well design, well-control-equipment inspection and testing), detecting changes in pressure quickly, and efficiency in the process for temporary closing of a well (personnel training and proficiency drills).

In addition to these prevention measures, EEPGL also has developed a detailed Oil Spill Response Plan (OSRP) to ensure an effective response to an oil spill, if one were to occur. The OSRP identifies the organizations that would respond to a release event depending on the magnitude and complexity of the spill. The OSRP clearly delineates the responsibilities of each entity that would take part in a response and describes how EEPGL would mobilize both its own resources and those of its oil spill response contractors, as well as notifying the government of Guyana with respect to mobilizing its resources.

Due to the precautionary measures proposed by EEPGL to prevent and control an oil spill, as described above, the chance of an oil spill occurring is unlikely. Nevertheless, EEPGL has conducted oil spill modeling and coastal sensitivity mapping to identify and characterize the resources/receptors with the potential to be exposed to oil in the unlikely event of a spill. An overview of this modeling and mapping is provided below.

The spill modeling evaluated the range of possible trajectories and rate of travel of an oil slick from each of the two above-referenced loss-of-well-control scenarios. Several factors would inherently reduce the severity of an oil spill occurring in the PDA and would increase subsequent ecosystem recovery rates, including the following:

- Location of Spill—A Payara loss-of-well-control incident would occur approximately 207 kilometers (approximately 128 miles) offshore. It would take some time for oil to reach the Guyana shoreline, which allows time to implement the Project's OSRP, and also allows more time for evaporative and dispersive forces to act on the spilled material.
- Prevailing Currents—The Guiana Current is a strong, nearly year round westerly flowing current along the coast of Guyana. The SAT-OCEAN current model used in the oil spill modeling analysis is based on the Hybrid Coordinate Ocean Model that includes three-dimensional current speeds in a 4°×4° grid over the Stabroek Block region (56°-60°W, 7°-11°N). The horizontal resolution of the model is 1/64°, and the model defines current speed and direction on 64 vertical layers through the water column. The time series data set defines three-dimensional currents at a 3-hour interval for the 10 years between 2005 and 2014. The data from the SAT-OCEAN current model were calibrated by current data measured at a location offshore Guyana (8.08°N, 56.95°W) during 2015. Considering the extent of the historical record and calibration with measured data, these data are

appropriately representative of the region and are expected to capture expected variability in the current forcing. Modeling indicates that this current significantly reduces the probability of spilled oil reaching the coast of Guyana; however, this effect also increases the probability of an oil spill impacting the coastal zones of nearby countries to the north and west.

- Properties of Spilled Oil—The Project will be producing a medium crude oil. Medium crude oils exhibit greater evaporation and lower emulsification, and are less persistent in the environment than heavy crude oils. These qualities make the oil readily amenable to oil spill response strategies such as chemical dispersion and in-situ burning, which are appropriate and highly effective in this offshore environment. This medium crude is also amenable to more traditional oil spill response strategies such as mechanical booming and recovery.
- Climate—The relatively warm year-round waters of the AOI would keep any spilled oil less viscous, which helps clean-up operations such as skimming and pumping.

The modeling predicted that surface oil would generally travel towards the northwest in all scenarios during both the Jun–Nov and Dec–May seasons. A type of modeling known as stochastic modeling was performed for a number of spill scenarios. Stochastic modeling accounts for the variability in conditions such as winds and ocean currents by simulating hundreds of individual spills (theoretically occurring at different times and under different wind/current conditions) and generating a map that is a *composite* of all of the trajectories and provides a *probability footprint* showing the most likely path that a spill would follow. Stochastic modeling of an unmitigated subsea release of crude oil from a loss-of-well-control event indicates that even in the unlikely event of an oil spill, there is only a 5 to 20 percent chance of shoreline oiling in Guyana. It is important to note that this stochastic modeling does not account for any oil spill response (e.g., aerial, vessel, or subsea dispersant application; offshore containment and recovery; source control operations), so any preventative measures taken to keep oil from reaching the coast during a response would further reduce the potential of shoreline oiling in Guyana below the estimated 5 to 20 percent.

In addition to the low probability of oil reaching the Guyana shoreline (even in the absence of any spill response), stochastic modeling indicates it would take 5 to 30 days (depending on WCD scenario and actual wind and current conditions) for oil to reach the Guyana shoreline. This would allow ample time for mobilization of spill response resources to further reduce the risk of oil actually reaching the shoreline. Despite this, if oil were to reach the Guyana shoreline, those resources most at risk would include protected areas (i.e., Shell Beach), coastal habitats (especially mangroves and marshes), and coastal wildlife (especially birds), as well as coastal communities and indigenous peoples dependent on fishing in the ocean and other ecosystem services (Table EIS-4).

To assess the potential magnitude of impacts in the unlikely event of an oil spill, the 95th percentile spill event for shoreline stranding by oil with a thickness greater than 1 micrometer was selected from each stochastic scenario in the Jun–Nov and Dec–May seasons, and deterministic modeling was conducted for each of these scenarios. This deterministic modeling resulted in a prediction of the sea surface area swept by oil and the length of shoreline oiled with a thickness greater than 1 micrometer, assuming no implementation of response measures. For the four (unmitigated) loss-of-well-control event spill scenarios (Jun–Nov and Dec–May for each of the two WCDs), deterministic modeling of an unmitigated spill predicts no shoreline oiling in Guyana for any of the modeled scenarios.

To aid in preparing to respond to the unlikely event of an oil spill, coastal sensitivity maps were prepared for the entire Guyana coastline, and the coastlines of 11 other countries for which modeling indicates a potential risk of shoreline oiling due to an unmitigated release. To provide additional detail to these maps, ecosystem services mapping was conducted for Regions 1–6. In Region 1, the only Guyana region that could be directly affected by a spill resulting from an unmitigated loss-of-well-control event, provisioning services (focused on fishing, agriculture, hunting, and traditional resource use) and regulating services (associated with mangroves' role in stabilizing and protecting the coast) were key ecosystem services identified and field-verified.

The combination of the low probability of an oil spill actually reaching the Guyana shoreline and the time available to allow for spill response results in the residual risk to coastal resources being considered **Minor** (Table EIS-4). If an oil spill were to reach the coast during the migratory or breeding season for coastal birds or the mudflats that these species use to feed, the impacts could be significant. The ecosystem services component of the coastal sensitivity mapping also highlighted the role that the coastal habitats within the Shell Beach Protected Area play in sustaining marine fisheries on the western Guyana continental shelf, and the importance of ecosystem services to sustaining the coastal communities along the entire coast, and particularly in the Amerindian communities of Region 1.

Table EIS-4: Coastal Resources Potentially Impacted by an Oil Spill

Resource	Potential Impact	Residual Risk Rating
Protected Areas	Shell Beach Protected Area and its vicinity could be impacted if oil were to reach the Guyana shoreline.	Minor
Coastal Habitats and Coastal Wildlife (including Special Status Species)	Mangroves, wetlands, and mudflats are common habitats along the Guyana coastline that support many wildlife species, particularly coastal birds. These habitats and species are sensitive to oil contamination.	Minor
Ecosystem Services, Coastal Communities and Indigenous Peoples	Many rural coastal communities, and especially Indigenous communities, rely on many ecosystem services (e.g., for food, housing materials, medicinal plants, income producing products, flood protection) for sustenance and livelihoods.	Minor

Even though the probability of a spill impacting the coastal resources of Guyana is very low, such an oil spill would likely have adverse impacts on marine resources in the area impacted by the spill. Those resources most at risk would be marine water quality, seabirds, marine mammals, and marine turtles, as described in Table EIS-5. Although effective implementation of the OSRP would help mitigate this risk by further reducing the ocean surface area impacted by a spill and oil exposure to these species, the residual risk to all of these resources aside from marine mammals and seabirds as a whole is considered **Moderate**. In the case of Leach's Storm-Petrel, the offshore PDA is a migratory corridor for a relatively large number of this species. Accordingly, the residual risk to Leach's Storm-Petrel from an oil spill is considered **Moderate**.

Table EIS-5: Marine Resources Potentially Impacted by an Oil Spill

Resource	**Potential Impact**	**Residual Risk Rating**
Marine Water Quality	Dissolution of some spilled oil into the water column, but light oil expected to degrade quickly and the impacts are reversible.	Moderate
Seabirds (Non-special Status Species)	Seabirds are typically among the species most impacted by an oil spill because they spend significant time on the water surface and so may come in contact with the spilled oil, but seabirds are primarily transient in the PDA.	Minor [a]
Leach's Storm-Petrel (Special Status Species)	The nature of the impact on Leach's Storm Petrel (*Oceanodroma leucorhoa*) is the same as for (nonspecial status) seabirds as a whole. However, the residual risk rating for this species is considered **Moderate** based on the results of the marine bird post-permit study, which documented the importance of the offshore zone as a migratory corridor for this particular species.	Moderate
Marine Mammals	Ingestion and respiratory irritation from inhalation of vapors at the water surface, and the potential for fouling of baleen whale plates, which are used to feed.	Minor
Marine Turtles	Dermal irritation from contact with oil, ingestion, and respiratory irritation from inhalation of vapors at the water surface.	Moderate

[a] Excludes Leach's Storm-Petrel, which is discussed separately

3.3. TRANSBOUNDARY IMPACTS

Oil spill modeling indicates that transboundary impacts could potentially occur for the three largest spill scenarios considered (2,500-barrel FPSO offloading spill and the two loss-of-well-control scenarios), assuming no mitigation measures were implemented. The modeling results for these scenarios indicate there is the potential for an unmitigated oil spill to reach three main geographic regions:

- Trinidad and Tobago, the northern South American coast, and the so called "ABC Islands" (Aruba, Bonaire, and Curaçao);
- The southern Lesser Antilles; and
- The Greater Antilles.

An unmitigated oil spill from a loss-of-well-control event during the Dec-May season would take a west-northwesterly route through the Gulf of Paria and across the southern edge of the Caribbean Sea. Comparatively strong easterly winds in the Dec–May season would expose the northern coast of South America and the southern Lesser Antilles to the bulk of shoreline oiling risk. An equivalent spill during the Jun–Nov season would be exposed to lower wind speeds, allowing the surface plume to be transported to the north of Trinidad and Tobago and swept into the Caribbean Sea. The plume would track slightly more to the north, across the central Caribbean Sea and the central and southern portions of the Lesser Antilles, to the Greater Antilles.

Mitigated oil spills from each of the two loss-of-well-control scenarios would have the potential to reach all three of the above regions as well, but the extent of shoreline oiling associated with mitigated spills would typically be reduced relative to the corresponding unmitigated spill.

3.3.1. Trinidad and Tobago and the Northern South American Coast, including Aruba, Bonaire, and Curaçao

Due to its location at the southern end of the Lesser Antilles, Trinidad and Tobago is the only island country that would have the potential to be affected by the transboundary effects of any unmitigated loss-of-well-control event, regardless of season. The probability of oiling at least a portion of the coast of Trinidad and Tobago and/or its coastal waters is approximately 90 to 100 percent for any of the unmitigated loss-of-well-control event scenarios. With the exception of the Gulf of Venezuela, stochastic modeling indicates a 5 to 60 percent probability of surface oil reaching the Venezuelan coastal zone, depending on location and season. Deterministic modeling suggests the Maximum WCD loss-of-well-control scenario would pose oiling risks to the Venezuelan mainland in the Dec–May season, but only to Isla La Blanquilla in the Jun–Nov season.

Similar to Venezuela, deterministic modeling suggests that both unmitigated loss-of-well-control scenarios would result in oiling of the west coast of Bonaire in the Dec–May season. The only unmitigated loss-of-well-control scenario that would pose a risk of shoreline oiling in Bonaire in the Jun–Nov season would be the Most Credible WCD Case scenario. Much of Aruba's and Curaçao's east coasts would be at risk of oiling under both loss-of-well-control scenarios in the Dec–May season. There would be no risk of coastal oiling in either country during the Jun–Nov season under either of the scenarios. The only portion of Colombia that could be affected by an unmitigated loss-of-well-control event would be the northeastern portion of the La Guajira Peninsula, which is a very remote area at the extreme northern tip of the country. Deterministic model results suggest oiling risks under both loss-of-well-control scenarios in the Dec–May season.

Venezuela has numerous marine turtle nesting beaches, mangroves, important bird areas, coral reefs, and shallow coastal lagoons that would be at risk of oiling. The highest concentrations of most of these resources occurs in the Orinoco Delta in the eastern portion of country, although the corals and seagrasses tend to be more abundant surrounding offshore islands in the western portion of the country. The same types of resources tend to be found on Aruba, Bonaire, and Curaçao or their adjacent marine territories. Numerous fishing areas are located east of Trinidad and could be impacted by a large unmitigated spill from a loss-of-well-control event. The economies of Aruba, Bonaire, and Curaçao are dependent on tourism to varying degrees but especially so in Bonaire, which is known internationally as a destination for recreational diving. The economic effects of an oil spill on these countries would depend to a large degree on the extent to which these industries would be affected, and how rapidly they would recover.

3.3.2. Southern Lesser Antilles

The only Lesser Antillean countries north of Tobago that would be at risk of oil coming ashore from a loss-of-well-control event are Grenada and St. Vincent and the Grenadines. These countries would only be at risk of shoreline oiling under the Maximum WCD scenario for both the Jun–Nov and Dec–May seasons. The probability of nearshore waters in the southern Lesser Antillean region north of Tobago being affected by a spill under the Maximum WCD scenario varies widely according to location, season, and volume, from an 80 to 90 percent probability along the southern coast of Grenada in the Jun–Nov season to a 5 to 10 percent probability near Dominica in both seasons.

3.3.3. Greater Antilles

The Greater Antilles would be exposed to the greatest risk of shoreline oiling during the Jun–Nov season, when comparatively weak trade winds would allow an oil plume to track further north than at other times of the year. A Most Credible WCD spill would not be expected to reach the Greater Antilles at any time of year, but an unmitigated Maximum WCD spill would be predicted to reach the coasts of the Dominican Republic, Haiti, and Jamaica in the Jun–Nov season.

The portion of the Greater Antilles that could be affected by an unmitigated oil spill is notable for the number of protected areas it contains. These include:

- The Arrecifes de Suroeste (Southwest Reefs) Marine Sanctuary and Scientific Reserve in the Dominican Republic, which is an array of coral reefs and seagrass meadows located along the coast and is purported to support the West Indian manatee, dolphins, and other marine mammals;
- Jaragua National Park in the Dominican Republic, which has terrestrial and marine components and has cultural significance due its numerous caverns that contain pictograms and petroglyphs from the Taino culture, as well as other pre-Columbian archaeological sites. The park is reported to support 130 bird species (10 of them are endemic), solenodons and hutias, as well as West Indian manatees and bottlenose dolphins;
- The Portland Bight Protected Area (PBPA), which is the largest protected area in Jamaica. Its terrestrial area is 520 square kilometers (201 square miles) in the southern sections of St. Catherine and Clarendon parishes, including the coastline from east of Hellshire to almost Milk River in the west. It includes contiguous coastal land and the marine area out to the 200-meter (656-foot) depth contour (1 nautical mile, or approximately 20 kilometers [12.4 miles] south of Portland Point). It is a Ramsar wetland site, contains sandy beaches and cays which support nesting marine turtles, nesting seabirds), nearshore islands which support endemic lizards, and mangroves. Benthic marine resources in the PBPA include seagrass and coral reefs;

- The Black River Lower Morass, another wetland Ramsar site located approximately 15 kilometers (9 miles) west of the PBPA and Jamaica's largest wetland. It supports the IUCN-listed American crocodile (Vulnerable) and is listed as an IBA by Birdlife International; and

3.3.4. Impacts of International Importance

In addition to the country-specific impacts listed above, seabirds would have the potential to be affected at a regional scale. Since 2010, BirdLife International has focused its efforts on identifying Marine IBAs with specific significance to seabirds. There are 49 Marine IBAs of global or regional importance to seabirds that lie within the swept zone of a Maximum WCD unmitigated loss-of-well-control scenario (considering both seasons together). These sites contain regionally or globally important breeding and foraging sites for numerous species of seabirds, including species with elevated conservation status (i.e., IUCN listing status of Vulnerable or higher). Two of these 49 Marine IBAs that are located along the southern coastline of Hispaniola (Haiti and the Dominican Republic) are particularly significant as they support the world's only known breeding sites for Black-capped Petrel (*Pterodroma hasitata*) (IUCN Endangered).

3.3.5. Mitigation of Transboundary Impacts

The unmitigated oil spill modeling used to characterize potential transboundary impacts did not take into consideration any emergency response actions. Implementation of the OSRP would help to significantly reduce potential transboundary impacts just as it would reduce impacts within the Guyana Exclusive Economic Zone, as demonstrated by oil spill modeling that considers OSRP implementation (i.e., mitigated scenarios). In particular, EEPGL has put in place an interim solution that will facilitate installation of a capping stack on well location within 9 days in certain circumstances (e.g., where there is no debris that prevents or delays installation of the capping stack). Mitigated scenario modeling demonstrates that this, in combination with other response measures (e.g., dispersant application), would significantly reduce the extent of transboundary impacts. In any case, EEPGL will work with representatives of the respective countries that could be potentially impacted by a large oil spill to be prepared for the unlikely event of a spill by:

- Coordinating operations and communications between different command posts;
- Creating a transboundary workgroup to manage waste from a product release, including identifying waste-handling locations in the impacted regions and managing commercial and legal issues;
- Identifying places of refuge in the impacted region where response vessels could go for repairs and assistance;
- Determining how EEPGL and the impacted regional stakeholders can work together to allow equipment and personnel to assist in a spill response outside the region while still retaining a core level of response readiness within the jurisdictions;

- Determining financial liability and establishing claims and/or livelihood remediation processes during a response to a transboundary event; and
- Working with local communities within the impacted areas to raise awareness of oil spill planning and preparations.

3.4. CUMULATIVE IMPACTS

The Project's expected contribution to cumulative impacts will be limited by its distance offshore, by the distance between EEPGL projects/activities, and by the small number of non-EEPGL projects or activities either operating or currently planned to be operating offshore Guyana. There are other offshore Guyana oil and gas exploration and development activities planned by EEPGL, including the approved Liza Phase 1 Development and Liza Phase 2 Development projects, continued exploration drilling, two other future planned development projects in the Stabroek Block (assumed to be south or southeast of the Payara Project FPSO), a fiber optic cable installation project, and the Gas-to-Shore Project - a project which is expected to transport associated gas from the Liza Phase 1 PDA to shore for creation of natural gas liquids and natural gas power production (gas from the Payara Project is currently not planned to be transported to shore as part of the Gas-to-Shore Project). Additionally, there is a limited number of non-oil and gas related projects proposed by others that could potentially impact the same types of resources that could be impacted by the Project. Three other oil and gas operators are planning exploration programs in blocks adjacent to the Stabroek Block, but the current schedules for these efforts and their locations are such that they would not be expected to overlap in time or geographically with Project activities.

The Project activities, other planned EEPGL activities, and non-EEPGL activities together could cumulatively impact some resources such as climate (via increased emissions of GHGs), marine water quality (via discharge of drill cuttings and associated increases in TSS concentrations), special status fish (via changes in distribution due to altered water quality), special status seabirds (via attraction to offshore facilities or disturbance from Project activities), marine mammals (via vessel strikes or potential disturbance from underwater sound), marine turtles (via vessel strikes), marine fish (via degraded water quality), community health and wellbeing (via increased demand on limited medical treatment capacity), marine use and transportation (via additional marine congestion, especially near Georgetown Harbour), employment and livelihoods (via interference with artisanal fishing activities), social infrastructure and services (via increased demand for limited housing and lodging), and waste management infrastructure capacity (via increased burden on waste treatment or disposal facilities in Georgetown). Many of the above potential impacts that require offshore interaction between the Project and others to result in a cumulative impact have a limited chance of occurring, given the size of the Stabroek Block.

The Project will adopt a number of embedded controls, mitigation measures, and management plans. These are considered sufficient to address the contributions of the Project to cumulative impacts. With respect to the contributions of multiple EEPGL projects/activities to potential cumulative impacts, it is recommended that EEPGL, when designing and undertaking these additional projects/activities, ensure that the same level of potential impact management (i.e., as for the Payara Project) be implemented. In addition, with the intention of minimizing the potential interactions between effects of multiple projects, it is recommended that EEPGL take measures, where feasible and practicable, to share logistical resources between development projects—to reduce the number of additional vessel movements associated with additional projects. This approach would be expected to be sufficient to address contributions of the Project and other EEPGL projects/activities to cumulative impacts on marine mammals. Regarding climate, EEPGL has developed a flare minimization plan for its operations in Guyana, as well as committing to continue measuring and reporting its GHG contributions to national emissions. It is recommended that EEPGL continue to assess measures that can be taken to minimize GHG emissions during each Project's production operations stage, and ensure that a Best Available Technology assessment process (i.e., as conducted for the Payara Project) be undertaken to assess the feasible and appropriate embedded controls and mitigation measures that can be implemented to reduce GHG emissions. In the case of waste management infrastructure capacity, the mitigation measures already initiated by EEPGL represent appropriate collaborative efforts with industry and government to manage the cumulative impacts on this resource.

3.5. Degree of Irreversible Damage

The planned Project would not cause irreversible damage to any onshore areas of Guyana. There would be a very minor (approximately 0.8 km^2 [0.3 mi^2]) permanent loss of benthic habitat offshore as a result of the installation of wells, flowlines, and other subsea equipment, which may be proposed to be left in place upon decommissioning. However, this equipment can ultimately provide the substrate for recolonization of the impacted areas. Even in the unlikely event of a large marine oil spill, little irreversible damage would be expected, although it could take a decade or more for all resources to fully recover, depending on the volume and duration of the release, as well as the time of year at which the release were to occur.

3.6. Environmental and Socioeconomic Management Plan

An ESMP has been developed to manage and mitigate the impacts identified in the EIA. The ESMP includes the following:

- ESMP Framework
- Environmental Management Plan, including:
  - Air Quality Management
  - Water Quality Management
  - Marine Ecosystems Management
- Socioeconomic Management Plan, including:
  - Stakeholder Engagement Plan
  - Grievance Management
  - Marine Transportation Management
  - Road Transportation Management
  - Cultural Heritage Management and Chance Finds

- Environmental and Socioeconomic Monitoring Plan
- Emergency Response Plan Summary
- Oil Spill Response Plan, including:
  - Oil Spill Modeling
  - Net Environmental Benefit Analysis
  - Emergency Preparedness and Response Procedures
  - Wildlife Response Plan
  - Geographic Strategic Response Maps
- Waste Management Plan
- Preliminary End of Operations Decommissioning Plan

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. CONCLUSIONS

The planned Project activities are predicted to have **Negligible** to **Moderate** residual impacts on physical resources (i.e., air quality and climate, marine geology and sediments, marine water quality), no impacts on coastal biological resources, **Negligible** to **Moderate** residual impacts on marine biological resources, and **Negligible** to **Minor** residual impacts on socioeconomic resources—with largely positive impacts on socioeconomic conditions. These predictions are due to the fact that the bulk of the Project will occur approximately 207 kilometers (approximately 128 miles) offshore; and the Project will capture and re-inject recovered natural gas (the portion that is not used as fuel on the FPSO) into the reservoir, treat all wastewater streams as required prior to discharge to the sea, have a very small physical footprint (e.g., installation of infrastructure will only physically disturb about 0.8 km^2 (0.3 mi^2) of benthic habitat), and use Marine Mammal Observers and "soft starts" during VSP and pile driving operations to reduce the potential for auditory damage to marine animals. The Project will generate benefits for the citizens of Guyana through revenue sharing with the Government of Guyana, a minor increase in employment and select Project purchasing from Guyanese businesses.

Unplanned events, such as a potential oil spill, are considered unlikely to occur because of the extensive preventative measures employed by EEPGL; nevertheless, an oil spill is considered possible. The types of resources that would potentially be impacted and the extent of the impacts on those resources would depend on the volume and duration of the release, as well as the time of year at which the release were to occur, but impacts would tend to be most significant for a well-control event with loss of containment during the drilling stage. EEPGL has conducted oil spill modeling to evaluate the range of likely spill trajectories and rates of travel. The location of the Project 207 kilometers (approximately 128 miles) offshore, prevailing northwest currents, the medium nature of the Payara field crude oil, and the region's warm waters would all help reduce the severity of a spill. Accounting for these factors, modeling of an unmitigated subsea release of crude oil from an unmitigated loss-of-well-control event indicates only a 5 to 20 percent probability of oil reaching the Guyana coast, without taking into consideration the effectiveness of any oil spill response, and in the unlikely event that a spill were even to occur.

Although the probability of an oil spill reaching the Guyana coast is very small, an unmitigated subsea release of crude oil from a loss-of-well-control event at a Payara well would likely impact any marine resources found near the well—which could include marine turtles and certain marine mammals (especially baleen whales) that may transit or inhabit the area impacted by a spill, as well as marine water quality. Other physical and biological resources such as air quality, seabirds, marine fish, and marine benthos could also be impacted, although likely to a lesser extent because the duration of acute impacts would not be long and the impacts are reversible. A spill could potentially impact Guyanese fisherfolk if commercial fish and shrimp resources were impacted. The magnitude of this impact would depend on the volume and duration of the release as well as the time of year at which the release were to occur (e.g., whether a spill would coincide with the time of year when these resources are more abundant in the PDA). Effective implementation of the OSRP would reduce this risk by reducing the ocean surface area impacted by a spill and thereby reducing the exposure of these resources to oil.

Additional unplanned events, also considered unlikely to occur because of the preventative measures employed by EEPGL, could include collisions between Project vessels and non-Project vessels; Project vessel strikes of marine mammals, marine turtles, riverine mammals, or rafting seabirds; collisions between Project vehicles and non-Project vehicles; and a release of untreated wastewater from the FPSO. The extent of the impacts from these types of events would depend on the exact nature of the event. However, in addition to reducing the likelihood of occurrence, the embedded controls that EEPGL has or will put in place (e.g., training of vessel operators to recognize and avoid marine mammals, riverine mammals, and marine turtles; adherence to international and local marine navigation procedures; adherence to a Road Safety Management Procedure) would also serve to reduce the likely extent of impact, were such an event to occur.

Table EIS-6 provides a summary of the predicted residual impact significance ratings (taking into consideration proposed mitigation measures) for impacts on each of the resources that may potentially result from the planned Project activities in each Project stage (i.e., development well drilling and SURF/FPSO installation, production operations, and decommissioning). For each resource, the table shows the highest residual impact significance rating among the potential impacts relevant to each Project stage. The table also summarizes, for each resource, the highest residual risk rating for potential risks to resources from unplanned events (e.g., oil spill, vessel strike, etc.) and the priority rating for potential cumulative impacts on each resource, as determined by the cumulative impact assessment.

Table EIS-6: Summary of Residual Impact Significance Ratings, Residual Risk Ratings, and Cumulative Impact Priority Ratings

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Drilling and Installation	Production Operations	Decommissioning		
Air Quality	Negligible	Negligible	Negligible	Minor	NA
Climate	Negligible	Moderate	Negligible	Minor	Medium
Sound [a]	None	None	None	None	None
Marine Geology and Sediments	Negligible	None	None	Minor	NA
Marine Water Quality	Minor	Negligible	Negligible	Moderate	Low
Protected Areas	None	None	None	Minor	NA
Special Status Species: [b]					
• Critically Endangered and terrestrial species	Negligible	Negligible	Negligible	Minor	Low
• Vulnerable/Near Threatened fish species	Minor	Minor	Negligible	Minor	Low
• Endangered fish and Endangered black-capped petrel (*Pterodroma hasitata*)	Negligible	Minor [d]	Negligible	Minor	Low
• Vulnerable Leach's storm-petrel (*Oceanodroma leucorhoa*)	Negligible	Minor [d]	Negligible	Moderate [e]	Low
Coastal Habitats	None	None	None	Minor	NA
Coastal Wildlife	None	None	None	Minor	NA
Seabirds [c]	Negligible	Minor	Negligible	Minor	NA
Marine Mammals	Moderate	Minor	Negligible	Moderate	Medium
Riverine Mammals	Minor	Minor	Minor	Minor	Low
Marine Turtles	Negligible	Negligible	Negligible	Moderate	Low
Marine Fish [f]	Minor	Negligible	Negligible	Minor	Low
Marine Benthos	Minor	Positive	Positive	Minor	Low
Ecological Balance and Ecosystems	Negligible	Minor	Negligible	Minor	Low
Socioeconomic Conditions	Positive	Positive	Positive	Minor	NA
Employment and Livelihoods	Positive	Positive	Positive	Minor	Low
Community Health and Wellbeing	Minor	Minor	Minor	Minor to Moderate	Low
Marine Use and Transportation:					
• Commercial cargo	Negligible	Negligible	Negligible	Minor	Low
• Commercial fishing	Minor	Minor	Minor	Minor	Low
• Subsistence fishing	Minor	Minor	Minor	Minor	Low
Social Infrastructure and Services:					
• Lodging	Minor	Negligible	Negligible	Minor	Low
• Housing and utilities	Minor	Negligible	Negligible	Minor	Low

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Drilling and Installation	Production Operations	Decommissioning		
• Ground and air transportation	Negligible	Negligible	Negligible	Minor	Low
Waste Management Infrastructure Capacity	Minor	Minor	Minor	Minor	Medium
Cultural Heritage	Negligible	None	None	Minor	NA
Land Use	Negligible	Negligible	Negligible	Minor	NA
Ecosystem Services	None	None	None	Minor	NA
Indigenous Peoples	None	None	None	Minor	NA

NA = Not assessed in cumulative impact assessment; scoped out as potentially eligible (see EIA Chapter 10, Cumulative Impact Assessment)
[a] Potential underwater sound-related impacts on marine mammals, marine turtles, and marine fish are assessed in the resource-specific sections for those resources.
[b] Excludes listed marine turtles, which are covered in the Marine Turtles resource category.
[c] Excludes listed seabirds, which are covered in the Special Status Species resource category.
[d] Based on the 20-year presence of the FPSO (as a lighted attractant), the potential impact significance to special status marine birds during the production operations stage is considered Minor.
[e] The residual risk rating for Leach's Storm-Petrel is considered Moderate based on the results of marine bird surveys in 2017, 2018, and 2019, which documented the importance of the offshore zone as a migratory corridor for this special status marine bird.
[f] Excludes listed marine fish, which are covered in the Special Status Species resource category

The Project will generate benefits for the citizens of Guyana in several ways:

- Through revenue sharing with the Government of Guyana, as detailed in the Petroleum Agreement between the Government of Guyana and EEPGL et al., which was made available to the public in December 2017. The type and extent of benefits associated with revenue sharing will depend on how decision makers in government decide to prioritize and allocate funding for future programs, which is unknown to EEPGL and outside the scope of the EIA.
- By procuring select Project goods and services from Guyanese businesses in alignment with the Petroleum Agreement and the EEPGL Local Content Plan approved by the Ministry of Natural Resources on 6 April 2018.
- By hiring Guyanese nationals in alignment with the Petroleum Agreement and the EEPGL Local Content Plan.

In addition to direct revenue sharing, expenditures, and employment, the Project will also likely generate induced economic benefits. These induced benefits could result from the re-investment, hiring, and spending by Project-related businesses and/or workers, which in turn benefits other non-Project-related businesses and generates more local tax for the government. These beneficial "multiplier" impacts are expected to occur throughout the Project life (at least 20 years).

4.2. RECOMMENDATIONS

The Consultants recommend the following measures be considered by the EPA, the Environmental Advisory Board, and other relevant Government of Guyana agencies as conditions of issuance of an Environmental Authorisation for the Project:

- Embedded Controls—incorporate all of the proposed embedded controls (see EIA Chapter 13).
- Mitigation Measures—adopt the recommended mitigation measures (see EIA Chapter 13).
- Management Plans—implement the proposed Environmental and Socioeconomic Management Plan to manage and mitigate the potential impacts identified in the EIA.
- Oil Spill Preparedness—EEPGL has proactively embedded multiple controls into the Project design to prevent a spill from occurring, and we agree that a large spill that affects the Guyana coastline and/or other regional coastlines is unlikely. But given the sensitivity of many of the resources that could potentially be impacted by a spill (e.g., Shell Beach Protected Area; marine mammals; critically endangered, endangered, and vulnerable marine turtles; and Amerindian, fishing, and other communities reliant on ecosystem services for sustenance and their livelihood), we believe it is critical that EEPGL commit to regular oil spill response drills, simulations, and exercises—and involve appropriate Guyanese authorities and stakeholders in these activities, document the availability of appropriate response equipment on board the FPSO, and demonstrate that offsite equipment could be mobilized for a timely response.

With the adoption of such controls, mitigation measures, and management plans, and requirements for emergency response preparedness, the Payara Development Project is expected to pose only minor risks to the environmental and socioeconomic resources of Guyana, while potentially offering significant economic benefits to the residents of Guyana.

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ENVIRONMENTAL IMPACT ASSESSMENT

1. INTRODUCTION

Esso Exploration and Production Guyana Limited (EEPGL) is seeking environmental authorization for a third development in the eastern half of the Stabroek Block, in the Payara, Pacora, Liza Deep, and northern area of the Liza fields (hereafter referred to as the Payara Development Project, or the Project). EEPGL is the designated Operator[1] of the Stabroek Block and is seeking authorization for the Project on behalf of itself, its co-venturers, Hess Guyana Exploration Limited, and CNOOC Petroleum Guyana Limited. The objective of the Project will be to develop oil reserves from the Stabroek Block. The area that will be developed as part of the Project is located approximately 207 kilometers (128 miles) northeast of the coastline of Georgetown, Guyana (Figure 1-1). Based on exploration and assessment activities, EEPGL has estimated that the Stabroek Block contains more than 6 billion barrels of oil-equivalent recoverable resource, including the most recent discoveries at Tilapia-1, Haimara-1, and Yellowtail-1.

The Guyana Environmental Protection Agency (EPA) has required EEPGL to hire qualified independent environmental consultants to conduct an Environmental Impact Assessment (EIA) in support of EEPGL's Application for Environmental Authorisation (Application) for the Project.

EEPGL has not yet made a Final Investment Decision on the Project, and is continuing to evaluate cost considerations during the Project development process. EEPGL has previously indicated the development cost for its second development in the eastern half of the Stabroek Block—the Liza Phase 2 Development Project—to be approximately $1.254 trillion GYD ($6 billion USD)[2]. For the purposes of the Payara Development Project Environmental Authorisation process, the Payara Development Project development cost is estimated to be greater than $6 billion USD, as the Project cost is anticipated to be higher than that of the Liza Phase 2 Development Project—given the higher numbers of development wells and associated subsea, umbilicals, risers, and flowlines (SURF) and drilling costs.

[1] EEPGL will be the Operator of the Project, and is used in this Environmental Impact Assessment to represent the co-venturers.
[2] $1 U.S. dollar = $209 Guyanese dollars

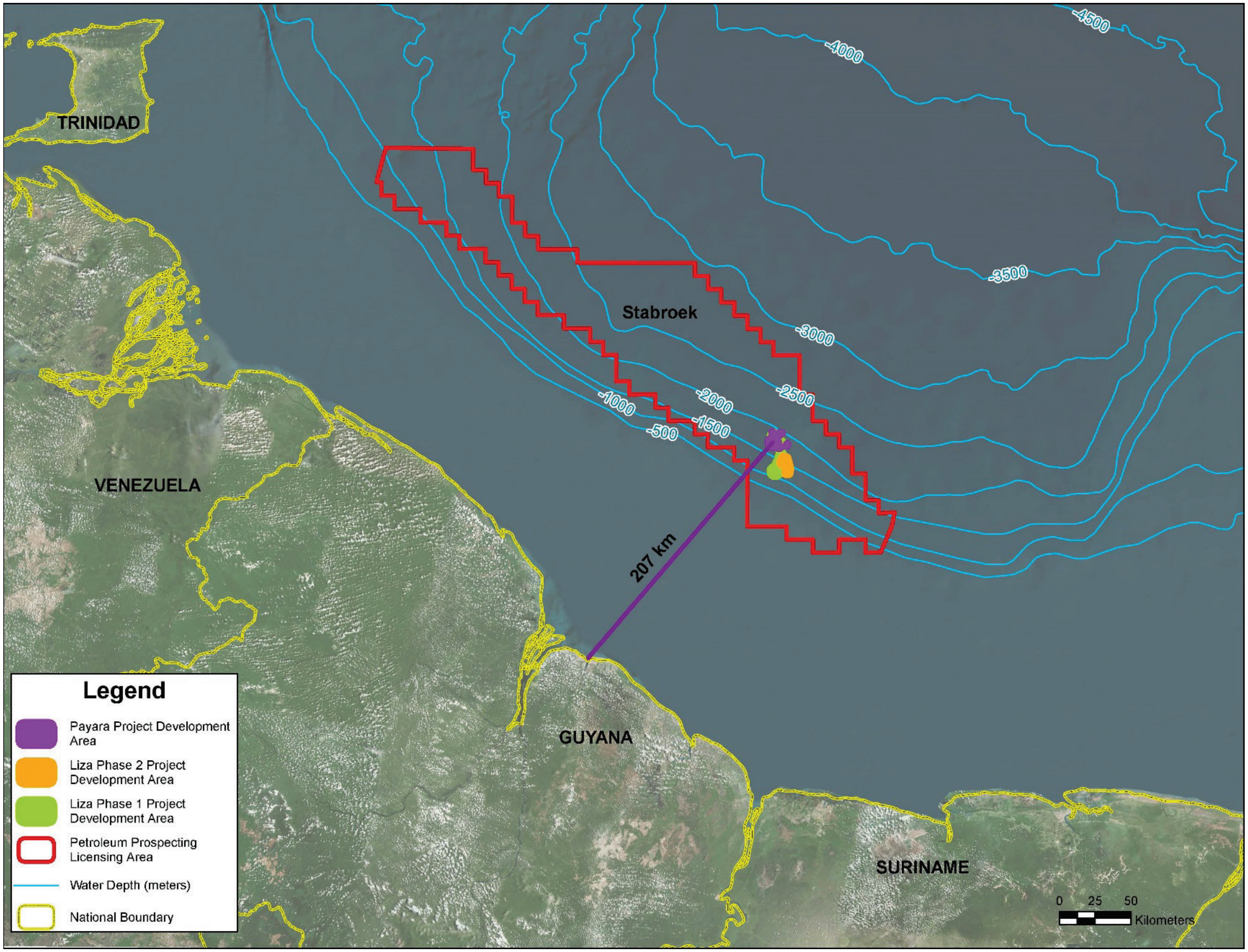


Figure 1-1: Location of the Payara Project Development Area within Stabroek Block

1.1. PURPOSE OF THIS EIA

Guyanese law requires EEPGL to obtain an environmental authorization from the EPA to undertake the Project. The EPA oversees the effective management, conservation, protection, and improvement of the environment in Guyana. In this role, the EPA is responsible for managing the environmental authorization process. EEPGL filed an Application to permit the Project with the EPA on 3 December 2018. Based on an initial assessment of the Application, the EPA determined that an EIA was required in support of the Application.

The purpose of this EIA is to provide the factual and technical basis required by the EPA to make an informed decision on EEPGL's Application to permit the Project. After submission and review of this EIA, the EPA will take into account the review of other government agencies, the public's comments, EPA's own review - including support from technical experts, and recommendations from the Environmental Assessment Board (EAB) in deciding whether and under what conditions to grant EEPGL an Environmental Authorisation[3] for the Project.

The Guyana Geology and Mines Commission (GGMC) has several functions relating to the Project, including promoting and regulating the exploration and development of the country's mineral and petroleum resources. The GGMC has a dedicated Petroleum Unit charged specifically with regulatory supervision of the oil and gas sector; however, regulation of petroleum-related activities also occurs in other divisions, such as the Geological Services Division and the Environment Division. The GGMC oversees EEPGL's Prospecting Licence, under which EEPGL's offshore exploration and drilling activities are conducted. Since the shift in oversight responsibilities from the Ministry of Natural Resources to the Ministry of the Presidency, the Department of Energy (DE), under the Ministry of the Presidency, has been playing a lead role in matters regarding the oil and gas sector. In this regard, on matters of oil and gas, the GGMC, through the Petroleum Unit, has been working closely with the DE. The GGMC will provide technical input into the review of the EIA, as discussed above, and will consider the granting of an Environmental Authorisation by the EPA as part of its evaluation of EEPGL's application for a Petroleum Production Licence for the Project.

The EAB is an independent body that contributes to the development and review of the EIA and makes recommendations to the EPA on whether the EIA should be accepted, amended, or rejected; whether the environmental authorization should be granted; and if so, under what terms and conditions.

This EIA was prepared by a team of consultants including Environmental Resources Management (ERM), an international environmental and social consulting firm with a local registration in Guyana and extensive experience in the preparation of EIAs for offshore oil and gas development projects, and the Guyanese consultancies Environmental Management Consultants (EMC) and Ground Structures Engineering Consultants Ltd. (GSEC). ERM, EMC, and GSEC are collectively referred to herein as "the Consultants." In a letter dated

[3] The Environmental Authorisation granted by the EPA is also commonly referred to as an environmental permit, and the two terms may be used interchangeably.

11 March 2019, the EPA approved this team as the independent consultant to undertake the EIA. This EIA has been prepared in compliance with the Guyana Environmental Protection Act (as amended in 2005), the Environmental Protection (Authorisation) Regulations (2000), the Environmental Impact Assessment Guidelines—Volume 1, Version 5 (EPA 2004), the Environmental Impact Assessment Guidelines—Volume 2, Version 4 (EPA/EAB 2000), international good practice, and EEPGL's corporate standards, and in accordance with the Consultants' standard practices.

1.2. EEPGL Exploration Well Drilling History

EEPGL has drilled 21 wells and is in the process of drilling the twenty-second (exploration) well and twenty-third (appraisal) well within the Stabroek Block offshore Guyana, as indicated in Table 1.2-1. After completion, each of these wells was plugged or will be plugged consistent with good industry practice. A small number of appraisal wells were, or will be, re-entered to perform a well test and then plugged permanently. EEPGL has plans to explore in other blocks, but has not yet engaged in drilling outside of the Stabroek Block.

Table 1.2-1: EEPGL Stabroek Block Exploration Well Drilling History

Well Name	Year Drilled	Result
Liza-1	2015	Successful (oil found)
Liza-2	2016	Successful
Liza-3	2016	Successful
Skipjack-1	2016	Dry well (no oil found)
Payara-1	2016–2017	Successful
Liza-4	2017	Successful
Snoek-1	2017	Successful
Payara-2	2017	Successful
Turbot-1	2017	Successful
Ranger-1	2017–2018	Successful
Pacora-1	2018	Successful
Sorubim-1	2018	Dry well
Liza-5	2018	Successful
Longtail-1	2018	Successful
Hammerhead-1	2018	Successful
Ranger-2	2018	TBD (currently being drilled)
Pluma-1	2018–2019	Successful
Tilapia-1	2019	Successful
Haimara-1	2019	Successful
Yellowtail-1	2019	Successful
Hammerhead-2	2019	Successful
Hammerhead-3	2019	Successful
Tripletail-1	2019	TBD (currently being drilled)

TBD = to be determined

1.3. Goal and Objectives of the EIA

In accordance with the Final Terms and Scope for this EIA, issued by the EPA on 26 June 2019, the goal of the EIA is to provide the factual and technical basis required by the EPA to make an informed decision on EEPGL's Application to permit the Project.

To that end, this EIA has the following objectives:

- Describe the components and activities of the Project, including:
  - Development drilling, including well design and drill ships;
  - SURF;
  - Floating Production, Storage, and Offloading (FPSO) vessel, including topsides facilities and the vessel mooring system;
  - Installation, hookup, and commissioning of FPSO and SURF components;
  - Production operations, including offloading tankers;
  - Onshore support, including shorebases;
  - Marine and aviation support vessels and equipment; and
  - End of Project operations (decommissioning).
- Describe the existing conditions within the Project Area of Influence (AOI). The evaluation of existing conditions in the Project AOI will leverage the scientific body of knowledge that has been acquired through various prior and ongoing studies.
- Identify and assess the potential direct, indirect, and cumulative environmental and socioeconomic impacts that could credibly result from the Project during the drilling, installation, production, and decommissioning stages.
- Describe, to the extent possible, potential induced impacts associated with ancillary/support activities or facilities that may not be a component of the Project itself, but are associated with the Project.
- Describe a strategy to manage the potentially significant adverse impacts of the Project.
- Characterize potential positive benefits of the Project.
- Recommend monitoring to assess the effectiveness of the management strategy.

1.4. Components of the EIA

As required by the Guyana Environmental Protection Act (as amended in 2005) and as further described in the Guyana Environmental Impact Assessment Guidelines, this EIA includes the following required components:

- Project Description: Chapter 2, Description of the Project;
- Environmental Baseline Studies and Environmental Assessment:
  - Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources

- Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources
- Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
- Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events
- Chapter 10, Cumulative Impact Assessment

- Environmental Impact Statement: provided at the beginning of the EIA; and
- Environmental and Socioeconomic Management Plan: Chapter 11, Environmental and Socioeconomic Management Plan Framework; and Volume III—Environmental and Social Management Plan (ESMP).

EEPGL has elected to submit these components as one document.

The Environmental Impact Assessment Guidelines Volume 1—Rules and Procedures for Conducting and Reviewing EIAs, Version 5 (EPA 2004) includes an EIA Review Checklist. Provided below in Table 1.4-1 is an EIA "roadmap" that shows where in the submittal the checklist items can be found.

Table 1.4-1: EIA Review Checklist Roadmap

EIA Review Checklist Items	Corresponding EIA Reference
1. Adherence to the Terms of Reference (ToR) *Adherence to the ToR must be verified simply by checking that all items and information requested in the ToR have been presented, regardless of the content or quality of such information.*	• Adherence to the approved Terms and Scope issued by EPA on 26 June 2019 confirmed
2. Multidisciplinary Team *The accuracy of the EIA depends on the qualifications of the multidisciplinary team not only regarding the EIA process and methods but also regarding their knowledge of the several stages of the specific type of project. Therefore, individual CVs should be submitted as part of the EIA Annexes. Signatures of each member of the team must be affixed.*	• Chapter 14, Project Team, lists core team members, Appendix A provides core team signatures, and Appendix B includes core team Curricula Vitae.
3. Inter-disciplinary Achievement *An EIA must present information regarding the interactions and integration between the physical, biological and socio-economic aspects of the environment in that particular area of the study.*	• Chapter 6 assesses impacts on physical resources/receptors • Chapter 7 assesses impacts on biological resources/receptors • Chapter 8 assesses impacts on socioeconomic resources/receptors[4]

[4] Findings in the one section that are pertinent to resources in another section (e.g., changes in physical habitat conditions that result in potential impacts to biological resources, changes in biological resources that are socioeconomically important, etc.) are integrated into the discussion of potential impacts to the other section.

EIA Review Checklist Items	Corresponding EIA Reference
4. Executive Summary *The Executive Summary, also referred to as the non-technical summary, should provide a brief description of the project and information regarding the potential impacts of the project, arranged in order of significance, along with the proposed mitigation/compensatory measures for each impact. The summary should end with the consultants' recommendations.*	• Executive Summary included in Environmental Impact Statement
5. Project Description *The process of environmental impact assessment depends on the full understanding of the project proposal and accurate identification of the project actions. If actions are unclear, sufficiently detailed impacts are not likely to be identified with the accuracy and specificity needed to enable the development of appropriate mitigation measures.*	
5.01 Is the project proposal fully understood?	• Chapter 2, Description of the Project
5.02 Are all phases identified (e.g. planning, construction, operation and decommissioning)?	• Section 2.5, Drilling and Well Design • Section 2.8, Installation, Hookup, and Commissioning • Section 2.9, Production Operations, • Section 2.11, End of Payara Operations (Decommissioning)
5.03 Is the geographical area for each phase identified?	• Section 2.1, Project Area (all stages occur within this same area)
5.04 Are the land use requirements for each phase identified?	• Section 2.10, Onshore, Marine, and Aviation Support (only onshore supply and support activities have any land use requirements)
5.05 Is there an inventory of the nature and quantity of materials used in the production process?	• Section 2.12, Materials, Emissions, Discharges, and Wastes
5.06 Are there inventories of the type and quantity of products, by-products and effluents expected to be produced by the project?	• Section 2.12, Materials, Emissions, Discharges, and Wastes
5.07 Is there an inventory of the type and quantity of residues?	• Section 2.12, Materials, Emissions, Discharges, and Wastes
5.08 Are the levels of emissions expected detailed with respect to *- Noise?* *- Vibration?* *- Light?* *- Heat?* *- Radiation?* *- Gases?* *- Liquids? Are the types and levels of any other emissions included?*	• Noise impacts: Section 6.2.3, Impact Assessment—Sound; Section 7.5.3, Impact Assessment—Marine Mammals; Section 7.7.3, Impact Assessment—Marine Turtles; Section 7.8.3, Impact Assessment—Marine Fish • Thermal and liquid discharges: Section 6.4.3, Impact Assessment—Marine Water Quality • Radiation: Section 2.12.5, Radiation Emission Sources • Air (gaseous) emissions: Section 6.1.3, Impact Assessment—Air Quality and Climate
5.09 Is information on employment provided?	• Section 2.3, Project Workforce

EIA Review Checklist Items	Corresponding EIA Reference
6. Identification and Description of Alternatives *The assessment of sound alternatives is necessary to validate the EIA process. Therefore reasonable alternatives have to be fully and comprehensively considered. As a minimum, one of the following alternatives must be considered: location, project layout, technology, scheduling, project scale.*	• Section 2.17, Alternatives
6.01 Did the developer consider alternatives?	• Section 2.17, Alternatives
6.02 Was the "no-project" scenario considered?	• Section 2.17.4, No Action Alternative
6.03 Were the environmental factors adequately presented for each alternative?	• Section 2.17, Alternatives
6.04 Is the final choice adequate?	• Section 2.17, Alternatives • Chapter 12, Conclusions and Summary of Impacts
7. Definition and Justification of Physical Boundaries (Direct and Indirect Area of Influence) *Inconsistency in identifying the correct areas of influence will inevitably lead to inconsistency in the baseline data and the impact analysis. The indirect area of influence is the area likely to be affected by indirect, secondary and/or long term impacts.*	• Section 5.1, The Area of Influence
8. Analysis of the Legal Aspects Involved *The analysis of the legal framework involves more than a list of legal Acts. It involves assessing the consequences for the project of enforcing all the environmental legislation and regulations regarding the proposed site and sectoral requirements related to the proposed activity.*	• Chapter 3, Administrative Framework • Additionally, resource-specific administrative framework discussions are provided in each resource-specific section in Chapters 6, 7, and 8
9. Identification of Other Existing Planned Activities or Projects in the Area of Influence *This information is of utmost importance to ensure that land-use and other types of conflicts do not arise later during the project implementation.*	• Chapter 10, Cumulative Impact Assessment
9.01 Has the compatibility between the proposal and the identified existing activities been analysed?	• Section 10.4, Other Projects and External Drivers
9.02 Are the activities compatible?	• Section 10.4, Other Projects and External Drivers
9.03 Does the inventory of existing activities match what is observed?	• Section 10.4, Other Projects and External Drivers
10. Adequacy and Completeness of Relevant Baseline Data *Baseline data must be specific and relevant to the area of influence. General and superficial information does not allow for the use of adequate impact prediction techniques.*	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources

EIA Review Checklist Items	Corresponding EIA Reference
10.01 Is the information presented specific and relevant?	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
10.02 Were difficulties in attaining information (if any) documented?	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
10.03 Have the impact indicators identified been adequately covered (see Section 13)	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
11. Appropriateness of EA Methods *The use of appropriate EA methods is necessary to ensure reliability of the results of the EIA study. Each type of EA method has different strengths and vulnerabilities regarding its appropriateness to perform each step of the EIA study. Some EA methods are unable to provide the means of identification of cause-effect relationships; others do not enable the identification of indirect, secondary and/or long-term impacts. Scientific and technical accuracy of the EIA methods used must therefore be evaluated to ensure the reliability of the conclusions drawn from the impact assessment.*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment • Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
12.1. Physical Impacts *- Have all the identified impacts on air, water, soil, noise, landscape and natural resources been checked against the relevant impacts defined in the ToR?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?*	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources

EIA Review Checklist Items	Corresponding EIA Reference
12.2. Biological Impacts *- Have all the identified impacts on flora, fauna, rare / endangered species, sensitive ecosystems, species habitats and ecological balance been checked against the relevant impacts in the ToR.* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?*	• Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources
12.3. Social and Health Impacts *- Have all the identified impacts on the social and health context been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to human health, demographic and household characteristics, employment opportunities, size and distinguishing characteristics of resident population, the provision of social services and infrastructure?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?* *- To what extent does the project protect/improve human health?* *- To what extent does the project protect/improve human living conditions?*	• Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
12.4. Cultural, Historical and/or Archeological Impacts *- Have all the identified impacts related to cultural, historical and/or archeological sites and heritage been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to cultural heritage?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?*	• Section 8.7, Cultural Heritage

EIA Review Checklist Items	Corresponding EIA Reference
12.5. Economic Impacts *- Have all the identified impacts on the economy (local, regional, national) been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to economic assets and activities?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?* *- Are impacts identified with respect to income generation for the community and at the National Level?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?*	• Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
12.6. Other impacts *- Have all other impacts been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to ______________?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Has the social distribution of the impacts been identified?* *- Have cause/effect relations been properly identified?*	• Other potentially impacted resources not specifically listed above have been included, such as marine geology and sediments (Section 6.3), marine use and transportation (Section 8.4), and indigenous peoples (Section 8.10).
13. Cumulative Impacts *There may be cases where an activity/project will contribute to a cumulative impact on the environment although individually it may not have a significant environmental impact. This may be as a result of the presence of similar activities within the vicinity of the project.*	• Chapter 10, Cumulative Impact Assessment
13.01 Have cumulative impacts been adequately identified and characterized?	• Chapter 10, Cumulative Impact Assessment
13.02 Have the magnitudes been estimated?	• Section 10.6, Assessment of Cumulative Impacts on VECs (Valued Environmental and Social Components)
13.03 Have the impacts been assigned a significance?	• Section 10.6, Assessment of Cumulative Impacts on VECs

EIA Review Checklist Items	Corresponding EIA Reference
13.04 Has the social distribution of the impacts been identified?	• Section 10.6, Assessment of Cumulative Impacts on VECs
13.05 Have cause/effect relations been properly identified?	• Section 10.6, Assessment of Cumulative Impacts on VECs
14. Impact Indicators *Impact indicators are the parameters used to estimate the magnitude of the impacts.*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment
14.01 Were the impact indicators used adequate for all the impacts identified?	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
15. Prediction Techniques *Impact prediction techniques are necessary to enable the estimation of the magnitude of the impacts. Without the use of adequate impact prediction techniques, accurate impact analysis is not possible.*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment
15.01 Have the impact prediction techniques used been described? *Are they adequate?*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment • Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
15.02 Are they adequate?	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment • Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources

EIA Review Checklist Items	Corresponding EIA Reference
16. Magnitude of Impacts *Magnitude is the estimate of the absolute measure/value/dimension of the difference between the environmental situation of a given parameter before and after the project is implemented. In the majority of cases – physical, biological and economic impacts – it must be expressed in **quantitative** values. The estimation of the magnitude of each relevant impact is one of the most important steps in impact analysis. It ensures the accuracy of the EIA and allows for the identification of appropriate and cost-effective mitigation measures. Have the magnitude of all the relevant impacts been adequately estimated (refer to impact indicators – Section 14)?*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment • Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
17.0 Importance/Significance of Impacts *Usual methods involve objective criteria regarding the ecological and social relevance of the project*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment
17.01 Is the relative importance/significance of each impact with regard to the environmental factor affected, and with regard to the other impacts given?	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment
17.02 Is the significance based on objective criteria in order to minimize subjectivity of judgments?	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
18 Social Distribution of Impacts *Identifies which social groups will be affected by the positive and the negative impacts. These groups are often not the same. The balance between positive and negative impacts cannot be done without the correct identification of the social distribution of the impacts, because it would not have scientific and technical relevance.*	• Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
19 Stakeholder Participation	
19.01 Are the results of stakeholder participation, such as the results of interviews, hearings etc. clearly documented?	• Section 4.5, Stakeholder Engagement
19.02 Have questionnaires used been included?	• Numerous Key Informant Interviews, informal meetings, and capacity-building workshops, as well as five scoping consultation meetings were held.
19.03 Are the extent and method of stakeholder participation adequate?	• Section 4.5, Stakeholder Engagement
19.04 Are the conclusions drawn valid, based on available data?	• Section 4.5, Stakeholder Engagement
20 Analysis and Selection of Best Alternative *Selection must be based on criteria derived from the impact assessment, and appropriate analysis and decision-making methods must be used.*	• Section 2.17, Alternatives • Chapter 12, Conclusions and Summary of Impacts

EIA Review Checklist Items	Corresponding EIA Reference
21 Environmental Management Plan (EMP) *An EMP is sometimes called an Impact Management Plan. It is a necessary step to ensure that the developer is effectively committed to the implementation of the mitigation measures. It is also a useful corporate management tool. Does the EMP, as a minimum, present* *- The set of mitigation, remedial or compensatory measures?* *- A detailed description of each one, with indication and criteria for their effectiveness?* *- Detailed budgets for each one?* *- Timetables for implementation?* *- Assignment of responsibilities, including an Environmental Manager?* *- The Environmental Policy*	• Chapter 11, Environmental and Socioeconomic Management Plan Framework • ESMP
22 Monitoring *Monitoring is a necessary step to ensure cost-effectiveness of the EMP. It is usually addressed under the EMP (see Section 20) Does the monitoring plan, as a minimum, address* *- What is going to be monitored (impact indicators)?* *- Where will samples be taken?* *- How the samples will be analysed (method/technique)?* *- Criteria used to evaluate the results?* *- Financial and human resources required?*	• ESMP
23 Implementation Plan for the Mitigation Measures and the Environmental Management Plan *Implementation mechanisms must be in place to ensure effective implementation of the mitigation measures and all other recommendations that might arise from the EIA study. It usually involves the assignment of a person responsible for environmental management and an approved timetable for implementation of measures.*	• Chapter 11, Environmental and Socioeconomic Management Plan Framework • ESMP

2. DESCRIPTION OF THE PROJECT

Based on exploration and assessment activities, EEPGL has identified the presence of multiple reservoirs of crude oil with an estimated recoverable resource in excess of 6 billion barrels[1] of oil-equivalent resource in the eastern half of the Stabroek Block. The Project described herein represents EEGPL's third development in the eastern half of the Stabroek Block, in the Payara, Pacora, Liza Deep, and northern area of the Liza fields.

The Project will consist of the drilling of up to 45 development wells (including production, water injection, and gas re-injection wells); installation and operation of Subsea, Umbilicals, Risers, and Flowlines (SURF) equipment; installation and operation of a Floating Production, Storage, and Offloading (FPSO) vessel in the eastern half of the Stabroek Block (Figure 2-1); and ultimately, Project decommissioning. Onshore logistical support facilities and marine/aviation services will be used to support each stage of the Project.

This chapter discusses the following information related to the Project:

- Project area;
- Project schedule;
- Project workforce;
- Overview of development concept;
- Drilling and well design;
- SURF;
- FPSO vessel, including topsides facilities and the vessel mooring system;
- Installation, hookup, and commissioning activities;
- Production operations, including offloading by third-party owned/operated conventional tankers;
- Onshore, marine, and aviation support;
- End of operations (decommissioning);
- Materials, emissions, discharges, and wastes;
- Embedded controls[2];
- Worker health and safety;
- Project benefits; and
- Project alternatives.

[1] A barrel of oil-equivalent is a unit of energy based on the approximate energy released from combusting one barrel (42 U.S. gallons or approximately 159 liters) of crude oil.

[2] Embedded controls are physical or procedural controls that are planned as part of the Project design (i.e., not added solely based on a mitigation need identified by the impact significance assignment process). These are considered from the very start of the impact assessment process as part of the Project, and are factored in to the pre-mitigation impact significance ratings.

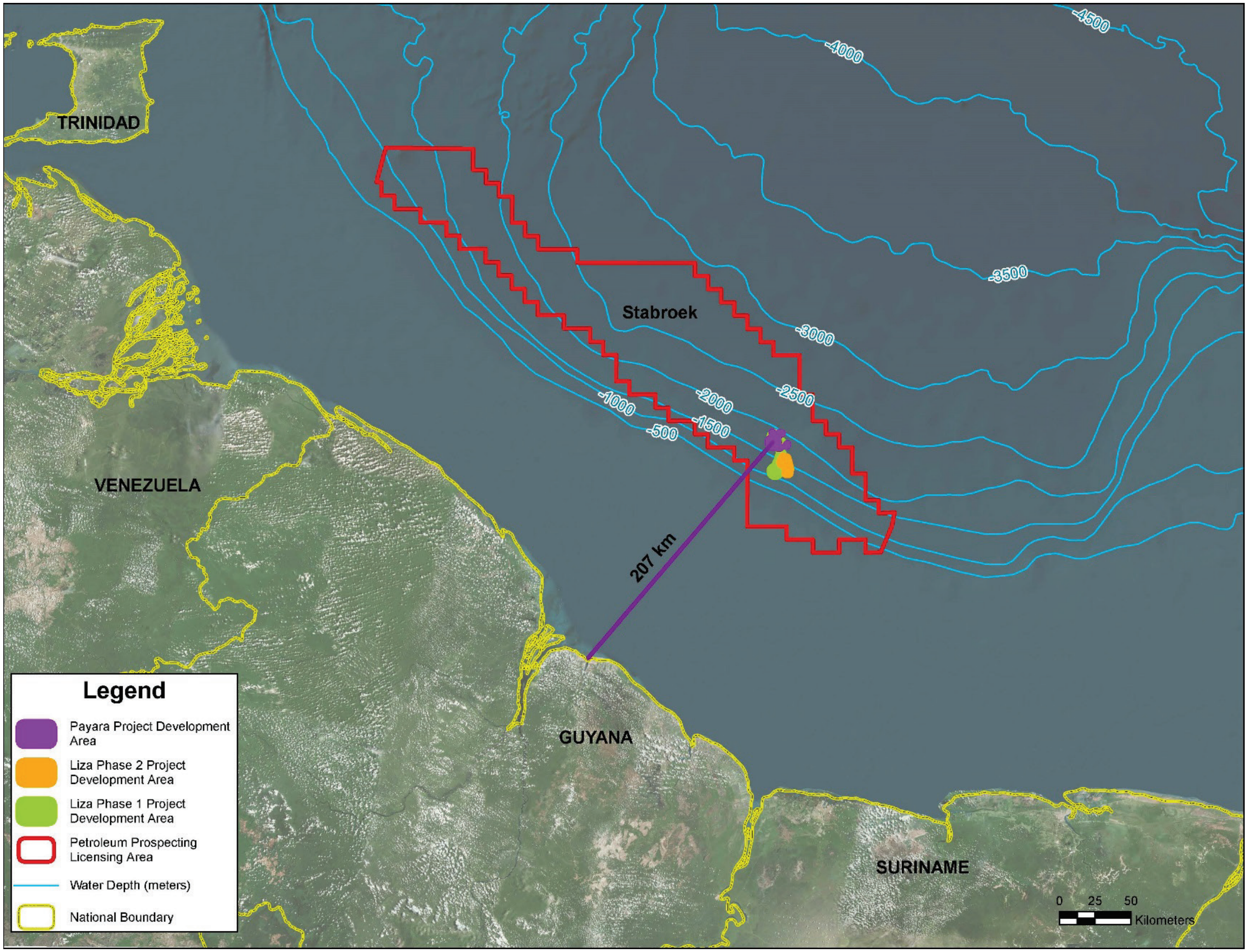


Figure 2-1: Location of the Payara Project Development Area within Stabroek Block

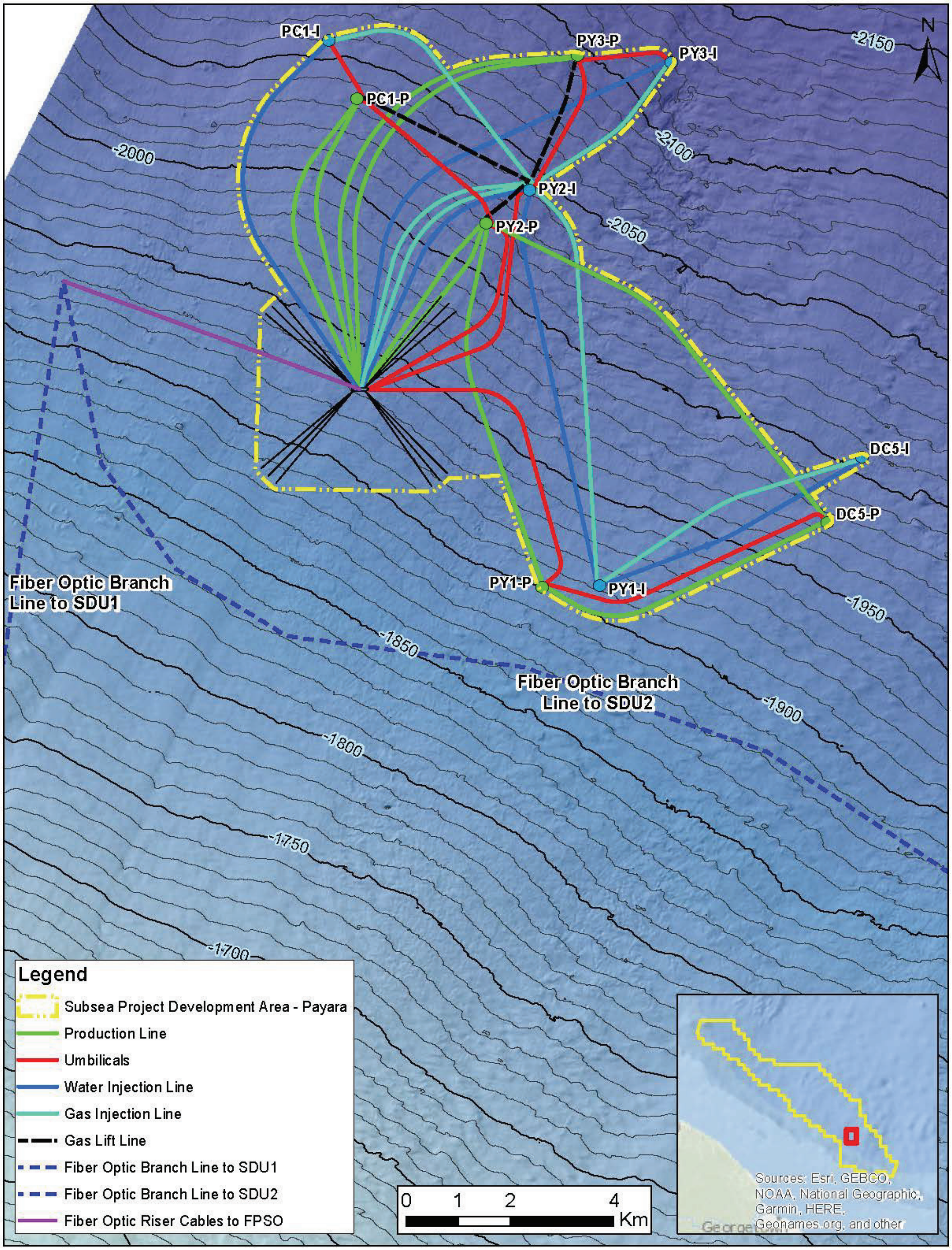
2.1. PROJECT AREA

The Stabroek Block, which covers an area of approximately 26,800 square kilometers (km^2) (6,622,398 acres), is oriented roughly parallel to the Guyana coastline, extending across the entire width (northwest to southeast) of Guyana territorial waters. There will be components of the Project located on the seafloor, in the water column, and at the ocean surface. The combined extent of the area affected by both surface and subsea components and activities is referred to as the Project Development Area (PDA). Figure 2-1 illustrates the location of the PDA within the Stabroek Block; the PDA is located approximately 207 kilometers (128 miles) northeast of the coastline of Georgetown, Guyana. Figures 2.1-1 and 2.1-2 illustrate the preliminary conceptual layout of the FPSO, the SURF equipment, and the drill centers within the PDA.

The exact locations of the Payara development wells have not yet been finalized; however, the wells will be drilled from ten drill centers[3]. During drilling and installation of the FPSO/SURF facilities, work may be performed in a subsea area within the PDA that could potentially cover an estimated 7,800 hectares. This area is referred to as the Subsea PDA. Much of this subsea area will not involve physical disturbance of the seafloor, except where the SURF equipment and the FPSO mooring system are sited, as shown on Figure 2.1-1.

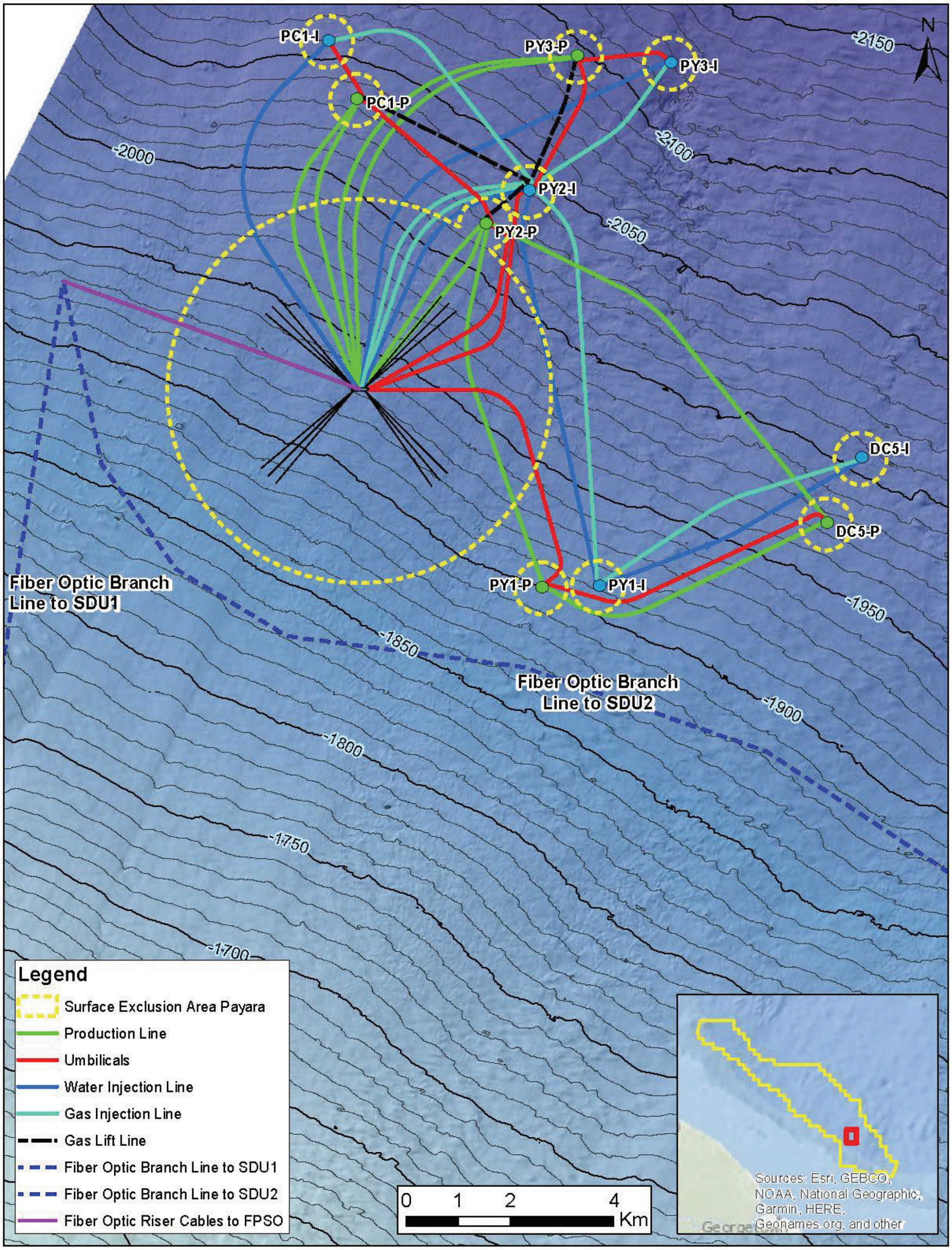
During the production operations stage, work performed on the surface of the ocean could potentially occur within an estimated 5,000 to 5,500 hectares. This area is referred to as the Surface PDA. As further described in subsequent sections and shown on Figure 2.1-2, this area of the ocean surface may have operational constraints that would restrict unauthorized vessels from entering defined marine safety exclusion zones during drilling, installation, and production operations. While Figure 2.1-2 shows ten marine safety exclusion zones around the drilling manifold locations, drilling will not occur at all locations simultaneously. The marine safety exclusion zones for the large installation vessels that will conduct FPSO and SURF facility installation are not denoted on Figure 2.1-2; however, the size of these marine safety exclusion zones will be similar to those used for the drill ships.

[3] For the Project, *a drill center* is defined as a group of wells (including production, water injection, and/or gas re-injection wells) clustered around one or more manifolds. Each of the ten drill centers incorporates separate manifolds that are separated by several kilometers and are designed for production or injection. For example, Drill Center 5 will be separated into production (DC5-P) and injection (DC5-I) components.



Note: Locations on figure subject to change

Figure 2.1-1: Payara Subsea Project Development Area



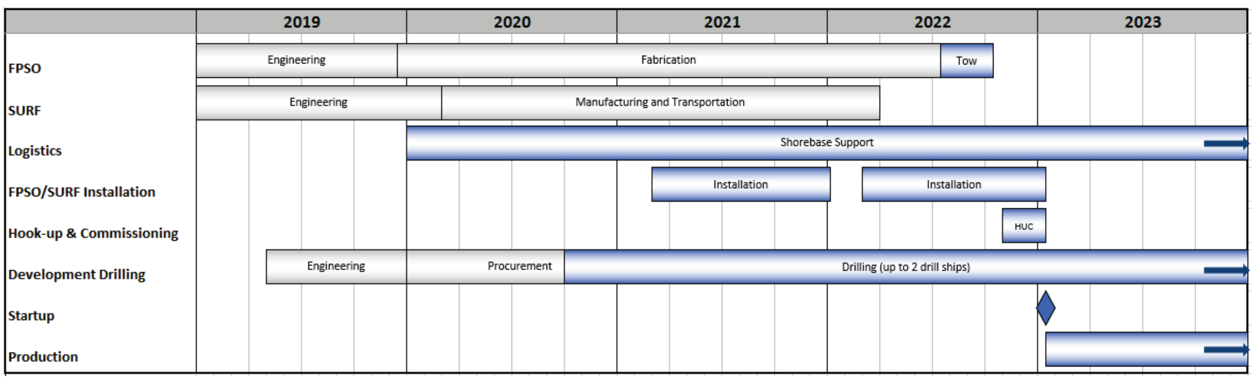
Note: Locations on figure subject to change

Figure 2.1-2: Payara Surface Project Development Area

2.2. PROJECT SCHEDULE

The Project life cycle will include engineering, development drilling, installation, hook-up, commissioning, startup, production operations, and decommissioning. Production operations will follow startup, and will be the longest stage of the Project.

Figure 2.2-1 provides a preliminary schedule for the major Project components and activities up to the start of production operations. As depicted on Figure 2.2-1, initial oil production is planned for early 2023. To support this timing, development-well drilling is planned to start in late 2020. Installation of subsea components is planned to begin in 2021; the FPSO installation is planned to occur in late 2022. Production will continue for at least 20 years. These milestones are still being refined and are subject to change. This schedule provides for simultaneous development drilling and FPSO/SURF production operations after startup.



HUC = hook-up and commissioning

Figure 2.2-1: Preliminary Project Schedule

2.3. PROJECT WORKFORCE

Preliminary workforce estimates are provided in Table 2.3-1. These estimates may be further refined following selection and contracting for the drill ship(s), FPSO, SURF installation, support vessels, and shorebase support facilities. The current plan is to conduct primary support activities from shorebases in Guyana and Trinidad and Tobago.

Table 2.3-1: Preliminary Workforce Estimates

Project Stage	Estimated Workforce
Development well drilling	Approximately 600 personnel at peak (Assuming two full-time drill ships used concurrently; dependent upon final drill ship and support vessel selection)
FPSO and SURF mobilization, installation, and hook-up	Approximately 600 personnel at peak (Dependent upon final construction/installation and support vessel selection)
Production operations, including FPSO and conventional export tankers	Approximately 100 to 140 personnel at peak (an additional 25 to 30 personnel will be on board each export tanker)
Decommissioning	Approximately 60 personnel at peak

In addition to the offshore components, there will also be personnel providing shorebase and marine logistical support on shore (approximately 100 to 150 personnel), some of whom will be Project-dedicated while others will be shared resources. The onshore logistical support staff will ramp up gradually through the mobilization and installation stage until reaching a peak during the development drilling campaign and FPSO/SURF installation activities.

The majority of the workforce required offshore during all stages of work will be skilled labor. During the drilling and installation stages, the majority of the offshore workforce will be foreign workers, while the onshore workforce (shorebase, marine logistical support, and operations management) will be a mix between skilled and semi-skilled labor requiring both foreign and local workers. During the production stage, the workforce will evolve to comprise a majority of Guyanese personnel. It is estimated that only a small percentage (approximately 10 percent in 2019, with the potential to be 20 percent by 2021) of the total foreign labor will require long-term housing in/around Georgetown. It is further estimated that a large majority (more than 95 percent) of the offshore foreign labor during the drilling and installation stages will not require onshore housing, as they will use their companies' shared guest houses or will spend single nights (if any) in hotels while rotating in/out of country.

2.4. OVERVIEW OF THE DEVELOPMENT CONCEPT

2.4.1. Development Concept

The Payara, Pacora, Liza Deep, and northern area of the Liza fields will be developed as part of the Project with up to 45 development wells drilled from ten drill centers, each with separate production, gas re-injection, and water injection manifolds. Figure 2.4-1 illustrates the preliminary field layout for the Project facilities, including the development wells, SURF, and a spread-moored FPSO. The facility layout will continue to evolve during the design development process. The various components included in Figure 2.4-1 are further described below in the relevant drilling, SURF, and FPSO sections.

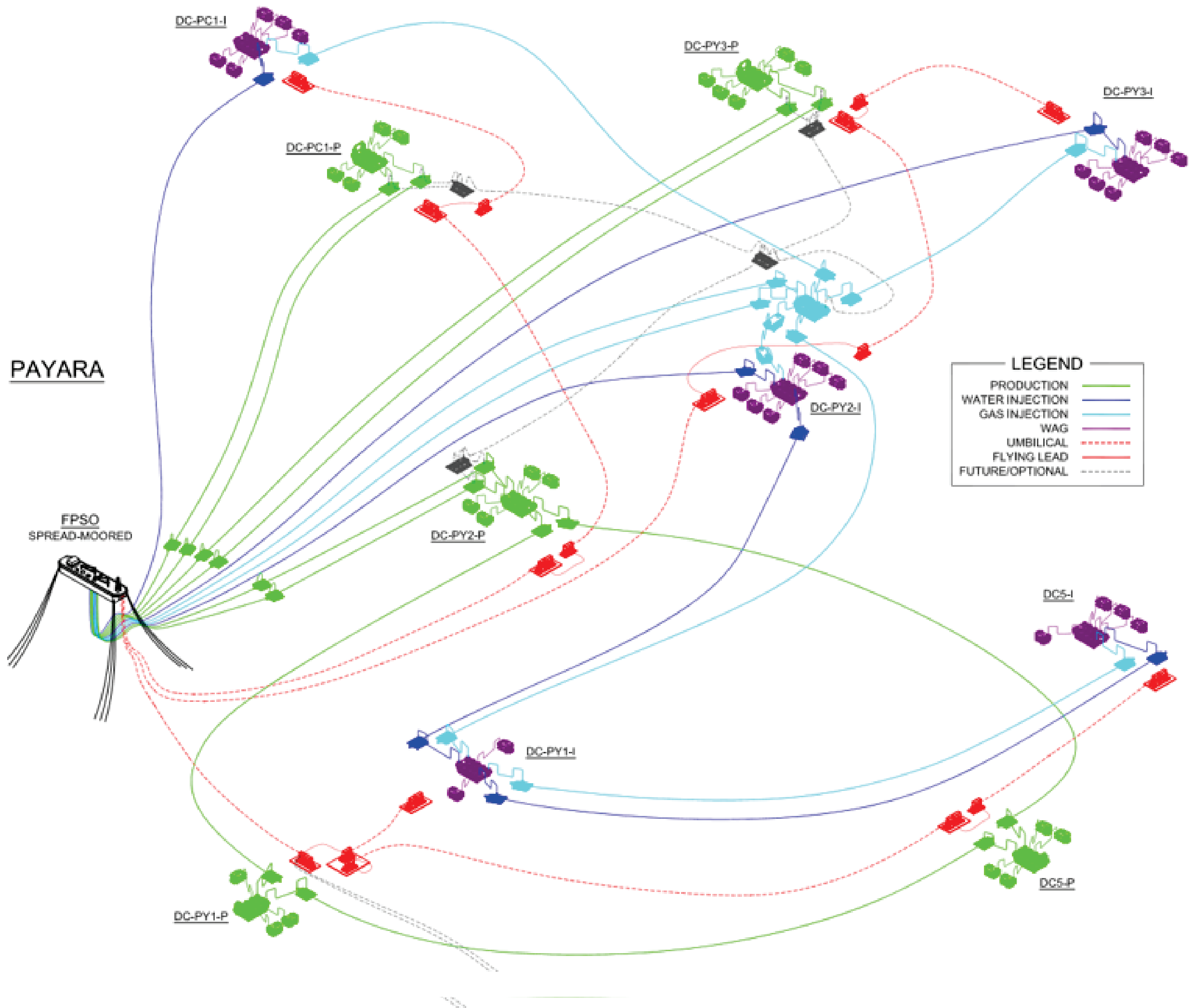


Figure 2.4-1: Preliminary Payara Field Layout

The development wells include production wells, water injection wells, and gas re-injection wells. A portion of the associated gas produced from the reservoir will be used on board the FPSO as fuel gas, and the remaining balance will be re-injected back into the reservoir via the gas re-injection wells. Water and gas injection will be used as needed to maintain reservoir pressure for optimal production over the life cycle of the Project.

The Project will use a spread-moored FPSO (see Section 2.7, Floating Production, Storage, and Offloading Vessel). The FPSO will support the topsides facilities, process the produced fluids from the production wells, and store the processed crude oil until offloading. Offloading of the processed crude oil for export will occur directly to conventional tankers. Subsea production, gas re-injection, and water injection wells and manifolds will be linked directly to the FPSO via flowlines and risers (see Section 2.6, Subsea Umbilicals, Risers, and Flowlines).

2.4.2. Applicable Codes, Standards, and Management Systems

The various aspects of engineering design and operations will be carried out according to applicable Guyana statutory requirements, applicable international design codes and standards, applicable EEPGL and contractor design specifications, the EEPGL Operations Integrity Management System (OIMS) and EEPGL Safety, Security, Health, and Environment policies[4]. EEPGL and its contractors will have a structured management system to verify the ongoing application of all necessary codes, standards, procedures, and management systems. An overview of the EEPGL OIMS framework is included in Chapter 3, Administrative Framework.

2.5. DRILLING AND WELL DESIGN

2.5.1. Drilling Program

The Project will use several drill ships similar to that shown on Figure 2.5-1 to drill the development wells. The number of drill ships required will be determined during the design development process based primarily on the number of wells required for initial oil production. For the purposes of environmental assessment, two full-time drill ships working concurrently on Project development wells will be the basis of analysis. Additional drill ships may be used to accelerate the drilling schedule, as allowed by simultaneous operations. Drilling operations may occur prior to, during, and after the installation of the FPSO and SURF components.

During the drilling process, drill ships will require various tubulars[5], instruments, and devices (collectively referred to as the drill string) to conduct the well construction process, which consists of drilling the borehole, running and cementing casings using a sequential batch drilling program, and installing the completion and production tubing. The wellheads will be clustered around ten drill centers rather than being distributed over the seabed above the producing reservoirs. This approach reduces the number of drilling locations, thereby reducing the seabed

[4] The policies are part of the overall Standards of Business Conduct policy: http://corporate.exxonmobil.com/en/company/about-us/guiding-principles/standards-of-business-conduct.

[5] Tubulars include various types of piping, such as drill pipe, drill collars, casing, and production tubing.

area potentially affected by drilling operations, including discharge of drill cuttings[6]. The planned development-drilling program and its cuttings management approach is consistent with industry practices, has previously been the basis for exploration wells in the Stabroek Block, and is also the basis for the development wells for the Liza Phase 1 and Liza Phase 2 Development Projects.

Figure 2.5-1: Typical Drill Ship

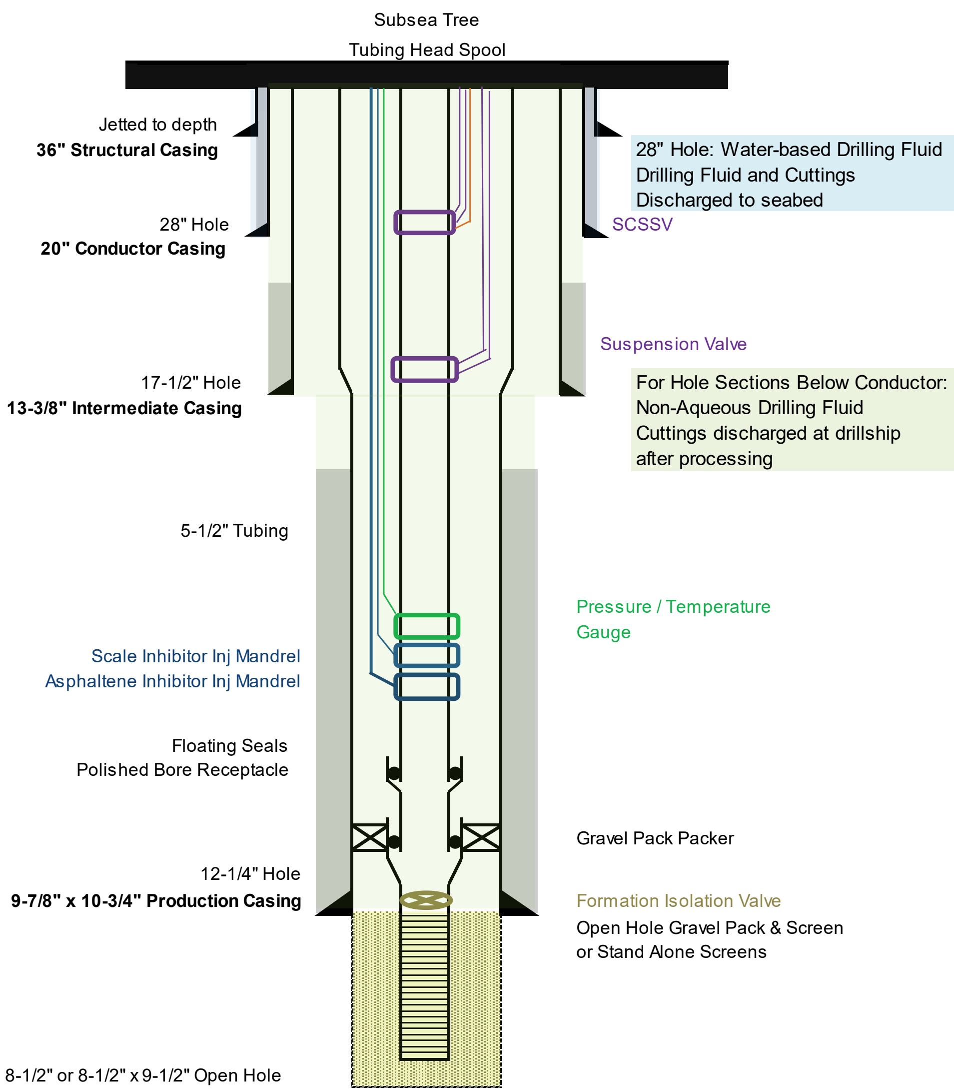
2.5.2. Typical Well Design

The following information describes development wells for the purposes of the Project. Exploration wells are structurally similar to development wells and are drilled using similar processes and equipment.

Once the borehole is started for a well, pipe (also known as casing) is inserted into the borehole and cemented in place to keep the well from collapsing and to seal the casing to the formation. Various-sized casings are progressively set as the well is drilled deeper. After each casing

[6] Drill cuttings are the broken bits of solid material produced as the drill bit advances through the borehole in the rock or soil.

(for the conductor casing and deeper casings) is installed, pressure and integrity testing is performed according to standard industry practices. A provisional well program and design for the Payara development-drilling program, including preliminary casing types and sizes, setting depths, drilling fluid types, and discharge locations, is shown on Figure 2.5-2. Figure 2.5-3 shows the various components of a typical subsea drilling system.



SCSSV = surface-controlled subsurface safety valve

Figure 2.5-2: Provisional Casing Program for Development Drilling Program

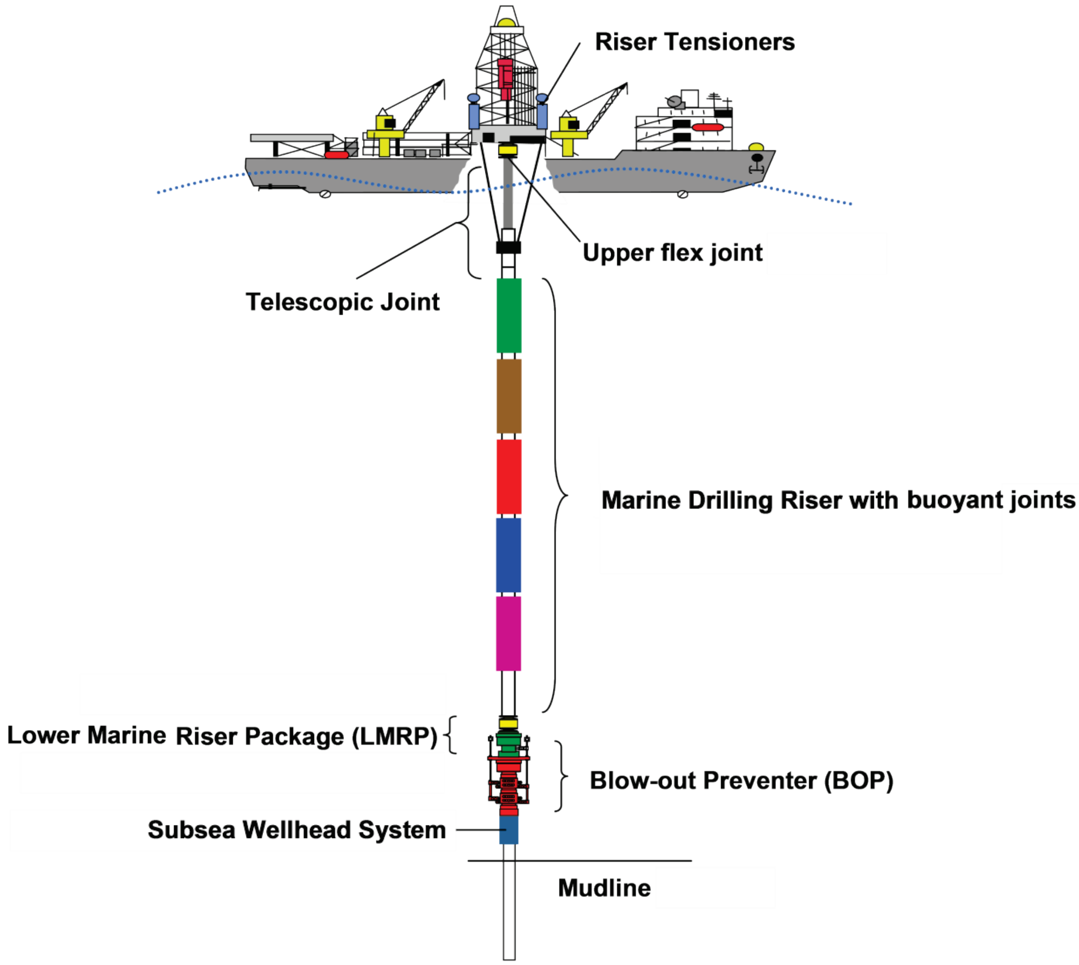


Figure 2.5-3: Typical Subsea Drilling System

2.5.3. Drilling Fluids

The drilling process will require drilling fluid to remove cuttings and to control formation pressures. The choice of drilling fluids will be based on the challenges associated with drilling in deep-water environments, which differ from shallow-water drilling in the following aspects:

- Colder temperature/higher seawater hydrostatic pressure at the mudline;
- More narrow window between pore pressure[7] and fracture gradient[8]; and
- Longer drilling risers requiring larger volumes of drilling fluid.

Three categories of drilling fluids will be used: seawater, water-based drilling fluids (WBDF), and non-aqueous drilling fluids (NADF) in which the continuous phase is an International Association of Oil and Gas Producers (IOGP) Group III low-toxicity NADF with low to negligible aromatic content. WBDF will be used when drilling the upper sections of the well. Based on wellbore stability analysis and experience gained from exploration drilling, NADF

[7] Pressure of fluids within the pores of a reservoir
[8] Pressure required to induce fractures in rock at a given depth

will be required to maintain borehole stability while drilling all well sections below the conductor casing.

Solids control and cuttings drying equipment will be installed on the drill ships to process and reduce the percentage of non-aqueous base fluid (NABF) retained on cuttings. The cuttings will be discharged to the sea after treatment, in accordance with standard industry practice. The use of this equipment on other similar projects has significantly reduced the percentage of NABF retained on cuttings.

2.5.4. Well Cleanup and Ancillary Processes

2.5.4.1. Well Cleanup

Development wells will be drilled, completed, and tied back to the FPSO. Injection wells will not be flowed back (i.e., unloaded) to the FPSO or to the rig before commencing injection. For oil-producing wells, fluids left in the well bore will be flowed back to the FPSO and cleaned up through the subsea tree/flowlines/production equipment.

Well cleanup fluids are fluids (wellstream, completion fluids, etc.) that initially come from the reservoir; these fluids are directed back to the FPSO topsides facilities for processing:

- Non-aqueous fluids will follow the oil stream and will be blended into the oil shipment.
- Water soluble components will be treated via the produced water treatment system prior to discharge overboard in alignment with produced water performance criteria (does not exceed 29 milligrams per liter (mg/L) monthly average or 42 mg/L daily maximum).

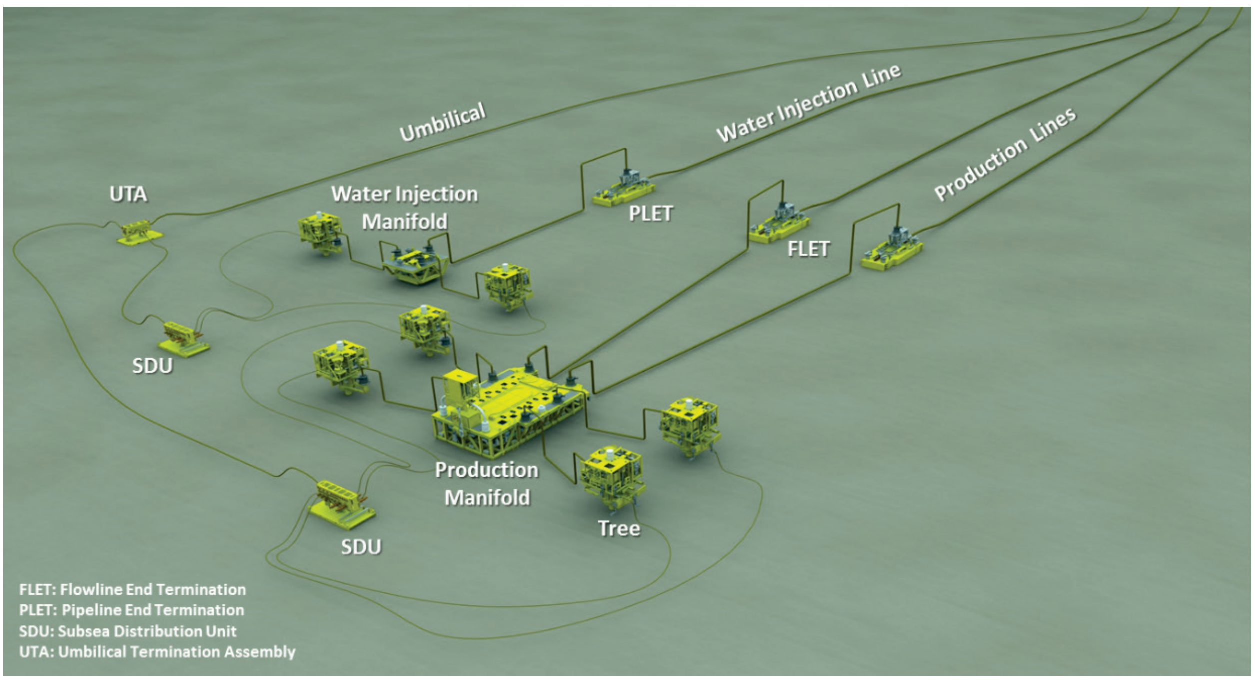
2.5.4.2. Vertical Seismic Profiling

Vertical Seismic Profile (VSP) data may be collected to improve velocity modeling and reduce uncertainty in reservoir mapping. VSP surveys can be used to correlate the surface-seismic data to the information on the physical properties and characteristics of the hydrocarbons gained from drilling the well. VSP data, along with check shots and well logs, provide further time/depth information from which to improve knowledge and understanding of the structure and stratigraphy of a reservoir.

A VSP survey requires a sound source (commonly compressed air) and a receiver. Data are acquired by the receiver, which is installed within the wellbore. The source may be located above the wellhead or may be located farther away or “walked away” using a boat. The final scope of such a survey and specific geophysical tools to be used is still under review.

2.6. SUBSEA, UMBILICALS, RISERS, AND FLOWLINES

The SURF facilities for the Project will include subsea production, gas re-injection, and water injection wells clustered around subsea manifolds. The development wells will be drilled from ten subsea drill centers. This approach of clustering the wells around drill centers reduces the required number of manifolds, flowlines, and umbilicals[9], as well as the size of equipment and marine vessels needed for installation. The risers and umbilicals will connect the infrastructure on the seafloor to the FPSO. The manifolds will connect the individual development wells to the rest of the subsea system. The subsea system will be monitored and controlled from the FPSO using a control system connected to the FPSO through umbilicals that also supply power, hydraulic fluid, and chemicals to the subsea manifolds and wellhead trees[10]. The hydraulic fluid for operating the subsea control system will be a low-toxicity, water-soluble hydraulic fluid. The SURF system will be designed to withstand the full shut-in pressure from the production wells, and the gas/water injection components will be designed to withstand the highest required injection pressures. Overpressure protection will be provided on the FPSO, in accordance with Good International Oil Field Practice, to protect the subsea systems. Figure 2.6-1 shows an illustration of a representative SURF system similar to what is currently being designed for the Project.



Note: Schematic is not necessarily representative of number of drill centers or wells, and subsea equipment required

Figure 2.6-1: Representative SURF System

9 A cable and/or hose that provides the electrical, hydraulic, chemical, and communications connections needed to provide power and control between the FPSO and subsea equipment.
10 Assembly of valves, spools, pressure gauges, and chokes fitted to the wellhead of a completed well to control production

The production drill centers also will be connected to the FPSO with round-trip "piggable" production flowlines. A "pig" is a specially designed device that is placed in the flowline at a "launcher" at one end and pushed by pressure until it reaches a receiving trap or "catcher" at the other end. Pigging is performed to aid in the maintenance, operations, cleaning, and/or inspection of flowlines. Figure 2.6-2 shows an example of a pig.

Figure 2.6-2: Example of Wire Brush Cleaning Pig

2.6.1. Well Flow Connections

Well flow connections between the subsea wells and the FPSO include several components. Each subsea development well is capped by a wellhead tree, which includes a choke valve to control production or water/gas injection. For a given set of wells tied to the same manifold, each wellhead tree is connected by jumpers to the well manifold, which is connected by a flowline jumper to a flowline end termination (FLET) located at the drill center end of the flowline.

A typical configuration of subsea wells, flowlines, and manifolds at a drill center is shown on Figure 2.6-3.

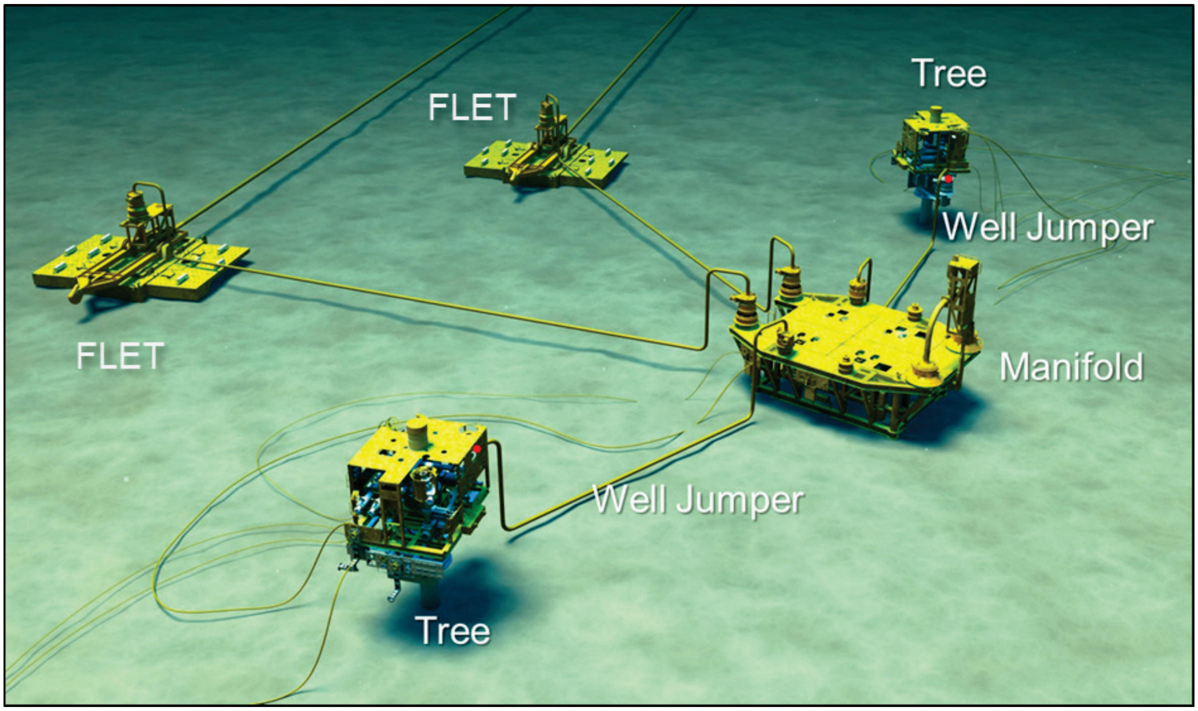


Figure 2.6-3: Typical Subsea Wellhead Tree, Jumper, and Manifold

From the drill center, the rigid flowline travels on the seabed to the vicinity of the FPSO. At the FPSO end of the flowline, the flowline transitions to a riser, which carries the fluids between the seafloor and the FPSO at the surface.

The risers transition from the seabed to the FPSO in a "lazy wave" configuration as shown on Figure 2.6-4.

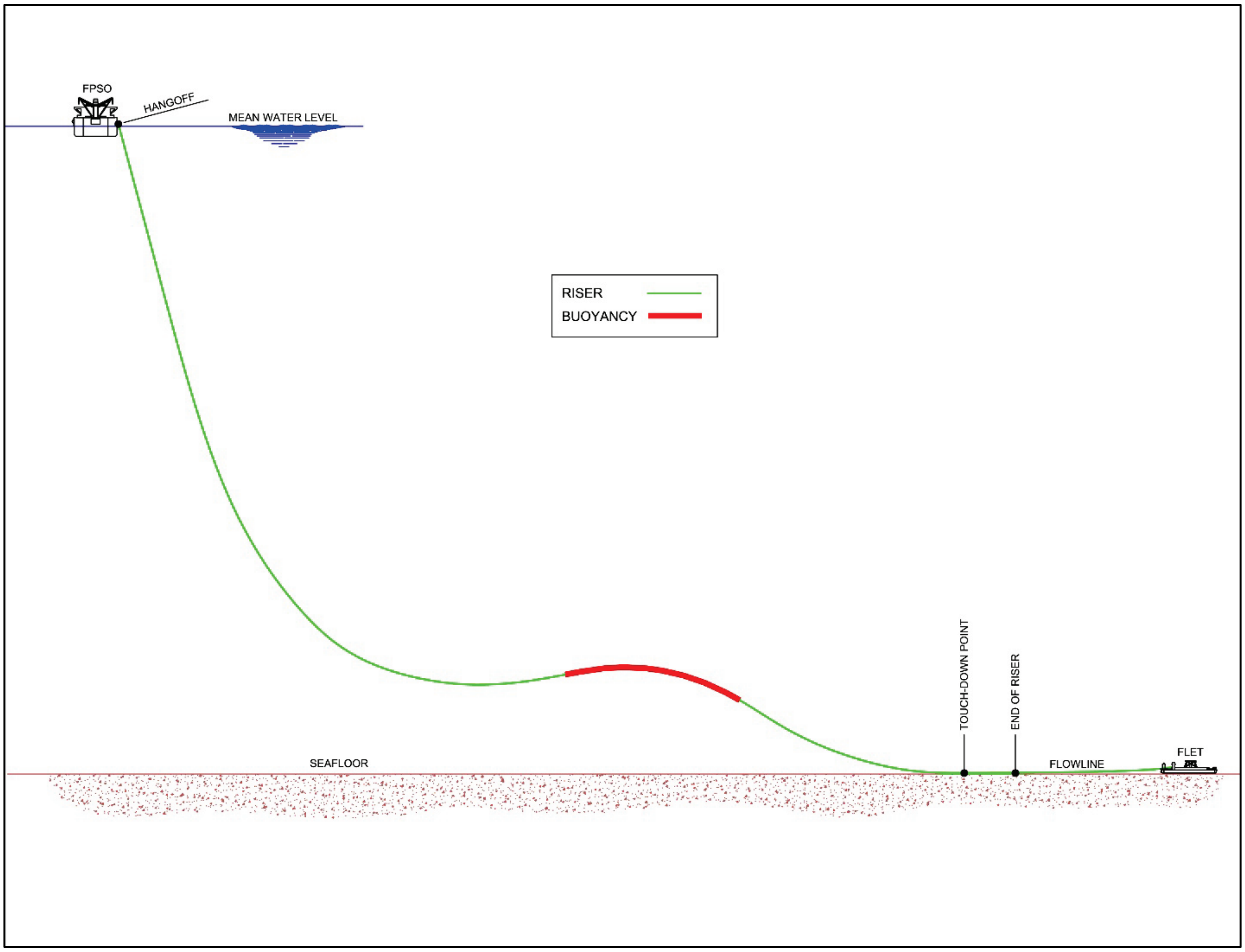


Figure 2.6-4: Representative Lazy Wave Riser

2.6.2. FPSO Subsea System Control

The FPSO will provide power, utilities, cabling, and tubing/piping tie-ins to equipment installed on its topsides to control the subsea equipment (see Figure 2.6-5). The FPSO will be configured with backup power so operations can continue in the event primary power is lost.

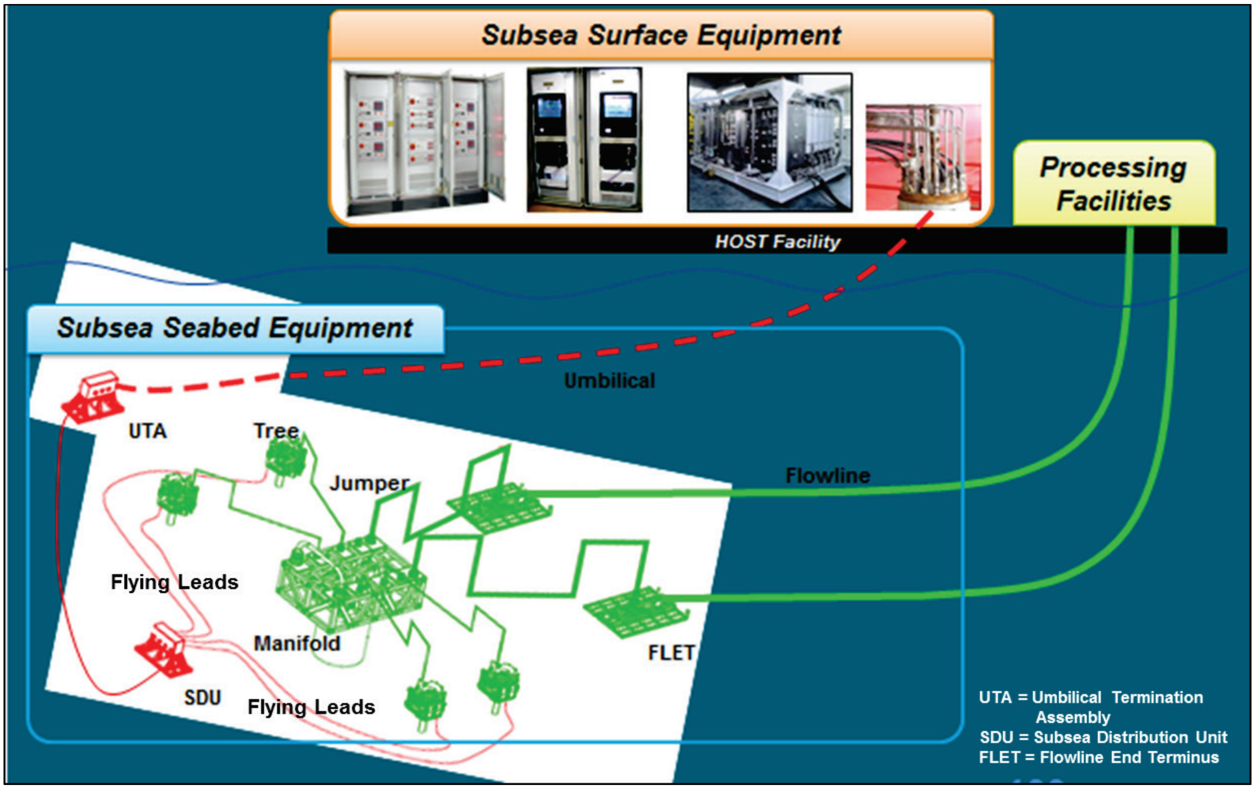


Figure 2.6-5: Representative Subsea Control System

The subsea wells and manifolds will be monitored and controlled from the FPSO. Each tree will have a Subsea Control Module mounted on it that controls and monitors the tree functions (e.g., choke-valve position) and associated manifold functions. Subsea controls will accommodate typical monitoring requirements such as pressure and temperature measurement.

The control systems at each drill center will be supplied from the Process Control System (PCS) on the FPSO by an umbilical. The umbilical will supply control fluid to operate all hydraulically operated valves, provide chemicals as required to ensure flow to the FPSO, and provide low-voltage power and communication to operate and monitor the SURF facilities. The umbilical will terminate subsea to an Umbilical Termination Assembly. Hydraulic and electrical leads (“flying leads”) will be used to connect the Umbilical Termination Assembly to the Subsea Distribution Unit (SDU), and the SDU to the well-mounted subsea control modules.

2.6.3. Risers, Flowlines, Umbilicals, and Manifolds

2.6.3.1. Risers and Flowlines

The Project will incorporate production, water injection, and gas injection flowlines and risers, as shown on Figure 2.4-1. Flowline and umbilical lengths will range from approximately 1 to 9 kilometers (approximately 1 to 6 miles), excluding risers, in water depths of approximately 2,100 meters (6,890 feet). The current design lengths are based on preliminary shallow hazard surveys and current field layout, and may be adjusted slightly during detailed design.

2.6.3.2. Umbilicals

Umbilicals will be designed as an integrated bundle of tubes and cables to serve multiple functions (see Figure 2.6-6). Three dynamic umbilicals connected to the FPSO will service the entire Payara field. The remaining drill center components, composed of the subsea trees, manifolds, flying leads, and jumpers, will be connected via seven in-field/static umbilicals.

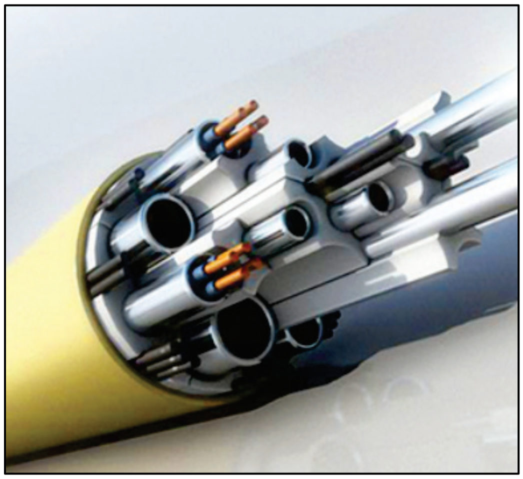


Figure 2.6-6: Representative Dynamic Umbilical

2.6.3.3. Manifolds

Manifolds are gathering points or central connections made up of valves, hubs, piping, sensors, and control modules. Manifolds (see Figure 2.6-7) include a protective structural framework that rests on a foundation on the seabed where multiple trees, jumpers, and flowlines gather to consolidate flows before they are transported either to the surface as part of production or back downhole as part of injection into the reservoir.

Figure 2.6-7: Representative Subsea Manifold

2.6.3.4. Gas-Lift System

The FPSO riser support system will be designed for gas-lift capability. The gas-lift system is not required for initial startup and may be installed at some future time during the Payara service life based on the production characteristics of the field. This system will include gas-lift flowlines with connections to the production flowline FLETs.

2.7. FLOATING PRODUCTION, STORAGE, AND OFFLOADING VESSEL

2.7.1. General Description

The Project FPSO will use a spread-moored configuration to maintain station continuously for at least 20 years. The FPSO will be designed to receive the full production wellstream from the development wells and will process crude oil at a design rate of 220,000 barrels of oil per day (BOPD). For the purposes of the EIA, potential impacts generated by the Project will be based on a conservative production rate of 264,000 BOPD. The FPSO will be capable of storing 2 million barrels of stabilized crude oil. The FPSO will be able to offload approximately 1 million barrels to a tanker in a period of approximately 28 hours.

The FPSO will also have the capability to process, dehydrate, compress, and re-inject the gas produced from the reservoir. The FPSO will be configured to treat seawater used for facility cooling purposes for discharge and injection into the reservoir and to process produced water for discharge overboard. Living quarters and associated utilities will be provided to support the operations on the FPSO. The FPSO topsides equipment and design will have a design life of at least 20 years.

Table 2.7-1 provides an estimate of the design rates for the FPSO facility.

Table 2.7-1: FPSO Key Design Rates

Service	Design rate [a,b]
Oil production	220,000 BOPD
Produced water	215,000 BPD
Total liquids	270,000 BPD
Produced gas	395 MMscfd
Gas injection	365 MMscfd (assumes 30 MMscfd of produced gas will be used as fuel gas for the FPSO)
Water injection	250,000 BPD

BPD = barrels per day; MMscfd = million standard cubic feet per day
[a] All design rates are presented as the peak annual average.
[b] For the purposes of the EIA, 264,000 BOPD will be used as the conservative basis to assess potential impacts from the Project.

Key FPSO design features include the following:

- The FPSO will be designed to remain moored for at least 20 years without dry-docking, and will include facilities to support in-water hull/structural surveys and repair and maintenance.
- The FPSO will be designed to operate in extreme (100-year return period) environmental conditions (associated wind, waves, and current).

- The FPSO will be designed to re-inject produced gas back into the reservoir except during times of injection system unavailability, which will require temporary, non-routine flaring during maintenance/repair.

A picture of a typical FPSO is provided on Figure 2.7-1.

Figure 2.7-1: Typical FPSO

2.7.2. FPSO Topsides

The FPSO's topsides design uses an interconnected module concept where process equipment is packaged in modules. The design concept maximizes pre-commissioning and functional testing of the modules prior to arrival offshore Guyana. The FPSO will arrive for installation, hook-up, and commissioning in the Stabroek Block fully fabricated and preassembled.

The following are the principal functions of the topsides process facilities:

- To receive, separate, and process the produced reservoir fluids to provide:
  - Crude oil for offloading onto conventional tankers;
  - Produced water of sufficient quality for environmentally acceptable discharge to the sea; and
  - Produced gas that meets fuel gas requirements for FPSO power and for re-injection into the reservoir;
- To treat seawater to provide a suitable supply of water for injection into the reservoir; and

- To provide support systems for the safe accommodation of approximately 80 to 120 personnel involved in the operation of the production facilities and, on occasion, personnel involved with the drilling program.

Temporary accommodations may also be used during key activities including hook-up, commissioning, and maintenance operations to increase accommodations capacity up to 180 personnel. In some cases, accommodations vessels may be used in the PDA to support needs for additional bunk space offshore.

The FPSO accommodations block will be located at the stern of the vessel, isolated from processing equipment, and positioned in proximity to the fully enclosed lifeboats. It will be outfitted, decorated, and furnished according to current shipbuilding standards and of a modern European style. The cabins will be a mix of one and two person cabins. Some cabins will have an associated dayroom/office, some will be superintendent-type cabins, and some will be regular sleeping cabins. Noise levels within the cabins are designed for less than 45 decibels (A-weighted). The cabins in the accommodation block are designed to accommodate a total complement of up to 160 personnel on board.

The accommodations block will also be outfitted with recreational spaces available to all personnel onboard, including a quiet lounge and library, recreation lounge, gymnasium, and smoking room. Catering services and provision stores will be located in the block. Additional ancillary spaces in the accommodation block will include the following:

- Clinic
- Control Room and Emergency Response Base
- Offices
- Male/female change rooms and laundry
- Technical equipment rooms and duty lockers

The air conditioning and ventilation system in the accommodation block will be designed for 25 years in accordance with industry standards and guidelines. The accommodation spaces will be pressurized to +50 pascals relative to the external atmospheric pressure. Differential pressure transmitters will be provided at each deck level within the accommodation block, and alarms will be raised in the Central Control Room (CCR) in the event of a loss of pressurization inside the accommodations. Entrance into the accommodation block will be completed via an airlock. The airlock will be provided with two doors; the design of this two-door airlock system will ensure that the accommodations remain pressurized and will prevent outdoor air from entering in the accommodation block when outer doors are open. The outer door will be at a minimum weather tight while the inner door will be the self-closing type. The linings and ceiling used in the airlock will be constructed with air-sealed joiner panels.

The accommodation spaces will also be equipped with fire and gas detection systems. In the CCR, there will be a direct line of sight to the fire and gas monitors from the operators' positions. With regards to passive fire protection, class and other flag state requirements will be used to determine the necessary structural fire protection.

At a minimum the following spaces will be at least A-60 insulated:

- CCR
- Galley
- Accommodation Equipment Room
- Telecom Equipment Room
- Computer Equipment Room

The forward facing bulkhead of the accommodation block will be marine-grade H-60[11] insulated up to the C-deck and A-60 insulated for everything beyond the C-deck. All doors and windows located in this bulkhead will have the same insulation rating as the bulkhead in which they are installed. In general, all windows within the accommodation block are expected to have the same fire integrity as the wall in which they are installed. The entire window unit will be gas tight and weatherproof and have a minimum blast resistance of 0.5 barg[12]. The blast wall (an extension of the forward accommodation bulkhead) will be A0 rated and will run transversally up the sides of the vessel and vertically from the main deck to the D-deck. Structural deckhouse extensions forward of the accommodation front bulkhead and unprotected deckhouse areas 3 meters aft of the accommodation front bulkhead will also be H-60/A-60 protected.

The following signage within the accommodation block will be photo-luminescent at a minimum to indicate the following:

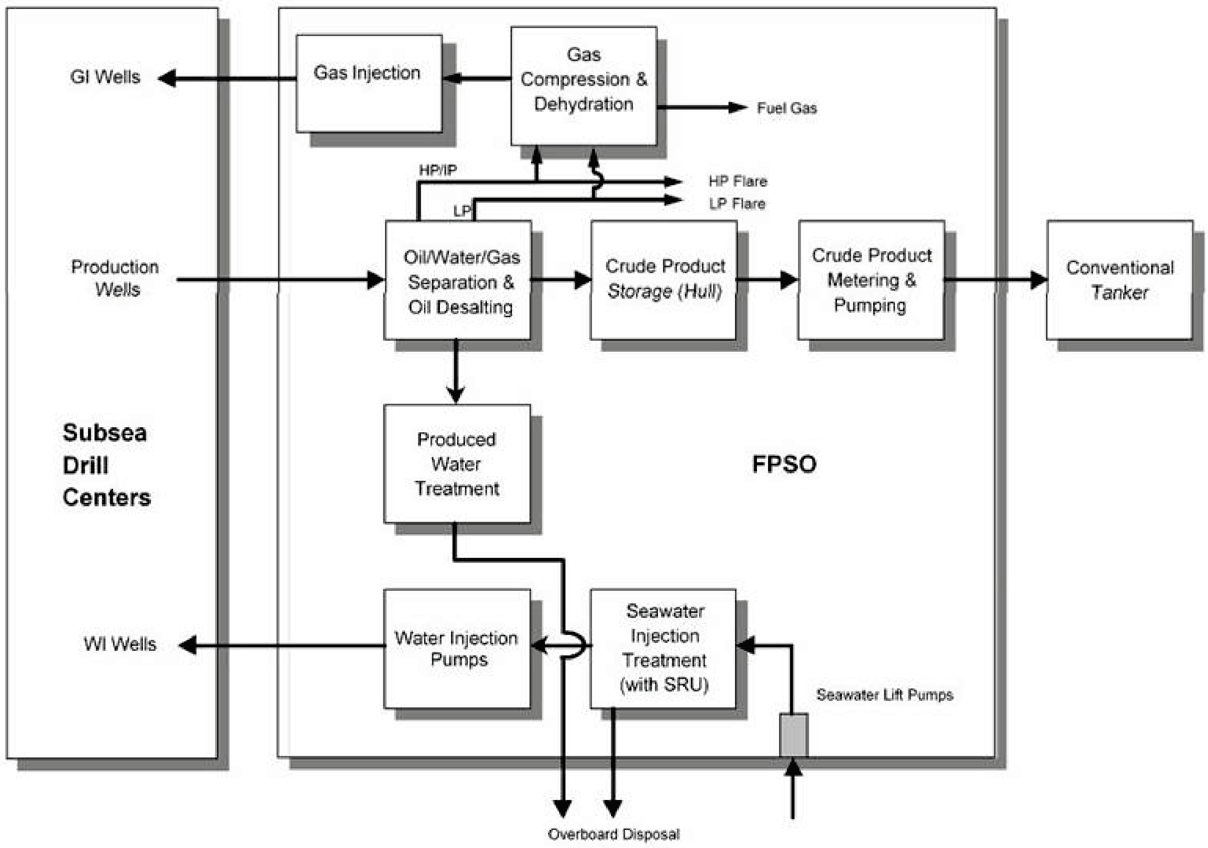
- Emergency exit signs on emergency exit doors;
- Push/pull signs or handle position signs on emergency exit doors;
- Exit signs on high traffic area doors such as mess room, recreation room, and conference room;
- Direction markers indicating escape routes positioned at low levels in corridors and escape ways;
- Signs indicating route to and direction of internal stairways;
- Signs indicating route to and direction of external stairways; and
- Signs indicating directions to the lifeboat loading areas

2.7.3. FPSO Process Systems

The process facilities on the FPSO topsides are shown schematically on Figure 2.7-2 and are described in the following sections.

[11] If subjected to the standard fire test for 60 minutes, has an average temperature rise on the unexposed side of the insulated bulkhead or deck of less than 139°C (250°F) above the temperature before the standard fire test and has a temperature rise at any point on the unexposed surface, including any joint, of less than 180°C (325°F) above the temperature before the standard fire test. *Source: Mobile Offshore Drilling Units, 46 [U.S.] Code of Federal Regulations 107-109 (2013)*

[12] Barg pressure is the pressure, in units of bars, above or below atmospheric pressure.



GI = gas [re]injection; HP = high pressure; IP = intermediate pressure; LP = low pressure; SRU = Sulfate Removal Unit; WI = water injection

Figure 2.7-2: FPSO Topsides Process Flow Diagram

2.7.3.1. Oil/Water/Gas Separation and Oil Desalting

An inlet manifold is required to receive full wellstream-produced fluids from the reservoir (consisting of oil, gas, and water) via the production flowlines, and to route the fluids to the FPSO processing facilities. The full wellstream-produced fluids will be separated into oil, water, and gas phases. Fresh water will then be added to the stabilized crude oil to remove dissolved salts as part of what is known as "oil desalting." An electrostatic coalescer is also employed in crude oil dehydration and desalting. The final crude oil from the separation/stabilization process will be treated to meet the specifications for sale prior to being sent to the crude oil storage tanks in the FPSO hull. Further processing of the water and gas streams from the separation process and the process for treating seawater for injection are described below.

2.7.3.2. Gas Processing

The purpose of the FPSO gas-processing system is to condition the associated produced gas (that which is not consumed as FPSO fuel gas) to the appropriate specification prior to re-injection into the reservoir. The gas-processing system consists of the following subsystems:

- Flash Gas Compression: recovers and compresses flash gas from the intermediate-pressure (IP) separator, low-pressure (LP) separator, and produced water flash vessel to mix with the gas from the high-pressure (HP) separator.
- Main Gas Compressor: compresses untreated gas from the HP and Test separators and the flash gas compressor to an inter-stage pressure where it can be used as fuel gas, with the remaining gas compressed up to an appropriate pressure for gas lift (when required).
- Gas Dehydration: removes water vapor from gas to prevent hydrate formation in the gas lift and gas injection systems where HP gas will cool to seabed temperatures.
- Fuel Gas: provides fuel gas to all electrical power generation gas turbines, direct-drive gas turbines, and all other LP gas users (marine boilers, pressure control of vessels, etc.).
- Injection Gas Compression: compresses discharge gas from the main gas compressor(s) to an appropriate pressure level where it can be re-injected into the reservoir. The HP re-injection gas is routed to the gas injection riser and then directed to the remote, subsea injection wells.

The Project is planning to re-inject any produced gas (that which is not consumed as fuel gas on the FPSO) back into the reservoir.

During equipment maintenance and process upsets, including startup and shutdown scenarios, part or all of the off-gas from the separation/stabilization process will be sent to the HP or LP Flare Systems. Flaring will be temporary and non-routine.

2.7.3.3. Produced Water Treatment

The produced water treatment system will be designed to collect produced water from process facilities and treat the water for discharge overboard. Produced water that does not meet the overboard discharge specification after treatment will be routed to an appropriate tank in the hull and managed as described in Section 2.7.8.1, FPSO Cargo Systems.

2.7.3.4. Seawater Treatment and Water Injection System

Seawater will be used for water injection and will be treated prior to injection into the producing reservoirs. Water injection will be used for reservoir pressure maintenance to enhance oil production. Seawater lift pumps on the FPSO will be used to pump seawater from depths up to 100 meters (328 feet) below the surface to access colder seawater than is available from the shallower depths. The filtration system will remove particulate from the incoming seawater. Following filtration, the seawater will be treated to remove dissolved oxygen and sulfate ions. The treated seawater will then be pumped at the pressure necessary for injection into the reservoir.

A portion of the treated seawater will be further treated through a reverse osmosis system to make fresh water. Fresh water is required both for potable water requirements as well as for removal of salt from the crude oil as part of oil desalting, as described in Section 2.7.3.1, Oil/Water/Gas Separation and Oil Desalting.

2.7.4. FPSO Utility Systems

This section discusses the utility system requirements for the FPSO.

2.7.4.1. Process Cooling

Cooling of process streams via a closed-loop, water-based cooling medium system is required to dissipate heat generated by the oil and water treating systems, compression systems, and miscellaneous utility systems.

The seawater lifting system will supply the required seawater for cooling (see Section 2.7.3.4, Seawater Treatment and Water Injection System). Process hydrocarbon fluids will not come into contact with this seawater. After use in the cooling system, seawater will be discharged overboard at a rate and configuration suitable to maintain ocean temperatures at or below permitted levels established to avoid adverse effects to marine life.

2.7.4.2. Process Heating

A process heating system is required as part of the crude oil treatment process to achieve the required crude oil specifications. A closed-loop, water-based heating medium system will be used to add heat to the incoming production stream. Waste heat from the power generation system will be used as the source of heat.

2.7.4.3. Flaring System

EEPGL intends to re-inject produced gas under routine conditions, except that which will be used as fuel gas for FPSO operations. A flare system will be provided for the collection and safe disposition of produced hydrocarbon gases resulting from unplanned, non-routine relief and blowdown events. Relief events occur to prevent overpressure scenarios in the process equipment. Blowdown events occur to depressurize the facilities in a controlled manner as a result of emergency shutdown events. In addition, temporary, non-routine flaring will occur during equipment maintenance and process upsets, including startup. The flare system will include both an HP and LP flare sharing a common flare tower. The flare tower has elevated flare tips for both HP and LP flares, which provides for the safe ignition of hydrocarbon gases. Both flares will support high-efficiency combustion and will use pilots that have minimal emissions.

The estimated flaring volumes from FPSO start-up and commissioning through the end of the production operations stage are presented in Table 2.7-2.

Table 2.7-2: Estimated Flaring Volumes during Payara Production Operations Stage

Production Operations Year	FPSO Total Flaring Volumes (MMscf/year)
2023	24,640
2024	3,719
2025	4,015
2026	4,179
2027	4,606
2028	4,486
2029	4,409
2030	4,387
2031	4,387
2032	4,267
2033	3,884
2034	3,468
2035	3,084
2036	3,238
2037	2,865
2038	2,460
2039	3,128
2040	3,533
2041	2,986
2042	2,953
2043	2,953
2044	2,953

MMscf = million standard cubic feet

2.7.4.4. Topsides and Subsea Chemical Injection

The FPSO will have storage and injection facilities to inject the required amounts of chemicals and methanol into the production fluids to support production operations, both for subsea chemical injection requirements and for topsides chemical injection requirements.

Topsides chemicals may include corrosion inhibitors, scale inhibitors, asphaltene inhibitors, emulsion breakers, anti-foam agents, demulsifiers, oxygen scavengers, biocides, water-treatment chemicals, and hydrogen sulfide (H_2S) scavengers. Subsea chemicals may include methanol, scale inhibitor, corrosion inhibitor, asphaltene inhibitor, and xylene. Methanol and xylene will be stored in tanks that are integrated into one of the FPSO hull cargo tanks.

2.7.4.5. Air

An air compression system will be provided to supply hull and topsides equipment. Compressed air is required primarily for the operation of control valves and other process instrumentation requirements.

2.7.4.6. Nitrogen

Instrument air will feed the nitrogen generation system. Nitrogen will be provided as required for purging, inerting, and blanketing, and as required for miscellaneous utilities.

2.7.4.7. Drains

The topsides will be equipped with the following drain systems:

- Nonhazardous drain system: used to collect drain fluids (e.g., rainwater) from non-hydrocarbon areas and to route them either to the slop tank in the FPSO hull or directly overboard in case of excessive drain rates;
- Hazardous drain system: used to collect drain fluids (e.g., oil-contaminated water) from hydrocarbon areas and to route them to the slop tank in the FPSO hull; and
- Closed drain system: used to collect drain fluids from produced water systems and to route them back into the process.

2.7.4.8. Other Utility Systems

A minimum of two deck cranes will be provided for supply boat offloading and materials handling and to support general maintenance activities. Workshops, a laboratory capable of checking the properties of the produced and injection fluids as well as select discharges for compliance, a medical facility, and a storage facility for supplies and spare parts will also be provided. Heating, ventilation, and air conditioning systems will be provided for buildings and enclosures.

2.7.5. Power Generation System

The required power for the FPSO will be generated by three systems:

- The main power generation system will be gas turbine-driven generator sets with spares available in the case of unplanned downtime. All generator sets will be dual-fuel (diesel and produced gas).
- The essential services power generation system will be a diesel-driven generator set. Essential services include systems required for facility restart and for flow assurance hydrate mitigation activities after an unplanned shutdown.
- The vessel emergency power generator set will be diesel-driven and will provide power to both the hull and topsides emergency systems (e.g., safety systems including emergency lighting, telecommunication, etc.).

Additionally, for backup power during emergency situations, an uninterruptible power-supply system will be provided to power equipment such as the Integrated Control and Safety System (ICSS), subsea controls, etc.

2.7.6. Integrated Control and Safety System

Monitoring and control of the FPSO production operations will be performed by an ICSS. Located in the main control room of the FPSO, the ICSS will include process shutdown, emergency shutdown, and fire and gas systems to protect the facilities and personnel. These systems will interface with a public address and general alarm system to provide distinct audible and visual alarm notification. The ICSS includes the following subsystems:

- PCS: the PCS will perform primary process control, monitoring, and data acquisition functions.
- Safety Instrumented System (SIS): the SIS will implement functions for abandoning the host facility, emergency shutdown, fire and gas detection, and process shutdown. Also included in the SIS will be a shutdown function for the subsea control/safety system. The SIS will provide detection, logic sequencing, and actuation of devices to place the facility in a safe state.
- Fire and Gas System.
- Alarm Management System.
- Operator graphics/consoles.
- Third-party interfaces to packaged systems (such as compressors, subsea, marine, etc.).

2.7.7. Communication Systems

Telecommunications equipment will be installed on the FPSO to enable safe operation of the facilities in normal and emergency conditions. This equipment will allow communication with the shorebases, support vessels, helicopters, and tankers, as well as communication within the FPSO.

2.7.8. Additional Vessel Systems

2.7.8.1. FPSO Cargo Systems

The main purpose of the FPSO cargo system will be as follows:

- To receive, distribute, and store on-specification crude oil from the process facilities into designated FPSO cargo tanks;
- To receive and store off-specification crude oil from the process facilities into a designated FPSO cargo tank; and
- To offload the crude oil stored in the FPSO cargo tanks into a conventional tanker at regular intervals.

In addition to the FPSO cargo tanks, there will be a slop tank that will receive stripping water from the cargo tanks and discharge from the topsides nonhazardous and hazardous drain systems. The oil and water in the slop tank will be gravity-separated by a minimum residence and retention time. Once separated, the oil will be skimmed off the top and sent to the cargo tanks and the water will be discharged overboard to residual oil and grease in water discharge specifications.

The FPSO cargo tanks are normally blanketed with hydrocarbon gas that is supplied from the fuel gas system. When the tanks are being loaded, hydrocarbon gas is displaced and routed to the flash gas compression system. When the cargo tanks are offloaded, low-pressure fuel gas is used to blanket the tank. The inert gas generator is only used to blanket the tanks if the fuel gas system is offline or prior to tank entry. When the tank is blanketed with inert gas, any vapor discharge is routed to cold vents stacks located at a safe height at the bow of the FPSO.

The marine cargo system supports the following routine activities:

- Flushing of the crude oil offloading export hose;
- Emergency and temporary ballasting of FPSO cargo tanks with seawater; and
- Inspection and maintenance of FPSO cargo tanks and piping systems between offloading operations.

2.7.8.2. Crude Oil Offloading

Export of the crude oil from the FPSO will be via a floating hose connected to the manifold of a conventional tanker. The FPSO will be configured for tandem offloading to a conventional tanker. The separation distance between the stern of the FPSO and the conventional tanker will be approximately 120 meters (390 feet). The maximum conventional tanker classification envisioned is a Very Large Crude Carrier class. During offloading operations, the conventional tanker will maneuver and hold station relative to the FPSO with the assistance of up to three assistance tugs, as shown on Figure 2.7-3. Crude oil will be transported to the buyers' final location(s) by the conventional tankers after each offloading operation.

Figure 2.7-3: General Offloading Configuration

2.7.8.3. Ballast System

Ballast water will be required during the FPSO transit from the shipyard to offshore Guyana. Once on site, the un-needed ballast water from the FPSO may be discharged overboard in accordance with International Maritime Organization (IMO) requirements.

2.7.8.4. Spread Mooring System

The FPSO will be permanently moored by fixed, spread mooring with an up to 22-point mooring line system, with each line connected to its respective anchor pile embedded into the seafloor. The anchor piles will be either suction piles or driven piles. The mooring system will be designed to maintain the FPSO on-station for a 100-year environmental condition.

2.7.9. Safety and Personnel Protection Systems

Safety systems will include the following:

- Firewater System—The firewater system will have pumps located at the fore and aft ends of the FPSO.
- Fire and Gas Detection Systems—Fire and smoke detectors will be located throughout the topsides and living quarters and will be wired centrally with alarms sounding in the CCR, which will activate the general alarm system on the FPSO. Gas detectors will be placed in areas where gas might be released or could accumulate.
- Blanket Gas Generation—To prevent fires, the cargo tanks are normally blanketed with hydrocarbon gas that is supplied from the fuel gas system. The inert gas generator is only used to blanket the tanks if the fuel gas system is offline or prior to tank entry. Other spaces,

including the methanol and xylene tanks, will be blanketed by nitrogen, which is produced by routing compressed air through the nitrogen membrane package.

- Lifeboats and Life Rafts—The FPSO will be provided with lifeboats on either side of the accommodation, having a capacity on each side for 100 percent of the personnel on board. A fast rescue boat will also be provided, complete with a davit launching and retrieving system.

2.8. Installation, Hookup, and Commissioning

Final design of the installation, hookup, and commissioning activities for the SURF, FPSO, and associated moorings has not been completed; however, key installation, hook-up, and commissioning activities will include the following:

- FPSO Mooring Installation—Installation of the FPSO's anchor piles and mooring lines. Following installation, the mooring lines will be staged on the seafloor until arrival of the FPSO.
- Flowline/Riser Installation—Installation of the production, water injection, and gas re-injection flowlines and risers. These components will be cleaned and tested to verify integrity after installation. Some components may be staged on the seafloor until arrival of the FPSO; others may be brought in and installed with the FPSO.
- FPSO Positioning and Mooring Connection—Positioning of the FPSO using support tugs, followed by retrieval of the FPSO mooring lines from the seafloor and hook-up of the FPSO to its mooring system.
- Manifold/Drill Center Components—Installation of the manifold foundation piles/mud mats and subsea components at the drill centers and testing to verify integrity after installation.
- Umbilical Installation—Installation of the umbilicals and SDU.
- Riser Connection—Retrieval from the seafloor, pull-in, and connection of the risers to the FPSO.
- Testing and Commissioning—Testing and commissioning of the connected, integrated FPSO and SURF production systems, including testing and dewatering/displacing flowlines and umbilicals with commissioning fluids and testing SURF control and shutdown systems.

The above activities will be executed in an optimal sequence with activities completed in parallel where possible.

During the installation stage, a remotely operated vehicle may be periodically utilized underwater to support the above-mentioned activities (e.g., observations, connections, sampling, etc.).

2.9. PRODUCTION OPERATIONS

This section discusses the production operations for the FPSO.

2.9.1. Common Flow Assurance Additives

Some industry-standard chemicals will be required to process the produced oil on the FPSO. Both the FPSO and SURF facilities will also require the use of industry-standard additives to provide flow assurance and prevent corrosion, scale formation, hydrate formation, and asphaltene formation, as previously noted in Section 2.7.4.4, Topsides and Subsea Chemical Injection. The chemical requirements and estimated quantities will be determined as part of the ongoing FPSO and SURF facilities design work, and will be addressed in the EIA process. Particular attention will be paid to scenarios that could result in flow instabilities, restrictions, or blockages, or which could jeopardize the integrity of the fluid-transfer systems or reduce overall system operability. The objective of the following sections is to provide a general overview of the flow assurance challenges and strategies.

2.9.2. Hydrogen Sulfide Management

The concentration of H_2S will be extremely low for the initial stage (i.e., 1 to 5 years) of FPSO/SURF production operations. There may be potential for the reservoir to sour[13] over time, which influences material selection and corrosion inhibition for certain FPSO, SURF, and drilling systems. In the unlikely event that concentrations of H_2S increase to a level that could represent potential health or safety concerns for the Project's offshore workforce, additional management measures will be implemented as appropriate (e.g., training programs, personal protective equipment (PPE), response planning, and equipment for leak detection and alarms).

2.9.3. Marine Safety

The Maritime Administration Department (MARAD) of the Ministry of Public Infrastructure is responsible for issuing notices to mariners concerning safety at sea. MARAD will be advised of the locations of drill ships during the drilling of the development wells and the performance of well workovers in the PDA so that mariners can be made aware of these activities. As shown on Figure 2.9-1, marine safety exclusion zones with a 500-meter (1,640-foot) radius will be established around drill ships during drilling operations and around drill centers during well workovers, as well as around major installation vessels, in accordance with industry standards and practices.

[13] A reservoir "souring" means the levels of sulfur in the recovered crude oil increases over time, relative to levels at the initial stages of recovery.

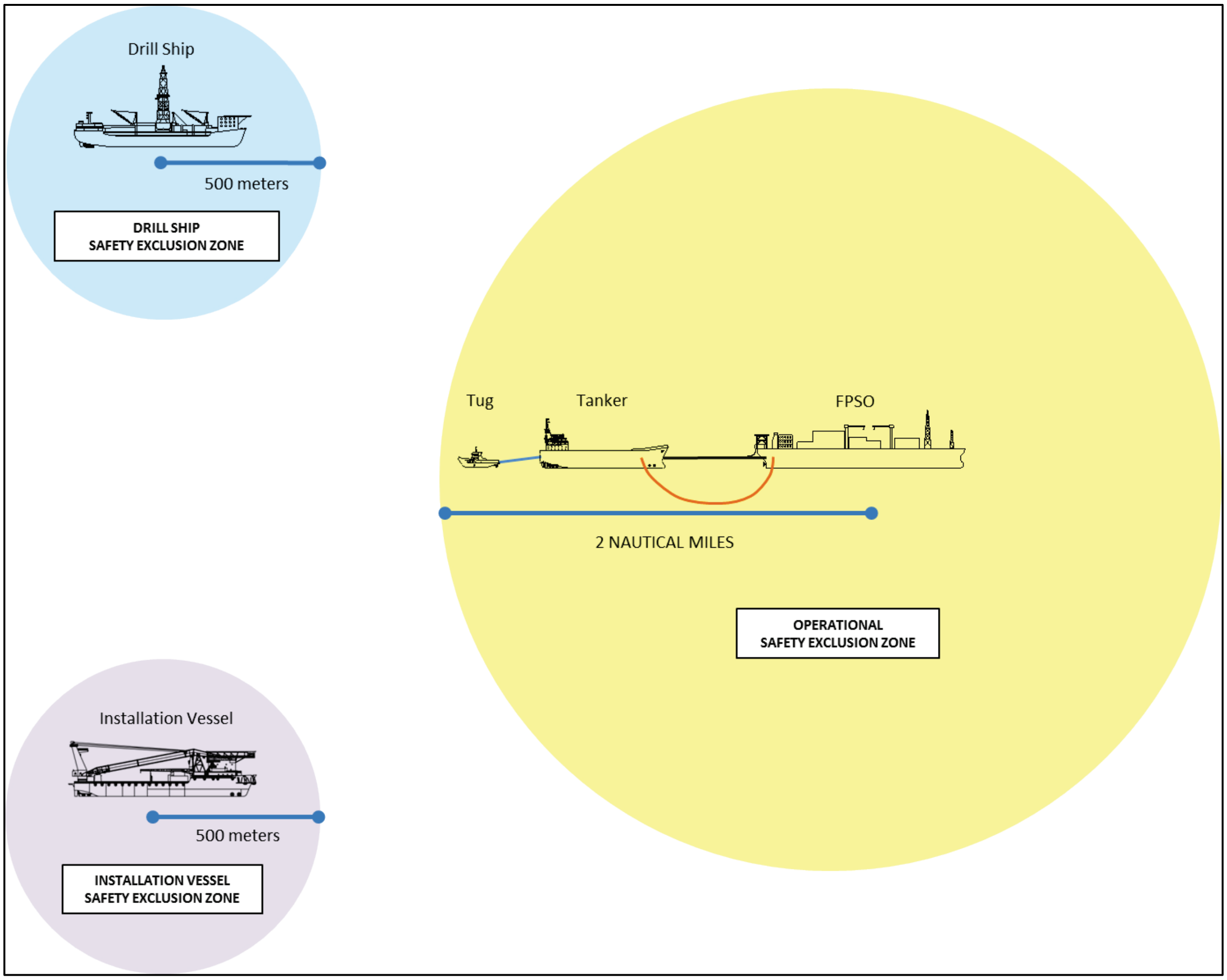


Figure 2.9-1: Preliminary Marine Safety Exclusion Zones

Authorizations for major in-water activities will be obtained from MARAD and notices to mariners will be issued for all marine vessels, including the FPSO, supply and support vessels, tugs, and those vessels to be used during the installation, hook-up, and commissioning stage.

As shown on Figure 2.9-1, the FPSO will have a 2-nautical mile-radius marine safety exclusion zone centered on the FPSO during offloading activities, where marine support and tanker offloading will occur. No unauthorized vessels will be allowed to enter this approximately 4,000-hectare operational marine safety exclusion zone during offloading activities.

2.9.4. Offloading Tankers

Conventional tankers supporting offloading operations will typically arrive anywhere from 1 day to several hours ahead of the scheduled loading time, as a function of weather and ocean conditions. To accommodate these vessels, an anchorage area will be established several kilometers away from the FPSO. When the tanker is ready to approach, a Mooring Master will board the conventional tanker approximately 2 kilometers (1.2 miles) from the FPSO to guide the conventional tanker to the FPSO and to support the offloading operation. The conventional tankers will export the crude oil for sale after offloading operations have been completed. Conventional tankers will be owned/operated by others and will not be dedicated to the Project.

The following is a summary of the tanker activities anticipated as a result of the Project, as well as the operational procedures and controls (maritime navigation protocols, safety procedures, communication protocols, etc.) that will be implemented in relation to these activities, including tanker transit within Guyana waters and during offloading of oil from the FPSO to the tankers on the Stabroek Block. Although outside the scope of the EIA, the information below also includes a conceptual description of the key marine and terminal operational procedures and safety controls that will be used during international transit outside of Guyana waters. The discussion is presented for two phases: pre-cargo (activities up to the point where crude oil is offloaded from the FPSO to the offloading tanker) and post-cargo (activities from the completion of offloading at the FPSO up to the offloading of the crude oil at the delivery port).

2.9.4.1. Pre-Cargo Phase

The Pre-Cargo Phase covers the offloading tanker from the time of Nomination by Lifter[14] through the start of cargo operations at the FPSO. This includes ocean transit to the tanker waiting area, final approach to the offloading station, mooring operations, and activities to prepare for the commencement of offloading operations. The operations and controls for this phase include the following:

- Ocean transit to waiting area: The offloading tanker will be under the control of the Vessel Master, governed by international and flag-state regulation and owner/operator policies.
- Final approach to station[15] and mooring operation: The offloading tanker will be under the control of the Vessel Master, assisted by the Mooring Master from the FPSO. The Mooring Master acts as the FPSO representative and advisor and will be located onboard the offloading tanker. The Mooring Master is tasked with coordinating and directing the offloading tanker's approach, communications with assist tugs and the FPSO, and mooring operations between the offloading tanker and the FPSO. The Vessel Master is ultimately responsible for safety, security, regulation, and owner/operator policy enforcement as relates to the operations of the offloading tanker.
- Activities to prepare for the commencement of cargo operations: The offloading tanker will be under the control of the Vessel Master, assisted by the Mooring Master from the FPSO. The Mooring Master may assist with communications and enforcement of FPSO procedures onboard the offloading tanker. The Vessel Master is ultimately responsible for safety, security, regulation, and owner/operator policy enforcement as relates to the operations of the offloading tanker.

[14] The "Lifter" is the party that is obligated to offload from the FPSO on certain dates based on the designated schedule. "Nomination" is when the Lifter provides the name and details of the planned offloading vessel to EEPGL. This is anticipated to be no later than 10 days prior to the lifting window.

[15] "Station" is the point where the offloading tanker is located when the offloading of crude oil takes place.

2.9.4.2. Post-Cargo Phase

The Post-Cargo Phase covers the offloading tanker from the completion of offloading of crude oil from the FPSO through the eventual discharge of the loaded cargo at the delivery port. This includes completion of cargo documentation, pre-departure safety checks, unmooring, departure from station, ocean transit to the discharge port, and discharge of loaded cargo. The operations and controls for this phase include the following:

- Completion of cargo documentation and pre-departure safety checks: The offloading tanker will be under the control of its Vessel Master, who is responsible for the safety, security, and regulation/company policy enforcement as relates to operations of the offloading tanker.
- Unmooring and departure from station: The offloading tanker will be under the control of its Vessel Master, assisted by the Mooring Master from the FPSO. The Mooring Master is tasked with coordinating and directing the unmooring operations, and communications with assist tugs and FPSO. The Vessel Master is ultimately responsible for safety, security, and regulation/company policy enforcement as relates to operations of the offloading tanker.
- Ocean transit to discharge port and discharge of loaded cargo (outside the scope of the EIA): The offloading tanker will be under the control of its Vessel Master, governed by international and flag state regulation and company policies.

2.9.4.3. Governance and Industry Standards

A number of protocols and procedures will be followed in relation to tanker activities in Guyana waters, and outside of Guyana waters (i.e., in transit to the international delivery port). These include the following:

- Safety of Life at Sea (SOLAS) Convention: Specifies minimum standards for the construction, equipment, and operation of ships, focused on safety standards. Key topics in SOLAS include Safety of Navigation (Chapter V) and Management for the Safe Operation of Ships–ISM Code (Chapter XI-2), among others.
- International Convention for the Prevention of Pollution from Ships, as modified by the Protocol of 1978 (MARPOL 73/78): Developed by the IMO; includes international standards for seafarer training, regulations on mandatory traffic separation schemes, and requirements for segregated ballast tanks and double hulls for tankers, among other standards.
- International Safety Guide for Oil Tankers and Terminals: An industry-wide accepted guide for the safe carriage and handling of crude oil on tankers and at terminals; recommended to be kept and used onboard every tanker and in every terminal so there is a consistent approach to operational procedures and shared responsibilities for operations at the ship/shore interface; covers General Information (properties, hazards of petroleum, hazards for ship and terminal, etc.), Tanker Information (shipboard systems, equipment and operations, carriage and storage of hazardous materials, etc.), Terminal Information (terminal systems and equipment, cargo transfer equipment, emergency preparedness, etc.), and Management of the Tanker and Terminal Interface (communications, mooring, precautions on ship and terminal during cargo operations, etc.).

- Oil Companies International Marine Forum (OCIMF): Developed under a voluntary association of oil companies having an interest in the shipment and terminalling of crude oil, oil products, petrochemicals and gas; objective is to develop and publish guidance, recommendations and best practice by harnessing the skills and experience of OCIMF members and the wider industry; the OCIMF consults with IMO to influence and create internationally-accepted regulations aimed at improving the safety of tankers and protecting the environment.

2.10. Onshore, Marine, and Aviation Support

2.10.1. Onshore Supply and Support Activities

Shorebases, laydown areas, pipe yards, fabrication/maintenance facilities, warehouses, fuel supply, heliport, and waste management facilities are planned to support development drilling, FPSO/SURF installation, production operations, and ultimately, decommissioning. EEPGL plans to use the existing Guyana shorebases on the east side of the Demerara River as the primary shorebases supporting the Project. Additional onshore facilities may be used by other companies. All onshore support facilities will be owned/operated by others and will not be dedicated to the Project.

Accordingly, the EIA was conducted on the basis that the Project will primarily use the existing Guyana shorebases located in Georgetown. Should any new or expanded shorebases or onshore support facilities be used, the construction/expansion and any required dredging of such facilities, as well as the associated environmental authorization, would be the responsibility of the owner/operator and such work scope is therefore not included in the scope of the EIA for Payara.

A typical shorebase quay is shown on Figure 2.10-1, and a typical laydown yard is shown on Figure 2.10-2. Additional logistical support may be provided by other regional suppliers outside of Guyana, as informed by inputs from EEPGL contractors after contract award, to address Project needs (e.g., deepwater port access in Trinidad).

Figure 2.10-1: Typical Shorebase Quay

Figure 2.10-2: Typical Laydown Yard

Onshore facilities to be used will include pier/port/quayside space with sufficient draft for receipt of cargo vessels bringing materials to and from the shorebase; marine support vessels will be used to service the offshore activities and operations. A marine berth and secure warehousing space for indoor and outdoor storage of materials and goods, trucking, stevedoring, freight forwarding, customs logistics, receiving, inspection, and associated container handling and storage operations will also be used.

Daily activities and operations to be performed at the shorebases will generally include the following:

- Storage of pipe, equipment, and spares;
- Loading and unloading cargo from trucks and marine vessels;
- Use of cranes and other lifting equipment;
- Bulk storage of chemicals, fuels, and industrial consumables;
- Operation of a cement and drilling fluids and mud plant to support offshore drilling operations; and
- Secure handling, storage, and treatment of wastes pending final recycling, treatment, or disposal.

Most of the major SURF equipment will be preassembled, pretested, and shipped directly to the Payara PDA from their points of origin. Other minor equipment, supplies, and materials may be temporarily staged at shorebases, laydown yards, and warehouses until transferred offshore for installation or use. The owners/operators of these contracted facilities will be responsible for obtaining any needed environmental authorizations for any changes to current operations (e.g., bulk storage of chemicals and fuels).

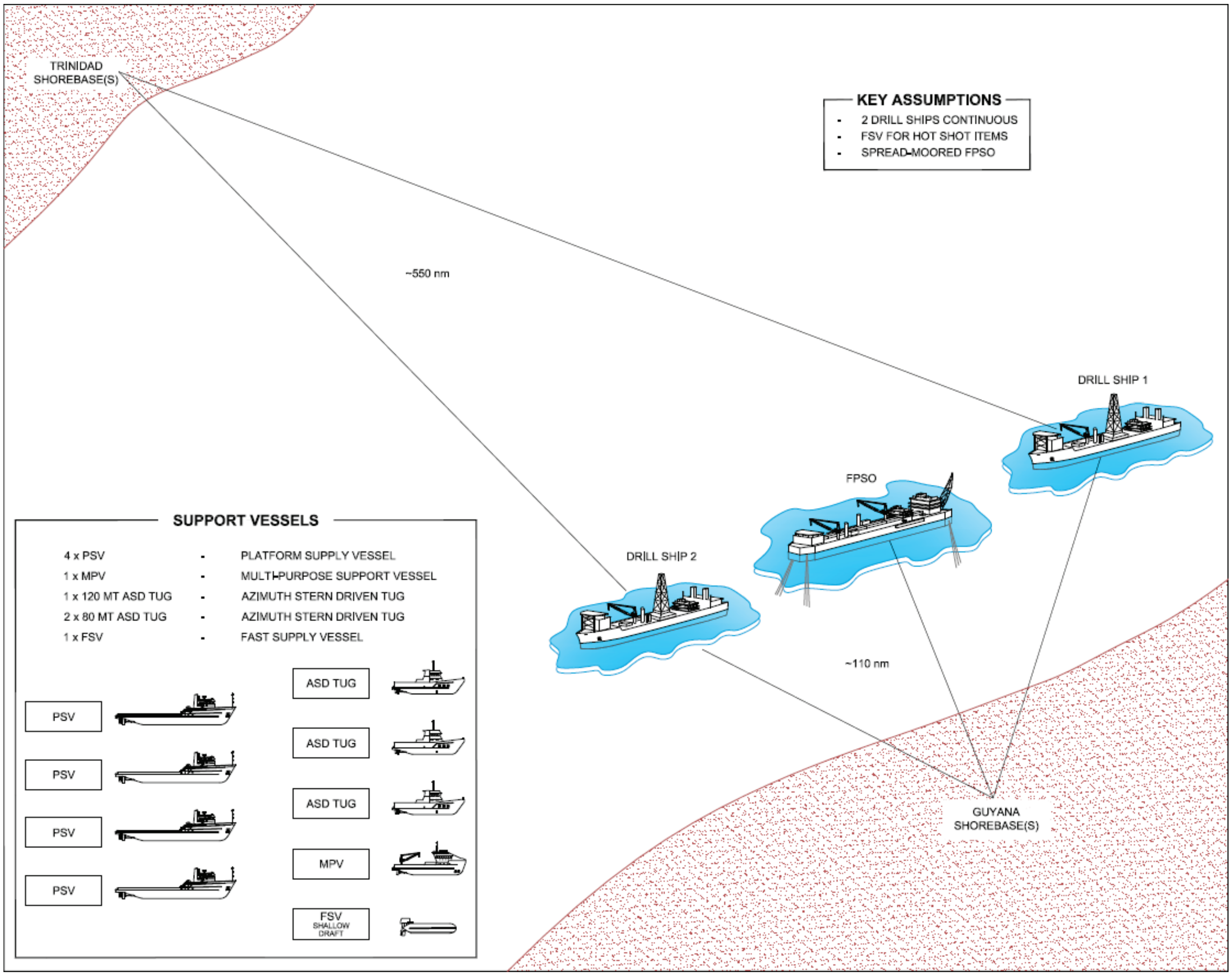
Support and supply vessels will require sufficient water depths to transit between the Payara PDA and the shorebases. There is potential for some initial and periodic maintenance dredging to be performed by the owners/operator(s) of the shorebases. Any such dredging will be subject to receipt of environmental authorization by the owners/operator(s) of the shorebases.

2.10.2. Logistical Support

Logistical support will be optimized and shared among Liza Phase 1, Liza Phase 2, and Payara. It is estimated that during development drilling and FPSO/SURF installation, helicopter flights may increase at peak to a total of approximately 45 to 55 round-trip flights per week. During production operations, an estimated maximum of 20 to 30 round-trip flights per week will be necessary to support production operations and continued development-drilling activities.

There will be a variety of marine and aviation support equipment supporting the FPSO, installation vessels, and drill ship(s), as shown on Figure 2.10-3. The support vessels will consist of multiple platform-supply vessels and a fast-supply vessel conducting resupply trips to the FPSOs and drill ships, tug vessels supporting tanker-offloading activities, and multi-purpose vessels supporting subsea installation and maintenance activities. Based on current drilling activities and past experience with similar developments, it is estimated that during development drilling and FPSO/SURF installation, an average of approximately 12 to 15 round-trips per week may be made to the Stabroek Block by marine vessels. During production operations, it is estimated that this number will be reduced to approximately 5 to 10 round-trips per week. The vessels will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad. Figure 2.10-4 depicts a conceptual diagram of the number and types of logistical support equipment that will be used to support the Project.

Figure 2.10-3: Typical Logistics Support Vessels



Note: Total number of drill ships and support vessels to be confirmed based on detailed planning

Figure 2.10-4: Marine Support Vessels

2.10.3. Waste Management

Waste generated offshore will be reduced, recycled, and treated offshore where practicable, with the remainder directed for onshore treatment, recycling, reuse, or disposal. For the exploration and Liza Phase 1 drilling programs, EEPGL is currently using a regional supplier that is operating an existing waste management facility in Georgetown (see Figures 2.10-5 and 2.10-6). EEPGL is planning to use this facility or similar facilities in Guyana or the region during the Project development drilling and FPSO/SURF production operations stages. EEPGL would potentially consider the use of alternative Guyanese or regional waste management services according to Project needs, should they become available in the future. All waste streams will be managed in accordance with the Waste Management Plan for Guyana Development Projects, which is included as an appendix to the Payara Environmental and Socioeconomic Management Plan (ESMP) (Volume III of the regulatory submittal).

Figure 2.10-5: Typical Waste Management Facilities at Shorebase

Figure 2.10-6: Vertical Infrared Unit with Wet Scrubber and Oxidizer at Typical Waste Management Facilities

2.11. END OF PAYARA OPERATIONS (DECOMMISSIONING)

In advance of the completion of the Payara production operations stage, EEPGL will prepare a decommissioning plan for the facility in compliance with the contracts and licenses governing the Project and laws and regulations in effect at that time, while also considering the technology available at that time. The decommissioning plan and strategy will be based on a notice of intent for decommissioning the production facilities and plugging and abandonment of the development wells, which will be provided to the Guyana Geology and Mines Commission and Department of Energy to obtain approval in accordance with the requirements of the Guyana Petroleum (Exploration and Production) Act (1998) and Environmental Protection Act (as amended in 2005).

EEPGL will perform inspections, surveys, and testing to assess current conditions that will provide the basis and required information to prepare a plan for decommissioning. All risers, pipelines, umbilicals, subsea equipment, and topsides equipment will be safely and properly isolated, de-energized, and cleaned to remove hydrocarbons and other hazardous materials to a suitable level prior to being taken out of service.

Near the time of decommissioning, EEPGL will select, in consultation with the EPA, Guyana Geology and Mines Commission, and Department of Energy, the final decommissioning strategy based on a comparative assessment designed to evaluate the potential safety, environmental, technical, and economic impacts, and associated mitigation measures to finalize the decommissioning plan.

Wells will be permanently plugged and abandoned by restoring suitable cap rock[16] to prevent escape of hydrocarbons to the environment. Plugging and abandonment barriers will be installed in the wellbore, and will be of adequate length to contain reservoir fluids and deep enough to resist being bypassed by fracturing. The number of barriers required will depend on the distribution of hydrocarbon-bearing permeable zones within the wellbore.

It is expected that the risers, pipelines, umbilicals, subsea equipment, FPSO mooring lines, and anchor piles will be disconnected and abandoned in place on the seafloor, unless an alternative strategy is selected based on the results of the comparative assessments.

The FPSO will be disconnected from its mooring system, removed from the production location, and towed to a new location for re-use or decommissioning.

Selected waste streams associated with decommissioning activities, including hazardous and nonhazardous wastes, will be managed and disposed in accordance with standard industry practice and applicable regulations. Methods may include injection downhole into the reservoir, separation and incineration offshore, or transport to onshore waste management facilities for treatment and/or disposal in accordance with standard industry practice and applicable regulations.

The Payara Development Project Preliminary End of Operations Decommissioning Plan is included as an appendix to the Payara ESMP (Volume III of the regulatory submittal).

2.12. MATERIALS, EMISSIONS, DISCHARGES, AND WASTES

This section describes the materials (i.e., primarily chemicals) used across the various stages of the Project, as well as the Project's planned emissions, discharges, and wastes.

The Project may potentially produce small amounts of Naturally Occurring Radioactive Material (NORM) from the reservoir over the life of the production operations stage. The Project may also use radiography periodically to support installation and maintenance activities (e.g., non-destructive examination of materials for quality control purposes). The Project will follow standard industry practices to manage any workforce or third-party exposure to NORM or radiography sources. Any equipment containing such sources will be registered, strictly tracked, controlled, and returned to the vendor at the end of its use or if it must be replaced at any time.

[16] Refers to the placement of cement plugs as part of the overall process and procedures for safely plugging and abandoning wells

The Project will not generate any meaningful vibration that could impact resources/receptors. EEPGL will manage airborne sound through engineering controls, through administrative controls, and by providing appropriate PPE to its Project workforce as described in Section 6.2.3, Impact Assessment—Sound. Underwater sound is discussed in the marine mammals and marine turtles impact evaluations (see Sections 7.5.3 and 7.5.4 and Sections 7.7.3 and 7.7.4, respectively). The Project will generate heat, primarily in the form of a cooling water discharge to the sea, which is discussed as part of the marine water quality impact evaluation (see Sections 6.4.3 and 6.4.4). The Project will generate light, which is discussed as part of the seabirds and marine turtles impact evaluations (see Sections 7.4.3 and 7.4.4 and Sections 7.7.3 and 7.7.4, respectively).

2.12.1. Materials Inventory

Offshore oil development is primarily an extractive process (e.g., producing oil from the reservoir). This extractive process will, however, require the use of various equipment described in this chapter (e.g., drill ships, pipes, flowlines, FPSO), as well as some chemicals used to facilitate well drilling, crude oil recovery, water/waste treatment, pipeline maintenance, and other purposes, which have been described in prior sections of this chapter. The required volumes of these chemicals are yet to be determined.

Table 2.12-1 below provides a preliminary list of the primary chemicals that will be used as part of the Project's drilling, installation/commissioning, and production operation stages. Table 2.12-2 provides estimates, where known at this time, of the quantities of materials that will be used during development well drilling (on a per-well basis). Tables 2.12-3 and 2.12-4 provide estimates, where known at this time, of the quantities of materials that will be used during the installation and production operations stages.

EEPGL is committed to chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Further, EEPGL's intent is to use low-hazard substances and consider the Offshore Chemical Notification Scheme (Cefas 2019) as a resource for chemical selection in its production operations. EEPGL's chemical selection process is aligned with applicable Guyanese laws and regulations and includes:

- Review of Safety Data Sheets;
- Evaluation of alternate chemicals;
- Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including:
  - Using the minimum effective dose of required chemicals; and
  - Minimizing safety risk related to flammability and volatility;
- Risk evaluation of residual chemical releases into the environment.

EEPGL's chemical selection processes and principles will include, without limitation:

- Specifying in contracts that offshore chemical supply contractors shall protect the health and safety of people and the environment;
- Specifying that contractors shall perform services in compliance with applicable laws and EEPGL health and safety policies; and
- Working with established chemical suppliers.

Specific examples of EEPGL's chemical selection process include the selection of low-toxicity hydraulic fluids for Blowout Preventer (BOP) testing and low-toxicity corrosion inhibitors and minimal use of biocides for operational maintenance of the FPSO cooling water system.

Residual quantities of drilling and production chemicals may be discharged to the sea as components of drilling fluid or produced water, injected into the reservoir, or emitted to the atmosphere, as described in prior sections of this chapter. Unused or used and recovered chemicals will be re-used, recycled, or disposed of in accordance with applicable regulations and best practices.

All chemicals will be stored, either at the shorebases, at contractor facilities, or on the drill ships or FPSO, in appropriate storage containers with either secondary containment or appropriate drainage control.

Table 2.12-1: Project Materials and Chemicals

Project Phase	Primary Chemical Materials/Products	
Drilling	• WBDF • Inorganic salts • Barite • Water-soluble biopolymers and modified biopolymers • Thinners • Calcium carbonate • Lost circulation material [a] • Brines • Acids • Caustic soda • Surfactants • Hydrate inhibitor • Oxygen scavenger • Biocide • Soda ash • NADF • Base oil (IOGP Group III) • Emulsifier • Non-emulsifier • Rheology modifier	• Wetting agent • Viscosity modifiers • Fluid loss modifiers • Lime • Corrosion inhibitor • Sand suspension additive • Cement class "G" • Extender • Defoamer • Retarder • Dye • Breaker • Silica flour • Lubricant • Alkalinity control agent • Fluids loss control agent • Filtration medium • Gas control agent • Diesel (as fuel to power drill ships, vessels, and equipment) • Proppant

Project Phase	Primary Chemical Materials/Products	
SURF Equipment Commissioning	• Hydraulic fluid • Nitrogen • Hydrate inhibitor (e.g., methanol, ethylene glycol) • Marine gas oil (as fuel to power vessels and equipment)	• Corrosion inhibitor • Scale inhibitor • Asphaltene inhibitor • Xylene
Production Operations	• Corrosion inhibitor • Scale inhibitor • Asphaltene inhibitor • Xylene • Methanol • Demulsifier • Defoamer • Floatation aid • Sodium bisulphite	• Polyelectrolyte • Triethylene glycol • Oxygen scavenger • Biocide • Clarifier/coagulant • Hydraulic fluid • Methylene glycol • Diesel (as fuel to power vessels and equipment)

[a] The collective term for substances added to drilling fluids when drilling fluids are being lost to the formations downhole

Table 2.12-2: Estimated (Per Well) Project Materials and Chemicals Quantities—Drilling Stage

Chemical Material/Product	Quantity	Units
WBDF	10,500	bbl
Inorganic salts	94,000	lb
Barite	1,200	tonne
Water-soluble biopolymers and modified biopolymers (liquid)	40	bbl
Water-soluble biopolymers and modified biopolymers (solid)	16,100	lb
Thinners	40	bbl
Calcium carbonate	126,000	lb
Lost circulation material	5,500	lb
Brines	10,000	bbl
Acids	100	lb
Caustic soda	2,500	lb
Surfactants	180	bbl
Hydrate inhibitor	600	bbl
Oxygen scavenger	2	bbl
Biocide	15	bbl
Soda ash	350	lb
NADF	2,700	bbl
Base Oil (IOGP Group III)	5,000	bbl
Emulsifier	170	bbl
Non-emulsifier	120	bbl
Wetting agent	120	bbl
Viscosity modifiers (liquid)	170	bbl
Viscosity modifiers (solid)	40,000	lb
Fluid loss modifiers	18,000	lb

Chemical Material/Product	Quantity	Units
Lime	80,000	lb
Corrosion inhibitor	25	bbl
Sand suspension additive	60	bbl
Cement class “G”	400	ton
Extender	15	bbl
Defoamer	15	bbl
Retarder	5	bbl
Dye	2	bbl
Breaker	550	lb
Silica flour	50,000	lb
Lubricant	3	bbl
Alkalinity control agent	200	lb
Fluids loss control agent	20	bbl
Filtration medium	5,500	lb
Gas control agent	25	bbl
Diesel (as fuel to power drill ships, vessels, and equipment)	29,000	bbl
Proppant	125,000	lb
Viscoelastic surfactant	70	bbl
Rheology modifier	3	bbl

bbl = barrel; gal = gallon; lb = pound

Table 2.12-3: Estimated Project Materials and Chemicals Quantities—Installation Stage

Chemical Material/Product	Quantity	Units
Hydraulic fluid	30	bbl
Nitrogen	20,000,000	scf
Hydrate inhibitor (e.g., methanol, ethylene glycol)	3,500	bbl
Marine gas oil (as fuel to power vessels and equipment)	41,000	bbl
Corrosion inhibitor	100	bbl
Scale Inhibitor	160	bbl
Asphaltene inhibitor	670	bbl
Xylene	80	bbl

bbl = barrel; scf = standard cubic feet

Table 2.12-4: Estimated Project Materials and Chemicals Quantities—Production Operations Stage

Chemical Material/Product	Quantity	Units
Corrosion inhibitor	18,526	bbl
Scale inhibitor	1,222	bbl
Asphaltene inhibitor	46,424	bbl
Xylene	44,560	bbl
Methanol	79,700	bbl
Demulsifier	9,444	bbl

Chemical Material/Product	Quantity	Units
Defoamer	8,672	bbl
Floatation aid	323	bbl
Polyelectrolyte	106	bbl
Triethylene glycol	77	bbl
Oxygen scavenger	338	bbl
Biocide	450	bbl
Clarifier/coagulant	519	bbl
Hydraulic fluid	49	bbl
Methylene glycol	28	bbl
Diesel (as fuel to power vessels and equipment)	76,923	bbl
Sodium bisulphite	288	bbl

bbl = barrel

2.12.2. Emissions

The Project will include several sources of atmospheric emissions. The principal sources of atmospheric emissions from the Project operations can be divided into four main categories:

- **Combustion Emissions**: generated from combustion of liquid fuel or natural gas during aviation and marine support and installation activities, operation of the FPSO and drill ships, and non-routine flaring of gas that is not re-injected into the reservoir;
- **Venting Emissions**: consisting of emissions related to tank storage operations (flashing emissions, standing/working/breathing losses [e.g., FPSO crude oil storage tanks], secondary seals);
- **Vessel-Loading Emissions**: dominated by emissions released during the transfer of crude oil from FPSO to tankers, but also including fuel transfer operations; and
- **Fugitive Emissions**: leakage through process equipment components (e.g., valves, flanges).

Table 2.12-5 provides estimated maximum annual Project atmospheric emissions in three distinct periods, selected to account for differing activity levels over the Project life. Primary activities in each of these periods to which the corresponding emissions can be attributed are as follows:

- 2020–2022: Development well drilling, SURF installation and commissioning, FPSO installation, and operation of related support vessels;
- 2023–2025: Continued development well drilling; operation of related support vessels; FPSO startup and associated temporary, non-routine flaring; beginning of production operations; and tanker loading; and
- 2026–2044: Production operations following cessation of drilling - including temporary, non-routine flaring; operation of related support vessels; and tanker loading.

Table 2.12-5: Estimated Annual Atmospheric Emissions Summary

Pollutant	Source Category	Annual Emissions (tonnes)		
		2020–2022	2023–2025	2026–2044
Nitrogen Oxides	FPSO	0	2,730	2,635
	FPSO Flaring (temporary, non-routine)	0	865	165
	Tanker Loading	0	290	230
	Area Sources [a]	3,110	3,365	1,670
	Drill Ships	1,675	1,675	0
	Total	4,785	8,925	4,700
Sulfur Dioxide	FPSO	0	140	140
	FPSO Flaring (temporary, non-routine)	0	150	30
	Tanker Loading	0	50	40
	Area Sources	110	120	60
	Drill Ships	60	60	0
	Total	170	520	270
Particulate Matter	FPSO	0	65	60
	FPSO Flaring (temporary, non-routine)	0	25	5
	Tanker Loading	0	25	20
	Area Sources [a]	220	240	120
	Drill Ships	120	120	0
	Total	340	475	205
Carbon Monoxide	FPSO	0	695	675
	FPSO Flaring (temporary, non-routine)	0	4,685	880
	Tanker Loading	0	65	50
	Area Sources [a]	650	705	350
	Drill Ships	350	350	0
	Total	1,000	6,500	1,955
Hydrogen Sulfide	FPSO Flaring (temporary, non-routine)	NA (no emissions)	<5	<1
Volatile Organic Compounds	All Sources	125	6,825	2,775
Greenhouse Gases (kilotonnes carbon dioxide-equivalents)	All Sources	250	3,075	1,355

Notes: The annual estimated totals currently reflect the preliminary Project schedule, which could change. The emission rates in this table reflect annual totals. In some cases, the activities generating the emissions are not continuous during the year, or do not operate at full capacity throughout the year. For these sources, the annual emissions reflect this non-continuous operation over the year. Annual emissions are rounded to the nearest 5 tonnes (or kilotonnes in the case of greenhouse gases); totals may not add up to activity-specific values due to rounding. Volatile organic compounds are, by U.S. Environmental Protection Agency definition, a broad class of carbon-containing compounds that, due in part to their ability to volatilize and become airborne, participate in atmospheric photochemical reactions that contribute to the formation of ozone. Methane and ethane are specifically excluded from the U.S. Environmental Protection Agency definition of volatile organic compounds.

[a] Area Sources are mobile equipment such as aviation and marine support vessels (besides the FPSO and drill ships) used during drilling, installation, production operations, and decommissioning.

2.12.3. Discharges

The Project will have several planned discharges to water. These planned discharges, based on the preliminary design information, are listed in Tables 2.12-6 and 2.12-7. Potential discharges include drill cuttings and fluids, cement, well completion and treatment fluids, produced water, cooling water, sulfate removal and potable water processing brines, topsides drainage, hydrostatic test water, commissioning fluids, ballast water, BOP testing fluids, and sanitary and domestic wastewater and food preparation wastes, as described below. All Project vessels will be equipped to comply with the water pollution control standards required by the IMO MARPOL 73/78.

- **Drill Cuttings and Fluids**: WBDF, as listed in Table 2.12-1, and associated cuttings will be discharged to the sea without treatment per standard industry practice. The process for treating and discharging cuttings with residual NADF, as listed in Table 2.12-1, is described in Section 2.5.3, Drilling Fluids.
- **Cement**: Cement slurry returns are only expected during the cementing of the first casing string for each development well. The excess spacer and lead slurry will be discharged directly to the seafloor immediately around the well. Excess/unused cement will be discharged to the sea.
- **Well Completion and Treatment Fluids**: Well completion and treatment fluids will be treated and discharged to the sea or shipped to shore for appropriate treatment/disposal per standard industry practice.
- **Produced Water**: The produced water treating system will collect produced water from process facilities and treat the water prior to discharge overboard, as described in Section 2.7.3.3, Produced Water Treatment.
- **Cooling Water**: Seawater is used to dissipate heat generated by the crude oil and water treating systems, the compression systems, and miscellaneous utility systems. Process hydrocarbon fluids will not come into contact with this seawater. Cooling water will be disposed of overboard at a suitable temperature so as not to significantly impact marine life.
- **Sulfate Removal and Potable Water Processing Brines**: These brine disposal streams are byproducts of the membrane processes used offshore to generate sulfate-free water for injection and to generate fresh water for crude oil desalting and for living quarters' requirements. No treatment of these streams (essentially seawater) is required prior to discharge.
- **Topsides Drainage**: The topsides will have non-hazardous and hazardous drain systems. The hazardous drain system will direct drainage to a slop tank, where oil and water will be gravity separated. Once separated, the oil will be skimmed off the top and sent to the cargo tanks, and the water will be discharged overboard in accordance with treatment specifications. The non-hazardous drain system (e.g., rainwater) will route the drain fluids to the slop tank in the FPSO hull or directly overboard.

- **Hydrostatic Test Water**: Seawater treated with chemicals (e.g., biocides) will be injected in the flowlines and risers to ensure the lines are sealed properly during installation, prior to the flow of hydrocarbons. The treated seawater used for hydrostatic testing of the water and gas injection lines will be discharged near the seafloor per standard industry practice. The treated seawater used for hydrostatic testing of the production lines will be round-trip pigged to the FPSO and will be treated and discharged overboard with produced water.
- **Commissioning Fluids**: A hydrate-inhibiting substance (e.g., methanol or ethylene glycol) will be used to prevent formation of hydrates during commissioning of the production and gas injection lines. The fluid used for the gas injection line will be discharged at the seafloor, and the fluid used for the production lines will be returned to the FPSO, treated, and discharged from the overboard water line.
- **Ballast Water**: Discharges of ballast water will be required for initial FPSO installation and recurring tanker offloading. Un-needed ballast water may be discharged as per the Ballast Water Management Plan.
- **BOP Testing Fluids**: During periodic testing (approximately every two weeks) of the BOP system, approximately 30 barrels of low-toxicity power fluid (i.e., fluid used to hydraulically move the preventers) will be discharged near the seafloor. The typical composition of this fluid is approximately 97 percent water with approximately 3 percent biocide/lubrication/ corrosion protection chemicals.
- **Gray Water/Black Water/Food Preparation Wastes**: The Project will provide wastewater treatment for sanitary wastes (black water/sewage) and food preparation wastes in accordance with MARPOL requirements. Gray water will be discharged overboard.

Table 2.12-6 summarizes drilling-related discharges and Table 2.12-7 summarizes commissioning and production-related discharges.

Table 2.12-6: Summary of Drilling and Completion-Related Discharges

Fluid Type	Estimated Discharge Per Well (bbl) [a]
Drill Cuttings Discharges	6,740–7,032
WBDF Discharges	10,397–10,700
NABF Retained on Cuttings	393–399 [b]
Cement Returns	1,500
Completion and Treatment Fluids	5,300

bbl = barrel
[a] Values based on deepest well
[b] When NADF is used, drill cuttings will be treated such that end-of-well maximum-weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings

Table 2.12-7: Summary of Commissioning and Production-Related Discharges

Type of Discharge and Effluent Characteristics	Expected Discharge Volume/Rate	Discharge Criteria	Treatment Required to Meet Criteria?
SURF and FPSO Installation/Commissioning Discharges			
Ballast Water (FPSO initial deballasting)	≤ 550,000 bbl total	1) Perform discharge in accordance with IMO requirements 2) No visible oil sheen on receiving water	No
Hydrostatic Test Water • Biocide: ≤ 500 ppm • Oxygen scavenger ≤ 100 ppm • Corrosion inhibitor ≤ 200 ppm	65,000 bbl (total volume for all flowlines and risers, occurring throughout SURF commissioning phase)	No visible oil sheen on receiving water	No
Gas Injection Line Commissioning Fluids • Hydrate inhibitor (e.g., methanol or ethylene glycol)	1,400 bbl total	None	NA
Production Discharges			
Produced Water • Oil and grease • Temperature (55°C at point of discharge) • Residual production and water treatment chemicals: – Scale Inhibitor ≤100 ppm – Corrosion Inhibitor ≤200 ppm	≤ 300,000 BPD	Oil in water content: 29 mg/L (monthly average); 42 mg/L (daily maximum) Temperature rise <3°C at 100 meters from discharge	Yes
Cooling Water • Hypochlorite: ≤ 5 ppm • Temperature (50°C at point of discharge)	≤ 1,600,000 BPD	No visible oil sheen on receiving water Temperature rise <3°C at 100 meters from discharge	No
Sulfate Removal and Potable Water Processing Brines • Hypochlorite: ≤ 1 ppm • Electrolyte: ≤ 1 ppm • Biocide: ≤ 5 ppm • Oxygen scavenger: ≤ 10 ppm • Scale inhibitor: ≤ 5 ppm	≤ 265,000 BPD	None	NA
Subsea Hydraulic Fluid Discharge • Water soluble, low-toxicity	≤ 5 BPD	None	NA
FPSO Bilge Water	1,800 BPD	Oil in water content: <15 mg/L	Yes
Inert Gas Generator Cooling Water	Negligible	None	NA
FPSO Slop Tank Water (includes off-specification oil from process and deck drainage)	Rainfall dependent, but expected to be negligible	Oil in water content: 29 mg/L (monthly average); 42 mg/L (daily maximum)	Yes
Miscellaneous Discharges including Boiler Blowdown, Desalinization Blowdown, Lab Sink Drainage	<10 BPD	None	NA

Type of Discharge and Effluent Characteristics	Expected Discharge Volume/Rate	Discharge Criteria	Treatment Required to Meet Criteria?
Tanker Ballast Water	Maximum 1,200,000 bbl total (at each tanker crude loading)	1) Perform in accordance with IMO requirements 2) No visible oil sheen on receiving water	No
BOP System Testing Water-Soluble Low-Toxicity Hydraulic Fluid	30 bbl every 2 weeks	None	NA
Gray Water	250 BPD	None	NA
Black Water (sewage)	70 BPD	Total residual chlorine as low as practical but not less than 1 ppm	Yes
Food Preparation Wastes	<40 BPD	Macerated to <25 mm diameter	Yes

°C = degrees Celsius; bbl = barrel; BPD = barrels per day; mm = millimeter; NA = not applicable; ppm = parts per million

2.12.4. Wastes

The Project will generate a variety of solid wastes including both hazardous and non-hazardous wastes, which vary over time by Project stage. As Table 2.12-8 indicates, waste will begin to be generated when drilling commences, in late 2020 per the current Project schedule. Waste volumes generated will increase as drilling activity increases in 2021 and 2022. Additional waste will be generated from SURF installation and FPSO commissioning and hookup activities in the 2021–2022 timeframe. Waste volumes will then begin to decrease as drilling activity declines over 2024 and 2025 and will significantly decrease during the production operations stage once drilling activity is complete (2026 to 2044). When production operations cease, some waste will be generated from decommissioning activities.

Solid waste generated offshore will be reduced, recycled, treated, and disposed offshore where practicable, with the remainder directed for onshore treatment, recycling, reuse, or disposal. EEPGL is currently using a regional supplier who is operating an existing onshore waste treatment/incineration facility at a local shorebase in Georgetown, Guyana (see Figure 2.10-5). The Project is planning to use similar facilities in Guyana or the region during the development drilling, FPSO/SURF installation and commissioning, production operations, and decommissioning stages. To the extent that solid wastes are being disposed of by a licensed Guyanese onshore disposal facility (e.g., landfill, incinerator) in accordance with its permit, then impacts from the proper disposal of these wastes are not further discussed in this EIA. All Project waste streams will be managed in accordance with the Waste Management Plan that will be part of the Project ESMP.

Table 2.12-8: Summary of Estimated Annual Project Waste Generation and Management Methods

Waste Generated by Category	Volume By Year/Metric Tonnes [a]							
	2020	2021	2022	2023	2024	2025	2026-2043	2044
Non-Hazardous wastes (total) [b]	250	1070	1100	1320	1340	1340	530	530
Hazardous wastes (total) [b]	1530	6240	6270	6420	6430	6430	480	480
Totals by Management Method/Final Destination								
Landfill [c]	150	640	640	810	830	830	350	350
Recycle [d] (if feasible) or Landfill	130	570	590	650	660	660	210	210
Solids Thermal Treatment at Approved Third Party Facility/Landfill [e]	170	750	770	750	750	750	120	120
Liquids Wastewater Treatment/Thermal Treatment and/or Discharge Onshore at Approved Third Party Facility	1330	5340	5350	5500	5510	5510	290	290
Special Waste/Send to Approved Facility	2	20	20	30	30	30	40	40

[a] The annual totals reflect the current preliminary Project schedule, which could change.
[b] Totals may not sum exactly due to rounding.
[c] Onshore landfill volumes include estimated quantities of residue from treatment of hazardous waste.
[d] Includes items recycled into offshore operations process
[e] After treatment of hazardous wastes onshore, the residual non-hazardous solid wastes that are not recycled, reclaimed, or reused will be transported for disposal in an approved landfill.

2.12.5. Radiation Emission Sources

Radiation sources and radiation-producing devices imported and used by the Project and its contractors may potentially include radiographic equipment (e.g., welding inspection application), certain types of process instrumentation (such as level gauges), and certain types of lab equipment (e.g., crude oil testing application). As of the submission date of the EIA, consideration is being given to incorporating radiation source(s) on the FPSO to assist with level measurements on the HP, LP, and Test separators; if such equipment is used on the FPSO, the controls described below would be applied.

Additionally, NORM can sometimes be found in trace concentrations in underground formations and in oil and gas production streams. NORM from production reservoirs can accumulate within production equipment (vessels, piping, valves, etc.) as a scale or sludge. It is not yet known whether the crude that will be extracted for the Project will contain NORM at some point during production operations; this will be determined via monitoring conducted during production operations.

To manage occupational health risks associated with radiation, EEPGL and its contractors will apply standard industry health controls. Typical radiation related health controls, which can be variable depending on the application, may include:

- Compliance with local regulations, including administrative controls related to importation permits and licensing;
- Use of a qualified Radiation Safety Officer;

- Use of site inventory for radiation sources;
- Clearly labeled radiation sources managed under a chain of custody protocol;
- PPE;
- Barricading and signs;
- Personnel exposure monitoring procedures;
- Medical surveillance for identified personnel;
- Radiography performed outside of common work areas or at lower workforce exposure times (i.e., night shift) where feasible;
- Documented baseline surveys for facilities with NORM;
- Exposure control practices for personnel where NORM is present (i.e., for line breaks);
- Clear hazard warning labeling of equipment or materials sent offsite that may have residual NORM contamination;
- Management of any wastes with residual NORM contamination by a qualified waste contractor;
- Training requirements and
- Emergency procedures for source damage/loss.

2.13. Embedded Controls

EEPGL has incorporated the embedded controls[17] provided in Table 2.13-1 into the Project.

Table 2.13-1: Embedded Controls Incorporated into the Project

Embedded Controls	Resources/Receptors Benefited
Development Well Drilling and SURF/FPSO Installation and Commissioning	
Use water-based drilling fluids to the extent reasonably practicable (upper sections of the wells). For well sections requiring NADF, use only low-toxicity IOGP III base fluid.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
When NADF is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Install a BOP system that can be closed rapidly in the event of an uncontrolled influx of formation fluids and that allows the well to be circulated to safety by venting the gas at surface and routing oil so that it may be contained.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos

[17] Embedded controls are physical or procedural controls that are planned as part of the Project design (i.e., not added solely based on a mitigation need identified by the impact significance assignment process). These are considered from the very start of the impact assessment process as part of the Project, and are factored in to the pre-mitigation impact significance rating.

Embedded Controls	**Resources/Receptors Benefited**
Test BOP equipment at installation, after disconnection or repair of any pressure containment seal, and at regular intervals (at least every 14 days or as operations allow).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Employ trained Marine Mammal Observers during the conduct of seismic-related activities.	Marine mammals, marine turtles
Conduct a continuous observation of a mitigation zone (500 meters [1,640 feet] around the sound source) to verify whether it is clear of marine mammals and marine turtles before commencing sound producing seismic operations. Do not conduct sound-producing seismic operations (including soft starts) if marine mammals or turtles are sighted within the mitigation zone during the 30 minutes prior to commencing sound-producing operations in water depths less than 200 meters [656 feet], or 60 minutes prior to commencing sound-producing operations in water depths greater than 200 meters [656 feet].	Marine mammals, marine turtles
Where reasonably practicable, ensure that sound-making devices or equipment are equipped with silencers or mufflers and are enclosed, and/or use soft-start procedures (e.g., for pile driving, vertical seismic profiling, etc.) to reduce noise to levels that do not cause material harm or injury to marine species.	Marine mammals, marine fish, marine turtles
Adhere to the Joint Nature Conservation Committee guidelines (JNCC 2017) during the conduct of seismic-related activities.	Marine mammals, marine turtles
If well testing is performed, implement the following measures: • Flow only the minimum volume of hydrocarbons required for the test and reduce the test duration to the extent practical; • Use an efficient test-flare burner head equipped with an appropriate combustion enhancement system to minimize incomplete combustion, black smoke, and hydrocarbon fallout[18] to the sea; • Record volumes of hydrocarbons flared and make available to the EPA upon request; • Provide adequate gas sensors that are appropriately located during testing operations, to ensure all sources of gas can be detected; • Monitor pipes and joints on a daily basis for leakages and fugitive emissions. Burn all collected gaseous streams in high-efficiency flares, and implement and maintain a leak detection and repair program; • Keep the well test to the minimum practical time, in keeping with a pre-approved schedule with the EPA. Notify the EPA immediately in case of any deviation/variation to the well test; and • Provide sufficient compressed to the oil burner for efficient flaring assignment.	Air quality and climate
With respect to prevention of spills of hydrocarbons and chemicals during the drilling stage: • Change liquid hydrocarbon transfer hoses periodically; • Use dry-break connections on liquid hydrocarbon bulk transfer hoses; • Use a liquid hydrocarbon checklist before every bulk transfer;	Marine geology and sediments, marine water quality, protected areas and special status species, coastal habitats, coastal wildlife, marine mammals, marine turtles,

[18] Hydrocarbons that are deposited on the ocean surface due to both wet and dry deposition processes

Embedded Controls	**Resources/Receptors Benefited**
• Perform required inspections and testing of all equipment prior to deployment/installation; • Use overbalanced drilling fluids to control wells while drilling; • Perform operational training certification (including well-control training) for drill ship supervisors and engineers; • Regularly audit field operations on the drill ships to ensure application of designed safeguards; and • Use controls for mitigating a failure of the Dynamic Positioning (DP) system on the drill ships and maintaining station-keeping, which include: – Use of a Class 3 DP system, which includes numerous redundancies; – Rigorous personnel qualifications and training; – Sea trials and acceptance criteria; – Continuous DP proving trials; – System Failure Mode and Effects Analysis; – Continuous DP failure consequence analysis; and – Establishment of well-specific operations guidelines.	marine fish, marine benthos, ecological balance and ecosystems
During pile-driving activities, gradually increase the intensity of hammer energy to allow sensitive marine organisms to vacate the area before injury occurs (i.e., soft starts).	Marine mammals, marine turtles, marine fish
Maintain marine safety exclusion zones to be issued through MARAD with a 500-meter (approximately 1,640-foot) radius around drill ships and major installation vessels, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Marine use and transportation
Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with IMO/ MARPOL 73/78 requirements.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Ensure leak detection systems are in place for equipment, treatment, and storage facilities (fuel, chemical, etc.) on drill ships in accordance with international offshore petroleum industry standards.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use leak detection controls during installation and operation of SURF equipment (e.g., pigging and pressure testing of lines, periodic remotely operated vehicle surveys of subsea trees, manifolds, flowlines, and risers).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Production Operations	
Use aero-derivative turbines instead of industrial turbines on the FPSO.	Air quality and climate
Install waste heat recovery units (WHRUs) on turbine generators to reduce the demand of more power generation or fired heaters, thus decreasing fuel gas consumption. Two WHRUs provide sufficient heat for the entire FPSO, but the Project is designed to use WHRUs on three of the four turbine generators, which adds spare capacity to ensure achieving maximum uptime and reducing flaring.	Air quality and climate
Use a crude–crude exchanger to recover heat from the dead crude to heat up live crude, instead of using a fired heater.	Air quality and climate

Embedded Controls	Resources/Receptors Benefited
Use a large power plant and maximize the use of mechanical driven equipment that is more energy efficient. Use a gas turbine to drive the compressor directly, allowing savings in fuel versus using a gas turbine to generate electricity, and then using an electric motor to drive the compressor - reducing motor losses and power generation losses.	Air quality and climate
Use large, high-voltage motors, which are more efficient than industry standard machines.	Air quality and climate
Use the same gas turbines for the main generators, designed slightly larger than the need for the compressor such that when one compressor trips, the second unit still can meet 60 percent of production and thus reduce flaring.	Air quality and climate
Implement an FPSO topsides leak detection and repair program to reduce fugitive emissions.	Air quality and climate
Implement a flare minimization plan	Air quality and climate
Instead of continuous flaring, re-inject produced gas that is not used as fuel gas on the FPSO into the reservoir, to avoid routine flaring.	Air quality and climate
Adopt highly efficient combustion equipment using recovery heat systems as part of the heat and power production.	Air quality and climate
With respect to non-routine flaring, the following measures will be implemented: • Ensure flare equipment is properly inspected, well maintained, monitored, certified, and function-tested prior to and throughout operations; • Install the flare at a safe distance from storage tanks containing flammable liquids or vapors and accommodation units; • Ensure combustion equipment is designed and built to appropriate engineering codes and standards; • Do not operate the flare outside design operating ranges; • Use efficient flare tips and optimize the size and number of burning nozzles; • Minimize risk of pilot blowout by ensuring sufficient exit velocity and provision of wind guards; • Use a reliable pilot ignition system; • Install high-reliability instrument pressure protection systems, as appropriate, to reduce overpressure events and avoid or reduce flaring situations; • Operate the flare to control odor and visible smoke emissions; • Record volumes of hydrocarbons flared and submit a copy of the record to the EPA annually; • Maximize efficiency of flaring through flare tip design to ensure correct ratio of fuel and air are present to support efficient combustion • Implement burner maintenance and replacement programs to ensure continuous maximum flare efficiency; • Minimize liquid carryover and entrainment in the gas flare stream with a suitable liquid separation system, with sufficient holding capacity for liquids that may accumulate, and which is designed in accordance with good engineering practice; • Equip liquid separation system (e.g., knockout drum) with high-level facility shutdown or high-level alarms and empty as needed to increase flare combustion efficiency; • Implement source gas reduction measures (i.e., gas re-injection into reservoir) to the extent possible to avoid or reduce flaring from FPSO;	Air quality and climate

Embedded Controls	Resources/Receptors Benefited
• Minimize flaring from purges and pilots without compromising safety through measures such as installation of purge gas reduction devices, vapor recovery units, inert purge gas, and soft seat-valve technology where appropriate, and installation of pilot flares; and • Minimize flame lift off and/or flame lick.	
Develop equipment strategies and execute a maintenance program to minimize equipment breakdowns and plant upsets that could result in flaring, and make provisions for equipment sparing and plant turn-down protocols where practical.	Air quality and climate
Implement inspection, maintenance, and surveillance programs to identify and prevent unplanned emissions to atmosphere onboard the FPSO.	Air quality and climate
In the event of an emergency or equipment breakdown on the FPSO, or when facility upset conditions arise, excess gas should not be vented but rather should be sent to an efficient flare gas system, where practical and operationally safe.	Air quality and climate
Notify the EPA via email, correspondence, and/or telephone within 24 hours after process upset events or unplanned maintenance occur that result in a flaring event on the FPSO sustaining a volume of at least 10 million standard cubic feet per day. Capture volumes from minor flaring events not requiring notification in aggregate in annual emissions reporting.	Air quality and climate
Avoid routine venting (excludes tank flashing emissions, standing/ working/breathing losses) except during safety and emergency conditions.	Air quality and climate
Avoid use of chlorofluorocarbons and polychlorinated biphenyls on the FPSO.	Air quality and climate
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 mg/L on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored and the discharge meets the noted specification.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C at 100 meters (approximately 328 feet) from discharge point.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Measure residual chlorine concentration of sewage discharges from the FPSO monthly to ensure it is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Perform daily visual inspections on the FPSO of discharge points to ensure that there are no floating solids or discoloration of the surrounding waters.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems

Embedded Controls	**Resources/Receptors Benefited**
Maintain marine safety exclusion zones to be issued through MARAD with a 2-nautical-mile (approximately 12,150-foot) radius around FPSO during offloading operations, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Ensure offloading activities are supervised by a designated Mooring Master, according to the conditions of the sea. The conditions and characteristics of the export tankers will be assessed by the Mooring Master and reported to the Offshore Field Manager prior to commencing offloading operations. Use only properly registered and well-maintained double-hull vessels.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use support tugs to aid tankers in maintaining station during approach/departure from FPSO and during offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use a hawser with a quick release mechanism to moor the FPSO to the tanker at a safe separation distance during offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Ensure FPSO offloading to tankers occurs within an environmental operating limit that is established to ensure safe operations. In the event that adverse weather occurs during offloading operations that is beyond the environmental operating limit, the tanker will cease offloading operations, and may disconnect and safely maneuver away from the FPSO as appropriate.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use a certified marine-bonded, double-carcass floating hose system that complies with the recommendations of Oil Companies International Marine Forum Guide to Manufacturing and Purchasing Hoses for Offshore Moorings 2009 Edition (OCIMF 2009) or later.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use breakaway couplers on offloading hose that would stop the flow of oil from FPSO during an emergency disconnect scenario.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use a load-monitoring system in the FPSO control room to support FPSO offloading.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use leak detection controls during FPSO offloading (e.g., for breach of floating hose, instrumentation/procedures to perform volumetric checks).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Inspect and maintain onboard equipment (engines, compressors, generators, sewage treatment plant, and oil-water separators) in accordance with manufacturers' guidelines, in order to maximize efficiency and minimize malfunctions, and unnecessary discharges into the environment.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use low-sulfur fuels for major Project vessels, where available and commercially viable.	Air quality and climate
Use dust-suppression measures at the shorebases to reduce impacts on air quality.	Air quality and climate

Embedded Controls	**Resources/Receptors Benefited**
Abide with IMO (2004) guidelines including the International Convention for the Control and Management of Ship's Ballast Water and Sediments, with the exception of Regulation D-2 (Ballast Water Performance Standard) while the FPSO is on station, and abide with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78).	Ecological balance and ecosystems
General Measures	
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' specifications and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.	Air quality and climate, sound, marine water quality, marine mammals, marine turtles, riverine mammals
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Equip Project vessels with radar systems and communication mechanisms to communicate with third-party mariners.	Marine use and transportation
Regularly inspect and service shorebase cranes and construction equipment to mitigate the potential for spills and to reduce air emissions to the extent reasonably practicable.	Air quality and climate, marine water quality
Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.	Air quality and climate
Implement a chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment;	Air quality and climate, marine water quality, marine geology and sediments, marine mammals, marine turtles, riverine mammals, marine fish, marine benthos, seabirds
Use secondary containment for storage of bulk fuel, drilling fluids, and hazardous materials, where reasonably practicable.	Marine water quality
Regularly check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks.	Marine water quality
Ensure wastewater released from the onboard sewage treatment plant complies with aquatic discharge standards in accordance with MARPOL 73/78 regulations.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
For transport of hazardous wastes offsite for treatment or disposal, ensure the waste is accompanied by a manifest signed by the hazardous waste generator and transporter.	Waste management infrastructure capacity

Embedded Controls	Resources/Receptors Benefited
Provide for adequate onshore waste-management equipment and facilities for the proper management of waste in accordance with local regulation and good international oil field practice.	Waste management infrastructure capacity
For wastes that cannot be reused, treated, or discharged/disposed on the drill ships or FPSO, ensure they are manifested and safely transferred to appropriate onshore facilities for management.	Waste management infrastructure capacity
Periodically audit waste contractors to verify appropriate waste management practices are being used.	Waste management infrastructure capacity
Avoid, reduce, and reuse/recycle wastes preferentially prior to disposal in accordance with waste management hierarchy.	Waste management infrastructure capacity
Perform onshore waste treatment for certain categories of waste, thereby reducing demand on landfill capacity.	Waste management infrastructure capacity
Operate incinerators in accordance with the manufacturers' operating manuals and Waste Management Plan. Ensure that the incinerators are operated only by trained personnel.	Waste management infrastructure capacity, air quality and climate
Ensure there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Treat bilge water in accordance with MARPOL 73/78 to ensure compliance with an oil-in-water content of less than 15 parts per million, as applicable.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and riverine mammals at the sea surface. Provide standing instruction to Project-dedicated vessel masters to avoid marine mammals, riverine mammals, and marine turtles while underway and reduce speed or deviate from course, when possible, to reduce probability of collisions.	Marine mammals, marine turtles, riverine mammals
Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from Project Development Area.	Seabirds
Provide standing instructions to Project-dedicated vessel masters to reduce their speed within 300 meters (984 feet) of observed marine mammals and marine turtles, and to not approach the animals closer than 100 meters (328 feet).	Marine turtles
Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.	Marine use and transportation
Provide health-screening procedures to Project workers to reduce risks of transmitting communicable diseases.	Community health and wellbeing
Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practicable. Partner with select local institutions and agencies to support workforce development programs and proactively message Project-related employment opportunities.	Socioeconomic conditions, employment and livelihoods
Procure Project goods and services locally when available on a timely basis and when they meet minimum standards and are commercially competitive.	Socioeconomic conditions, employment and livelihoods
Develop and implement a Stakeholder Engagement Plan.	Community health and wellbeing

Embedded Controls	Resources/Receptors Benefited
Implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) early on, prior to onset of Project activities. Ensure CGM is well publicized and understood by the public.	Community health and wellbeing
Monitor grievances received and resolved by the CGM; adjust CGM and other management measures, as appropriate	Community health and wellbeing
Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to vehicle incidents.	Social infrastructure and services, community health and wellbeing
Implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The procedure will include, at a minimum, the following components: • Definition of typical, primary travel routes for ground transportation in Georgetown area; • Development of an onshore logistics/journey management plan to reduce potential conflicts with local road traffic when transporting goods to/from onshore support facilities; • Definition of required driver training for Project-dedicated drivers, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as applicable; • Designation and enforcement of speed limits through speed governors, global positioning system, or other monitoring systems for Project-dedicated vehicles; • Avoidance of deliveries during typical peak-traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; • Monitoring and management of driver fatigue; • Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment for Project-dedicated vehicles; and • Community outreach to communicate information relating to major delivery events or periods.	Social infrastructure and services, community health and wellbeing
Coordinate with relevant aviation authorities and stakeholders to understand peak Project-related utilization rates.	Social infrastructure and services
Use an established Safety, Security, Health, and Environment program to which all Project workers and contractors will be required to adhere to mitigate against risk of occupational hazards. Ensure all workers and contractors receive training on implementation of these principles and are required to adhere to them in the daily execution of their duties.	Occupational health and safety
Maintain an Oil Spill Response Plan to ensure an effective response to an oil spill, including maintaining the equipment and other resources specified in the Oil Spill Response Plan and conducting periodic training and drills.	All resources and receptors potentially impacted by an oil spill
Where reasonably practicable, direct lighting on FPSO and major Project vessels to required operational areas rather than at the sea surface or skyward. Ensure lighting on vessels adheres to maritime safety regulations/standards.	Seabirds, marine turtles
Provide screening for seawater intakes, if safe and practical, to avoid entrainment and impingement of marine flora and fauna.	Marine fish

˚C = degrees Celsius

2.14. Worker Health and Safety

EEPGL is committed to protecting the safety, security, and health of its employees, contractors, and the public, with a goal of *Nobody Gets Hurt*. Consistent with this commitment, the Project will employ a robust and effective management system to protect its Project workforce. EEPGL will implement its OIMS (see Section 2.4, Overview of the Development Concept) during each Project stage. This program is designed to manage occupational risks to Project workers and. Additional information regarding EEPGL's occupational safety and health program is provided in the Project ESMP.

2.15. Purpose and Need of the Project

The purpose of the Project is to achieve safe and efficient production of hydrocarbons from the reservoir in the Stabroek Block. The Petroleum Agreement (PA) between EEPGL, Hess Guyana Exploration Limited, CNOOC Petroleum Guyana Limited, and the Government of Guyana defines how revenues from the Project are to be shared between the parties. The Government of Guyana will begin receiving oil revenues when oil is produced.

2.16. Project Benefits

The Project will generate benefits for the citizens of Guyana in several ways:

- Through revenue sharing with the Government of Guyana, as detailed in the PA between the Government of Guyana and EEPGL et al., which was made available to the public in December 2017. The type and extent of benefits associated with revenue sharing will depend on how decision makers in government decide to prioritize and allocate funding for future programs, which is unknown to EEPGL and outside the scope of the EIA.
- By procuring select Project goods and services from Guyanese businesses in alignment with the PA and the EEPGL Local Content Plan approved by the Ministry of Natural Resources on 6 April 2018.
- By hiring Guyanese nationals in alignment with the PA and the EEPGL Local Content Plan.

In addition to direct revenue sharing, expenditures, and employment, the Project will also likely generate induced economic benefits. These induced benefits result from the re-investment, hiring, and spending by Project-related businesses and/or workers, which in turn benefits other non-Project-related businesses and generates more local tax for the government. These beneficial "multiplier" impacts are expected to occur throughout the Project life.

2.17. ALTERNATIVES

This section describes the alternatives to the proposed Project that were considered, including the following:

- Location alternatives
- Development concept alternatives
- Technology and process alternatives
- No-go alternative

2.17.1. Location Alternatives

The location of the offshore Project infrastructure, particularly the development wells and SURF hardware, is primarily driven by the location of the resource to be recovered. Accordingly, there are no feasible alternative PDA locations that could effectively recover the resource. However, within the proximity of the resource, there is some flexibility in selecting the location of the FPSO and associated mooring system. This section discusses the drivers for selecting an FPSO location and the alternative locations that were considered.

The Payara FPSO will be located approximately 20.3 kilometers (12.6 miles) and 22.7 kilometers (14.1 miles), respectively, northwest of the Liza Phase 1 and Liza Phase 2 FPSOs. The Payara Surface PDA will be separated by approximately 13 kilometers (8.1 miles) and 15.5 kilometers (9.6 miles), respectively, from the Liza Phase 1 and Liza Phase 2 Surface PDAs. The Payara Subsea PDA will be separated by approximately 3.4 kilometers (2.1 miles) and 6 kilometers (3.7 miles), respectively, from the Liza Phase 1 and Liza Phase 2 Subsea PDAs.

A key consideration in FPSO location is to minimize interference with four-dimensional (4D) seismic operations. To assist in maximizing resource recovery, EEPGL intends to perform 4D seismic over the Payara field. 4D seismic operations consist of regular, identical, high-resolution seismic shoots conducted at regular intervals throughout the life of the field. The data from this operation will allow EEPGL to assess the movement of fluid contacts over time, which will in turn support planning future drilling to target areas with remaining oil. The FPSO would represent an obstacle in gathering 4D seismic data, and would leave a “shadow” if it were located above the Payara field. It is therefore important that the FPSO is not located directly over the Payara field, in order to allow maximum coverage by 4D seismic.

A further factor for FPSO location related to 4D seismic is positioning the FPSO so as to facilitate efficient 4D seismic operations. The 4D seismic vessel must maneuver around the FPSO, and the FPSO location therefore needs to consider this, recognizing the challenges in maneuvering a seismic vessel and its approximately 10-kilometer (6.2-mile) array towed behind it.

Another consideration for the FPSO location is to avoid positioning FPSO anchor piles in areas that could create geotechnical challenges (e.g., maintaining a distance from any shallow canyons, seabed characteristics that indicate greater potential for rafted blocks, other features that could significantly increase the complexity and risk of anchor pile design and execution, etc.).

Additional considerations include assessment of seabed slopes relative to SURF layout, with preference for flowlines to ideally have an uphill run toward the FPSO. This is important in reducing system slugging[19], which can have material impacts on the design and operation of the FPSO.

The Project will require up to 45 wells, comprising a combination of producers and injectors. The bottom-hole location for each well will be selected to maximize recovery from the Payara field, based on extensive subsurface modeling. At the seabed, each well will be tied back to a manifold, which reduces the Project footprint and cost relative to tying back each well individually. Manifold locations are selected to minimize overall drilling length and hence drilling cost. Given the aerial extent of the Payara field and the technical limits of drilling reach, the geographic spread of the bottom-hole locations will be such that it will not be possible to reach them all from a single drill center. The Project will therefore use ten drill centers, each having manifolds for production and injection. The location of each manifold will be selected to minimize overall length of the drilling well paths (from seabed to bottom-hole) and hence minimize drilling cost, while also ensuring the well paths avoid shallow hazards and do not exceed the limits of drilling complexity.

There will be seven to eight producers/injectors at each drill center as part of the base development. However, provision has been made for four to five additional producers/injectors at each drill center to account for in-fill drilling[20] to improve overall recovery in the future. Attempting to include all producers/injectors into single production/injection manifolds would have result in very large subsea structures. Instead, each drill center will have two production manifolds and two injection manifolds. To improve execution efficiency, all the production manifolds are the same (six-slot), as are the injection manifolds (also six-slot). Furthermore, the Project production manifolds will be identical to those for the Liza Phase 1 and Liza Phase 2 projects, which will further improve design and execution efficiencies.

The manifolds will be tied back to the FPSO by flowlines, pipelines, and risers. Routing of flowlines/pipelines/risers between the manifolds and FPSO primarily seeks to minimize overall length while also avoiding clashing (e.g., between risers, umbilicals and mooring lines). Minimizing length not only minimizes Project cost but also Project footprint (and environmental impact).

With respect to onshore components of the Project, the preferred alternative from an environmental perspective is to use existing shorebases in Georgetown with sufficient capacity to meet Project needs. If additional shorebases are developed in the future by third parties through separate permitting processes, EEPGL will consider the potential benefits (environmental, technical, and economic) of using these shorebases in addition to or in lieu of the shorebases that currently exist.

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[19] A condition arising in oil wells and flowline risers, characterized by an intermittent two-phase flow regime (elongated bubbles of gas, separated by slugs of liquid)

[20] The addition of wells in a field that decreases average well spacing. This practice can both accelerate expected recovery and increase estimated ultimate recovery in reservoirs by improving the continuity between injectors and producers. As well spacing is decreased, the shifting well patterns can alter the formation-fluid flow paths and increase access to areas where greater hydrocarbon saturations exist.

2.17.2. Development Concept Alternatives

This section describes the following types of major development concept alternatives considered:

- Drilling facility alternatives
- Production facility alternatives
- Crude offloading alternatives
- Associated gas management alternatives

2.17.2.1. Drilling Facility Alternatives

The primary alternatives considered for development well drilling included a drill ship and a semi-submersible drilling rig. Drill ships allow for more efficient development operations as compared to semi-submersibles, given their increased variable deck load—which is critical due to multi-well drilling and completion equipment requirements. Drill ships also allow for faster transit speeds between drill centers, resulting in significant time-savings due to frequency of well movements during batch drilling[21] operations.

2.17.2.2. Production Facility Alternatives

Several different types of production facility alternatives were evaluated during the early stages of the design process. Fixed-leg platforms (facilities built on steel or concrete legs anchored directly into the seabed) are normally only found in water depth less than 500 meters (1,640 feet), so this type of design concept was screened out. Tension-leg platforms (floating facilities moored to the seabed by vertical steel tendons) can be used in greater water depths, but only up to water depths of approximately 1,500 meters (4,921 feet), so this type of design concept was also screened out. For water depths greater than 1,500 meters (4,921 feet), offshore developments normally use a floating structure. As the water depth in the PDA is in excess of 1,900 meters (6,233 feet), this left two feasible production facility alternatives for further screening: a semi-submersible structure (Figure 2.17-1) and an FPSO (Figure 2.17-2).

[21] The process of drilling the same sections (e.g., top-hole sections) of multiple wells sequentially before drilling begins on the next sections.

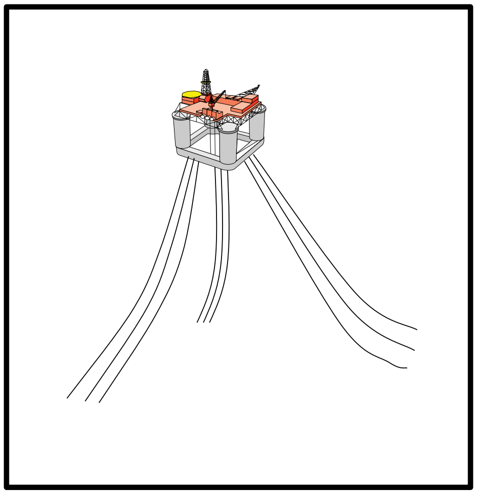

Figure 2.17-1: Semi-Submersible Platform

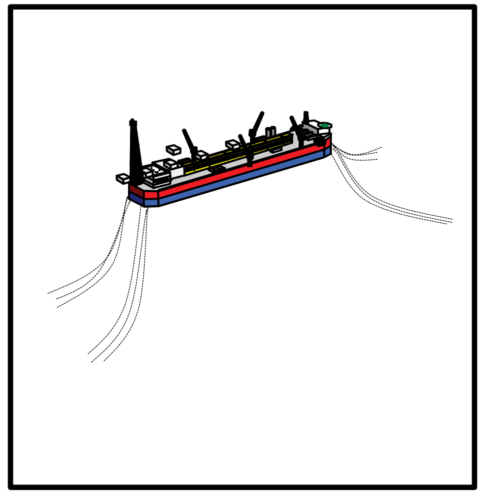

Figure 2.17-2: FPSO

Semi-submersible platforms use ballasted columns that extend below the surface of the ocean. These columns are connected to a surface deck above the water on which the production facilities are built. The columns used to support the operating platform can extend high above the wave height, allowing for semi-submersibles to operate in harsh environmental conditions. The deep draft of the vertical columns also helps to stabilize the structure. To keep the semi-submersible stationary, the columns are moored to the ocean floor with a spread-moored system.

FPSOs are typically ship- or barge-shaped, with the facilities for processing oil and gas built on the top deck and the oil stored in the vessel's cargo tanks. The two main construction methods are either converting an existing oil cargo tanker into an FPSO or building a new hull. Conversions limit the design and size of the topsides that can be integrated. New-build hulls allow for larger topsides.

There are several ways to moor an FPSO to the seafloor. For calmer sea states, spread mooring an FPSO, as pictured in Figure 2.17-2, is common. For harsher sea states, turrets can be installed that extend from the FPSO vertically down to the sea floor. The turret can either be integrated into the hull of the FPSO or affixed externally to the FPSO and the FPSO can "weather vane" around the turret depending on the direction of the current.

Regardless of the structure, the chosen facility for the Project would need to process the same volumes of oil, gas, and water. As such, topsides facilities are similar between an FPSO and a semi-submersible. The real distinction is the need for oil storage. An FPSO has storage integrated into its facilities. A semi-submersible would require an additional floating, storage, and offloading (FSO) facility to allow for the oil storage (Figure 2.17-3). The FSO adds cost above the FPSO design and a semi-submersible with an FSO would also require additional moorings as compared to an FPSO. The use of an FSO would thus significantly increase the Project offshore infrastructure, which would increase potential Project impacts on air quality (e.g., increased air emissions), marine water quality (e.g., additional wastewater effluent discharges), marine benthos (e.g., increased disturbance of the seafloor for the FSO mooring system), and marine use and transportation (e.g., additional marine safety exclusion zones for additional marine vessels). For these reasons, an FPSO was selected as the preferred production facility alternative for the Project.

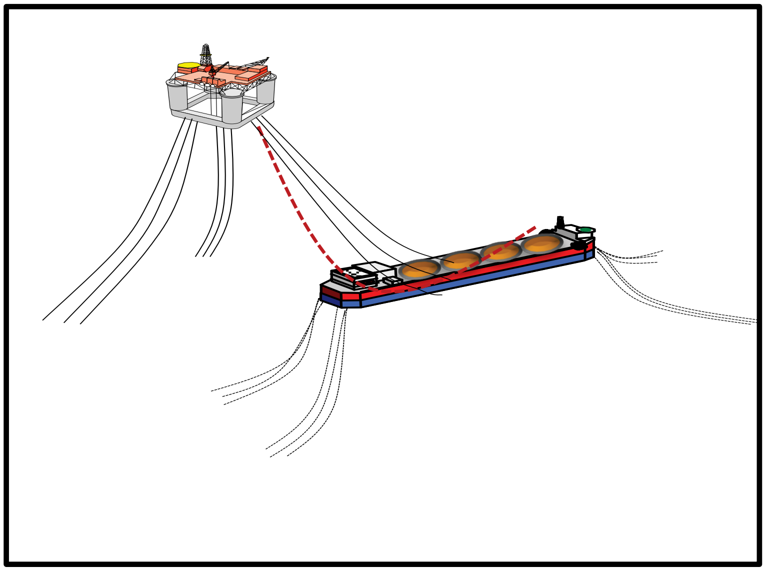

Figure 2.17-3: Semi-Submersible Platform with FSO

2.17.2.3. Crude Offloading Alternatives

With respect to commercialization of recovered crude oil, the principal alternatives for an offshore development are: (1) transmission to shore via subsea pipeline infrastructure to an onshore refining facility; and (2) offloading to export tankers for transport to onshore refining facilities located further from the resource than can be feasibly connected via pipeline infrastructure. As there are no existing petroleum refineries in Guyana or existing regional offshore pipeline infrastructure in close proximity, the only feasible alternative is offloading to export tankers for sale to existing refining facilities around the world.

During the Project design, two alternatives were evaluated for crude offloading to tankers: tandem offloading (having export tankers directly link to the FPSO for offloading), and using what is known as a catenary anchor leg mooring (CALM) buoy for offloading.

Tandem Offloading

Figure 2.17-4 shows a schematic of a tandem offloading operation. The bow of the tanker is connected to the stern of the FPSO via a hawser line. A marine hose string connects the mid-ship cargo manifold on the tanker to the stern of the FPSO for offloading of the crude oil.

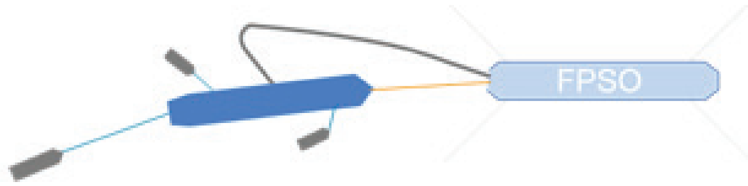

Figure 2.17-4: Schematic of Tandem Offloading from a Spread-moored FPSO

In this schematic, three tugs are connected to the tanker to keep the tanker on station during offloading. In most operations, only the single holdback tug pulling at the stern of the tanker is required. The second tug, shown pulling near the bow of the tanker, can provide additional station-keeping capacity in more demanding sea states. The third tug is on stand-by most of the time, and is typically only activated in special circumstances (e.g., breakdown of other tugs, significant change of weather, etc.).

Tandem offloading of crude oil is an industry-common practice. Based on extensive desktop study and marine/bridge simulations, it was confirmed to be a suitable option for the Project, with minimal anticipated deferred production on a yearly basis during peak production period. For off-peak production periods, the anticipated deferred production rate is negligible.

To further reduce risk associated with tandem offloading, the Project has incorporated several embedded controls representing significant improvements over typical industry practice, as noted in Table 2.17-1.

Table 2.17-1: Project Embedded Controls to Reduce Risk Associated with Tandem Offloading

Parameter	Payara FPSO	Industry Typical
Number of tugs	3	2
Holdback tug bollard pull capacity (ton)	120	~100
Separation distance from FPSO (meters)	120	~90
FPSO onboard metocean station?	Yes	No
Offloading hose type	Double carcass [a]	Single/dual/double carcass

[a] A primary carcass (the body of the hose) surrounded by a secondary carcass—in essence a hose within a hose. Both carcasses are independently secured to integral hose-end fittings.

CALM Offloading

CALM buoy offloading has been used in the industry for many years. With the CALM buoy method, the export tanker connects to a buoy some distance from the FPSO. The advantage of a CALM buoy is that the export vessel can “weather vane” around the buoy. This allows for export of crude during harsher weather, as it allows for a larger separation distance between the FPSO and the tanker (typically a few hundred meters). Figure 2.17-5 is a schematic of a CALM buoy offloading operation.

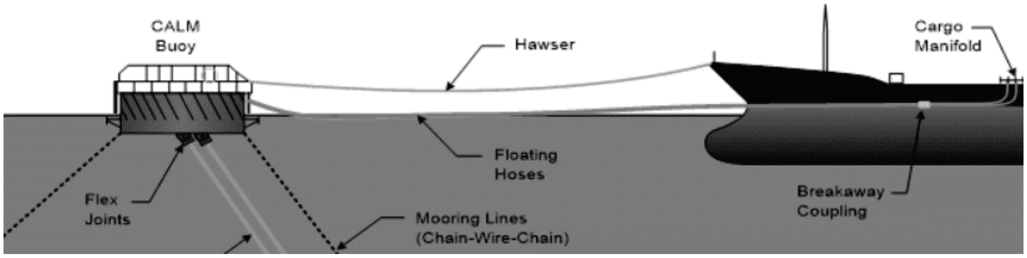

Figure 2.17-5: Schematic of Oil Offloading from a Deepwater CALM Buoy

Use of a CALM buoy for the Project faces a few key challenges due to the unique site-specific environments in the PDA:

- Site-specific currents—The deep current environment (with relatively high-speed currents from surface all the way down to 1,000+ meter [3,280+ foot] depth, and with sometimes current direction reversal at depth versus at the surface) would pose significant challenges to a flowline from the FPSO to the CALM buoy, possibly requiring risers and deep submerged/ subsea flow lines that would significantly increase the complexity and cost of the CALM buoy solution.
- Water depth—The PDA has a water depth of more than 1,900 meters (6,234 feet). Typically, the industry employs deepwater CALM buoys in water depths of 1,000 meters (3,280 feet) or less. The much deeper water depth would require larger/stronger mooring system, which in turn may require a larger CALM buoy to provide sufficient buoyance for the mooring system.
- Footprint—A CALM buoy would increase the Project's environmental footprint relative to tandem offloading. The CALM buoy may be moored in a similar top chain (polyester rope) bottom chain—pile configuration as that of the FPSO. To provide sufficient station-keeping capability to the CALM buoy, a nine-line mooring system (i.e., three groups of three configuration) could be required, which would bring the additional mooring footprint to a level at the same order as the footprint for the FPSO mooring system.
- Piles—For each additional mooring line, a seabed pile will be required. The large dynamic motion of the CALM buoy may lead to concerns related to potential pile trenching. CALM buoy pile trenching is a greater concern than for FPSO mooring piles, where the dynamic motion of the FPSO is much smaller.
- Cost—Overall, the additional cost associated with a CALM buoy does not justify the savings associated with the minimal anticipated deferred production for the tandem offloading option during the peak production period.

Based on the considerations noted above, tandem offloading was selected as the preferred crude offloading alternative.

2.17.2.4. Associated Gas Management Alternatives

The Payara field contains material quantities of associated gas. A key use for this associated gas is for use as fuel on the FPSO. This includes use in gas turbines for power generation and in heaters for managing process temperatures. Gas not used as fuel is then available for alternative uses. The three primary alternatives considered for use of associated gas include flaring, reinjection, and export.

Flaring of associated gas is a method to deal with natural gas production in oil developments, but introduces significant environmental considerations. Subsurface studies indicated significant value in gas re-injection for reservoir pressure maintenance and recovery uplift purposes, thus supporting related facilities investment.

From a facilities perspective, given the relatively high pressure of the Payara field, the gas compression required for reinjection is considerable. EEPGL worked extensively with leading gas compression contractors on studies that ultimately confirmed the technical feasibility of reinjecting gas into the Payara field.

From a subsurface perspective, it was important to assess the implications of gas reinjection on reservoir recovery. A key concern was that reinjected gas would be immiscible (i.e., with a tendency to remain separated from the liquid phase in the reservoir) and therefore move quickly through the reservoir back to the production wells, resulting in significant gas cycling, with considerable negative implications for oil production. However, subsurface studies established that the associated gas at Payara is miscible with the reservoir fluid for several of the developed reservoir segments. This not only reduces gas cycling, but it also means that use of gas reinjection—particularly as part of a water-alternating-gas strategy—results in considerable uplift in recovery.

Gas export options were also considered. There is currently a very limited gas industry in Guyana, not enough to consume the quantities of associated gas that will be produced from the Project (expected to peak at around 395 MMscfd). It was therefore not possible to export associated gas from the Project without substantial new infrastructure such as power generation, liquefaction technology, and/or chemicals. Furthermore, it is important to note that export of associated gas is often challenged by the fact that the gas is not produced independently and therefore does not provide the long plateau (10+ years) typically required to support new gas infrastructure. This means that it would be highly likely that even if a feasible gas export alternative was available, gas reinjection would still be required to balance associated gas production with the demands of the gas export facility.

Gas reinjection was ultimately selected for associated gas management due to the additional oil recovery it provides, the environmental advantage it represents as compared to flaring, and the limited availability of gas export options. However, while gas reinjection is the preferred alternative for associated gas management, it is recognized that future gas export options may become available. While gas export facilities would not be initially installed on the Payara FPSO due to strategy to maximize gas injection, they can be added if future gas export from Payara is pursued. Any future gas export would be considered a separate project.

2.17.3. Technology Alternatives

EEPGL is using the most appropriate industry-proven technologies in developing the Project, in terms of well drilling, drilling fluids, equipment selection, development concepts, and environmental management. EEPGL's parent company ExxonMobil and its contractors have extensive experience in delivering offshore deepwater development projects around the world, particularly with FPSO and SURF components, and are applying that knowledge, experience, and technology in the development of this Project.

In alignment with the Guyana Environmental Protection Act Part IV: Environmental Impact Assessments, Requirement of Environmental Impact Assessment, "the developer shall have an obligation to use the most appropriate technology" and to further provide "a description of the best available technology." This section outlines the fundamental basis of decision making for key equipment and environmental performance criteria and what EEPGL considers best available technology (BAT) considering technical and commercial considerations. In this respect, EEPGL has referred to the following condition from the Liza Phase 1 and Phase 2 Environmental Permits when making BAT decisions for the Project:

> "The best available techniques, which consider economic and technical feasibility, as well as the facilities and controls described in the EIA, shall be used to prevent or mitigate pollution in relation to any aspect of the operation."

EEPGL has considered the following aspects when making BAT design and operational decisions:

- Technology options and selection
- Feasibility evaluation
- Economic evaluation
- Regulatory requirements/benchmarking
- Environmental aspects and impacts
- Discussion and conclusion

The sub-sections below describe the BAT decision process undertaken for the following technology aspects:

- Drill cuttings
- Gas processing
- Injection compressors
- Power generation
- Produced water
- Sulfate removal

2.17.3.1. Drill Cuttings

Options and Techniques—Choice of Drilling Fluid

When considering the choice of drilling fluid for deepwater operations, the options are drilling with WBDF or NADF. WBDF are not commonly used in deepwater drilling. At these conditions, the WBDF experiences low-temperature conditions at the seafloor, typically less than 5°C (41°F), and high pressure from the weight of the drilling fluid (in excess of 1,500 psi). This allows ice-like crystals (so-called hydrates) to form in the presence of gas and potentially plug the safety control devices located near the seafloor. The WBDF has to be formulated using suitable inhibitors, consisting of a combination of salt and glycols. Formulations of such WBDF have been reported in the literature, but for many operators, risk management and well safety has led to the choice to use NADF. Next to well control, borehole stability is a priority to the well construction. WBDFs, through the flow of water and chemicals into the formation, destabilize the formation over time and may lead to the loss of the wellbore through severe borehole instability. The lubricity of WBDF is low and, even with the use of lubricants, limits the reach of development wells, requiring more drill centers to access and produce the hydrocarbon reservoirs. Some physical limitations of the WBDF such as a lower solids tolerance and a lower solids control efficiency of the rig equipment compared to NADF make the typical waste volume generated approximately twice as large as for a typical NADF.

Such limitations and risks are not present in a typical NADF. Risk mitigation leads to NADF being the most frequently used drilling fluid in deepwater operations. A properly formulated NADF does not promote the formation of ice-like crystals, and the lubricity of the NADF allows longer and higher deviation wells to access hydrocarbon reserves from fewer drill centers. A typical NADF does not invade into the formation and also ensures and maintains safety through borehole stability during drilling all well sections below the conductor casing. While the technical advantages of NADFs are undeniable, the environmental life cycle of the chosen drilling fluid also needs to be considered.

Options and Techniques—Effect of Base Oil

Early applications of NADF cuttings discharges using diesel and other low-refined base oils in shallow water depths showed cuttings piles in the near vicinity of the drilling location and slow recovery from the drilling impact. This led to the development of incrementally refined enhanced mineral oils and low toxicity mineral oils. An important study by the IOGP (2003) found that the environmental impact of the discharged cuttings can be largely categorized in three groups based on the type of base oil used:

- Group I with high aromatic content such as diesel and conventional mineral oil based fluids. These fluids have a high aromatic content (greater than 5 weight percent [wt%]) and polycyclic aromatic hydrocarbons (PAH) greater than 0.35 wt%.
- Group II base oils with medium aromatic content have between 0.5 to 5 wt% and PAH between 0.001 and 0.35 wt%.

- Group III base oils, which include synthetic base oils and highly refined base oils with aromatic content less than 0.5 wt% and PAH less than 0.001 wt%. While differences in the environmental performance between the synthetic and highly refined base oil in Group III exists, they were not considered significant enough to warrant a separate group classification.

A follow up to the IOGP 2003 report 13 years later (IOGP 2016b) reviewed additional studies that investigated the effects of IOGP Group III NADF cuttings discharge. It showed that the effects on the seafloor are primarily from burial, concentrated in a 250-meter (820-foot) radius from the well site. In most studies, the recovery usually started after drilling activity was ceased, and was often well-advanced within a year from the deposition. The effects were largely lower in water depths deeper than 600 meters (1,968.5 feet). No bioaccumulation of Group III NADF and its constituents has been reportedly observed. Note that PAH in Group I and Group II base oils have been reported to bioaccumulate.

Options and Techniques—Cuttings Discharge

After going through the standard solids control equipment on the rig, cuttings made with NADF contain residual drilling fluid. Additional methods are used to remove the excess drilling fluid from the cuttings and make them suitable for disposal.

The disposal methods include offshore discharge or cuttings are transported to shore, treated, and disposed there. While transport to land may limit the impact offshore, transportation, emissions from transportation, treatment, and disposal onshore have an impact on the environment and require a mature infrastructure for transportation, handling, and treatment of the cuttings.

Other approaches treat cuttings offshore by reducing the oil retained on cuttings. The NADF and base oil are selected such that the remaining base oil and additives have minimal impact on the environment. The plume from the cuttings discharge and deposited cuttings beds are modeled to assess the feasibility of discharge and potential impact. Water depth and water movement are considered in such studies. These studies verify that cuttings beds that are deposited in the vicinity of the drilling location allow the benthic community to recover in a reasonable time.

Various techniques exist to treat cuttings and reduce the non-aqueous base oil on cuttings; the applicability of these techniques are discussed in detail elsewhere (IOGP 2016a). Of these techniques, two offshore applications are noteworthy for their ability to reduce base oil retained on cuttings, namely the cuttings dryer and thermo-mechanical desorption.

Thermo-mechanical desorption treatment generates large heat from friction, which in turn evaporates the fluid retained on cuttings. Using this method, the base oil retained on cuttings can be reduced to less than 1 wt%. This technically proven method requires a large space for installation on the rig site, and may not be suitable for many rigs without re-engineering the deck space to retrofit the equipment and buffer storage, as the real-time processing rate is less than the rate of cuttings generated in the larger boreholes. The reported rate of cuttings treatment is 3.5 to 5 tonnes per hour. The significant energy consumption to generate the heat may also generate emissions and volatile organic compounds.

Another more commonly used technique is the usage of so-called cuttings dryers. Using this method, the base oil retained on cuttings can be reduced to less than 6.9 wt%, as required by many regulations, suitable for discharge offshore. Cuttings dryers can be readily installed on most rigs; the hourly processing rate is between 45 to 65 tonnes per hour (depending on model). Emissions and energy consumption are moderate to low.

Feasibility and Economic Evaluation

The availability of materials at a sustainable cost is an important consideration. Thermo-mechanical desorption methods are frequently applied onshore, and less often offshore. The space requirements and slower rate of treatment make it more suitable for treatment off the critical path schedule. There are several suppliers of the treatment for onshore applications; at the time of this report, there are two companies that offer offshore treatment with this method, and only one of the providers has a proven track record to reliably treat and dispose the cuttings offshore. Since its first introduction in the 1990s, the cuttings dryer technology has been proven to be a reliable technology, capable of reducing the base oil retained on cuttings in real time, as the cuttings are generated. The treatment is reliable and available from several providers.

Feasibility in terms of availability, rig installation, and energy consumption is also an important consideration. At superficial observation, the thermo-mechanical desorption unit appears just somewhat larger than the set-up of a cuttings dryer. However, the differentiating performance is in the energy consumption and rate of treatment. The average 3.5 to 5 tonnes per hour thermo-mechanical unit operates at 950 kilowatts, whereas a conventional cuttings dyer uses less than 10 percent of this amount of energy, around 60 to 75 kilowatts. Examining the rate of treatment, average rates of cuttings generations should be considered. For example, in a typical well construction, NADF usage starts at the 17½-inch-diameter hole interval. The rate of penetration is, on average, 30 meters per hour (100 feet per hour). Assuming the wet cuttings that return have an equal amount of NADF and rock, the drilling operation generates 14 to 17 tonnes per hour. This exceeds the capacity of the thermo-mechanical unit and the excess rock plus fluid have to be stored, every hour, for the entire interval until the unit can catch up. For a length of interval of 1,500 meters (4,921 feet), it takes 50 hours to drill and requires on-site storage of 650 to 800 tonnes of cuttings because the equipment cannot keep up with the drilling progress.

Regulatory Requirements/Benchmarking

Drill ships are not considered new facilities per the World Bank Environmental, Health, and Safety (EHS) Guidelines (World Bank 2007) as they are existing equipment and are selected and contracted for global deepwater exploration, appraisal, and development drilling by multiple clients/operator as an existing commercially available vessel for such drilling operations. Use of IOGP Group III NADF, solids control, and cutting-dryer systems as used by all drill ships operation by EEPGL offshore Guyana is fully consistent with global deepwater drilling programs with a maximum residual non-aqueous base oil 6.9 percent by weight wet cuttings average per well. This performance criteria is also consistent with the June 2015 World Bank Group Environmental Health and Safety Guidelines for Offshore Oil and Gas Development (World Bank 2015). This performance criterion of 6.9 percent is also consistent with multiple regulatory jurisdictions and global drilling operations across multiple countries including Guyana (via environmental permit conditions) and the United States–Gulf of Mexico (via regulations).

The use of solids control and cuttings dryer systems such as those on the drills ships currently being used in Guyana (e.g., *Stena Carron*, *Noble Tom Madden*, and *Noble Bob Douglas*—all considered existing facilities) are consistently achieving an average by wet weight residual NADF on cuttings of 3.5 percent with a range of 2.36 percent to 3.82 percent per well. The drilling cuttings requirements of the EPA-issued Liza Phase 2 Development Project environmental permit are consistent with those of the EPA-issued Liza Phase 1 environmental permit. These performance criteria are also consistent with the World Bank (2015) guidelines with regard to existing facilities (applicable to offshore rigs deployed for development well programs).

Guyana does not have any specific regulations on drill cuttings discharge offshore. As such, requirements are identified, reviewed, and approved in the environmental impact assessment and supporting ESMP, and further described and enforced under the final executed environmental permit. Therefore, EEPGL will ensure that drill ships use solids control and cuttings dryer systems to treat cuttings, such that, for discharged cuttings, end of well maximum weighted mass ratio averaged over all well sections drilled using NABF does not exceed 6.9 percent wet weight base fluid retained on cuttings.

Also, in alignment with the Liza Phase 1 and Liza Phase 2 environmental permits, EEPGL is and will continue to (1) visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings; (2) prohibit the discharge of cuttings generated using drilling fluids that contain conventional mineral oil (IOGP Group I), except when the mineral oil is used as a carrier fluid (transporter fluid), lubricity additive, or pill; and (3) for well sections requiring NADF, use only low-toxicity IOGP Group III base fluid.

Environmental Aspects and Impacts

As described in the Liza Phase 1 and Liza Phase 2 EIAs and this EIA, EEPGL will mitigate impacts from NADF cuttings discharges by well as follows:

- Use low-toxicity IOGP Group III NADF and manage in accordance with the associated safety data sheet.
- Use solids control and cuttings dryer systems to treat cuttings such that end of well maximum-weighted mass ratio averaged over all well sections drilled using non-aqueous fluids shall not exceed 6.9 percent wet weight base fluid retained on cuttings.

As reflected in the Liza Phase 1, Liza Phase 2, and Payara EIAs and supporting cuttings discharge modeling, the significance of impacts on marine benthos as well as water and sediment quality is considered Negligible when using the 6.9 percent by wet weight concentration of NABF on cuttings through existing solids control and cutting dryer systems. Furthermore, actual drilling operations are consistently achieving an even lower average of less than 4.0 percent. This conclusion is also consistent with published investigations of the fate of cuttings in offshore discharges (IOGP 2016).

The wellheads will be clustered around major drill centers rather than being distributed over the seabed above the producing reservoirs. This approach reduces the number of drilling locations, thereby reducing the seabed area potentially affected by drilling operations, including discharge of drill cuttings. The planned development drilling program and its cuttings management approach are consistent with industry practices and have previously been the basis for exploration wells in the Stabroek Block; they are also the basis for the development wells for the Liza Phase 1, Liza Phase 2, and Payara Development Projects.

The embedded controls in the Project design that will reduce the potential impact of drilling discharges on sediment quality include: (1) use of WBDF to the extent reasonably practicable (for drilling of initial open-hole well sections), and (2) use of IOGP Group III NADF in all other cases. WBDF contains no hydrocarbons; accordingly, no treatment of WBDF-based cuttings is required. When NADF is used, the discharge of treated cuttings will be controlled such that residual base fluid content on discharged cuttings will average no more than 6.9 percent (wet weight). The NABF to be used in the NADF will be IOGP Group III, with low to negligible aromatic content, reducing the potential that changes in sediment quality as a result of discharge of the treated cuttings will lead to potential toxicological impacts on benthic fauna.

Discussion and Conclusion

The drill ships supporting the Liza Phase 1, Liza Phase 2, and Payara Development Projects will utilize a performance criteria for overboard discharge of NADF which does not exceed 6.9 percent wet weight base fluid retained on cuttings average by well. This performance criterion is consistent with the World Bank guidelines for existing facilities (World Bank 2015), as well as performance criteria and industry practice in other jurisdictions.

2.17.3.2. Gas Processing

Three primary alternatives were considered for addressing associated gas produced during operations: gas export, continuous flaring and gas reinjection. Gas export alternatives for future development continue to be evaluated, with due consideration of the challenges related to commercialization of associated gas. Gas export alternatives would be managed as a separate project and would also have separate environmental authorization. Continuous flaring of gas is not preferred, primarily due to the associated air emissions, and is not aligned with ExxonMobil's internal policy expectation that continuous gas flaring should be avoided. Gas re-injection was determined to be feasible, and it also provides benefits in terms of reservoir management by helping to maintain pressure in the reservoir (thereby increasing the amount of crude oil that can be recovered over time) and reduced air emissions (as compared to continuous flaring). Another alternate injection method to maintain reservoir pressure is water injection. However, water injection increases power demand, which would generate more carbon dioxide emissions than gas injection due to increased water injection capacity requirements.

To re-inject gas into a reservoir, the gas temperature, pressure, and composition have to meet the reservoir injection requirements. The gas treatment process includes heat exchangers and compressors to achieve desired injection conditions. For the Guyana projects, several stages of compression are included in the design. Moreover, natural gas usually contains significant amounts of water vapor. This water must be removed to mitigate the risk of flow capacity issues, hydrate formation, and corrosion issues in downstream systems. Thus, the gas treatment process also includes a dehydration unit. The gas dehydration technology selection has an impact on energy consumption, and therefore greenhouse gas (GHG) emissions.

Technology Options and Selection, Technical Feasibility, and Economic Feasibility

Three gas-dehydration processes were considered: absorption dehydration (e.g. triethylene glycol [TEG] absorption), adsorption dehydration (solid desiccant adsorption, e.g., molecular sieve), and condensation.

Absorption Dehydration: The process scheme is illustrated in Figure 2.17-6. In this method, process water is absorbed by TEG. Absorption is done in a glycol contactor (tray column or packed bed) by countercurrent flow of wet gas (at 20 to 35°C) and TEG. TEG is enriched by water and flows out in the bottom of the contactor, then runs through the flash drum and heat exchanger into the reboiler. In the reboiler, the water is boiled out. Regenerated (lean) TEG is then recycled through a heat exchanger back into the top of the TEG contactor.

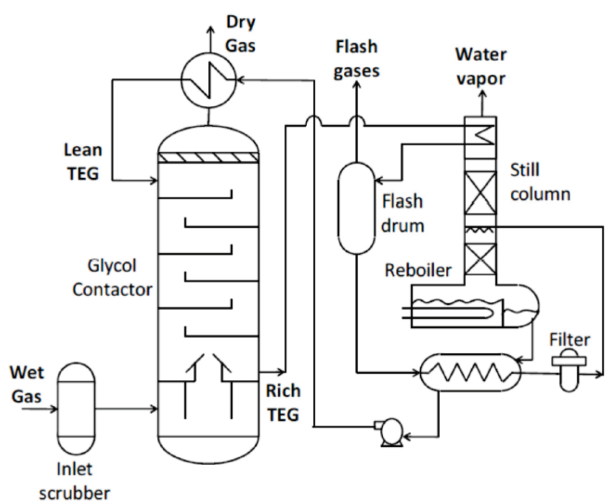

Figure 2.17-6: Process Scheme of TEG Absorption Dehydration

Adsorption Dehydration: In this method, solid desiccants (e.g., mole sieve, silica gel, or alumina) are used to adsorb water. As a minimum, two beds are used. Typically, one bed is drying gas and the other is being regenerated. Regeneration is done by preheated gas, as is shown in Figure 2.17-7 below (Netusil and Ditl 2010). Typically, adsorption dehydration is applied in situations where extremely low dehydration specifications are required, such as natural gas liquids (NGL) recovery or liquefied natural gas production. Project requirements do not require this level of gas dehydration.

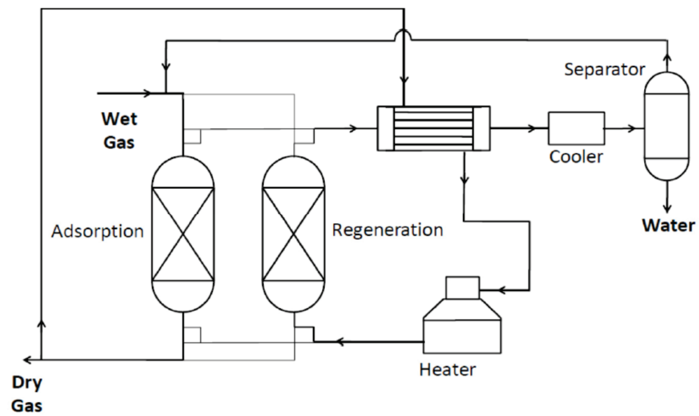

Figure 2.17-7: Process Scheme of Adsorption Dehydration Process

Condensation Dehydration: This method (Figure 2.17-8) employs gas cooling in order to condense water molecules into the liquid phase and then separating the water condensate from the gas stream (Guo and Ghalambor 2005). NGLs and condensed heavy hydrocarbons can also be recovered from the gas stream by cooling. Therefore, the condensation method is usually applied for simultaneous dehydration and recovery of NGLs.

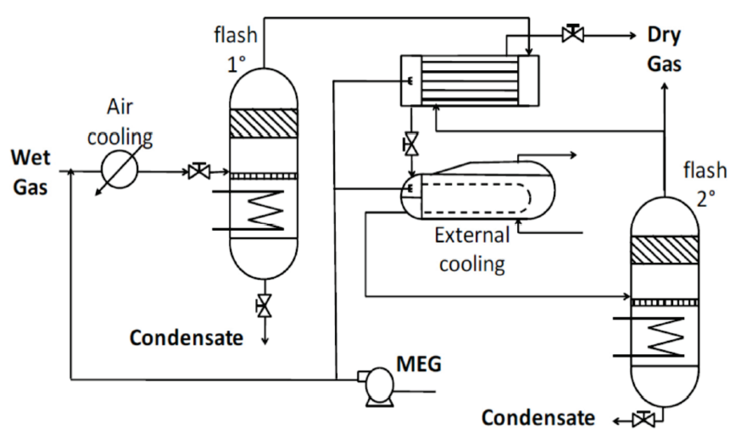

Figure 2.17-8: Process Scheme of Condensation Dehydration

To choose a suitable gas dehydration technology for the FPSO, several factors were evaluated including the water content specification of the gas after dehydration, size, and weight of the dehydration equipment, etc. The size and weight of the dehydration process corresponds with the capital expenditure (CAPEX) required to install the equipment. Gas dehydration system energy consumption corresponds with operational cost.

The absorption dehydration system (i.e., TEG) has the lowest weight and space requirements and is therefore the lowest CAPEX technology that meets the Project gas dehydration specification.

Figure 2.17-9 compares the energy consumption of these three gas dehydration technologies. The energy calculations were performed on a model where 105 Nm^3/hour[22] water-saturated natural

[22] normal cubic meters per hour

gas is processed at 30°C. In this comparison, the required outlet concentration of water in natural gas was set at a dew point temperature of -10°C at a gas pressure of 4 megapascal (MPa). The blue dashed line on the graph indicates the approximate operating pressure (9.6 MPa) of the dehydration process for Guyana projects.

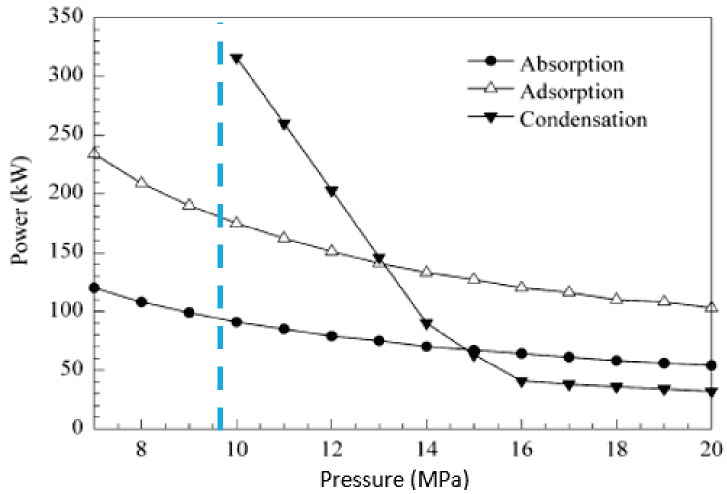

Figure 2.17-9: Modeling Results of Energy Consumption for Each Dehydration Method

Based on the total energy consumption, the most efficient dehydration operation is the absorption dehydration method (TEG) for the Project process conditions and gas dehydration specification. Thus, the Project selected the absorption dehydration method (TEG), as this technology has the lowest CAPEX and the lowest energy use of the considered options. The use of TEG gas dehydration in this application is consistent with Good International Oil Field Practice (GIOFP).

Regulatory Requirements/Benchmarking

The World Bank has established EHS guidelines for offshore oil and gas development (World Bank 2015) and EHS general guidelines (World Bank 2007), which are technical reference documents with examples of good environmental practices. The offshore guideline states that new facilities should be designed, constructed, and operated so as to avoid routine flaring. The guideline also states that methods for controlling and reducing fugitive emissions should be considered and implemented in the design, operation, and maintenance of offshore facilities and leak detection and repair (LDAR) programs should be implemented. The general EHS guidelines (World Bank 2007) state that the generation and release of emissions of any type should be managed through a combination of:

- Energy use efficiency;
- Process modification;
- Selection of fuels or other materials; and
- Application of emissions control techniques.

While the World Bank is not involved in the Project, the EEPGL gas processing system has been designed consistent with the good practices identified in the offshore oil and gas and general World Bank guidelines.

Conditions of the Liza Phase 1 and Liza Phase 2 environmental permits state:

- Implement internationally recognized methods for controlling and reducing fugitive emissions in the design, operation, and maintenance of facilities to maximize energy efficiency; and
- Design facilities for the lowest energy use.

Based on the above guidelines and requirements, the FPSO gas processing system was designed to ensure compliance with Project permits, maximize energy efficiency, and minimize environmental impacts.

Environmental Aspects and Impacts

As described above, alternatives were considered for addressing associated gas produced during operations: gas re-injection, continuous flaring, and gas export. Continuous flaring of associated gas would have significantly increased GHG and other air emissions from the FPSOs, so this option was not selected. Additionally, gas export is more energy intensive than re-injecting gas. Gas export options would require additional study and, if pursued, would be managed as a separate project with separate environmental authorization. Therefore, the re-injection of gas is the most environmentally beneficial option from an energy use and flaring perspective, which required a gas processing system.

As outlined in the World Bank general EHS guidelines (World Bank 2007), energy efficiency options should be evaluated. Various gas-processing systems were evaluated, and it was determined that the use of the absorption dehydration method (TEG) as the gas processing dehydration technology is the least energy intensive option, which also means it has the least GHG impact of the technology options considered.

Discussion and Conclusion

The gas-processing system has been designed and will be operated consistent with the World Bank EHS guidelines (World Bank 2007) described above and to ExxonMobil internal environmental standards. EEPGL has designed and will operate the Project FPSO consistent with these guidelines as well as the Guyana EPA Environmental Protection Act and the associated Environmental Permit requirements. EEPGL's decision was based on a defined decision making process including the evaluation of technical feasibility, economics, regulatory requirements, environmental impacts and industry practice.

2.17.3.3. Injection Compressors

Technology Options and Feasibility and Economic Evaluation

Three alternatives were considered for addressing associated gas produced during operations: gas re-injection, continuous flaring, and gas export. Continuous flaring of gas is not preferred, primarily due to the associated air emissions, and is not aligned with ExxonMobil's policy expectation that continuous gas flaring should be avoided. Gas re-injection was determined to be feasible, and also provides benefits in terms of reservoir management by helping to maintain pressure in the reservoir (thereby increasing the amount of crude oil that can be recovered over time) and reduced air emissions (as compared to continuous flaring). Gas export alternatives for future development continue to be evaluated, with due consideration of the challenges related to commercialization of associated gas. Gas export alternatives would be managed as a separate project and would also have a separate environmental authorization.

In addition to the challenges related to the commercialization of associated gas, exporting gas reduces the amount of associated gas available for re-injection into the reservoir, thereby negatively impacting oil recovery due to a reduction in the reservoir pressure over the field life. This reduction in reservoir pressure could be offset by increasing the seawater injection system capacity. If all the associated gas was exported instead of being re-injected, the seawater injection system capacity would increase by approximately 200,000 barrels per day, nearly doubling the current seawater injection system capacity. This additional capacity would require additional power and additional equipment (filters, sulphate reduction packages, pumps) to deliver this incremental capacity resulting in higher CAPEX. From an energy consumption standpoint, gas injection requires approximately 30 percent less power as compared to seawater injection, which results in lower emissions over the life of the Project.

High-pressure injection compressors (pressure greater than 500 bars) are at the edge of industry experience. Several manufacturers were evaluated during concept selection to ensure manufacturers could safely and reliably build the compressors required for the Project. Three suppliers were qualified based on their experience in building compressors for the required pressures and flow rates. Once qualified, a standard bidding process was used to select the final supplier.

In addition to evaluating manufacturer's experience, the compressor design was audited by subject matter experts to assess safe and reliable design. Furthermore, a full-pressure, full-load hydrocarbon test[23] will be conducted on the compressors at the manufacturer's shop to prove that the performance of the compressor meets the design requirements.

The compressors use dry gas seals to seal the compressor and minimize risk of leakages. The dry gas seals are equipped with instrumentation that alerts the operator and shutdown the compressor in case of damage to the seal. The seals are supplied with a primary and backup source of clean dry gas.

Regulatory Requirements

The Guyana Environmental Protection Act has not established flaring standards. As such, EEPGL considered World Bank standards and internal ExxonMobil environmental standards as references. The World Bank has established EHS guidelines for offshore oil and gas development (World Bank 2015), which is a technical reference document with examples of

[23] American Society of Mechanical Engineers—Performance test code 10 (ASME PTC-10) type I

good environmental practices. The offshore guideline states that new facilities should be designed, constructed, and operated so as to avoid routine flaring. The guideline also states that methods for controlling and reducing fugitive emissions should be considered and implemented in the design, operation, and maintenance of offshore facilities and LDAR programs should be implemented.

ExxonMobil internal environmental standards establish a design approach to reduce flaring emissions, which provides guidance that facilities should be designed to avoid routine flaring of associated gas and include an evaluation for the most advantageous use of alternatives for managing associated gas, which would otherwise be flared.

The Liza Phase 1 and Liza Phase 2 Environmental Permits issued by the EPA in 2017 and 2019 respectively, have the following conditions:

- Implement internationally recognized methods for controlling and reducing fugitive emissions in the design, operation, and maintenance of offshore facilities and onshore support activities conducted by the Permit Holder or its dedicated contractors to maximize energy efficiency and design facilities for lowest energy use. The overall objective is to reduce air emissions.
- Operate all mechanical equipment in accordance with the manufacturer's specifications.
- Routine flaring and venting are prohibited on the FPSO.
- Re-inject gas into the reservoir or utilize as fuel gas on the FPSO during normal operations.
- Implement inspection, maintenance, and surveillance programs to identify and prevent unplanned emissions to atmosphere onboard the FPSO.

EEPGL elected to follow the World Bank guidelines (World Bank 2015) and internal environmental standards for the design of the injection compressor system to ensure the BAT was selected and to meet permit requirements.

Environmental Aspects and Impacts

As described above, alternatives were considered for addressing associated gas produced during operations: gas re-injection, continuous flaring, and gas export. Continuous flaring of associated gas would have significantly increased GHG and other air pollutant emissions from the FPSOs, so this option was not selected. Additionally, gas export is more energy intensive than re-injecting gas. Therefore, the re-injection of gas using compressors is the most environmentally beneficial option from an energy use and flaring perspective.

Fugitive emissions from compressors are another source of potential air quality impact. Consistent with best practices outlined in the World Bank EHS guidelines (World Bank 2007) and GIOFP for fugitive emissions, EEPGL will control fugitive emissions from the injection compressors by implementing a LDAR program that regularly monitors to detect leaks, and repairs any leaks identified within a defined time period. Implementing an LDAR program will minimize impacts associated with volatile organic compounds and GHG emissions.

Discussion and Conclusion

The use of injection compressors to inject associated gas into the reservoir for reservoir management is consistent with GIOFP and the World Bank EHS offshore guidelines (World Bank 2015). EEPGL has designed and will operate the Project FPSO consistent with these guidelines as well as the Guyana EPA Environmental Protection Act and the associated Environmental Permit requirements. EEPGL's selection of the injection compressors was based on a defined decision making process including the evaluation of technical feasibility, economics, regulatory requirements, environmental impacts and industry practice.

2.17.3.4. Power Generation

Technology Options and Feasibility and Economic Evaluation

The power-generation system was selected for the Project after taking into account technical feasibility and economic evaluations with a consideration of regulatory requirements and predicted environmental impacts. The power-generation system has been designed consistent with GIOFP and will be operated consistent with internationally recognized environmental performance criteria for the offshore oil and gas industry.

Power demand for the FPSO was estimated on anticipated flow rates from multiple reservoir scenarios. Several cases were evaluated for optimum configuration of electric consumers of the major loads. The electric power demand for the FPSO was estimated, and based on that power demand, potential options for power generation were evaluated.

Options considered for power generation included reciprocating engine-driven generators and turbine-driven generators. Nuclear, wind, wave energy, etc. were ruled out as technically infeasible power sources due to distance from shore, requirement for a steady power supply, and lack of existing infrastructure. Steam turbines in single cycle as an overall power-generation method were ruled out given low thermal efficiency and in combined cycle given increased weight, space, and water-treating requirements. Gas turbines are the industry-preferred method of generating electricity in the required power range for offshore applications. This is because turbines require a smaller footprint and require less maintenance compared to reciprocating engines. For example, several additional reciprocating engines would be required compared to the number of required turbines; this incremental equipment would negatively impact the FPSO equipment layout. Based on the CAPEX and operating expense (OPEX) drivers mentioned above, turbine-driven generators were selected for power generation service.

Once turbines were selected as the preferred power-generation source, individual turbine capacity was evaluated to minimize footprint while providing a reliable power source that achieved the required power demand. To provide continuous power in an isolated offshore location, the standard practice is to install power generation in an "N+1" configuration. This means that there is an installed spare generator, such that during planned and unplanned generator outages, production is not impacted. Additionally, to ensure reliability of the power generation and distribution system, the system is split into two electric buses and at a minimum two generators supply the base load to provide load-shedding capabilities in case of upsets.

Therefore, to ensure reliability and minimize the equipment footprint, a “3+1” configuration was selected. This provided a small footprint and cost efficiencies from building two identical modules as well as the required reliability for the power-generation system.

Turbines were evaluated further to ensure selection of the BAT. There were several options evaluated, which included industrial and aero-derivative turbines. Aero-derivative turbines were selected over industrial turbines due to the higher efficiency resulting in an approximate 5 to 6 percent reduction in fuel consumption. This resulted in approximately 1.5 million standard cubic feet per day (MMscfd) reduction in fuel consumption at peak load, thereby reducing GHG emissions.

Available fuel sources (diesel and natural gas) for the turbines were also evaluated taking into consideration operating expense and emissions impacts. Natural gas will be readily available offshore and is the cleanest-burning and lowest-cost source of fuel and was therefore selected as the primary source of fuel for the gas turbines.

Additionally, the turbines are designed with dual-fuel capabilities to run on diesel when natural gas is not available during FPSO shutdowns or process upsets. The turbines are designed to switch automatically to diesel in case of upset in the fuel gas system. This increases the uptime of the facility, which reduces the overall emissions by reducing flaring caused by startup and shutdown of the facility.

To further increase energy efficiency of the FPSO, the option of using waste heat recovery was selected. Waste heat recovery is a process by which residual heat (called waste heat) from the gas turbine exhaust is recovered in a WHRU. This captured waste heat is then transferred to a heating medium system that provides heat for various users on the FPSO. For example, the oil treating process requires heating of the oil to meet the oil product specification. This heat input could be provided by a fired-gas heater or by using the waste heat from the gas turbines via the heating medium system. If fired-gas heaters were used in this service, natural gas usage (fuel for the heater) would increase by approximately 5 to 6 MMscfd. Alternatively, the heating demand could be met by WHRUs with minimal additional investment and relatively low incremental power consumption. This reduces FPSO fuel consumption by approximately 15 percent.

Nitrogen oxide (NO_x) control technologies were evaluated for the Project. Based on World Health Organization (WHO) guidelines and internal ExxonMobil standards, it was determined through modeling that advanced NO_x control was not required for the gas turbines utilized in remote offshore locations such as the PDA, which is approximately 207 km from shore. The overall NO_x emissions are predicted to be 95 percent lower than the WHO allowable concentration limit based on the distance to shore. Implementing advanced NO_x control would result in increased cost and lower reliability of the system. This lower reliability would result in higher GHG emissions caused by process upsets. Therefore, with an understanding that advanced NO_x control would provide limited reduction in impact to onshore receptors, it was decided not to implement additional NO_x controls on the FPSO.

Regulatory Requirements/Benchmarking

The Guyana Environmental Protection (Air Quality) Regulations 2000 gives the EPA authority to establish national ambient air quality standards and parameter limits, although none have been established to date. As such, EEPGL considered recognized international standards for the design and operation of the power generation system: World Health Organization (WHO) air quality guidelines (WHO 2005) and the World Bank EHS guidelines (World Bank 2007).

The World Bank has established EHS guidelines for offshore oil and gas development (World Bank 2015) and EHS general guidelines (World Bank 2007), which are technical reference documents with examples of good environmental practices. The general World Bank EHS guidelines (World Bank 2007) established that WHO (2005) air quality guidelines should be used if no national ambient air quality standards exist. While the World Bank is not involved in the Project, the FPSO power generation system has been designed consistent with the performance criteria of the offshore and general World Bank guidelines.

The general World Bank EHS guidelines (World Bank 2007) also state that the generation and release of emissions of any type should be managed through a combination of:

- Energy use efficiency;
- Process modification;
- Selection of fuels or other materials; and
- Application of emissions control techniques.

The Liza Phase 1 and Liza Phase 2 Environmental Permits issued by the Guyana EPA in 2017 and 2019 respectively, mandate the following:

- Implement internationally recognized methods for controlling and reducing fugitive emissions in the design, operation, and maintenance of facilities to maximize energy efficiency; and
- Design facilities for the lowest energy use.

Based on the above guidelines and requirements, the FPSO power generation system was designed to maximize energy efficiency and minimize environmental impacts.

Environmental Aspects and Impacts

Power generation is the main source of air emissions from the FPSO. Through the evaluation of technical and economic feasibility, as well as applying relevant recognized international environmental guidelines, EEPGL has also minimized environmental impacts.

As outlined in the World Bank general EHS guidelines (World Bank 2007), emissions should be managed through energy efficiency options. As described above, an analysis of energy efficiency improvements, considering cost-reduction opportunities, was conducted and the technically feasible and cost effective opportunities were pursued. These minimized the amount of GHGs and other air emissions being generated from the power system. The decision to pursue aero-derivative turbines versus industrial turbines was driven by increased energy efficiency.

Additionally, WHRUs were pursued over fired heaters due to increased energy efficiency. These improved energy-efficiency options result in lower generation of GHG emissions.

The World Bank general EHS guidelines (World Bank 2007) also provide guidance that emissions should be managed through the selection of fuels. As described above, the use of natural gas over diesel as the primary fuel source for the power generation system is more environmentally beneficial since the combustion of natural gas, which is a less carbon intensive fuel option as compared to diesel, generates less air emissions.

The World Bank general EHS guidelines (World Bank 2007) also defines emissions should be managed through process modifications. The FPSO power generation system was designed to improve reliability of the system by including a spare generator to reduce upset time, which results in less flaring emissions. Additionally, designing the turbines as dual fuel improves reliability, and therefore decreases flaring emissions due to upsets, by allowing the turbines to run on diesel when fuel gas is not available.

Lastly, due to the distance of the FPSO from shore, advanced NO_x controls were determined not to be warranted due to the negligible predicted impacts to onshore receptors. Consistent with World Bank Guidelines, a baseline air quality assessment was conducted and an atmospheric dispersion model was generated to assess potential ground level concentrations. Modeled concentrations of air pollutants at potential onshore receptor locations were compared to guideline concentrations from WHO, which demonstrated that the maximum predicted onshore concentration is significantly below the WHO guidelines (WHO 2005) (approximately 95 percent below) and do not contribute a significant portion to the attainment of those standards.

Further, the ESMP describes EEPGL's monitoring program for sources of air emissions:

- Equipment will be maintained in good working order and operated in accordance with manufacturer's specifications;
- Inspection, maintenance, and surveillance programs will be implemented to identify and prevent leaks;
- Fuel consumption will be metered or estimated.

Discussion and Conclusion

In summary, the gas turbines selected for the Project provide a reliable source of power for the FPSO that is cost effective and technically feasible. Additionally the aero-derivative gas turbines are energy efficient, which is further enhanced by use of WHRUs. Furthermore, the units are designed with dual fuel capabilities with improve reliability/uptime with natural gas being the primary source of fuel. Natural gas is a clean burning fuel source with the additional benefit of being the lowest cost option.

EEPGL has designed and will operate the FPSO consistent with the WHO air quality guidelines performance criteria (WHO 2005) and the World Bank EHS guidelines (World Bank 2007) related to emissions practices, as well as the Guyana EPA Environmental Protection Act and the associated Environmental Permit requirements for the FPSO power generation system.

2.17.3.5. Produced Water

Produced water is water contained in an oil and gas reservoir formation. During production of oil and associated gas, nearly every oil and gas well generates water as part of the production process. The following two options were considered for disposal of produced water after onboard treatment:

- Option 1: Onboard treatment and overboard discharge of treated produced water. For this option, the treatment process includes a three-phase separator, a produced water flash vessel, a hydrocyclone, and an induced gas flotation vessel.
- Option 2: Onboard treatment and reinjection of treated produced water into the reservoir. For this option, the treatment process includes all the equipment required in Option 1 plus additional micro- or ultra-filtration units. These incremental filtration units are needed to remove contaminants to meet the produced water quality required for injection into the reservoir. The treated produced water would then be comingled with the treated seawater and pumped to a pressure suitable for injection into the reservoir. The production of produced water is not anticipated until several years after FPSO start-up and the produced water flow rates from the reservoir will vary over the life of the facility. Given the differences in demand of injection water and water supply from produced water, in Option 2, both a seawater treatment unit and produced water treatment unit would be required, thus increasing the required facilities to be installed. In Option 2, no optimization in the seawater treatment system capacity can be realized.

Overboard discharge of treated produced water (Option 1) was selected for the Project after taking into account technical feasibility and economic evaluations with a consideration of regulatory requirements and predicted environmental impacts. Overboard discharge of treated produced water is an industry practice used for offshore facilities.

Technology Options and Feasibility and Economic Evaluation

The main technical challenge of re-injecting treated produced water into the reservoir is that the water can be incompatible with injected seawater, which leads to scaling issues in the downstream subsea risers, flowlines, and water injection wells. Laboratory testing of Guyana produced water demonstrated a strong tendency to form scale. ExxonMobil's worldwide experience with co-mingling produced water and seawater for injection in other developments resulted in scaling issues and subsequent reduction in injectivity of the water injection wells. This reduction in water injectivity reduces the volume of water injected into the reservoir over the life of the field, which has a negative impact on oil recovery. Furthermore, from an FPSO facilities perspective, the addition of micro- or ultra-filtration units to the produced water treatment system increases the facility complexity, weight, and footprint in a FPSO area with limited space available. Furthermore, maintenance costs will increase due to the incremental equipment required for this process configuration.

ExxonMobil's operating experience indicates that the produced water treatment system availability, and subsequently oil production, is negatively impacted over the life of the facility as a result of technical complexities associated with reinjection of treated produced water into the reservoir. Discharging treated produced water overboard and injecting treated seawater for reservoir pressure maintenance decouples produced water treatment and seawater injection, which improves overall FPSO system reliability.

As summarized in this section, reinjection of treated produced water is not recommended. Overboard discharge of treated produced water was selected as the BAT for this application. Applicable performance criteria requirements (as described in the next section) which minimize impacts to water quality are incorporated in the produced water treatment design.

Regulatory Requirements/Benchmarking

The Guyana Environmental Protection Act has no offshore discharge standard for produced water. As such, EEPGL considered three international standards for the design and operation of the produced water treatment system: the World Bank, the U.S. Environment Protection Agency (USEPA), and the Convention for the Protection of the Marine Environment of the North-East Atlantic.

The World Bank Group has established EHS guidelines for offshore oil and gas development (World Bank 2015), which is a technical reference document with examples of good environmental practices. The offshore guideline has established that an effluent level of oil and grease content in produced water of no more than 42 milligrams per liter (mg/L) daily maximum, and no more than 29 mg/L monthly average. While the World Bank is not involved in the Project, the EEPGL produced water system design basis is consistent with the performance criteria of the offshore guideline and will meet the effluent standards for oil and grease content.

The USEPA's Oil and Gas Extraction Effluent Guidelines and Standards (40 CFR Part 435) have established effluent limitations guidelines representing the degree of effluent reduction attainable by the application of BAT, whereby point sources must achieve effluent limitations of a maximum for any one day not to exceed 42 mg/L and the average of daily values for 30 consecutive days not to exceed 29 mg/L.

Similar to the above standards, the Convention for the Protection of the Marine Environment of the North-East Atlantic (also known as the OSPAR Convention) sets a performance standard of 30 mg/L for dispersed oil in produced water as the maximum monthly average concentration to be discharged. This performance criterion is consistent with both the World Bank and USEPA standards.

The EEPGL Liza Phase 1 and Liza Phase 2 Environmental Permits issued by the EPA in 2017 and 2019 respectively, have the following condition:

> "Produced water from the reservoir will be treated onboard the FPSO to an acceptable specification prior to discharging. The oil content specification of produced water to be discharged shall not exceed 42 mg/L on a daily basis or 29 mg/L on a monthly average. If the oil content of produced water is observed to exceed these limits, the produced water shall be routed to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meet the specification above."

EEPGL elected to use a FPSO produced water treatment system design and discharge basis for the Project that is consistent with international produced water discharge performance criteria.

Environmental Aspects and Impacts

Following the above performance criteria for produced water discharge, predicted impacts to water quality were concluded to have a negligible significance in the Liza Phase 1, Liza Phase 2, and Payara EIAs. Further, the Liza Phase 1, Liza Phase 2, and Payara ESMPs describe EEPGL's monitoring program for produced water discharges:

- A minimum of one grab sample will be taken each day to ensure compliance with the daily maximum oil in water content of 42 mg/L. Samples will be analyzed for oil and grease content using an industry standard method in the lab on board the FPSO. Results will be documented in a log. A monthly average will be recorded to ensure compliance with the monthly average oil in water content of 29 mg/L.

The design and discharge basis of the Project FPSO produced water treatment systems, supported by the required environmental monitoring program, are aligned with the World Bank and USEPA produced water discharge performance criteria and will have a negligible impact on water quality.

Discussion and Conclusion

Overboard discharge performance criteria of produced water is consistent with the World Bank offshore EHS guidelines (World Bank 2015), the USEPA's Oil and Gas Extraction Effluent Guidelines and Standards (40 CFR Part 435), and the OSPAR Convention. EEPGL has designed and will operate the Project FPSO consistent with these guidelines, as well as the Guyana EPA Environmental Protection Act and the associated Environmental Permit requirements. EEPGL's decision to not inject treated produced water was based on a defined decision making process including the evaluation of technical feasibility, economics, regulatory requirements, environmental impacts, and industry practice.

2.17.3.6. Sulfate Removal

Injection of seawater for reservoir pressure maintenance in an offshore facility is a GIOFP. However, the presence of sulfate ions (approximately 2,800 to 3,000 mg/L) in the seawater, in combination with high concentrations of barium or strontium often found in reservoir formation waters, is a source of potential scale formation in the reservoir that could reduce seawater injectivity over the life of the field. To prevent this scale formation at the seawater injection wells, a GIOFP is to reduce the amount of sulfate ions in the seawater before it is injected into the reservoir. A further benefit of reducing the sulfate concentration in the injected seawater is the minimization of reservoir souring. Reducing the sulfate concentration in the injected seawater minimizes the H_2S generated in the reservoir by sulfate-reducing bacteria. Minimizing reservoir souring reduces equipment corrosion issues during the facility life and reduces likelihood that future equipment is required for scrubbing, removal, and handling of H_2S.

Technology Options and Feasibility and Economic Evaluation

The required seawater injection product specification is less than 40 parts per million (ppm) for sulfates. Two sulfate removal technologies were considered in this application. The first technology considered, precipitation of sulfates by chemical addition, cannot achieve the less than 40-ppm sulfate target. The second technology considered, the nanofiltration membrane process, is a proven industrial technology for this application.

Nanofiltration is a membrane process that selectively removes sulfate ions to produce low-sulfate injection water. The process is similar to reverse osmosis, used extensively worldwide for seawater desalination. The nanofiltration membrane has a larger pore size and possesses a slight negative charge and thus can reject divalent ions (e.g., sulfate). The nanofiltration membrane has feed-to-permeate conversion at 75 percent of the inlet flow rate. For every 100 barrels (bbl) of seawater that flows to the system inlet, 75 bbl of low-sulfate water are produced, and 25 bbl of high-sulfate water are disposed of overboard. This high-sulfate water is typically referred to as a brine.

Sulfate content of less than 40 ppm in injected water can be further reduced to less than 10 ppm by deploying nanofiltration units in series. However, this incremental equipment increases system complexity and cost and reduces the reliability of the sulfate removal unit. Implementing incremental sulfate reduction beyond the less than 40-ppm target was not pursued.

Regulatory Requirements

In Guyana, no offshore ambient water quality standards exist for the constituents in the sulfate removal processing brine.

The Liza Phase 1 and Liza Phase 2 Environmental Permits issued by the EPA in 2017 and 2019, respectively, have the following condition:

- Marine discharges from well drilling, hydrostatic testing of flow lines and risers, and the overall production operations shall be undertaken in a manner that does not cause or permit the entry of contaminants into the environment in amounts, concentrations, or levels in excess of that prescribed by the regulations or stipulated by any environmental authorization.

Environmental Aspects and Impacts

Using the recommended design basis for sulfate removal for seawater reinjection, impacts on water quality were concluded to be negligible in the Liza Phase 1, Liza Phase 2, and Payara EIAs. No treatment of the brine streams is required prior to discharging overboard since the streams are essentially seawater. Discharge of sulfate removal and potable water processing brines can result in localized increases in concentrations of chemical constituents in the marine environment. Cooling water, produced water, and brines from the sulfate removal unit and freshwater reverse osmosis system are the operational discharges that were the focus of modeling performed for the EIAs to assess the nature and extent of potential marine water quality impacts.

The USEPA-approved CORMIX dilution model was used to predict the nature and extent of discharge plumes from the various modeled discharges. The model showed that at 100 meters

(328 feet) from the discharge point, a greater than 99 percent reduction in constituent concentrations was achieved. The modeling of potential impacts from the discharges found that even under the most conservative bounding case for each discharge-modeling scenario, the discharges were subject to rapid mixing and consequently experienced substantial reductions in constituent concentrations within a relatively small distance from the point of discharge.

Since there are no prescribed limits for the constituents contained in the sulfate removal processing brine stream and water quality modeling demonstrated a negligible impact on the marine environment, the system has been designed to minimize impacts on the environment and therefore, the best available techniques have been used.

Additionally, the least energy-intensive technology was selected for sulfate removal compared to the addition of incremental nanofiltration units in series, which means associated GHG emissions from energy use have been minimized as well, reducing air quality impacts.

Consistent with the Liza Phase 1, Liza Phase 2, and Payara ESMPs, EEPGL will perform daily visual inspections on the FPSO of discharge points to ensure that there are no floating solids or discoloration of the surrounding waters and will document observations.

Discussion and Conclusion

EEPGL has designed and will operate the Project FPSO to remove sulfates via nanofiltration technology prior to injecting seawater into the reservoir. This technology has minimal environmental impact and complies with the Guyana EPA Environmental Protection Act and the associated Environmental Permit requirements for the overboard discharge of the resulting brine streams. EEPGL's selection of the sulfate removal technology was based on a defined decision making process including the evaluation of technical feasibility, economics, regulatory requirements, environmental impacts, and industry practice.

2.17.4. No Action Alternative

The "no action" alternative means that the Project would not be executed. If this alternative is selected, the existing conditions described in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, would remain unaffected by the Project and the potential positive and negative impacts assessed in these chapters would not be realized.

It is reasonable to expect that some environmental and socioeconomic conditions would likely change over time in the absence of the Project. In particular, without the Project's revenue sharing with the Government of Guyana, the associated potential for benefits to socioeconomic resources would be reduced and gross domestic product (GDP) growth through associated fiscal revenue would be affected. The National Resource Fund would be deprived of these revenues for sustainable development of the country and initiatives aimed at achieving the government's vision of an inclusive green economy would likely be reduced. The Government of Guyana would also not be able to take advantage of the Project revenues to fulfill its objectives to create more job opportunities, address poverty, and improve the overall quality of life. (IDB 2017).

Opportunities to boost economic growth through increased foreign direct investment in supporting goods and services in the time leading up to oil production would be reduced. Whereby economic growth was projected to hover around 3.5 percent from 2017 to 2019, the Inter-American Development Bank predicted that once oil production starts, GDP growth will reach 38.5 percent in 2021 (based on consideration of a 100,000 barrels per day production rate for 8 years [referring to production from Liza Phase 1 Development Project only]) (IDB 2017). Without the Project, these levels of GDP growth rate would be less achievable. Additional effects on the economy if the Project were not enacted would likely include a reduction in demand for goods and services from Guyanese businesses and employment opportunities for Guyanese nationals who would have benefited from the Project. The absence of the Project would also eliminate associated induced economic benefits resulting from the re-investment, hiring, and spending by Project-related businesses and/or workers, which in turn benefits other non-Project-related businesses and generates more local tax for the government.

While a No Action alternative would decrease opportunities for the country to grow its economy and diversify production and trade, there are potential benefits. These include, but are not limited to decreased economic dependence on natural resources, decreased economic vulnerability to commodity price fluctuations, and reduction in the competitiveness of other sectors.

Therefore, evaluating the No Action alternative means evaluating the tradeoff between positive and negative impacts.

With respect to the possibility of EEPGL electing to not finish the Project after initiating its execution, a primary decision point is Final Investment Decision, when EEPGL and its co-venturers make a formal decision to proceed with full Project implementation. Once that point is reached, it is unlikely that the Project would not be progressed through full implementation. However, in the unforeseen event that circumstances arose that warranted stopping the Project mid-development, EEPGL would abandon the (partially implemented) Project infrastructure in an appropriate manner, consistent with the concepts laid out in the Preliminary End of Project Decommissioning Plan (included in Volume III of the regulatory submittal).

2.17.5. Summary of Alternatives

EEPGL considered a range of alternatives for the various aspects of the Project, along with the potential environmental and socioeconomic impacts associated with these alternatives. The preferred alternatives, which comprise the Description of the Project, reflect EEPGL's identification of the preferred alternatives from the standpoint of environmental performance, and technical and economic feasibility. This selection is supported by the fact that the FPSO and SURF production system is a proven development concept for deepwater oil recovery, and would leverage both operator- and industry-proven technologies and experience.

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3. ADMINISTRATIVE FRAMEWORK

The Project will be regulated under several Guyanese statutes.

This chapter reviews the laws and regulations in Guyana that are relevant to the Project; the chapter is separated into five sections:

- Section 3.1, National Legal Framework, describes the laws and regulations that apply to environmental issues in a general context, such as the Constitution of Guyana, as well as national laws that focus specifically on environmental issues, such as the Environmental Protection Act as amended in 2005. This section also identifies several resource-specific environmental laws that are more narrowly focused and have either direct or indirect relevance to the Project.
- Section 3.2, Environmental Permits and Licenses, describes the major environmental-related permits and licenses EEPGL will be required to obtain to execute the Project.
- Section 3.3, National Policy Framework, describes the Government of Guyana's strategies and policies that apply to the Project. These strategies and policies articulate the government's management goals with respect to various environmental issues.
- Section 3.4, International Conventions and Protocols, describes the international and regional conventions and protocols to which Guyana is a signatory and which are relevant to the Project.
- Section 3.5, EEPGL's Operations Integrity Management System, describes EEPGL's framework for addressing risks inherent in its business that can potentially have an impact on personnel and process safety, security, health, and environmental performance.

Additionally, Section 2.5 of the Environmental and Socioeconomic Management Plan for the Project (Volume III of the regulatory submittal) includes a number of environmental and socioeconomic performance criteria that, although not required pursuant to the applicable laws, regulations, and conventions discussed in this chapter, EEPGL will apply to the Project, consistent with good international industry practice.

3.1. National Legal Framework

This section provides an overview of the key legislation currently in force in Guyana that pertains to resources that could be affected by the Project.

3.1.1. National Constitution of Guyana

Guyana is governed according to the Constitution of the Co-operative Republic of Guyana, as amended (the Constitution). The Constitution took effect in 1980 and expressly provides for protection of the environment. Article 25 establishes "improvement of the environment" as a general duty of the citizenry. In addition, Article 36 reads as follows:

> "In the interests of the present and future generations, the State will protect and make rational use of its land, mineral and water resources, as well as its fauna and flora, and will take all appropriate measures to conserve and improve the environment."

3.1.2. The Environmental Protection Act

In 1996, the Environmental Protection Act (hereinafter referred to as the Act) was enacted to implement the environmental provisions of the Constitution. The Act is Guyana's single most significant piece of environmental legislation because it articulates national policy on important environmental topics such as pollution control, the requirements for environmental review of projects that could potentially affect the environment, and the penalties for environmental infractions. It also provides for the establishment of an environmental trust fund. Most importantly, the Act authorized the formation of the EPA, and establishes the EPA as the lead agency on environmental matters in Guyana. The Act further mandates the EPA to oversee the effective management, conservation, protection, and improvement of the environment (EPA 2018). It also requires the EPA to take the necessary measures to ensure the prevention and control of pollution, assessment of the impact of economic development on the environment, and sustainable use of natural resources.

3.1.3. The Guyana Geology and Mines Commission Act

The Guyana Geology and Mines Commission Act was enacted in 1979 and authorized the government to establish the Guyana Geology and Mines Commission (GGMC), which is within the Ministry of Natural Resources. The GGMC promotes and regulates the exploration and development of the country's mineral and petroleum resources. The GGMC has a dedicated Petroleum Unit charged specifically with regulatory supervision of the oil and gas sector; however, regulation of petroleum-related activities also occurs in other divisions, such as the Geological Services Division and the Environment Division. Since the shift in oversight responsibilities from the Ministry of Natural Resources to the Ministry of the Presidency, the Department of Energy (DE), under the Ministry of the Presidency, has been playing a lead role in matters regarding the oil and gas sector. In this regard, on matters of oil and gas, the GGMC, through the Petroleum Unit, has been working closely with the DE.

3.1.4. Protected Areas Act

The Protected Areas Act was enacted in 2011. It provides for protection and conservation of Guyana's natural heritage and natural capital through a national network of protected areas. This act also allowed for the creation of the Protected Areas Commission to oversee the management of this network. It highlights the importance of maintaining ecosystem services of national and global importance and public participation in the conservation of protected areas. It establishes a protected areas trust fund to ensure adequate financial support for maintenance of the network. Other functions of this act include promoting national pride in and encouraging stewardship of Guyana's natural heritage; recognizing the conservation efforts and achievements of Amerindian villages and Amerindian communities; and promoting the recovery and rehabilitation of vulnerable, threatened, and endangered species.

3.1.5. The Petroleum Act

The Petroleum (Exploration and Production) Act was enacted in 1986 to regulate the prospecting for and production of petroleum in Guyana, covering the territorial sea, continental shelf, and exclusive economic zone. This act and the regulations promulgated thereunder identify persons allowed to hold prospecting licenses, establish the process for obtaining prospecting licenses, and specify requirements for further resource development in the event petroleum resources are discovered.

3.1.6. Amerindian Act

The Amerindian Act was enacted in 2006. It provides for the recognition and protection of the collective rights of Amerindian villages and communities, the granting of lands to Amerindian villages and communities, and the promotion of good governance with Amerindian villages and communities. The Ministry of Indigenous Peoples' Affairs oversees implementation of this act. Key aspects of this act include the following:

- This act includes a process for the granting of land. A community can apply for land once they can prove that they have been living on it for at least 25 years.
- The Ministry is not required to approve leasing of titled Amerindian land. The communities are only required to seek the advice of the Minister.
- With respect to the use of scientific research related to Amerindian issues, the researcher must, among other things, submit to the Village Council a copy of any publication containing material derived from the research.
- This act supports the need for the communities to use their natural resources in a way that lends support to the concept of sustainability. Impact assessments are required in accordance with the Environmental Protection Act.
- Amerindians have a legal right to traditional mining with the consent of the Village Council and they must comply with the relevant legislation. With regard to forestry, the Village Council plays an integral role in determining who is allowed to use their land and on what terms.
- The Village Council is empowered to establish rules for their communities and set fines within the legal confines of the law. Money received due to the non-adherence of the rules goes into the Village Council's account, not the government's account.

3.1.7. Natural Resource Fund Act

The Natural Resource Fund Act was enacted in 2019 to establish the National Resource Fund to manage Guyana's natural resource wealth in an efficient and effective manner for the present and future benefit of the people and for financing national development priorities, including initiatives aimed at achieving an inclusive green economy. This act empowers the Minister of Finance with the overall management of the Natural Resource Fund (the Fund), including preparing the Fund's Investment Mandate. The act establishes an Investment Committee, a Macroeconomic Committee, and a Senior Investment Adviser and Analyst to support the Minister in management of the Fund. The Bank of Guyana is responsible for operational management of the Fund. A Public Accountability and Oversight Committee is established to ensure that the Fund is managed transparently and to provide an independent assessment of withdrawals from the Fund. Deposits into the Fund are intended to come from Guyana's petroleum revenues, including from royalties, the government's share of profits, and signature bonuses, among others. Revenues from the mining and forestry sectors may also be deposited into the Fund.

3.1.8. Other Resource-Specific National Environmental and Social Laws

Several additional Guyanese environmental laws with more narrowly defined scopes pertain to specific biological or physical natural resources. Other laws that primarily have a public health-related focus may also be relevant to the Project. Several of Guyana's environmental statutes were enacted prior to the Constitution and were subsequently incorporated into the newly formed national legal framework, but most were enacted after 1980. These laws are discussed in the relevant resource/receptor-specific discussions in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

3.2. ENVIRONMENTAL PERMITS AND LICENSES

As part of Project implementation, the Project will be required to obtain the following key environmental-related permits:

- Environmental Permit—To undertake the Project, EEPGL is required to obtain an Environmental Authorisation (also commonly referred to as an Environmental Permit) from the EPA. The Application for Environmental Authorisation filed with the EPA on 3 December 2018 initiated this regulatory process. After submission and review of this EIA, the EPA will take into account comments from other agencies, the public's comments, EPA's own review—including support from technical experts, and recommendations from the Environmental Assessment Board in deciding whether and under what conditions to grant EEPGL an Environmental Authorisation for the Project.
- Hazardous Waste Permit—With regard to onshore waste management, an Application for Environmental Authorisation must be submitted to the EPA by the operator of the onshore

facility in order to operate a facility that generates, transports, treats, stores, or disposes of hazardous waste. The Application for Environmental Authorisation must be prepared in accordance with the provisions of regulation 17 of the Environmental Protection (Authorisations) Regulations 2000. As such, the vessel owners/operators supporting the Project will be required to obtain authorization for any marine vessels used to transport hazardous wastes to onshore facilities. In addition, vehicle owners/operators will be required to obtain authorization for any vehicles used to transport hazardous waste from the shore to offsite waste management facilities. For any third-party owned/operated marine vessels or vehicles used to transport hazardous waste from the Project, the Applications for Environmental Authorisation will need to be obtained by the third party. Similarly, any Environmental Authorisations for third-party operated facilities used to manage hazardous waste will be obtained by the owner/operators of such facilities.

3.3. National Policy Framework

Guyana's government has articulated national policies on several environmental and social topics that are relevant to the Project. This section provides an overview of the key government environmental and social policies applicable to the Project.

3.3.1. Green State Development Strategy: Vision 2040

In 2019, the Government of Guyana released the Green State Development Strategy: Vision 2040 (GSDS; DE 2019). The GSDS is Guyana's national development plan for the next 20 years and it outlines the country's priorities for economic and social development. The vision for a green state by 2040 is "an inclusive and prosperous Guyana that provides a good quality of life for all its citizens based on sound education and social protection, low-carbon and resilient development, providing new economic opportunities, justice and political empowerment." In this regard, the GSDS aims to achieve development that provides an improved quality of life for Guyanese people derived from revenues earned from the country's natural resources (e.g., land, water, forests, minerals, oil and gas). It also provides Guyana's roadmap for achieving the United Nations Sustainable Development Goals by the 2030s.

The GSDS sets out to achieve eight development objectives focused on sound fiscal and monetary policy; sustainable management of natural resources; economic diversification; transitioning to renewable energy; resilient infrastructure and green towns; trade investment and international cooperation; health and education; and governance. Moreover, the GSDS recognizes that revenues from Guyana's natural wealth will be deposited into the Natural Resource Fund, and the GSDS anticipates that these revenues will be used to modernize traditional sectors, maximize efficiency and investment opportunities in high growth sectors, invest in value-adding sectors, and ensure Guyanese people have access to better opportunities.

3.3.2. Low Carbon Development Strategy

In June 2009, the Government of Guyana announced the Low Carbon Development Strategy (LCDS). The LCDS aims to protect and maintain forests in an effort to reduce global carbon emissions and at the same time attract payments from participating developed countries for the climate services that the forests provide. In 2013, the LCDS was updated to focus on two main goals: (1) transforming the national economy to deliver greater economic and social development by following a low-carbon development path while simultaneously combating climate change; and (2) providing a model for how climate change can be addressed through low-carbon development in developing countries (Office of the President 2013). The LCDS identifies Reducing Deforestation and Forest Degradation Plus as the primary mechanism for achieving the goals of the strategy.

3.3.3. National Development Strategy

The National Development Strategy (NDS) sets priorities for Guyana's economic and social development policies for the next decade. The draft document (NDS 1997) contains technical analysis of problems and future prospects in all sectors of the economy and in areas of social concern.

The NDS contains six volumes. Volumes 3 and 5 are the most relevant to the Project. Volume 3 of the NDS sets government policy with regard to the environment as well as social equality issues. It identifies 12 distinct features of Guyana's natural resources and environment, and sets policies governing the management of each feature. Features covered under Volume 3 with relevance to the Project include the coastal zone, fisheries, waste management, pollution control, and environmental impacts of private-sector activities (NDS 1997).

Volume 5 relates in part to the energy sector. It describes the condition of the energy sector in Guyana, reviews past government policies related to the energy sector, identifies challenges facing the energy sector in Guyana, and describes the government's vision for future development and regulation of the sector (NDS 1997).

3.3.4. National Environmental Action Plan

Guyana's National Environmental Action Plan (NEAP) articulates the government's approach to managing the environment from the perspective of economic development. The NEAP considers the issues of environmental management, economic development, social justice, and public health to be inextricably linked. It identifies deforestation, pollution, and unregulated gold mining as historically minor but with growing environmental problems, and identifies private-sector investment as one of the primary opportunities to generate the necessary capacity within Guyana to (1) provide an appropriate level of public services to its citizens; (2) reduce and/or eliminate the avoidable environmental degradation that occurs when resource development occurs in a regulatory vacuum; and (3) reduce unsustainable uses of natural resources due to the socioeconomic pressures of widespread poverty.

The NEAP relates to the Project in several ways. It identifies the coastal zone within which Project activities will occur as an area in need of focused management action due to the concentrated human population along the coast and the susceptibility of the coastal environment to both natural and human-induced degradation. Additionally, it identifies private-sector-led development projects as a mechanism to build capacity and ultimately support more responsible environmental management. Finally, it identifies petroleum resources as a potential target for development.

3.3.5. Integrated Coastal Zone Management Action Plan

Guyana's Integrated Coastal Zone Management (ICZM) process is an ongoing initiative to promote the wise use, development, and protection of coastal and marine resources; enhance collaboration among sectorial agencies; and promote economic development. In 2000, after 2 years of study, the ICZM committee produced an ICZM Action Plan, which was approved by the Cabinet in 2001.

The ICZM Action Plan addresses policy development, analysis and planning, coordination, public awareness building and education, control and compliance, monitoring and measurement, and information management (EPA 2000). Other coastal zone-related tasks currently being undertaken by the government include strengthening the institutional setup for ICZM, conducting a public awareness campaign to increase public understanding of the vulnerability of the coastal zone to sea-level rise and climate change, and creating a database of coastal resources to facilitate improved ICZM. Currently, the EPA is mandated to coordinate the ICZM program and coordinate the development of the ICZM Action Plan through the ICZM Committee.

Under the Caribbean Planning for Adaptation to Climate Change project (CARICOM 2015), Guyana has also conducted a socioeconomic assessment of sea-level rise as part of a wider vulnerability assessment and developed a Climate Change Action Plan (Government of Guyana 2001).

3.3.6. Guyana's National Biodiversity Strategy and Action Plan

Guyana's current National Biodiversity Strategy and Action Plan (NBSAP) was formally adopted in 2015, and is the third iteration of the NBSAP. It establishes the national vision for biodiversity, which is to sustainably utilize, manage, and mainstream biodiversity by 2030, thereby contributing to the advancement of Guyana's bio-security, and socioeconomic and low-carbon development. It is intended to guide national policy with respect to biodiversity through 2020. It recognizes the importance of biodiversity to the growing ecotourism industry and other economic sectors. The NBSAP sets forth nine strategic objectives intended to promote conservation and sustainability on a national scale, improve biodiversity monitoring, harmonize legal and policy-based mechanisms across all levels of government to support biodiversity conservation, and prioritize funding to meet these objectives.

3.4. International Conventions and Protocols

Guyana is signatory to a number of international agreements and conventions relating to environmental management and community rights, although not all of these agreements have been translated into national legislation. The key agreements potentially relevant to the Project, to which Guyana has acceded or is a signatory, are summarized in the relevant resource/receptor-specific discussions in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from

Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

Guyana is a member state of two organizations that administer multiple international treaties and conventions: the International Labour Organization (ILO) and the International Maritime Organization (IMO). The ILO has established eight fundamental conventions that provide certain general protections to workers in signatory states, such as the right to organize, standards for remuneration, restrictions on child labor (including minimum ages to work), and protection from forced labor. In addition to these fundamental agreements, Guyana is signatory to several specific agreements that will govern certain specific aspects of the Project as they relate to labor. These conventions are further discussed in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

The IMO is a similar organization whose member states have agreed to one or more conventions related to maritime activities. These include three key conventions (the International Convention for the Safety of Life at Sea, the International Convention for the Prevention of Pollution from Ships, and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) as well as several other agreements concerning more specific aspects of maritime activity, such as safety and security at sea, maritime pollution, and liability for maritime casualties. One of these other agreements administered by the IMO is the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1992, often referred to as FUND92 or FUND. Guyana is an observer nation under the 1992 FUND Convention, which established the International Oil Pollution Compensation Fund and the protocol for the International Oil Pollution Supplementary Fund. The Guyana Maritime Administration Department manages compliance with the requirements of the IMO agreements to which Guyana is a signatory, with technical assistance from the IMO's Regional Maritime Advisory Office in Port of Spain, Trinidad. These conventions are further discussed in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

Guyana also belongs to other international organizations such as the Organization of American States, the International Monetary Fund, and the Caribbean Community.

To highlight Guyana's adherence to international standards and guidelines relevant to the oil and gas sector, in May 2010, the country announced its commitment to the implementation of the Extractive Industries Transparency Initiative (EITI) and most recently, in September 2015, the country recommitted its support to the ILO.

In October 2017, Guyana became the 53rd candidate country in the EITI. EITI is a global standard to promote the open and accountable management of extractives resources; it seeks to strengthen government and company systems, inform the public, and promote industry understanding. It was founded in 2003 with an aim of protecting the interests of developing or frontier countries such as Guyana (EITI 2018).

EEPGL's ultimate parent organization, Exxon Mobil Corporation (ExxonMobil), has been part of EITI since its inception and is a founding member. ExxonMobil has worked to help develop and support EITI initiatives.

To gain membership status, Guyana was required to assemble a multi-stakeholder group, which included equal representation from the government, civil society, and industry. The goal is to develop a consensus reporting system that applies to all extractive companies operating in the country and to make that report public every year. Guyana's report for the 2017 Fiscal Year was submitted in April 2019 and was subsequently publicly distributed for review (BDO 2019). Guyana's second EITI report is expected to be completed in December 2020.[1]

In collaboration with the Government of Guyana, in December 2017 EEPGL was the first energy company to release its Petroleum Agreement with the Government of Guyana. The Stabroek Block Petroleum Agreement provides transparent information on revenue share, cost recovery, royalties, taxes, signing bonus, and other topics of interest to the public.

3.5. EEPGL's Operations Integrity Management System

ExxonMobil (EEPGL's parent organization) and its affiliates (including EEPGL) are committed to conducting business in a manner that is compatible with the environmental and socioeconomic needs of the communities in which it operates, and that protects the safety, security, and health of its employees, those involved with its operations, its customers, and the public. These commitments are documented in its Safety, Security, Health, Environmental, and Product Safety policies. These policies are put into practice through a disciplined management framework called the Operations Integrity Management System (OIMS).

ExxonMobil's OIMS Framework establishes common expectations used by ExxonMobil affiliates worldwide for addressing risks inherent in its business. The term "Operations Integrity" is used to address all aspects of its business that can impact personnel and process safety, occupational safety, security, occupational health, and environmental performance.

Application of the OIMS Framework is required across all ExxonMobil affiliates, with particular emphasis on design, construction, and operations. Management is responsible for ensuring that management systems that satisfy the OIMS Framework are in place. Implementation is consistent with the risks associated with the business activities being planned and performed. Figure 3.5-1 provides a high-level description of the OIMS Framework and its 11 essential elements.

[1] For more information about Guyana EITI visit: https://gyeiti.org/

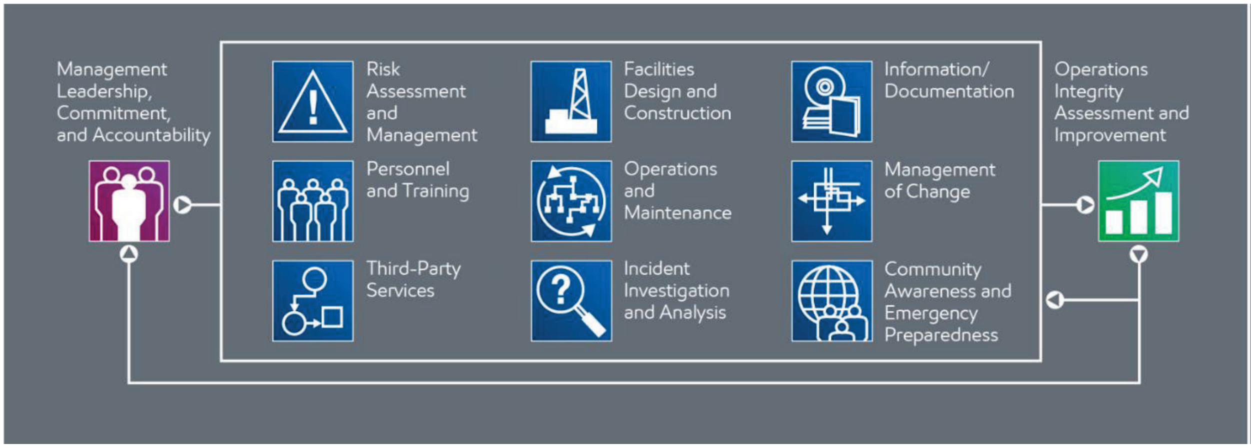


Figure 3.5-1: Operations Integrity Management System

Section 2.4.1 of the Project's Environmental and Socioeconomic Management Plan (Volume III of the regulatory submittal) includes a discussion of the key elements of EEPGL's occupational safety and health programs that will be used during the Project life cycle. These key elements stem from the expectations and requirements established by OIMS to identify and manage occupational safety and health risks associated with the Project's operations.

4. METHODOLOGY FOR PREPARING THE ENVIRONMENTAL IMPACT ASSESSMENT

The purpose of this EIA is to assess the potential physical, biological, and socioeconomic (including social, economic, community health, and cultural) impacts of the Project. This chapter provides a summary of the approach and methodology used to assess the potential impacts associated with the Project. The EIA has been prepared in compliance with the Guyana Environmental Protection Act (as amended in 2005), the Environmental Protection (Authorisation) Regulations (2000), the Environmental Impact Assessment Guidelines—Volume 1, Version 5 (EPA 2004), the Environmental Impact Assessment Guidelines—Volume 2, Version 4 (EPA/EAB 2000), other applicable Guyana regulations, international good practice, and EEPGL's corporate standards, and in accordance with the Consultants' standard practices.

This chapter also describes the process used to conduct the EIA. The EIA was prepared to provide an independent, science-based evaluation of the potential impacts associated with the development drilling, installation, production operations, and decommissioning stages of the Project. The EIA is also the primary mechanism for sharing those findings with stakeholders and decision-makers so they can make informed decisions regarding the potential benefits and impacts of the Project, as well as the measures proposed to enhance these benefits and mitigate these impacts.

The EIA has been undertaken following a systematic process that evaluates the potential impacts that the Project could have on physical, biological, and socioeconomic resources/receptors, and that identifies measures EEPGL will take to avoid, reduce, and/or remedy those impacts. For the purposes of the EIA, an impact is defined as any alteration of existing conditions (adverse or beneficial) caused directly or indirectly by the Project. Under the provisions of the Environmental Protection Act (as amended in 2005), potential adverse effects would include the following:

> "(i) impairment of the quality of the natural environment or any use that can be made of it;
>
> (ii) injury or damage to property or to plant or animal life;
>
> (iii) harm or material discomfort to any person;
>
> (iv) an adverse effect on the health of any person;
>
> (v) impairment of the safety of any person;
>
> (vi) rendering any property or plant or animal life unfit for use by human or unfit for its role in the ecosystem;
>
> (vii) loss of enjoyment of normal use of property; and
>
> (viii) interference with the normal conduct of business."

Although the Environmental Protection Act does not define positive impacts, examples of potential positive impacts include increased employment opportunities and revenue sharing with the Government of Guyana.

The EIA considers the possibility of both direct and indirect impacts of the Project. Information on potential impacts, including potential cumulative impacts related to the Project, was obtained by the Consultants from various primary and secondary sources, including consultations and key informant interviews with Government entities and other stakeholders (see Section 4.5.3, Stakeholder Engagement Process); field studies in the Project Area of Influence (AOI); environmental impact assessments for other similar projects in Guyana and worldwide; and scientific literature.

The key stages for the EIA approach are:

- Screening
- Scoping
- Assessment of Existing Conditions
- Project Description and Interaction with Design and Decision-Making Process
- Stakeholder Engagement
- Assessment of Impacts and Identification of Mitigation Measures
- Mitigation, Management, and Monitoring
- Disclosure and Reporting

4.1. SCREENING

The first stage of the EIA process involved the EPA screening the Project to determine the appropriate level of analysis to support the Application submitted by EEPGL on 4 December 2018. The EPA screens projects based on the information provided in the Application and determines the depth of environmental assessment/type of document required to support the review of the Application.

Based on the results of its screening assessment, the EPA can determine that the information included in the Application is sufficient to support a permitting decision, or it can require a Strategic Environmental Assessment, Environmental Management & Assessment Plan, and/or an EIA. In this case, the EPA determined that the Project could result in potentially significant impacts and, in accordance with the Environmental Protection Act (as amended in 2005), indicated in a letter dated 14 December 2018 that an EIA is required before an Environmental Authorisation can be granted. In a letter dated 11 March 2019, the EPA approved the Consultant team to undertake the EIA.

4.2. SCOPING

The key objectives of scoping are to:

- Identify key sensitivities and those Project actions having the potential to cause or contribute to significant impacts on physical, biological, and socioeconomic resources/receptors;
- Identify potential concept design and technology alternatives for the Project;

- Obtain stakeholder views through consultation; and
- Help inform the Terms and Scope for the EIA through consultation, to aid in focusing the EIA process and output on the key issues. The Terms and Scope describes the scope and technical approach for the EIA, and the key issues to be considered in the EIA.

Following EEPGL's submittal of the Application, a notice of the Application was published. This initiated a 28-day Public Notification Period, during which the public had the opportunity to provide comments on the Application and forthcoming Terms and Scope. The EPA conducted a series of scoping consultation meetings to aid in the development of the Terms and Scope (see Table 4.2-1). The objectives of the meetings were to provide stakeholders with information about the Project and the initially identified potential environmental and socioeconomic impacts of the Project, and to allow the public and government agencies to provide feedback that would inform the development of the Terms and Scope. This included feedback on the key issues to be addressed as part of the Terms and Scope development and eventual EIA process.

Table 4.2-1: Scoping Consultation Meetings

Meeting	Town	Location	Date
Region 1	Mabaruma	L&D Resort, Kamaka Waterfront	22 March 2019
Region 2	Anna Regina	Anna Regina Town Council	28 March 2019
Region 3/4	Georgetown	Umana Yana	26 March 2019
Region 5	Hopetown	Hopetown Community Center	13 March 2019
Region 6	No. 66 Village	No. 66 Village Port	14 March 2019

The EPA and the Consultants jointly considered the concerns, issues, and suggestions received during the public scoping consultation meetings. On 26 June 2019, the EPA issued the "Final Terms and Scope for Payara Development Environmental Impact Assessment Study" (referred to herein as the "Terms and Scope") to guide the undertaking of the EIA.

4.3. ASSESSMENT OF EXISTING CONDITIONS

The description of existing physical, biological, and socioeconomic conditions provides information on resources/receptors identified during scoping as having the potential to be significantly impacted by the Project.

The description of existing conditions is aimed at providing sufficient detail to meet the following objectives:

- Identify the key conditions and sensitivities in the Project AOI;
- Provide a basis for extrapolation of the current situation, taking into consideration natural variability, and development of future scenarios without the Project;
- Provide data to aid in the prediction and evaluation of potential impacts of the Project;
- Understand stakeholder concerns, perceptions, and expectations regarding the Project;

- Inform development of appropriate mitigation measures; and
- Provide a benchmark to inform assessments of future changes and of the effectiveness of mitigation measures.

Field studies conducted to document existing conditions for the EIA are described in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

4.4. Project Description and Interaction with Design and Decision-Making Process

The interaction between the EIA team and the design and decision-making process was one of the key areas in which the EIA influenced how the Project will be developed. It included involvement in defining the Project and identifying those activities with the potential to cause physical, biological, or socioeconomic impacts. Project planning, decision-making, and refinement of the Project description continued throughout the assessment process in view of identified potential impacts and proposed mitigation measures. During the EIA process, there was extensive communication between the impact assessment team and the Project design team with regard to identifying alternatives, potential impacts, and mitigation measures.

4.5. Stakeholder Engagement

Stakeholder engagement was conducted to support the development of the EIA and associated Environmental and Socioeconomic Management Plan (ESMP). The objectives of the Project's stakeholder engagement activities are to:

- Identify Project stakeholders and understand their interests and concerns in relation to Project activities, and incorporate such interests and concerns into the EIA and ESMP development processes, and, if appropriate, the Project design;
- Promote the development of respectful and open relationships between stakeholders and EEPGL during the Project life cycle (at least 20 years);
- Provide stakeholders with timely information about the Project in ways that are appropriate to their interests and needs, and also appropriate to the level of expected risks and potential adverse impacts;
- Satisfy regulatory requirements and EEPGL expectations for stakeholder engagement; and
- Record feedback and address any grievances that may arise from Project-related activities through a formal feedback mechanism.

4.5.1. Stakeholder Engagement Plan

Project stakeholder engagement activities are guided by a Stakeholder Engagement Plan (SEP) that describes the following:

- Stakeholders identified for engagement;
- A program of engagement and communications activities throughout the Project life cycle;
- A dedicated phone line and email address through which stakeholders can contact EEPGL to voice concerns, provide information, or ask questions about the Project and its activities; and
- Mechanisms through which EEPGL will monitor and report on external engagement and communications.

The SEP is a document that is updated periodically as the Project progresses to reflect new information, changing conditions, and additional stakeholders. The SEP is included as a part of this EIA in Volume III: ESMP.

4.5.2. Stakeholder Identification and Engagement Strategy

Project stakeholders have been identified through a combination of desktop research and in-country assessment and engagement. Stakeholder categories include, but are not limited to government officials, communities (including indigenous peoples), interest groups, non-governmental organizations (NGOs), the private sector, media, academic and research institutions, and professional, business, and worker associations.

Building on this stakeholder identification and mapping, EEPGL's stakeholder engagement strategy identifies mechanisms and tools to facilitate stakeholder communications and public information sharing. These tools are divided into two tiers that interact to facilitate informed engagement. The first tier is information sharing, in which EEPGL provides information about the Project to stakeholders to support their understanding of what is proposed to occur. The second tier is consultation, in which EEPGL seeks to support open dialogue and to receive stakeholder feedback, opinions, concerns, and knowledge regarding the way the Project may interact with the natural and social environment. The objective of consultation is to enable EEPGL to identify key stakeholder issues and concerns.

EEPGL may disseminate information through print and online publications and media releases, as well as presentations and open houses. The intent of these types of activities is to provide information to a broad audience or group of stakeholders as efficiently as possible. Consultation or dialogue activities involving a two-way flow or exchange of information between stakeholders and EEPGL or the Consultants may include one-on-one and small-group meetings, public meetings including a question and answer session, and feedback mechanisms such as a dedicated email address (guyanastaff@exxonmobil.com) and phone line (+592 231 2866). EEPGL also communicates regularly with its stakeholders through its Facebook page.[1] The intention of these activities is to allow for not only a two-way exchange of information, but also a means for EEPGL to gather information concerning topics that are important to its stakeholders. These activities also help ensure stakeholders' comments and opinions are heard and legitimate concerns are addressed.

[1] https://www.facebook.com/exxonmobilguyana/

Since 2017 and through the time of writing this EIA, EEPGL and its Consultants have held hundreds of stakeholder engagement events in the coastal Regions 1, 2, 3, 5, and 6, and more than 1,000 engagement events and individual stakeholder meetings in Region 4 related to Liza Phase 1, Liza Phase 2, and Payara Development activities. These include key informant interviews, EIA public scoping consultation and disclosure meetings, coastal mapping efforts, fisherfolk engagement, oil spill response training, community outreach events (e.g., informational booths, school fairs, job fairs), and capacity-building efforts. These activities are recorded by EEPGL and its Consultants in an engagement database to ensure follow-up of legitimate concerns. Project-specific engagement is discussed below in Section 4.5.3.

4.5.3. Stakeholder Engagement Process

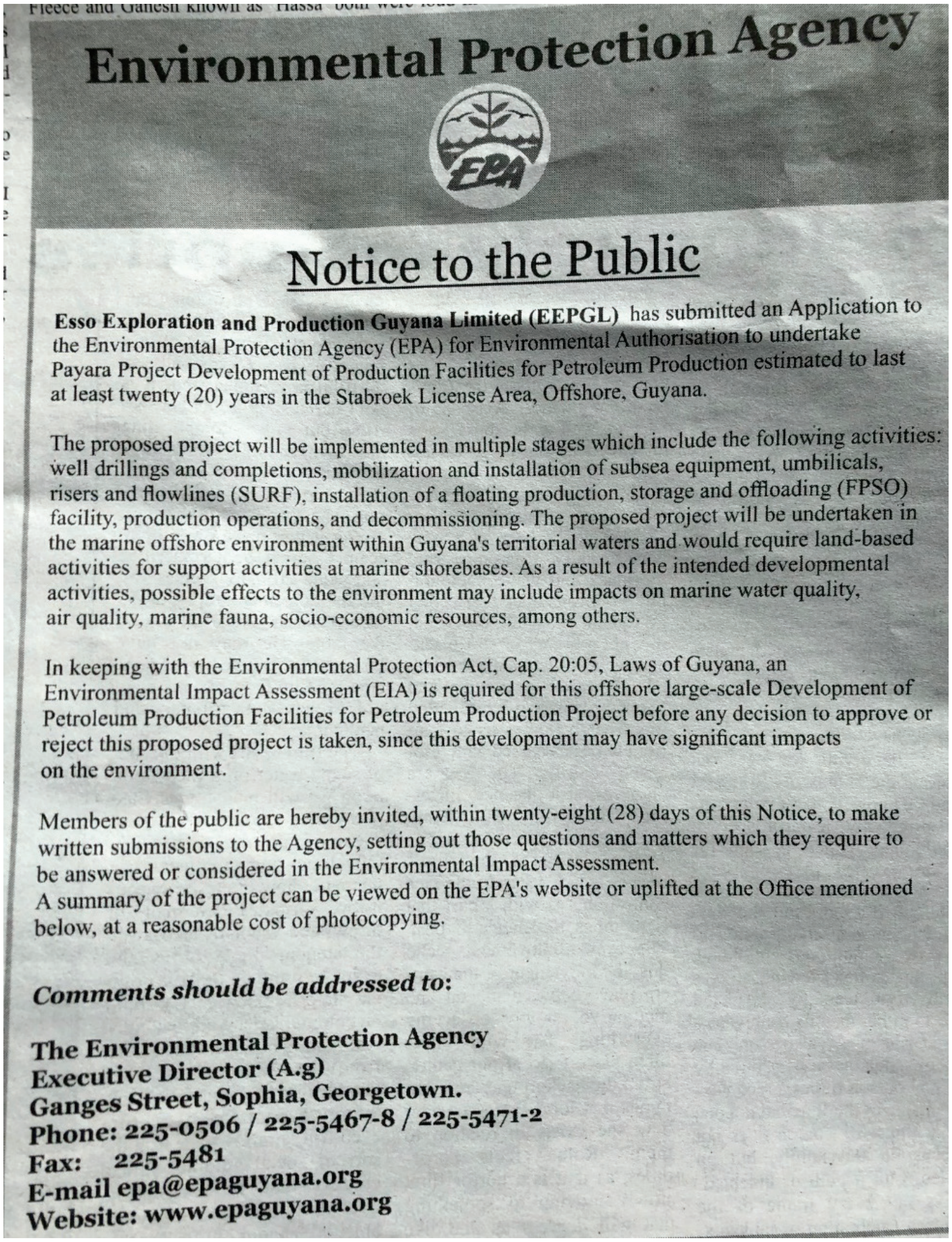
Stakeholder engagement activities are an integral part of the Project life cycle: from the initial notification when the Project is proposed, to the scoping of potential impacts, to the EIA, and throughout the life of the Project (at least 20 years). EEPGL has conducted a robust public consultation program to both inform the public about the Project and understand community and stakeholder concerns so they could be incorporated into the EIA. This engagement includes various opportunities that the Consultants have taken advantage of with different scopes of work (for Payara as well as Liza Phase 1 and Liza Phase 2) to reach vulnerable groups, including indigenous communities in the coastal areas of Region 1. The Consultants also took specific care during public engagements to take the opinions of women, the elderly, and youth into consideration by ensuring all participants were provided with the opportunity to speak, if they so desired. The different stages of the Project each require stakeholder engagement that is tailored in terms of its objectives and intensity, as well as the forms of engagement used. The various engagements completed specific to the scoping and EIA development stages are summarized below; more details are located in subsequent sections:

- EEPGL has held a number of engagements and workshops on specific topics with government agencies related to offshore oil and gas exploration and development in general and Payara specifically, including but not limited to the Department of Energy (which falls under the Ministry of Presidency and has been playing a lead role in matters regarding the oil and gas sector and recently took over that responsibility from the Ministry of Natural Resources), the Guyana Geology and Mines Commission, and the EPA.
- A Notice to the Public concerning the submission of the Application for the Project was published in the Stabroek News on 15 December 2018 (Figure 4.5-1), and was posted on the EPA's website (Figure 4.5-2), initiating the 28-day public comment period.
- EPA distributed letters of invitation for the public scoping consultation meetings to the Regional Democratic Councils of Regions 1 to 6, and public notices and flyers (see examples in Figure 4.5-3) were distributed in various towns throughout the coastal regions.
- As noted above, the EPA held five public scoping consultation meetings in March 2019. Sector agencies and members of the public in Region 3 were invited to the meeting held in Region 4. EEPGL participated in the meetings and Consultant representatives attended all meetings.

- As discussed in Section 4.2, Scoping, the EPA issued a final Terms and Scope on 26 June 2019.
- During the scoping and EIA development, EEPGL and/or the Consultants held meetings and key informant interviews with and/or gathered relevant data from 15 Guyana government agencies, commissions, professional or business associations, NGOs, elected officials, and regional administrators. Focus group meetings were also held with 464 members of coastal communities and over 80 artisanal and commercial fisherfolk. The information received from these engagements was incorporated into the existing conditions and impact assessment components of the EIA (Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources).
- As a result of feedback received during the Region 4 public scoping consultation meeting, EEPGL attended Consultant-led focus group meetings in Regions 1, 3, and 6 in June and July 2019. These meetings allowed members of communities who were unable to travel to the EPA-led public scoping consultation meetings in March 2019 to hear first-hand from EEPGL about the Project and their activities.

When this EIA is submitted, it is expected that the EPA will initiate a 60-day public comment period. It is anticipated that during this time, a series of public informational (disclosure) meetings and/or other stakeholder engagement events will be held to provide the opportunity for stakeholders to learn about details of the EIA findings from the Consultants (including the potential environmental and socioeconomic effects of the Project), and to allow the public and government agencies to provide feedback on key issues addressed as part of the EIA. The Consultants will incorporate information from these engagements into the Final EIA.

Once the EIA process is complete, and assuming EEPGL obtains an Environmental Authorisation and other approvals from the EPA and Department of Energy, the Project will transition into execution, subject to a final investment decision by EEPGL. Plans for stakeholder engagement during Project execution are described in the SEP, and engagement activities will be adjusted to reflect evolving Project status and activity level, as well as stakeholder concerns over the life of the Project. During Project execution, the emphasis of engagement shifts from input gathering to disclosure about planned activities as well as consultation (including receipt of feedback) on ongoing and planned activities. EEPGL will keep the public informed about the general progress of the Project (e.g., completion of Project stages such as development well drilling) and will respond to any grievances (i.e., specific concerns) filed under the Project's Grievance Procedure, which is described in the SEP. The Grievance Procedure will be in place throughout the life of the Project (at least 20 years).



Environmental Protection Agency

Notice to the Public

Esso Exploration and Production Guyana Limited (EEPGL) has submitted an Application to the Environmental Protection Agency (EPA) for Environmental Authorisation to undertake Payara Project Development of Production Facilities for Petroleum Production estimated to last at least twenty (20) years in the Stabroek License Area, Offshore, Guyana.

The proposed project will be implemented in multiple stages which include the following activities: well drillings and completions, mobilization and installation of subsea equipment, umbilicals, risers and flowlines (SURF), installation of a floating production, storage and offloading (FPSO) facility, production operations, and decommissioning. The proposed project will be undertaken in the marine offshore environment within Guyana's territorial waters and would require land-based activities for support activities at marine shorebases. As a result of the intended developmental activities, possible effects to the environment may include impacts on marine water quality, air quality, marine fauna, socio-economic resources, among others.

In keeping with the Environmental Protection Act, Cap. 20:05, Laws of Guyana, an Environmental Impact Assessment (EIA) is required for this offshore large-scale Development of Petroleum Production Facilities for Petroleum Production Project before any decision to approve or reject this proposed project is taken, since this development may have significant impacts on the environment.

Members of the public are hereby invited, within twenty-eight (28) days of this Notice, to make written submissions to the Agency, setting out those questions and matters which they require to be answered or considered in the Environmental Impact Assessment.
A summary of the project can be viewed on the EPA's website or uplifted at the Office mentioned below, at a reasonable cost of photocopying.

Comments should be addressed to:

The Environmental Protection Agency
Executive Director (A.g)
Ganges Street, Sophia, Georgetown.
Phone: 225-0506 / 225-5467-8 / 225-5471-2
Fax: 225-5481
E-mail epa@epaguyana.org
Website: www.epaguyana.org

Figure 4.5-1: Notice to the Public Initiating 28-Day Public Comment Period—Newspaper Notice

Environmental Protection Agency

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Phone: 225-0506 / 225-5467-8 / 225-5471-2
Fax: 225-5481
E-mail epa@epaguyana.org
Website: www.epaguyana.org

Figure 4.5-2: Notice to the Public Initiating 28-Day Public Comment Period—EPA Website

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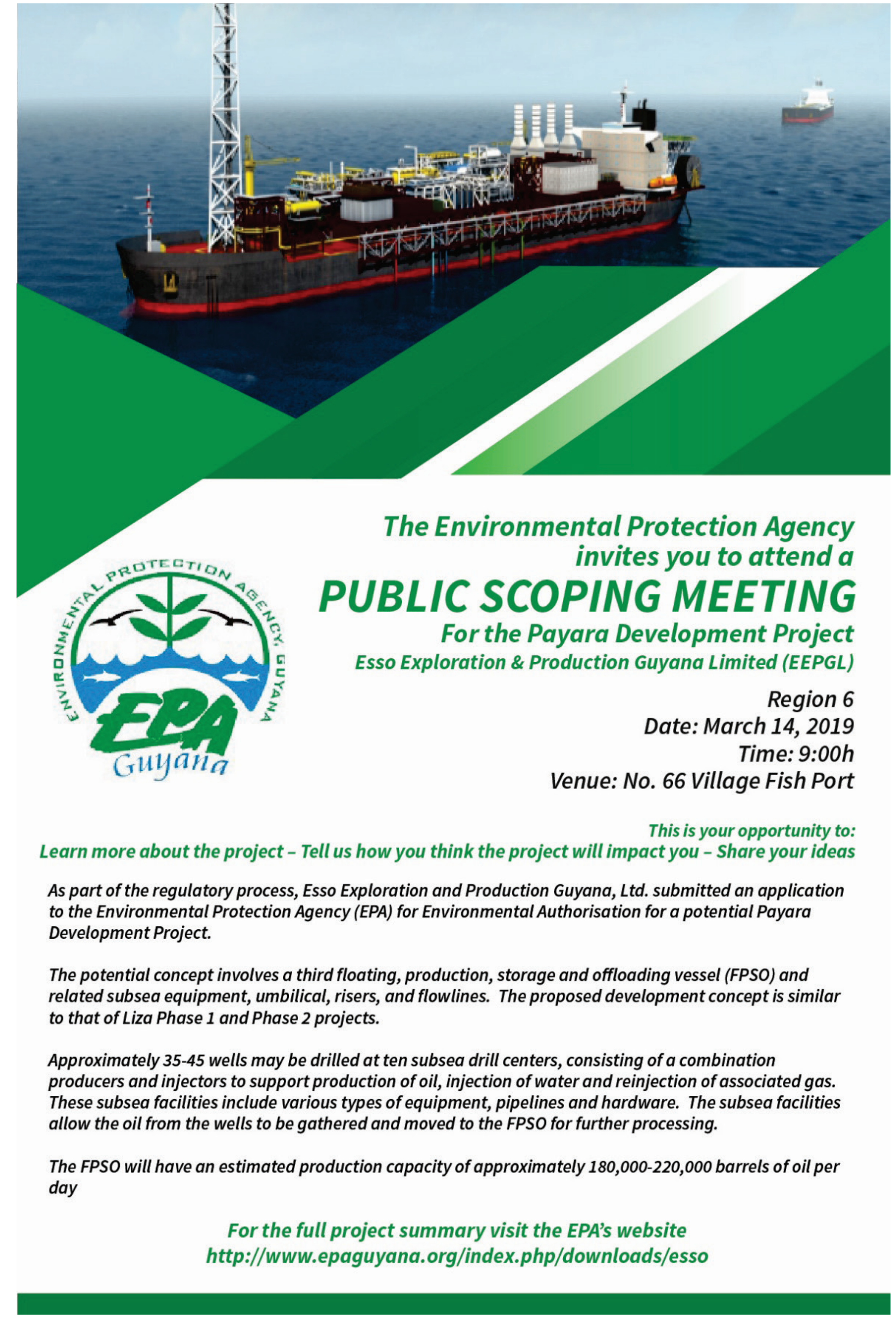

Figure 4.5-3: Examples of Public Notices Advertising Regional Public Consultation Meetings

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4.5.3.1. Details of Public Scoping Consultation Meetings

During the Project's EIA scoping phase, the EPA led a series of five scoping consultation meetings. These meetings served to inform stakeholders about, and receive feedback from, stakeholders on the Project. Stakeholders were also informed that comments could be submitted directly to the EPA. Approximately 336 people attended these meetings. Comments referencing a total of approximately 120 distinct[2] issues or concerns were received from public, government agency, and NGO stakeholders over the course of the scoping phase.

Key comments from these meetings with relevance to the scoping process were formally documented by the EPA and are summarized in Table 4.5-1, along with an explanation of how the comment was addressed, as applicable, within the EIA. For some comments, the EPA provided a response during the meeting and the table summarizes the EPA's response. The table does not list every individual comment received; rather, comments addressing a similar issue are grouped and the generalized comment is presented in the table (in some cases, a comment in the table represents a single individual comment). The generalized comments are organized by theme (e.g., Project Location, EIA Process, etc.). Comments and questions that are not relevant to the Project EIA scoping process (e.g., employment opportunities, regulator actions) are not included.

Table 4.5-1: Thematic Summary of Comments Received from Public Scoping Consultation Meetings

Comments (Meeting[s] where Comment was Raised)	Consideration in the EIA
Project Location, Description, and Schedule	
Can you describe onshore activities, as well as offshore? (5)	Chapter 2, Description of the Project, includes details related to the Project footprint, schedules, exclusion zones, onshore facilities to be used by the Project, and other pertinent Project engineering and operational details.
What is the size of an oil barrel? (1)	Chapter 2 discusses the size of a barrel (42 U.S. gallons or approximately 159 liters).
EIA Process and Procedures	
When will the Environmental Permit expire? What if there are discrepancies after the permit is issued? How will those be addressed? Can another EIA be done after the Environmental Authorization has expired? (2)	The EPA responded during the regional meeting that the Permit will have terms, conditions, and a time duration. There is a compliance and enforcement arm of the EPA that is responsible to monitor performance against the Permit and action taken where there is non-compliance.

[2] This number does not account for every individual comment received; rather, comments addressing a similar issue/concern were aggregated and represented as a single distinct issue/concern.

Comments (Meeting[s] where Comment was Raised)	**Consideration in the EIA**
Regarding impact matrices, are the impact ratings subjective? Do the consultants have a standard that is being using for impact ratings? Are those ratings (e.g. magnitude of impacts) updated or changed based on climate change? (3/4)	Chapter 4, Methodology for Preparing the Environmental Impact Assessment, and specifically Section 4.6, Assessment of Impacts and Identification of Mitigation Measures, describes the methodology used in the EIA to assess potential impacts and risks, including the methodology for assigning impact and risk ratings. Chapter 10, Cumulative Impact Assessment, describes the methodology for the cumulative impact assessment conducted for the Project. The cumulative impact assessment considers, among other factors, assessment of potential impacts resulting from the Project combined with potential impacts of changing climate conditions.
How will answers to the questions during the scoping phase be addressed? (3/4)	The EPA responded during the regional meetings that the EPA takes into consideration the questions and comments received during the scoping phase when developing the Final Terms and Scope.
Which stakeholders are being targeted in the scoping process? For example, Region 1 has limited awareness of ExxonMobil or its operations. (3/4)	Section 4.5, Stakeholder Engagement, describes methods used for identifying stakeholders during the scoping and EIA development process, including stakeholders in Region 1.
Are there any discussions with remote communities—many of which depend on fishing—regarding potential impacts on these communities, including impacts on rivers, waterways, and freshwater resources during the dry season, in the event of a spill? (1, 3/4)	Section 4.5 and the ESMP (specifically Appendix 2, Stakeholder Engagement Plan for Guyana Operations) describe ongoing engagement with stakeholders, including indigenous and coastal communities. Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, discusses risks to coastal communities from a spill.
Recommend that a separate meeting be held in Region 3 as stakeholders cannot come to Georgetown in the middle of the afternoon on a working day. (3/4)	Section 4.5 details the meetings held as part of the scoping and EIA development process, including in Region 3.
Does the consultant team have experience conducting EIAs for oil and gas? Have they worked in countries that have extracted oil before? (3/4)	Chapter 14, Project Team, presents the core members of the Consultant team responsible for conducting the EIA; Appendix A, List of Prepares (Volume II), includes the signatures and titles for contributors; Appendix B, EIA Team Curricula Vita (Volume II), includes curricula vitae for the core members of the Consultant team.
Non-routine, Unplanned Events (e.g., Spills or Releases, Natural Hazard Events)	
Is Region 1 the highest at risk for an oil spill? (1)	Chapter 9 and the Oil Spill Response Plan in the Environmental and Socioeconomic Management Plan (ESMP, in Volume III) discuss the results of oil spill modeling. This modeling simulates the trajectory of an unlikely oil spill and assesses the risk of oil reaching the coastline, including in Region 1.

Comments (Meeting[s] where Comment was Raised)	Consideration in the EIA
Modeling for oil spill should be done by oceanographers and not just computer modeling, like was done recently by WWF. Oil spill modeling should be undertaken by independent companies and incorporated in the EIA. (2)	Section 9.1, Introduction, and the Oil Spill Response Plan discuss the results of oil spill modeling, including contributions by third-party specialists, which have been incorporated into the EIA.
There are concerns regarding the adequacies of oil spill modeling that was prepared for Liza 1 and 2. Historically, the Essequibo River is considered a basin and studies should be done on the potential impacts of oil spills on the river. (1)	Section 9.1 and the Oil Spill Response Plan discuss the results of oil spill modeling.
Studies should be conducted on the readiness for oil spill response given that training takes places in calm/creek water. At sea where conditions are different, the efficiency of oil response must be demonstrated. (5/6)	The Oil Spill Response Plan in the Environmental and Socioeconomic Management Plan (ESMP, in Volume III) describes oil spill response procedures.
How would an oil spill affect beaches and farming (including Essequibo Coast), including agriculture and rice farming? (2)	Section 9.15 assesses potential risks to employment and livelihoods (including agriculture) from unplanned events such as oil spills.
Should there be a spill, our beaches, mangroves, and birdlife, as well as fishing industry will be affected. Are appropriate measures to mitigate impacts on biodiversity considered? Has the EPA determined if there will be compensation for fisherfolk as well as fish consumers? (2, 5, 6)	Section 9.15, Socioeconomic Conditions/Employment and Livelihoods, assesses potential risks to employment and livelihoods (including fishing) from unplanned events such as oil spills, and describes related mitigation measures. Section 9.1.9, Claims and Livelihood Remediation Processes, describes a claims and livelihood remediation process that would be implemented in the event of an oil spill causing losses to stakeholders. Sections 9.6 and 9.7, Coastal Habitats and Coastal Wildlife, assess potential risks to coastal habitat and coastal biodiversity from potential unplanned events such as oil spills, and describes related mitigation measures.
What arrangements have been made to consider liability insurance and/or compensation for impacts on livelihoods as a result of an oil spill? In the case of an oil spill, will EEPGL be responsible? There should be a compensation plan to address negative environmental and socio-economic impacts, particularly those affecting fisherfolk and the Indigenous Peoples. (2, 3/4, 5, 6)	Section 9.1.9 describes a claims and livelihood remediation process that would be implemented in the event of an oil spill causing losses to stakeholders (including fisherfolk and Indigenous Peoples).
How prepared is the EPA to deal with oil spills? Are there laws in place to monitor and enforce in order to prevent a disaster? (2)	Chapter 3, Administrative Framework, describes the laws and regulations that have been identified as potentially applicable to the Project.

Comments (Meeting[s] where Comment was Raised)	Consideration in the EIA
We are asking for a study of the economic value of the Guyana fishing industry and how a spill would affect it—in order to be given the right compensation. (6)	Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities— Socioeconomic Resources, provides socioeconomic data on the Guyana fishing industry. Section 9.1.9 describes a claims and livelihood remediation process that would be implemented in the event of an oil spill causing losses to stakeholders (including fisherfolk).
How does the EIA take into consideration potential metocean conditions (e.g., tides, winds, weather) effects on safety of drilling, production operations (i.e., related to the likelihood of a spill)? (6)	Chapter 2 and the ESMP (Volume III) include specific embedded controls that will be implemented to ensure safe offloading operations during the production operations stage of the Project.
Will the EIA assess potential impacts along routes taken by EEPGL's marine vessels, especially since there is increased vessel traffic? There should be standards and minimum criteria for all vessels. (3/4) What are the mitigation measures in place to ensure fisherfolk are not affected? Compensation should be established for when our vessels are struck by tankers. (3/4, 5, 6)	Section 8.4, Marine Use and Transportation, assesses potential impacts on marine use and transportation (including fisherfolk) as a result of Project vessel movements. Section 9.15 assesses potential risks to employment and livelihood from an accidental collision between a Project vessel and a non-Project vessel and discusses that in the case of a claim arising from such type of incident, appropriate provisions would apply, consistent with governing contracts and applicable laws. Section 9.16, Community Health and Wellbeing, assesses potential risks to community health and wellbeing from an accidental collision between a Project vessel and a non-Project vessel. Section 9.1.9 describes a claims and livelihood remediation process that would be implemented in the event of a loss to stakeholders from this type of event.
What is the effect of the empty space when oil is withdrawn? Will there be landslides? (1)	Section 5.2.1, Assessment of Potential for Geological/Seismic Impacts, discusses the assessment of the potential for geological/seismic impacts as a result of the Project.
Can there be leakage from movement of the earth since the well area will be filled with water? Can this also lead to earthquakes? (2)	Section 5.2.1 discusses the assessment of the potential for geological/seismic impacts as a result of the Project.
Will there be earthquakes as a result of weakened geology of the area? What effect does re-injection of water and gas (to replace oil) have on geology—can it lead to earthquakes? (3/4)	Section 5.2.1 discusses the assessment of the potential for geological/seismic impacts as a result of the Project.
The EIA should discuss whether/how removal of the hydrocarbons will increase seismicity potential as well as inland flooding. (5)	Section 5.2.1 discusses the assessment of the potential for geological/seismic impacts as a result of the Project.

Comments (Meeting[s] where Comment was Raised)	Consideration in the EIA
Will there be studies on overall climate change impacts, and the connection between natural disasters and the use of fossil fuels? (5, 6)	Section 5.2.1 discusses the assessment of the potential for geological/seismic impacts as a result of the Project. Section 6.1, Air Quality and Climate, assesses potential impacts on climate from planned Project activities.
How will equipment be monitored after decommissioning to prevent leaks like in Trinidad? Alternatives for decommissioning should be clearly outlined in the EIA. (3/4, 6)	A Preliminary End of Operations Decommissioning Plan for the Project is provided in the ESMP (Volume III).
Impacts on Environmental Resources	
If the Project is going to conduct research, it should be over multiple seasons, be thorough, and involve University of Guyana students for research and validation. (3/4)	Chapter 5, Scope of the Environmental Impact Assessment, discusses the resources that were identified for assessment of potential impacts, and the approach, including studies and their timeframes, that informed the assessment of potential impacts on these resources. The Stakeholder Engagement Plan (provided as part of the ESMP) includes details on involvement of stakeholders in the research and validation of studies.
Will there be studies to determine if there is migration of fish away from drilling areas? (3/4)	Chapter 5 discusses the studies used to assess potential impacts on marine fish, including a multi-season fish study and a participatory fish study. Section 7.8, Marine Fish, assesses potential impacts on marine fish as a result of planned Project activities (inclusive of drilling).
Will the EIA study the effect of invasive species as a result of ballast water discharge? Who will monitor the cumulative impacts of ballast water and possible invasive species? (5, 6)	Section 7.10, Ecological Balance and Ecosystems, assesses potential impacts on ecological balance and ecosystems as a result of planned Project activities (including discharges of ballast water.)
Will the EIA study the effects in 150 years (after operations have ceased)? (1)	A Preliminary End of Operations Decommissioning Plan for the Project is provided in the ESMP (Volume III).
Is there any danger from the abandonment of the equipment on the sea floor? (2)	A Preliminary End of Operations Decommissioning Plan for the Project is provided in the ESMP (Volume III).
The EIA should consider impacts on marine turtles and whether the migratory pattern of pregnant turtles will be impacted, especially considering the increase in the number of drilling ships with three development projects. Would they need to take an alternative route? (1)	Section 7.7, Marine Turtles, assesses potential impacts on marine turtles, including migratory patterns, from planned Project activities. Chapter 10 assesses potential cumulative impacts on marine turtles resulting from the Project combined with potential impacts of other EEPGL and non-EEPGL projects.

Comments (Meeting[s] where Comment was Raised)	**Consideration in the EIA**
It is recommended that the EIA include a cumulative impact assessment focused principally on the cumulative impacts of Liza Phase 1, Liza Phase 2, and Payara. (3/4, 5, 6)	Chapter 10 assesses potential cumulative impacts on marine turtles resulting from the Project combined with potential impacts of other EEPGL projects (including Liza Phase 1, Liza Phase 2, and two other prospective EEPGL development projects) and non-EEPGL projects.
What will be the effects on animal habitats? (1)	Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities— Biological Resources, assesses the potential impacts on a variety of biological resources as a result of planned Project activities.
If there are any positive benefits to the environment, especially to marine life, assessed from the previous two EIAs, can they be shared in this EIA? (3/4)	Chapter 7 assesses both potential positive impacts (benefits) and potential adverse impacts on marine life as a result of planned Project activities.
How is climate change as a result of the Project assessed? In the project summary, there was no mention of climate change or estimated greenhouse gases that will be released from this new development facility. This should be captured in the EIA. (5/6)	Section 6.1 assesses potential impacts on climate due to GHG emissions resulting from planned Project activities.
Waste Management	
The EIA should include evaluation of cumulative impacts in regards to waste disposal, as well as consideration of the construction of appropriate waste disposal facility in the Waste Management Plan. (3/4)	Chapter 10 assesses the potential cumulative impacts on waste management infrastructure capacity as result of planned Project activities and other EEPGL activities. The Waste Management Plan (ESMP, Volume III) details the waste management approach to be utilized by the Project.
Page 10 of Project Summary states "industry standard chemicals." What are these, how will these be used, and, other than Tiger Tanks, where will these hazardous materials be disposed of (especially considering the high water table along the coast)? The safe disposal of industry standard chemicals should be outlined in the EIA. (3/4)	Chapter 2 discusses chemical usage by the Project. Section 8.6, Waste Management Infrastructure Capacity, and the Waste Management Plan discuss the management of hazardous wastes generated by the Project.
Health, Safety, and Security	
What security measures will be on the drill ships and tankers to prevent sabotage (e.g., given tensions with Venezuela) therefore increasing potential for spills? (5, 6)	Chapter 2 discusses EEPGL's Safety, Security, Health, and Environment policies.

Comments (Meeting[s] where Comment was Raised)	Consideration in the EIA
Employment and Livelihoods	
How will livelihoods of fisherfolk be affected and how will the fishing boundaries be determined? Will a livelihood study on the impacts of fisherfolk as a result of the Project be included in the EIA? There are already complaints of fisherfolk over the past two years about dwindling catch. In Regions 5 and 6, there is a large fishing community that depends on the water. (1, 2, 3/4, 5, 6)	Sections 8.1 and 8.2, Socioeconomic Conditions and Employment and Livelihoods, provide baseline data on the Guyana fishing industry, as well as an assessment of potential impacts on fishing-related employment and livelihoods as a result of planned Project activities.
How will fisherfolk be compensated for loss accidents, depletion of fish stocks, etc.? Will a fund be set-up to alleviate impacts on fisherfolk? (5, 6)	Section 9.1.9 describes a claims and livelihood remediation process that would be implemented in the event of an oil spill or accident causing losses to stakeholders (including fisherfolk).
What positive benefits will villagers in Region 1 receive? Will there be analysis on percentage of Indigenous Peoples involved directly or indirectly in oil and gas sector, or studies on proposed alternative livelihood activities for Amerindians and post-oil effects and benefits to Indigenous Peoples? (1)	Sections 8.1 and 8.10, Indigenous Peoples, provide baseline data on the coastal communities in Region 1, including Indigenous Peoples.
Other Socioeconomic Factors	
Indigenous Peoples in Region 1 need more engagement on Payara, especially because an oil spill would be impacting them. Request more meaningful consultation with Indigenous Peoples and consultation on decision-making. (1, 3/4)	Section 4.5 and the Stakeholder Engagement Plan detail the meetings held as part of the scoping and EIA development process, as well as ongoing engagement pertaining to the Ecosystem Services Study and Oil Spill Training, in Region 1.
Impacts on land use in coastal communities as a result of the project should be considered in the EIA (3/4)	Section 8.8, Land Use discusses the potential impacts on land use in coastal communities as a result of planned Project activities.

Note: The number in the parentheses following the comments indicates the regional meeting at which the comment was made.

4.5.3.2. Details of Key Informant Interviews

Throughout the development of the EIA, the Consultants held a series of one-on-one meetings, focus groups, and key informant interviews to receive comments first-hand from stakeholders regarding important content for consideration in the Terms and Scope and EIA.

In January 2019, the Consultants and the Chelonian Research Institute, in collaboration with the Protected Areas Commission, conducted a Turtle Telemetry Capacity Building Workshop. At this workshop, the methodology, techniques, and findings of the Liza Phase 1 Development Project Turtle Telemetry Program (conducted in 2018) were presented to 17 members of the Protected Areas Commission, EPA, Fisheries Department, Guyana Marine Conservation Society, and Guyana Wildlife Conservation and Management Commission.

Over the period of January to April 2019, the Consultants interviewed 82 fisherfolk at 16 fisheries landing sites in Regions 1 to 6. This allowed the Consultants to obtain biological and socioeconomic data from these fisherfolk regarding artisanal and commercial fishing activities. This also allowed the Consultants to share relevant information about EEPGL's existing and upcoming marine activities, including providing copies of the Notices to Mariners, which are also published in the newspapers. Engagement with many of these individuals and fishing cooperatives in all six regions continues on at least a monthly basis as part of an EEPGL-commissioned Participatory Fishing Study.

Over the period from April to May 2019, the Consultants requested feedback from 14 hotels in Region 4 on their facilities, existing capacity rates, and demand forecasting, including any current and potential influence from the increased activity in the oil and gas sector. During the same period, the Consultants also requested feedback from eight realtors located in Georgetown on their perspectives of how the real estate market in Georgetown may be characterized, and whether existing or anticipated activities in the oil and gas sector may influence the real estate markets in Georgetown, Region 4, and other administrative regions. Responses were provided by 10 hotels and 3 realtors via written questionnaires. Details of the data received can be found in Section 8.5, Social Infrastructure and Services.

Beginning in May 2019, the Consultants began the data validation stage of the Liza Phase 1 Post-Permit Ecosystem Services Study data by initiating a process to conduct 62 unique engagements with coastal Neighborhood Democratic Councils, Regional Democratic Councils, Town Councils, and Village Councils in Regions 1 to 6. As of early July 2019, all engagements had been completed except for those in Region 3, which were ongoing. A total of 464 stakeholders in Regions 1, 2, 4, 5, and 6 participated in the engagement and ecosystem services validation efforts. Stakeholders stated their concerns and expressed an interest in learning more about oil and gas in general, and asked about potential benefits such as opportunities for employment and training. Meeting dates, attendees, and feedback from these engagements are summarized in Appendix V, Interim Ecosystem Services Validation Data Summary.

During the aforementioned data validation efforts in Region 1, the Consultants engaged first-hand with 13 coastal Amerindian communities about EEPGL's operations, including indigenous communities in and around Shell Beach Protected Area. All meetings were attended by a National Toshaos Council representative to ensure that the engagements were fair and impartial and that the concerns of the indigenous communities were raised. The participation of the National Toshaos Council was also beneficial since communities were more comfortable as a result of the presence of the representative and, as such, had more confidence in the engagement process and could participate freely in the discussions. A representative of the Guyana Marine Conservation Society also participated in this exercise in Region 1. Stakeholders expressed an interest in learning more about oil and gas activities in general, as well as oil spill response, and asked questions about potential environmental and social impacts as a result of oil and gas development projects. EEPGL representatives also attended meetings in Regions 1, 4, and 5.

In April through July 2019, the Consultants sent letters of invitation seeking key informant interviews with 19 government agencies, commissions, professional or business associations, NGOs, and elected officials and regional administrators (see Figure 4.5-4).

ERM
Environmental Resources Management
Lot 1 Croal Street, Stabroek
Georgetown, Guyana
T (592) 623 0702

16th April, 2019

Mr. Denzil Roberts
Chief Fisheries Officer
Ministry of Agriculture,
Regent & Shiv Chanderpaul Drive,
Georgetown, Guyana

Ref: Request to provide overview of Payara Project and EIA Process

Dear Mr. Roberts,

Esso Exploration and Production Guyana Ltd (EEPGL) initiated the environmental authorization process with the Guyana Environmental Protection Agency (EPA) for the third development within the Stabroek Block, referred to as the Payara Development, which would serve as the third oil and gas development project in Guyana.

Following submission of the application for an environmental permit to the EPA, the EPA determined that an Environmental Impact Assessment (EIA) is required for Payara. The EIA is aimed at identifying and assessing direct and indirect environmental, socioeconomic and community health impacts that could potentially result from the Payara Project. The EIA is being conducted by Environmental Resources Management (ERM), an international sustainability consulting firm, in partnership with Guyanese environmental firms Environmental Management Consultants (EMC) and Ground Structures Engineering Consultants (GSEC).

On behalf of the Payara Project team, EEPGL, ERM and EMC representatives would welcome the opportunity to present an overview of the proposed Project and EIA process, and to discuss Project-related issues of interest to the Ministry of Agriculture.

An EMC representative will be calling your office in the coming weeks to schedule an appointment. In addition, we may wish to request publicly available data from your organisation to assist our EIA technical specialists. We would appreciate if you can identify a point of contact within your organization for our team to follow up with. We look forward to meeting with you and to working with the Ministry of Agriculture as we undertake the EIA process.

Sincerely,

Neil Henry
Project Manager
Environmental Resources Management, Inc.

cc: Dr. Vincent Adams, Executive Director, Environmental Protection Agency
Deedra Moe, Senior Director, Public and Government Affairs, EEPGL
Jason Wiley, Payara Project Manager, ERM
Shyam Nokta, Managing Director, EMC

Figure 4.5-4: Example of Letter of Invitation for Key Informant Interviews

The Consultants received 15 positive responses from the stakeholder groups described below, and conducted the associated interviews. During these interviews, the Consultants provided an overview presentation of the Project (the same material that was presented in the March 2019 public scoping consultation meetings), which included the preliminary list of resources and receptors that were identified for inclusion in the EIA; anticipated studies and analyses that would support the EIA; and a preliminary discussion of potential impacts that could occur as a result of the Project. A summary of each meeting is provided below. Expert commentary and baseline data collected from these stakeholders have been included and referenced within the EIA. Where stakeholders raised specific concerns or issues to be addressed in the EIA, these are noted as such within the summary.

- On 26 April 2019, Centre for Local Business Development (CLBD) shared information on their Supplier Registration Portal; the training programs offered on behalf of EEPGL by the CLBD and some of the key issues participants in these program raised in relation to the sector; their views on how the CLBD contributes to local content; and how the oil and gas sector is likely to contribute to national development in Guyana.
- On 26 April 2019, National Trust of Guyana shared concerns on how the oil and gas sector may influence cultural heritage sites in Georgetown and plans for reconsidering the current system for historical preservation of these sites. The National Trust of Guyana also shared data on cultural heritage sites and archaeological sites in Guyana.
- On 30 April 2019, Ministry of Business Department of Tourism shared views on how the oil and gas sector may impact tourism in Guyana and plans for development of tourism initiatives in Regions 1 to 6.
- On 2 May 2019, Ministry of Agriculture Fisheries Department shared plans for enhancing the management of Guyana’s fisheries sector and further development of the sector, including deep-sea fishing; outlined the challenges facing the fishing industry; and indicated some of the concerns for the fishing sector as it pertains to oil and gas. The Fisheries Department also requested copies of the reports of the studies conducted in support of the EIA (those related to the fisheries sector). Appendix N, Marine Fish Study Interim Report—Dry Season 2018–2019 and Appendix T, Participatory Fishing Survey Quarterly Report are provided as part of the EIA.
- On 3 May 2019, National Agricultural Research and Extension Institute shared feedback on mangrove coverage in the coastal sensitivity maps prepared as part of the Liza Phase 1 Development Project Ecosystem Services Study; information on a mangrove-mapping project that is being implemented in collaboration with Conservation International (CI); and plans for additional mangrove restoration activities, including in Region 1.
- On 7 May 2019, The Ministry of Communities shared plans for the housing and water sectors. The Ministry of Communities also suggested that the EIA consider how oil and gas may influence the socioeconomic conditions of Regions 7 to 10, and suggested the EIA should include a study on commercial sex workers in relation to the oil and gas sector. (The rationale behind the focus on coastal communities in Regions 1 to 6 is discussed in

Chapter 5, Scope of the Environmental Impact Assessment. An assessment of communicable disease transmission as a result of the Project is discussed in Section 8.3, Community Health and Wellbeing)

- On 8 May 2019, CI requested the EIA assess critical habitats that need special treatment under International Finance Corporation Performance Standard 6; the cumulative research effort, in particular for biological studies, that was conducted in support of the Liza Phase 1, Liza Phase 2, and Payara projects; the goal of the EIA towards environmental management; volumes of waste that will be disposed at the Haags Bosch Landfill; and the need for a non-technical Executive Summary. Concerns on traffic congestion and safety in the vicinity of the Guyana Shorebase Inc. facility were also shared. CI also requested access to the data and reports of the studies conducted in support of the EIA. (A discussion on critical habitats is found in Section 7.1, Protected Areas and Special Status Species; cumulative impacts in Chapter 10, Cumulative Impact Assessment; environmental management in ESMP; volumes of waste in Chapter 2, Description of the Project, Section 8.6, Waste Management Infrastructure Capacity and Waste Management Plan; road traffic and safety in Section 8.5, Social Infrastructure and Services; non-technical summary in the EIS; and reports of studies have been appended to the EIA.)
- On 9 May 2019, University of Guyana advocated for one cumulative EIA instead of multiple EIAs for each development project. The university shared plans for developing courses to prepare students for employment in oil and gas, and welcomed partnerships with EEPGL and the Consultants to share knowledge and experiences with students.
- On 10 May 2019, Guyana Lands and Surveys Commission indicated how the oil and gas sector has impacted the demand for land in Region 4, particularly in Georgetown, and shared plans for enhancing the system for integrated land use planning in Guyana.
- On 12 May 2019, Ministry of Social Protection highlighted the need to ensure the welfare, health, and safety of Guyanese workers; and shared information on the process to develop occupational health and safety regulations for the oil and gas sector. (Chapter 2 and the ESMP (Volume III) include information pertaining to systems to manage occupational health and safety risks for Project workers.)
- On 17 May 2019, Ministry of Agriculture shared views on how the oil and gas sector may impact the agricultural sector and information on projects to develop the agricultural sector, including value-added initiatives. The ministry also shared statistics for the agricultural sector.
- On 17 May 2019, Guyana Geology and Mines Commission requested that the EIA consider the volumes and disposal methods for general solid waste that will be generated by the Liza Phase 1, Liza Phase 2, and Payara projects; methods for managing increased vessel traffic in Georgetown Harbour; probabilities of significant oil spills occurring in Guyana; and security for the Floating Production, Storage, and Offloading vessel against foreign military vessels. (Chapter 10 discusses cumulative impacts on waste management infrastructure capacity; Section 8.4, Marine Use and Transportation, discusses potential impacts on marine vessel

traffic; and Chapter 2 includes information pertaining to procedures for security related to Project operations).

- On 19 May 2019, Bureau of Statistics shared plans for including oil and gas in the national accounts and provided updates on several surveys that are being planned and implemented by the bureau. The bureau also requested copies of the reports of studies conducted in support of the EIA.
- On 13 June 2019, World Wildlife Fund shared their commitment to actively engage in the stakeholder engagement process for the Project as part of the regulatory process led by the EPA, including by participating in public scoping meetings, public disclosure meetings, and submitting written feedback to the EPA.
- On 26 June 2019, the Protected Areas Commission shared views that the National Toshaos Council and Guyana Marine Conservation Society should be included in engagement in Region 1 and enquired about the methods of biological and socioeconomic baseline data collection in indigenous communities. The Protected Areas Commission asked that Consultants meet with all stakeholders in a single session going forward (instead of one-on-one engagements) and provide regular EIA progress updates. (Engagement in Region 1, including participation of the National Toshaos Council and Guyana Marine Conservation Society, is detailed in Section 4.5 and the Stakeholder Engagement Plan.)

4.5.4. Stakeholder Comments and Considerations Summary

This section summarizes the key comments and suggestions received from stakeholders during the EIA scoping and consultation processes and how these comments have been considered and addressed in the EIA. The key themes of these issues/concerns included the following:

- Socioeconomic implications of the Project, most of which were focused on the expected benefits to society from the Project, including economic and community development and employment and livelihoods;
- Environmental impacts of the Project, including impacts on marine life and other biological resources, fishing livelihoods, and air quality;
- Regulatory process (e.g., EIA approach, process and/or methodology, scope and timeline of the EIA, data collected to support the EIA, and stakeholder engagement efforts over the course of the EIA process);
- Worker health and safety;
- Potential for unplanned events such as oil spills to occur;
- Project design, location, and schedule;
- Cumulative impacts, and how results from Liza Phase 1 and Liza Phase 2 will be incorporated;
- Waste management; and
- Stakeholder engagement process, especially with regard to Region 1 Indigenous People.

Table 4.5-2 summarizes key themes and addresses how the key themes were considered in the EIA.

Table 4.5-2: Summary of Comments Received and How They Were Considered in the EIA

Key Theme	Consideration in EIA
Socioeconomic impacts	Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, describes the assessment of potential socioeconomic impacts from planned Project activities. Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, describes the assessment of potential risks to socioeconomic resources from unplanned events (e.g., oil spills).
Environmental impacts	Each resource/receptor-specific discussion in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources, and Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources, describes the assessment of potential impacts on environmental resources/receptors from planned Project activities and the management measures recommended to address those potential impacts. Chapter 9 describes the assessment of potential risks to environmental resources/receptors from unplanned events (e.g., oil spills).
Regulatory process	Chapter 3, Administrative Framework, describes the administrative framework applicable to the Project, including the regulatory process for the EIA. Chapter 4, Methodology for Preparing the Environmental Impact Assessment, provides additional detail on the EIA process.
Worker health and safety	Chapter 3 describes the ExxonMobil Operations Integrity Management System Framework, which underpins EEPGL's processes and procedures to facilitate safe operation of the Project. The ESMP; Chapter 2, Description of the Project; and Chapter 13, Recommendations, describe the specific embedded controls that will aid in managing occupational health and safety-related risks.
Unplanned events	Chapter 9 assesses potential risks from unplanned events, including oil spills. The Oil Spill Response Plan, which is included as an attachment to the EIA, describes EEPGL's specific approach for managing the impacts of an oil spill, should one occur.
Project design, location, and schedule	Chapter 2 includes a description of the proposed Project, and a schedule describing anticipated timing for the major stages of the Project, assuming receipt of regulatory approval to proceed.
Cumulative impacts	Chapter 10, Cumulative Impact Assessment, assesses the potential cumulative impacts of the Project combined with the likely effects of other reasonably foreseeable activities with the potential to impact the same resources/receptors as the Project.
Waste management	Section 8.6, Waste Management Infrastructure Capacity, assesses potential impacts of planned Project activities on waste management infrastructure capacity. Chapter 10 assesses the potential cumulative impacts on waste management infrastructure capacity as a result of planned Project activities and other EEPGL activities. A Waste Management Plan, which is included as an attachment to the EIA, describes EEPGL's strategy for addressing Project-generated wastes.
Stakeholder engagement	Stakeholder engagement activities, including those with Indigenous Communities, are discussed in Chapter 4, and a SEP is included as an attachment to the EIA.

4.6. Assessment of Impacts and Identification of Mitigation Measures

The primary purpose of an EIA is to predict the potential impacts resulting from a proposed project and to identify measures to avoid, reduce, or remedy these potential impacts. The Consultants used a standard impact assessment methodology for identifying potential impacts and assessing their significance.

Impacts can be “direct,” “indirect,” or “induced,” as defined below:

- Direct—impacts that result from a direct interaction between a project and a resource/receptor (e.g., disturbance of a benthic community habitat on the seafloor);
- Indirect—impacts that follow from direct interactions between a project and other resources/receptors (e.g., impacts on marine fish who feed off a directly impacted benthic community); and
- Induced—impacts that result from other non-Project activities that occur as a consequence of a project (e.g., impacts from an influx of job seekers).

The assessment of impacts proceeded through an iterative four-step process, as illustrated in Figure 4.6-1.

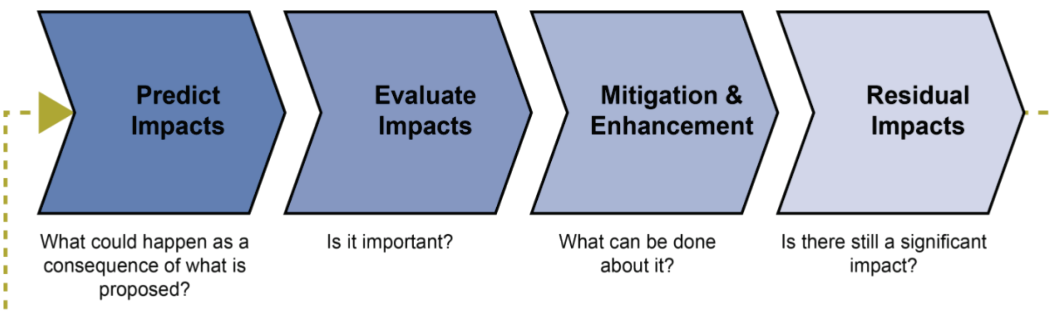

Figure 4.6-1: Impact Prediction and Evaluation Process

4.6.1. Step 1: Predict Impacts

The EIA evaluates potential Project impacts by predicting and quantifying, to the extent possible, the magnitude of those impacts on resources/receptors and the sensitivity/vulnerability/ importance of the impacted resources/receptors.

4.6.1.1. Predicting Magnitude of Impacts

Magnitude essentially describes the nature and degree of change that the potential impact is likely to impart upon the resource/receptor. Depending on the impact, magnitude is a function of some or all of the following impact characteristics:

- Geographical extent
- Intensity
- Frequency
- Duration

The magnitude of an impact takes into account the various dimensions of a particular impact to determine where the impact falls on the spectrum (in the case of adverse impacts) from **Negligible** to **Large**. Some impacts will result in changes to the resource/receptor that may be immeasurable or undetectable. Such changes are characterized as having a **Negligible** magnitude.

Taking into account the magnitude of impact characteristics identified above, the magnitude of each potential impact is assigned one of the following five ratings:

- Positive
- Negligible
- Small
- Medium
- Large

Based on prior stakeholder input received and modeling performed during the Liza Phase 1 and Liza Phase 2 Development project EIAs, each potential impact was characterized by one of three possible geographical extents:

- Direct AOI
- Direct AOI + Central Stabroek Block
- Indirect AOI

The definitions for duration and frequency designations used throughout the EIA are provided in Tables 4.6-1 and 4.6-2, respectively.

Table 4.6-1: Definitions for Duration Designations

Duration Designation	Definition
Short-term	Instantaneous to less than an week in aggregate
Medium-term	More than a week but less than a year in aggregate
Long-term	More than 1 year in aggregate

Table 4.6-2: Definitions for Frequency Designations

Frequency Designation	Definition
Episodic	Occurring occasionally and at irregular intervals
Continuous	Occurring more than occasionally or at regular intervals

In recognition that the same impact could be experienced differently by different resources/receptors, the definitions for intensity designations are described in the resource/receptor-specific sections of the EIA (Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources).

To establish a consistent basis for assigning magnitude ratings on the basis of the various impact characteristics (i.e., geographical extent, intensity, frequency, and duration), each of the possible combinations of characteristic designations was assigned a magnitude rating. Figure 4.6-2 lists the various combinations of impact characteristics and the corresponding magnitude ratings that were assigned for each combination.

4.6.1.2. Predicting Sensitivity, Vulnerability, or Importance of Impacts

Multiple factors are taken into account when defining the sensitivity/vulnerability/importance of a resource/receptor. For physical resources (e.g., marine water quality), the resource's sensitivity to change is typically considered. For biological or cultural resources/receptors (e.g., a mangrove forest), the importance (e.g., local, regional, national, or international importance) and sensitivity to the specific type of impact are typically considered. For human receptors, the vulnerability of the potentially impacted individual, community, or wider societal group is generally considered. Other factors may also be considered when characterizing sensitivity/vulnerability/importance, such as legal protection, government policy, stakeholder views, and economic value. Depending on the resource/receptor being considered, the EIA focuses on the factor (i.e., sensitivity, vulnerability, or importance) that is most relevant to that resource/receptor. However, for ease of reference, this factor is typically referred to hereinafter as "sensitivity."

As in the case of magnitude, the approach for designating sensitivity ratings will vary on a resource/receptor basis. The following sensitivity designations are used in the EIA:

- Low
- Medium
- High

Not all resources can be assessed according to the same criteria, so the sensitivity ratings for specific resources/receptors may be determined differently according to the resource/receptor (or the type of impact) being assessed. The specific criteria used to assign sensitivity ratings are therefore discussed in the resource/receptor-specific sections (Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources).

4.6.2. Step 2: Evaluate Impacts

The process of impact evaluation considers predicted impacts with the potential to occur due to planned activities of the Project, and impacts that could potentially occur due to unplanned events (e.g., oil spills), but would not otherwise be expected to occur as a result of planned Project activities.

Direct AOI

Intensity	Frequency	Duration	Overall Magnitude Rating
Negligible	Episodic	Short-term Medium-term	Negligible
Low	Episodic	Short-term	Negligible
		Medium-term	Small
Medium	Episodic	Short-term	Negligible
		Medium-term	Small
High	Episodic	Short-term	Medium
		Medium-term	Medium
Negligible	Episodic	Long-term	Negligible
Low	Episodic	Long-term	Small
Medium	Episodic	Long-term	Small
High	Episodic	Long-term	Medium
Negligible	Continuous	Short-term Medium-term	Negligible
Low	Continuous	Short-term	Small
		Medium-term	Small
Medium	Continuous	Short-term	Small
		Medium-term	Medium
High	Continuous	Short-term	Medium
		Medium-term	Medium
Negligible	Continuous	Long-term	Negligible
Low	Continuous	Long-term	Small
Medium	Continuous	Long-term	Medium
High	Continuous	Long-term	Large

Direct AOI + Central Stabroek Block

Intensity	Frequency	Duration	Overall Magnitude Rating
Negligible	Episodic	Short-term Medium-term	Negligible
Low	Episodic	Short-term	Negligible
		Medium-term	Small
Medium	Episodic	Short-term	Small
		Medium-term	Small
High	Episodic	Short-term	Medium
		Medium-term	Medium
Negligible	Episodic	Long-term	Negligible
Low	Episodic	Long-term	Small
Medium	Episodic	Long-term	Medium
High	Episodic	Long-term	Medium
Negligible	Continuous	Short-term Medium-term	Negligible
Low	Continuous	Short-term	Small
		Medium-term	Small
Medium	Continuous	Short-term	Small
		Medium-term	Medium
High	Continuous	Short-term	Medium
		Medium-term	Large
Negligible	Continuous	Long-term	Negligible
Low	Continuous	Long-term	Small
Medium	Continuous	Long-term	Medium
High	Continuous	Long-term	Large

Indirect AOI

Intensity	Frequency	Duration	Overall Magnitude Rating
Negligible	Episodic	Short-term Medium-term	Negligible
Low	Episodic	Short-term	Small
		Medium-term	Small
Medium	Episodic	Short-term	Small
		Medium-term	Medium
High	Episodic	Short-term	Medium
		Medium-term	Large
Negligible	Episodic	Long-term	Negligible
Low	Episodic	Long-term	Small
Medium	Episodic	Long-term	Medium
High	Episodic	Long-term	Large
Negligible	Continuous	Short-term Medium-term	Negligible
Low	Continuous	Short-term	Small
		Medium-term	Medium
Medium	Continuous	Short-term	Medium
		Medium-term	Medium
High	Continuous	Short-term	Medium
		Medium-term	Large
Negligible	Continuous	Long-term	Negligible
Low	Continuous	Long-term	Small
Medium	Continuous	Long-term	Large
High	Continuous	Long-term	Large

Figure 4.6-2: Impact Characteristics and Magnitude Ratings

4.6.2.1. Evaluating Potential Impacts from Planned Activities

For potential impacts associated with planned activities of the Project, the significance of each potential impact is assigned based on evaluation of the magnitude of the impact and the sensitivity/vulnerability/importance of the resource/receptor. The matrix depicted in Figure 4.6-3 is used for assigning impact significance ratings. The assignment of a significance rating enables decision-makers and stakeholders to understand and prioritize key potential Project impacts and consider what mitigation measures may be warranted.

		Sensitivity/Vulnerability/Importance of Resource/Receptor		
		Low	Medium	High
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major

Figure 4.6-3: Impact Significance Rating Matrix for Planned Activities

An impact of **Negligible** significance is one where a resource/receptor will not be noticeably impacted by a particular activity; the predicted impact is deemed to be imperceptible or is indistinguishable from natural background variations, or the impact is of a small magnitude and is expected to affect resources/receptors with a low sensitivity to the particular impact.

An impact of **Minor** significance is one where a resource/receptor will experience a noticeable effect, either due to a small magnitude impact affecting a resource/receptor with a medium sensitivity or due to a medium magnitude impact affecting a resource/receptor with a low sensitivity. In either case, the magnitude is expected to be within applicable standards, if any exist.

An impact of **Moderate** significance has an impact magnitude that is within applicable standards (if any exist), but falls somewhere in the range from an effects threshold below which the impact is considered Minor, and above which the impact is considered Major.

An impact of **Major** significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts are predicted to affect resource/receptors that have a medium or high sensitivity.

In the case of positive impacts, the EIA does not attempt to characterize magnitude; therefore, significance ratings for positive impacts are not assigned.

The specific criteria used to evaluate significance of impacts for each resource/receptor are presented in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

4.6.2.2. Evaluating Potential Impacts from Unplanned Events

Potential risks from non-routine/unplanned events related to the Project (e.g., oil spills, traffic accidents, or other events with a less-than-certain chance of occurrence) do not lend themselves readily to the analysis described above for planned Project activities. Rather than assigning significance ratings (as is done for potential impacts from planned activities), the EIA assigns risk ratings for potential risks from unplanned events. Assessing risk requires understanding:

- Potential consequence/severity of the unplanned event if it were to occur; and
- Likelihood of the unplanned event occurring.

For unplanned events, a risk matrix (Figure 4.6-4) is used to rate the risk to resources associated with these events.

		Consequence/Severity		
		Low	Medium	High
Likelihood	Unlikely	Minor	Minor	Moderate
	Possible	Minor	Moderate	Major
	Likely	Moderate	Major	Major

Figure 4.6-4: Risk Rating Matrix for Unplanned Events

Likelihood reflects the probability of occurrence of the unplanned event, and is defined as follows:

- Unlikely—considered a rare event; there is a small likelihood that such an event would occur during the Project life cycle;
- Possible—the event has a reasonable chance to occur at some time during normal operations of the Project; and
- Likely—the event is expected to occur at some point during the Project life cycle.

Likelihood is estimated on the basis of experience and/or evidence that such an outcome has previously occurred. It is important to note that likelihood is a measure of the degree to which the unplanned event is expected to occur, not the degree to which an impact is expected to occur as a result of the unplanned event. The latter concept is referred to as uncertainty, and this is typically dealt with in a contextual discussion in the impact assessment, rather than in the risk rating process.

The consequence/severity element of the risk rating is assigned based on the sensitivity of the resource/receptor and the magnitude of the impact (determined as if it were an impact from a planned activity)—essentially equivalent to the manner in which a significance rating is assigned for an impact from a planned activity—and then using Figure 4.6-5 to determine the assigned consequence/severity.

	Sensitivity/Vulnerability/Importance of Resource/Receptor		
Magnitude of Impact	Low	Medium	High
Negligible	Negligible	Negligible	Negligible
Small	Negligible	Minor	Moderate
Medium	Minor	Moderate	Major
Large	Moderate	Major	Major

Low Consequence/Severity (Negligible)

Medium Consequence/Severity (Minor, Moderate)

High Consequence/Severity (Major)

Figure 4.6-5: Consequence/Severity Determination for Unplanned Events

4.6.3. Step 3: Mitigation and Enhancement

The next step in the process is the identification of measures that can be taken to mitigate, as far as reasonably practicable, the identified potential impacts of the Project. A mitigation hierarchy is used, where the preference is always to avoid the impact before considering other types of mitigation. The following is the preferred hierarchy of measures followed in this EIA:

- Avoid—remove the source of the impact by employing alternative designs or operations to avoid potential adverse interactions with environmental and socioeconomic resources/receptors;
- Reduce—lessen the chance of adverse interaction between the Project and resources/ receptors and/or lessen the consequence of adverse interactions that cannot be avoided (e.g., reduce the size of the Project footprint); and
- Remedy—if adverse interactions between the Project and resources/receptors cannot be avoided or their consequences reduced, then “repair” the consequences of the impact after it has occurred through rehabilitation, reclamation, restoration, compensation, and/or offsets.

In support of the EIA process, the Consultants and EEPGL developed an adaptive management strategy to aid in tracking that committed mitigation measures are implemented as planned and produce the desired outcomes. This adaptive management strategy provides EEPGL, in consultation with the EPA and other stakeholders, the opportunity to:

- Address unanticipated adverse impacts that are encountered—by identifying and implementing new or different mitigation measures (following the same avoid/reduce/ remedy hierarchy);
- Adjust or replace existing mitigation measures when appropriate during the Project life cycle—to address evolving impacts; and
- Retire existing mitigation measures that no longer demonstrate value.

Mitigation measures were developed to address the potential impacts identified in the EIA process. These measures are described in each resource/receptor-specific discussion in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources. Chapter 13, Recommendations, summarizes all of these mitigation measures. Mitigation measures are generally not developed for potential adverse impacts that are assessed as having a significance rating of **Negligible**.

In addition, an ESMP was prepared that describes all the mitigation measures incorporated into the EIA, summarizes how each mitigation measure will be implemented, and identifies a monitoring strategy to evaluate the effectiveness of each mitigation measure. The ESMP is included as an attachment to the EIA.

EEPGL recognizes that demonstrating capacity to manage non-routine, unplanned events, such as oil spills, is an important and integral component of the impact management process. As such, the ESMP includes an Oil Spill Response Plan to address the management of potential impacts resulting from an unplanned oil spill.

4.6.4. Step 4: Determine and Manage Residual Impacts

The final step in the iterative impact evaluation process for this EIA is the assessment of “residual impacts/risks” (i.e., impacts/risks that are predicted to remain after both embedded controls and committed mitigation measures have been taken into consideration). This typically involves repeating the process described in Step 1 and Step 2 to re-evaluate the potential impact significance or risk rating, considering the implementation of proposed mitigation measures.

In cases where the residual impact significance rating or the residual risk rating is **Moderate** or **Major**, the management emphasis is on reducing the impact/risk to a level that is as low as reasonably practicable. This does not necessarily mean, for example, that residual impacts/risks of **Moderate** or higher have to be reduced to **Minor**, but rather that these impacts/risks are being managed as effectively and efficiently as practicable.

Although a standard goal of an impact assessment is to eliminate residual impacts/risks of a **Major** significance, for some resources/receptors, there may be residual impacts/risks of **Major** even after all practicable mitigation options have been exhausted. In these situations, decision-makers must weigh negative factors against the positive ones, in reaching a decision on the Project.

5 SCOPE OF THE ENVIRONMENTAL IMPACT ASSESSMENT

The scope of the EIA includes all Project stages described in Chapter 2, Description of Project (i.e., development drilling, installation, production operations, and decommissioning) and all planned activities listed in Section 5.1, The Area of Influence. The EIA also addresses non-routine, unplanned events (e.g., spills and releases). The EIA builds on a number of EIAs and environmental management plans (EMPs), including the following:

- 2014—Strategic Environmental Assessment, assessing exploration drilling impacts and mitigations in Liza and Sorubim areas of interest within the Stabroek Block (ERM 2014);
- 2015—Strategic Environmental Assessment Addendum, continuing to assess exploration drilling impacts and mitigations following the Liza discovery and supporting the drilling of the Liza-2 well (ERM 2015);
- 2016—EMP, assessing additional multiwell exploration drilling impacts, management and mitigation measures within Stabroek Block (ERM 2016);
- 2017—Liza Phase 1 Development Project EIA, assessing development wells, associated development infrastructure, production operations, and decommissioning in the Liza area of interest (ERM 2017);
- 2018—EMP Addendum, assessing additional multiwell exploration drilling impacts within the Stabroek Block (ERM 2018b);
- 2018—Liza Phase 2 Development Project EIA, assessing development wells, associated development infrastructure, production operations, and decommissioning in the Liza area of interest (ERM 2018a); and
- 2019—EMP, assessing additional multiwell exploration drilling impacts and mitigations across several areas of interest in the Stabroek Block (ERM 2019).

Supplementing the studies and analyses conducted as part of the above assessments, additional data collection and further analyses were conducted to evaluate the potential environmental and socioeconomic impacts of the Project, and these are discussed herein.

5.1 THE AREA OF INFLUENCE

The area potentially impacted by a project is referred to as its Project Area of Influence (AOI). For purposes of this EIA, a Direct AOI and an Indirect AOI were defined, as described below:

- Direct AOI, within which the Project is expected to have potential direct impacts (Figure 5.1-1). This area includes: (1) the Project Development Area (PDA) (i.e., the subsea development area including the wells, Subsea, Umbilicals, Risers, and Flowlines [SURF] equipment, and other subsea infrastructure; and the surface development area including the Floating Production, Storage, and Offloading [FPSO] vessel, drill ships, other Project marine vessels and associated marine safety exclusion zones); (2) the marine and aviation transit corridors between the PDA and onshore activity centers in Guyana and Trinidad (within the territorial boundary of Guyana); and (3) the City of Georgetown. These areas collectively were defined as the Direct AOI because they comprise, based on the potential impacts identified during the scoping phase, the geographic extent in which direct Project impacts (i.e., potential impacts resulting from a direct interaction between planned Project activities and environmental or socioeconomic resources) are anticipated to potentially occur. The planned Project activities will generate emissions to air and discharges to water, which could result in potential impacts on air quality and water quality, respectively, outside of the geographic extent encompassed by the Direct AOI. Modeling for these parameters was conducted to assess whether these emissions and discharges could result in potential impacts on air quality and water quality, respectively, outside of the geographic extent encompassed by the Direct AOI. The results of modeling (see Sections 6.1.3, Impact Assessment—Air Quality and Climate, and 6.4.3, Impact Assessment—Water Quality) confirmed that the Direct AOI is inclusive of the extent of potentially significant impacts on these resources.

- Indirect AOI, within which the Project is expected to have potential indirect impacts (Figure 5.1-2). This area includes: (1) coastal areas and marine waters within the territorial boundary of Guyana that could potentially be impacted by an unplanned event (i.e., an oil spill [see Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, for more details on oil spill modeling]); and (2) coastal Regions 1–6, which could be impacted to a greater extent than other regions because of their degree of reliance on subsistence and commercial marine fisheries (i.e., related to potential impacts on fish and marine transport) and increased exposure to potential Project socioeconomic impacts. Although all ten regions of Guyana will potentially benefit from the shared government revenue stream from the Project, the Indirect AOI does not include the entire country because the extent to which any specific region could benefit from the revenues is dependent on the government's policies rather than on the Project activities assessed in this EIA. Based on oil spill modeling conducted for the Payara Project, only (portions of) the Region 1 coastline could potentially be impacted by a spill. This modeling also indicates an oil spill would not have a reasonable likelihood of affecting marine waters southeastward or seaward of the FPSO. However, considering the potential for community members from all coastal regions (in particular fisherfolk and other marine users) to be indirectly affected in the event of an oil spill, as well as the potential for socioeconomic impacts from some planned Project activities (e.g., Project vessel movements), all six coastal regions and the entire extent of Guyana's marine waters downgradient of the FPSO were defined collectively as the Indirect AOI.

As described in Chapter 10, Cumulative Impact Assessment, cumulative impacts on environmental and socioeconomic resources could potentially result from incremental impacts of the Project, when combined with other past, present, and reasonably foreseeable future projects/ developments within the Project AOI. The geographic area of concern for the cumulative impacts analysis is generally consistent with the Project AOI.

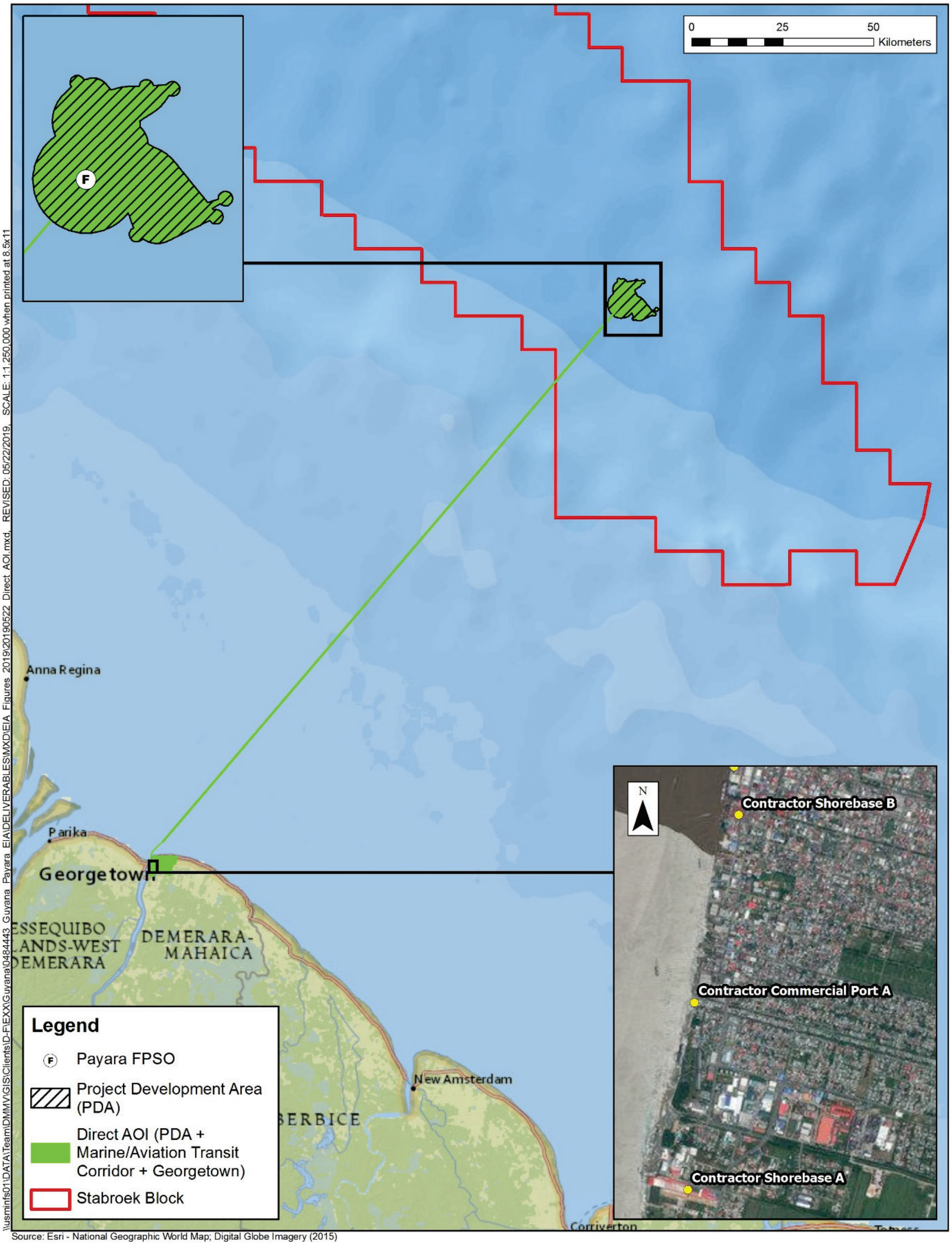

Figure 5.1-1: Direct Area of Influence

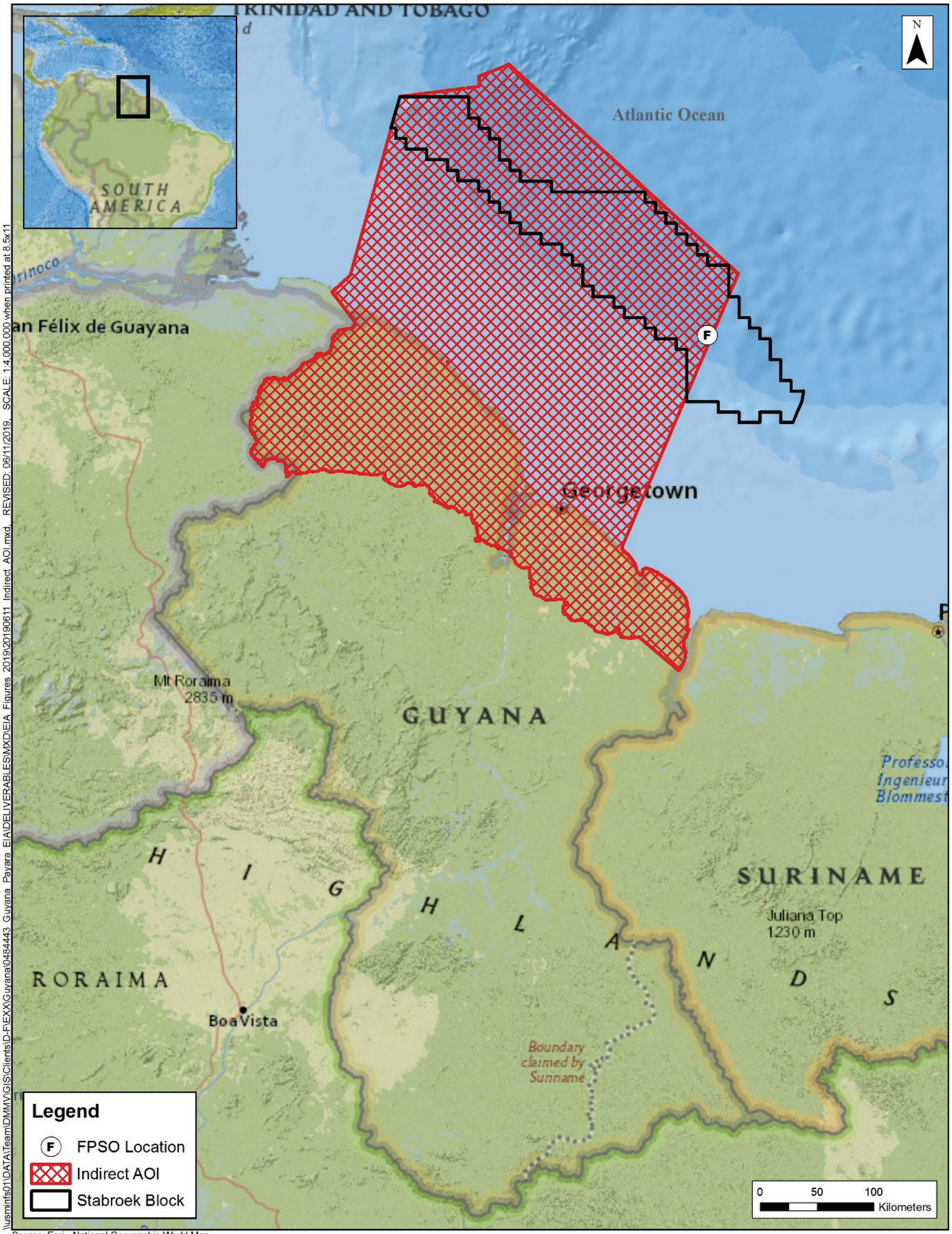

Figure 5.1-2: Indirect Area of Influence

To define the scope of the environmental and socioeconomic impact analysis, it is necessary to identify the potential interactions between the Project and the resources/receptors within the Project AOI. These interactions are the mechanisms that could trigger Project-related impacts on resources/receptors.

The Project activities and potential unplanned events listed below may potentially interact with existing resources/receptors, and these interactions could potentially create direct, indirect, or cumulative environmental or socioeconomic impacts:

- Development drilling stage
  - Drill ship and drilling operations
    - Power generation
    - Drill cuttings discharges
    - Drilling fluids discharges
    - Wastewater effluent discharges
    - Offshore waste treatment and disposal, potentially including incineration
  - Vertical Seismic Profiling operations
  - Remotely operated vehicle operations
  - Onshore waste management, recycling, treatment, and disposal
- Installation of FPSO/SURF components stage:
  - Marine installation vessels and FPSO
    - Power generation
    - Installation of FPSO mooring system
    - Discharge of hydrostatic test water, hydrate inhibitor, and ballast water
    - Wastewater effluent discharges
    - Offshore waste treatment and disposal, potentially including waste incineration
  - Remotely operated vehicle operations
  - Installation of SURF equipment
  - Hook-up and commissioning of FPSO and SURF equipment
  - Onshore waste management, recycling, treatment, and disposal
- Productions operations stage:
  - FPSO Vessel Operations
    - Power and heat generation
    - Non-routine, temporary flaring
    - Treated produced water discharge
    - Brine discharges from sulfate removal and potable water processing
    - Treated sanitary wastewater effluent discharge
    - Ballast water discharge (one time at mobilization)
    - Non-hydrocarbon (non-contact) cooling water discharges
    - Gas re-injection into reservoir
    - Seawater intake

    - Treated seawater injection into reservoir
    - Chemical use (topsides, subsea, downhole)
  - Oil offloading to conventional tankers
    - Tanker power generation
    - Venting of cargo tanks during oil loading
    - Seawater intake for ballast operations
    - Tanker ballast water discharge on arrival
    - Tanker treated domestic wastewater effluent discharge
  - Offshore waste treatment and disposal, potentially including waste incineration
  - Onshore waste management, recycling, treatment, and disposal
- Decommissioning stage
  - Marine decommissioning vessels and FPSO
    - Power generation
    - Treated sanitary wastewater effluent discharges
    - Offshore waste treatment and disposal, potentially including waste incineration
  - Well plugging and abandonment
  - Disconnection of mooring system and SURF equipment
  - Onshore waste management, recycling, treatment, and disposal, potentially including waste incineration
- Logistical support (across all Project stages)
  - Supply and support vessel/aircraft operations
  - Onshore fuel transfers from suppliers
  - Utilization of shorebases, including pipe yards and warehouses
  - Onshore waste management, recycling, treatment, and disposal
- Non-routine, unplanned events
  - Oil spill or release—FPSO/SURF production operations
  - Oil spill or release—loss-of-well-control event
  - Other oil spills or releases
  - Other unplanned events (e.g., vehicular accident, helicopter accident, vessel collision, untreated wastewater effluent discharge)

Ancillary activities or facilities (e.g., shorebases) that are not components of the Project but are associated with the Project also may potentially interact with existing resources/receptors, and these interactions could potentially create induced environmental or socioeconomic impacts. EEPGL will use existing onshore facilities owned and operated by others (noting that none of these will be Project- or EEPGL-dedicated facilities). Where EEPGL has obligations to ensure its employees and its contractors are working within regulatory requirements and the measures established in the EIA and related Environmental Permit conditions, the EIA discusses measures to ensure conformance with these requirements. The Project will not include any new onshore facility expansion. One of the shorebases planned for Project use is intending to expand by approximately 50 acres (20 hectares) on the eastern side of the East Bank Public Road, nominally scheduled to begin construction in 2020. This expansion would be covered under a separate environmental authorization granted to the owner/operator of the shorebase and is therefore not within the scope of this EIA.

5.2 Resources/Receptors Assessed in the EIA

One of the purposes of the scoping process is to identify which resources/receptors could potentially be significantly impacted by the Project and which resources/receptors would not have the potential to be significantly impacted by the Project. Based on the Project description and understanding of existing conditions at the time of scoping, Table 5.2-1 lists those resources/ receptors that were identified as having the potential to be significantly impacted by the Project, subject to further assessment. These resources/receptors were retained for further consideration in the EIA.

Table 5.2-2 lists those resources/receptors that were identified as being unlikely to have the potential to be significantly impacted by the Project and the rationale for this determination. These resources/receptors were excluded from further consideration in the EIA.

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Table 5.2-1: Summary of Resources/Receptors, Potential Impacts, Sources of Potential Impacts, and Assessment Approach

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
Physical Resources			
Air Quality and Climate	Air emissions resulting from the Project have the potential to change ambient air quality in the Project AOI on a localized basis. Air quality is important for health of humans and wildlife. Greenhouse gas (GHG) emissions from the Project may increase the GHG concentrations in the atmosphere.	• Power generation • Other marine vessel and support aircraft combustion sources • Non-routine, temporary flaring • Fugitive emissions from crude oil storage and offloading • Waste incineration	Ambient offshore air quality data were collected in and around the PDA for the Liza Phase 1 Development Project, approximately 200 kilometers (approximately 120 miles) offshore of Guyana, and included measurements of coarse particulate matter (PM_{10}), carbon monoxide, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, and volatile organic compounds. A similar set of data (with the additional of fine particulate matter [$PM_{2.5}$]) was collected in the vicinity of the Liza Phase 2 PDA. A third (similar) set of data was collected in the vicinity of the Payara PDA. Ambient onshore air quality data were collected at locations in Georgetown and Berbice and included measurements of sulfur dioxide, nitrogen dioxide, carbon monoxide, hydrogen sulfide, $PM_{2.5}$, PM_{10}, and benzene, toluene, ethylbenzene, and xylenes. The collective data sets for offshore and onshore ambient air quality monitoring informed the assessment of potential impacts on air quality by providing information regarding ambient air quality conditions. Project emission inventories have been prepared and air quality dispersion modeling has been conducted to predict potential onshore air quality impacts associated with planned Project activities. Estimated GHG emissions for the Project have been calculated and compared to current national emissions totals for Guyana and global emissions totals from the global oil and gas industry. Project-related GHG emissions were calculated in terms of the Project's proportional contribution to Guyana's total national emissions, and in terms of the quantity of GHGs that Guyana removes from the atmosphere annually (i.e., "net removals").
Sound	Operations on the FPSO and other Project marine vessels will have the potential to result in auditory impacts on Project workers. Underwater sound will have the potential to impact biological receptors.	• Equipment/machinery operating on board the FPSO, drill ships and other marine vessels (relative to potential impacts on Project workers)	The EIA discusses how occupational-related risks within Project-related workspaces will be managed through appropriate design and industrial hygiene and exposure management practices.
Marine Geology and Sediments	The Project will disturb marine geology and sediments on a localized basis in the PDA and could impact sediment quality from deposition of NABF adhered to discharged drill cuttings. Indirect impacts on seismicity and other natural hazards are not expected as a result of the Project.	• Drilling of development wells, including cuttings discharge • Installation of FPSO mooring lines and SURF components	EEPGL has conducted prior sampling of marine sediments in the Stabroek Block, including the Payara PDA, as part of iterative environmental baseline study (EBS) events. The collective EBS data set informed the assessment of potential impacts on sediment quality by describing the biophysical attributes of the seafloor. A fate and transport model has been used to simulate cuttings and drilling fluid deposition surrounding the Project development wells. The predicted changes to the native seafloor morphology from the accumulated drill cuttings and other Project-related activities that will impact the seafloor, as well as the distribution of residual NABF on drill cuttings, were described based on the results of the modeling analysis. The EIA describes the reasonably foreseeable effects of oil extraction and injection of water and gas on geological stability, as well as an assessment of the Project's foreseeable impact on geological/seismic hazards (to the extent they may exist).
Marine Water Quality	The Project will have localized impacts on marine water quality in the PDA from discharge of drill cuttings and from routine operational and hydrotesting discharges. The Project also could potentially impact marine water quality in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Drilling of development wells (cuttings and drilling fluid discharge) • Cooling water discharges • Wastewater effluent discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned event (i.e., oil spill or release)	EEPGL has conducted prior sampling of marine water quality in the Stabroek Block, including the Payara PDA, as part of iterative EBS surveys. The collective EBS data set informed the assessment of potential impacts on marine water quality by supporting the water quality modeling (see below). Fate and transport modeling has been used to evaluate total suspended solids (TSS) concentrations resulting from discharge of cuttings. Modeling has also be used to simulate the mixing zone around the FPSO, and to support an analysis of impacts on marine water

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
			quality from routine production operations discharges and one-time hydrotesting discharges. Oil spill modeling has been used to predict fate and transport of oil spills from various unplanned event scenarios (e.g., crude oil spill, diesel fuel spill).
Biological Resources/Receptors			
Protected Areas and Special Status Species	The Project is not expected to impact protected areas as a result of routine, planned activities in the Project AOI. The Project could potentially impact protected areas in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release). The Project could potentially impact some special status species individuals (i.e., listed endangered or threatened species) in the PDA as a result of underwater sound, light, seawater withdrawal, and/or changes in marine water quality. The Project could potentially impact special status species in the Project AOI as a result of non-routine, unplanned events (e.g., oil spill or release, vessel strike).	• Underwater sound generated by marine operations • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Wastewater effluent discharges • Drilling of development wells (cuttings and drilling fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Vessel movements • Non-routine, unplanned event (e.g., oil spill or release, vessel strikes with marine mammals or turtles)	As part of an ongoing study initiated prior to scoping for the Project EIA, data on marine fish abundance and distributions has been collected from the Stabroek Block and from areas between the Stabroek Block and shore. The combined data set from these surveys has been incorporated into the EIA to inform the assessment of impacts on special status marine fish species. The study was used to assess whether the fish community in the Project AOI includes any particularly sensitive species, as well as to characterize the distribution of fishery resources relative to the Project AOI. A study initiated prior to scoping for the Project EIA includes tagging and tracking of movements of nesting marine turtles in the Shell Beach Protected Area. Data from this study have been used to supplement existing information on marine turtle movements (and their consequent susceptibility to Project-related impacts). Marine mammal and other protected species observations from EEPGL contractors' offshore vessels have been ongoing since 2015. Findings from these observations have been incorporated into the assessment of impacts on protected marine mammal species and protected fish and turtle species. An additional study has been initiated to assess the presence of riverine mammals within the lower Demerara River based on visual observations from marine vessels. The findings of the study informed the assessment of Project vessels' potential impacts on riverine mammals in the Demerara Harbour. Based on a review of the Liza Phase 1 Development Project underwater noise modeling analysis, the attributes of the Payara Project subsea noise sources and the environmental features that affect subsea noise propagation (primarily water depths from which the source would emanate) are such that the underwater sound modeling conducted for the Liza Phase 1 Development Project EIA is relevant to the assessment of potential impacts from the Payara Project. Accordingly, these results were incorporated into the Payara Project EIA by reference, and used as the basis for the assessment of potential underwater noise impacts on sensitive species. The GEMSS model was used to simulate the mixing zone around the FPSO and to support an analysis of changes to marine water quality from routine operational discharges and one-time hydrotesting discharges (and to assess any associated impacts on special status marine species). A fate and transport model was used to evaluate TSS concentrations resulting from discharge of drilling fluid and cuttings, and to assess associated impacts on special status marine species. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and assess the potential risk of oiling impacting any designated protected areas. Consistent with the approach taken for marine mammals, turtles, and fish without special-status designation, the scientific literature was reviewed for information on the impacts of planned offshore activities on special status species, including marine turtles, marine fish, and marine mammals.

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
Coastal Habitats	The Project is not expected to impact beaches, mangroves, or wetlands in the Project AOI as a result of routine, planned activities. The Project could potentially impact beaches, mangroves, and wetland habitats in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Non-routine, unplanned event (e.g., oil spill or release)	As part of previous studies, coastal sensitivity maps characterizing coastal habitats within the indirect Project AOI have been developed based on a combination of remote-sensing and field data collection. These maps were used to aid in oil spill response preparation. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of the oil spill modeling were considered together with coastal sensitivity mapping data to assess the risk of oiling beaches, mangroves, or wetlands.
Coastal Wildlife and Shorebirds	The Project is not expected to impact coastal wildlife or shorebirds in the Project AOI as a result of routine, planned activities. The Project could potentially impact coastal wildlife and shorebirds in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Non-routine, unplanned event (e.g., oil spill or release)	As part of a study initiated in 2017, a number of surveys were conducted to characterize coastal bird abundance, diversity, and important habitats along the coastline of Guyana, across different seasons. The combined data set was used to inform the impact assessment for coastal birds. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of the oil spill modeling were considered together with coastal bird data to assess the risk to these receptors from an oil spill or release.
Seabirds	The Project could potentially impact seabirds in a localized manner as a result of light (i.e., disorientation) and other offshore marine operations. The Project could potentially impact seabirds in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Drill ships, FPSO, and support vessel operations • Lighting on offshore facilities (related to potential for disorientation of seabirds) • Non-routine, temporary flaring • Offshore waste incineration • Non-routine, unplanned event (e.g., oil spill or release)	As part of a study initiated in 2017, a number of surveys were conducted to characterize marine bird abundance, diversity, and distributions offshore Guyana, across different seasons. The combined data set was used to inform the impact assessment for marine birds. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling were considered together with marine bird data to assess the risk to these receptors from an oil spill or release.
Marine Mammals	The Project could potentially impact marine mammals in a localized manner in the Project AOI as a result of Project-related underwater sound, light, and/or changes in marine water quality. The Project could potentially impact marine mammals in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release, vessel strikes).	• Underwater sound generated by marine operations • Changes in forage availability • Lighting on offshore facilities (e.g., FPSO, drill ships) • Wastewater effluent discharges • Drilling of development wells (cuttings and fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned events (i.e., oil spill or release, vessel strikes)	Marine mammal and other protected species observations from EEPGL's offshore study vessels have been ongoing since 2015. Findings from these observations were reviewed together with information from scientific literature to inform the assessment of impacts on marine mammal species by identifying species presence and abundance in the Project AOI. Based on a review of the Liza Phase 1 Development Project underwater noise modeling analysis, the attributes of the Payara Development Project subsea noise sources and the environmental features that affect subsea noise propagation (primarily water depths from which the source would emanate) are such that the underwater sound modeling conducted for the Liza Phase 1 Development Project EIA are relevant to the assessment of potential impacts from the Payara Project. Accordingly, these results were incorporated into the Payara Project EIA by reference, and used as the basis for the assessment of potential underwater noise impacts on marine mammals. The GEMSS model was used to simulate the mixing zone around the FPSO and to support an analysis of changes to marine water quality from routine operational discharges and one-time hydrotesting discharges (and to assess any associated impacts on marine mammals). A fate and transport model was used to evaluate TSS concentrations resulting from discharge of drilling fluid and cuttings, and to assess associated impacts on marine mammals. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling were considered together with the marine mammal data to assess potential spill-related impacts on marine mammals.

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
Riverine Mammals	The Project is not expected to impact riverine mammals in the Project AOI as a result of routine, planned activities. The Project could potentially impact riverine mammals in the Project AOI as a result of non-routine, unplanned events (i.e., diesel fuel release, vessel strikes).	• Non-routine, unplanned event (e.g., diesel fuel release, vessel strike)	Surveys are ongoing in the Demerara Harbour to assess the presence of riverine mammals within the lower Demerara River. This study builds on the information gathered from the oceanic marine mammal and protected species observations conducted by EEPGL over the last several years. The findings of the study informed the assessment of potential disturbance impacts on riverine mammals and potential risks to riverine mammals in the Demerara Harbour from unplanned events (i.e., vessel strikes).
Marine Turtles	The Project could potentially impact marine turtle individuals in a localized manner in the Project AOI as a result of Project-related underwater sound, light, and/or changes in marine water quality. The Project could potentially impact marine turtle individuals in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release, vessel strikes).	• Underwater sound generated by marine operations • Changes in forage availability • Lighting on offshore facilities (e.g., FPSO, drill ships) • Wastewater effluent discharges • Drilling of development wells (cuttings and fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned events (i.e., oil spill or release, vessel strikes)	A study initiated in 2018 includes tagging and tracking of movements of nesting marine turtles in the Shell Beach Protected Area. Data from this study were used to supplement existing information on marine turtle movements (and their consequent susceptibility to Project-related impacts) Based on a review of the Liza Phase 1 Development Project underwater noise modeling analysis, the attributes of the Payara Development Project subsea noise sources and the environmental features that affect subsea noise propagation (primarily water depths from which the source would emanate) are such that the underwater sound modeling conducted for the Liza Phase 1 Development Project EIA is relevant to the assessment of potential impacts from the Payara Development Project. Accordingly, these results were incorporated into the Payara Development Project EIA by reference, and used as the basis for the assessment of potential underwater noise impacts on marine turtles. The GEMSS model was used to simulate the mixing zone around the FPSO and to support an analysis of changes to marine water quality from routine operational discharges and one-time hydrotesting discharges (and to assess any associated impacts on marine turtles). A fate and transport model was used to evaluate TSS concentrations resulting from discharge of drilling fluid and cuttings, and to assess associated impacts on marine turtles. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling were considered together with marine turtle data to assess potential spill-related impacts on marine turtles.
Marine Fish	The Project could potentially impact marine fish as a result of underwater sound, light, changes to seafloor habitat, seawater intake, and changes in marine water quality in the PDA. The Project could potentially impact marine fish in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Underwater sound generated by marine operations • Changes in forage availability • Changes in seafloor habitat • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Wastewater effluent discharges • Drilling of development wells (cuttings and fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned events (i.e., oil spill or release)	Data on marine fish abundance, diversity and distributions in deepwater, continental shelf, and nearshore/estuarine habitat offshore Guyana have been collected since 2017 as part of an ongoing study. In 1Q19, a participatory fish study was initiated to gather additional information, sourced from local fisherfolk, on the abundance and diversity of species caught in fishing areas along the coast. The combined data set from these efforts informed the assessment of impacts on marine fish species by identifying any particularly sensitive species and describing the distribution of fishery resources relative to the Project AOI. The GEMSS model was used to simulate the mixing zone around the FPSO and to support an analysis of changes to marine water quality from routine operational discharges and one-time hydrotesting discharges (and to assess any associated impacts on marine fish). A fate and transport model was used to evaluate TSS concentrations resulting from discharge of drilling fluid and cuttings, and to assess associated impacts on marine fish. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling were considered together with marine fish data to assess potential spill-related impacts on marine fish.

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
Marine Benthos	The Project could potentially disturb some benthic habitat and organisms in a localized manner in the PDA.	• Drilling of development wells (cuttings discharge and deposition) • Installation of FPSO (mooring structures) and SURF components	Since 2014, EEPGL has commissioned a series of EBSs, including sediment sampling and analysis of samples for benthos in the eastern Stabroek Block and along the continental shelf between the Stabroek Block and Georgetown. Additionally, as part of the ongoing marine fish study (discussed above), ancillary observations of marine benthos were collected from the Stabroek Block. The combined benthos data set informed the assessment of impacts on marine benthos by characterizing the benthic community and identifying any particularly sensitive species. A fate and transport model was used to predict the extent and thickness of drill cuttings deposition on the seafloor surrounding the development wells. These data were considered in combination with the above information to assess impacts on marine benthos as a result of drill cuttings deposition.
Ecological Balance and Ecosystems	The Project could have indirect impacts on ecological functions in the Project AOI, particularly if special status species or trophic relationships are disturbed.	• Underwater sound generated by marine operations • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Installation of FPSO and SURF components • Wastewater effluent discharges • Ballast water discharges • Offshore waste incineration • Non-routine, unplanned event (e.g., oil spill or release)	Two environmental deoxyribonucleic acid (DNA) studies were conducted in 2016 and 2017. These studies have provided information on the number of species present in the AOI based on remnant DNA in the water column from naturally shed tissue fragments. The results of these studies were used to enhance the understanding of biodiversity in the AOI. The data from these studies and from field studies of other taxon groups (see above) were considered together with scientific literature to assess impacts on the ecosystem as a whole. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling will be considered together with the above data to assess potential spill-related impacts on the ecosystem as a whole.
Socioeconomic Resources/Receptors			
Economic Conditions	The Project is generally anticipated to have a positive impact on the economy of Guyana as a result of government revenue sharing from the Project, as well as employment and local procurement opportunities. Potential adverse impacts may include potential short-term increases in the cost of living as a result of increased demand for specific goods and services. Potential adverse impacts on income from agriculture and fisheries could also occur as a result of non-routine, unplanned events (i.e., oil spill or release).	• Government revenue sharing from Project • Local Project purchases of select materials, goods and services • Limited local Project employment (direct and indirect) • Increased spending on select materials, goods and services (indirect multiplier impacts for local/regional population)	Government reports were reviewed and key informant interviews were conducted to identify key economic drivers in the national, regional, and local economies and assess the likely Project-related effects on these economic factors. Particular emphasis was placed on livelihoods that are important to coastal communities.
Employment and Livelihoods	The Project is expected to build capacity in the local labor force, increase demand for skilled labor, and increase demand for service industries. There is the potential for limited adverse impacts on fishing activities (and livelihoods stemming from those activities) as a result of marine safety exclusion zones or marine traffic, and non-routine, unplanned events (i.e., oil spill or release).	• Local employment for Project-related activities • Marine safety exclusion zones • Project-related marine traffic • Project operations (aspects relating to occupational health and safety for Project workforce) • Non-routine, unplanned event (e.g., spill or release)	Project workforce projections and types of labor requirements were assessed against data obtained through key informant interviews on the existing service industry within Guyana. The potential for adverse impacts on fishing activities was assessed by taking into consideration the distance from shore at which different fishery types typically operate, in comparison to the locations and durations of Project-related marine activity and marine safety exclusion zones. As part of the ongoing fish studies (see above), consultations have been conducted with fisherfolk and others that may be directly or indirectly dependent on fishing to characterize catch quantities at key fish landing sites. Additionally, in 1Q19, a participatory fish study was initiated to gather additional information, sourced from local fisherfolk, to characterize local fishing activities. The collective body of information from these data collection efforts was used to assess potential socioeconomic impacts on fisherfolk in the AOI. The EIA discusses that occupational-related risks will be managed through appropriate design and industrial hygiene and exposure management practices.
Community Health and Wellbeing	Most Project activities will be located offshore and will have no direct impacts on communities in Guyana. Project-related increases in vehicular and marine traffic could increase the potential for accidents. Introduction of limited levels of foreign labor for the Project workforce could potentially have community health impacts due to an increased risk of communicable diseases. The Project workforce could result in an increased use of medical and health resources in the Georgetown area, resulting in the potential to overburden those resources. The overall presence of	• Increased vehicular and marine traffic as a result of Project activities (related to increased potential for accidents) • Social interaction between foreign Project workers and residents, in particular with respect to an increased risk of transmission of communicable diseases • Public anxiety from perceptions of risk from a relatively new type of industry in the country	Marine traffic surveys conducted in the Demerara Harbour and vehicular traffic surveys were used to assess potential risks to safety and health of local communities posed by Project-related increases in marine and vehicular traffic (as relates to potential unplanned events—accidents). Key informant interviews were conducted to assess existing medical and health infrastructure, and were used to assess the risk of the Project overburdening these resources. Stakeholder interviews were also used to help assess impacts related to public anxiety over oil and gas operations.

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
	the Project and other related activities as a new industry in the country could lead to a level of public anxiety. Non-routine unplanned events (i.e., oil spill or release) could impact health and wellbeing of communities via impacts on resources on which these communities depend.	• Non-routine, unplanned event (e.g., oil spill or release)	As part of ecosystem services studies, the uses of natural resources by local coastal communities have been mapped to identify specific dependencies on resources that could be impacted by an unplanned event (i.e., oil spill). These data were used to assess potential Project impacts on the quality or accessibility of these services. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and to assess potential spill-related impacts on community health and wellbeing.
Marine Use and Transportation	The Project activities will result in increased marine-related traffic, which could potentially contribute to marine vessel congestion in port areas, as well as increasing the risk of unplanned events (i.e., marine vessel collisions).	• Project-related marine vessel operations	Key informant interviews were conducted to characterize communities dependent on marine transportation and use for livelihoods (e.g., speedboat operators and fisherfolk), and to characterize existing marine vessel operations in the Project AOI. This information was supplemented with the primary data previously collected via observations of marine vessel traffic operating between the Guyana shorebases and the mouth of the Demerara River. These data were considered in conjunction with estimates of anticipated Project-related traffic and marine use to assess the incremental change in demand on the port's and harbor's capacities to accommodate foreseeable marine use and transportation demands. The EIA also includes a discussion of tanker activities anticipated as a result of the Project, as well as the key operational procedures and controls (both within and outside of Guyanese waters) that will be implemented in relation to these activities.
Social Infrastructure and Services	The Project will increase use of public infrastructure and services and thus could potentially compete with other existing businesses and consumers across a range of services (e.g., roads, airports/helicopters, accommodations, and utilities). The Project will result in increased vehicular traffic in Georgetown, which could potentially contribute to vehicular congestion in certain areas.	• Project demand requirements for lodging, housing, and utilities, which could increase the burden on existing capacity and supply • Shorebase operations and other Project-related onshore transportation of materials and personnel, which could contribute to traffic congestion • Project-related use of helicopters and airports	Key informant interviews, reviews of publicly available government reports, and results from a social infrastructure study focused on Project-related use of Georgetown lodging and housing were used to assess existing demand on these resources and the potential impact that additional Project-related demand on these resources could have on affected communities. Existing vehicular traffic conditions were characterized through the prior traffic study conducted in the vicinity of the Guyana shorebases and an additional traffic study conducted for other Georgetown road segments. Information from these studies was considered together with estimates of Project-related onshore traffic to assess the impact of Project-related vehicle movements on local traffic conditions. Estimates of Project-related helicopter/airport use were used to assess the impacts on availability of helicopters for other industrial purposes.
Cultural Heritage	The Project has the potential to adversely affect cultural heritage through localized disturbance of any archaeological or historic resources present in the subsea Project footprint. Such resources could have conservation, cultural, and other values to stakeholders. The Project also could potentially impact cultural heritage resources outside of the subsea Project footprint as a result of non-routine, unplanned events (i.e., oil spill or release).	• Drilling of development wells • Installation of FPSO and SURF components • Non-routine, unplanned event (i.e., oil spill or release)	EEPGL has completed a geophysical and shallow geotechnical analysis that assessed the layout and field architecture for the PDA to aid in siting facilities away from faults, seabed obstructions, archaeological resources, sensitive biological resources, or other resources or hazards that could either damage the wells or SURF or be damaged by installation of these components. Autonomous underwater vehicles and other geophysical surveys were used to assess for the presence of manmade objects on the seabed within the PDA. As part of an ongoing study initiated prior to scoping for the Project EIA, coastal communities in the Project AOI, including indigenous communities, were engaged to characterize areas along the coast with cultural heritage significance. As part of this effort, key informant interviews were conducted and Traditional Cultural Knowledge was leveraged. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and to assess the potential for a release from an unplanned event to contact identified terrestrial cultural heritage sites.
Land Use	No new Project-dedicated land disturbance is planned. There is the potential that third-party onshore facilities may elect to expand or impact adjacent land as a result of supporting Project-related needs; however, these impacts are outside the scope of this EIA.	• Shorebase operations • Pipe yards • Warehouses • Bulk fuel storage and transfers • Onshore waste recycling, treatment and disposal facilities	Land use in the area surrounding onshore facilities planned for Project use was reviewed and assessed with respect to the potential for impacts on land use as a result of the Project.

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
Ecosystem Services	Project-related impacts on natural resources could lead to short-term direct or indirect impacts on the services and/or values derived from natural resources and ecosystems in the Project AOI.	• Direct or indirect impacts derived from one or more of the impacts on physical, biological, or socioeconomic resources described above	As part of an ongoing study initiated prior to scoping for the Project EIA, the uses of natural resources by local coastal communities, including indigenous communities, were mapped to identify specific dependencies on resources that could be impacted by the Project. Data from this effort, including Traditional Cultural Knowledge, were used to aid in assessing dependencies on natural resources that could be impacted by the Project in terms of local communities' access to and use of impacted resources. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill from the Project and to assess the potential for oil to contact areas providing ecosystem services.
Indigenous Peoples	The Project is not expected to directly cause any changes to population or demographics in indigenous communities. The Project could potentially impact indigenous peoples in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Non-routine, unplanned event (i.e., oil spill or release)	As part of an ongoing study initiated prior to scoping for the Project EIA, coastal communities, including indigenous communities, in the Project AOI were engaged to characterize coastal biodiversity and ecosystem services. As part of this effort, key informant interviews were conducted and Traditional Cultural Knowledge leveraged to characterize socioeconomic conditions in communities, and their reliance on natural resources. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill from the Project and, based on information collected from the above study, to assess the potential for oil to contact lands and natural resources of coastal indigenous communities.

EBS = environmental baseline survey; GEMSS = Generalized Environmental Modeling System for Surfacewaters; NABF = non-aqueous base fluid; $PM_{2.5}$= particulate matter with aerodynamic diameter of less than 2.5 micrometers; PM_{10} = particulate matter with aerodynamic diameter of less than 10 micrometers

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Table 5.2-2: Resources and Receptors Excluded from Further Consideration in the EIA

Resource/Receptor	Rationale for Excluding
Coastal (Onshore) Resources	
Onshore geology/soils	The Project will not result in any onshore disturbance to geology and soils.
Topography/landscape	The Project will not require any excavation, fill, or other land-based activities that could change onshore topography or landscapes.
Groundwater	The Project will not involve any activities that could impact ground water quantity or quality.
Terrestrial vegetation	The Project will not require any clearing or disturbance of terrestrial vegetation. Even in the case of an unplanned event such as a spill, only estuarine vegetation (e.g., mangroves) would be expected to be potentially impacted (this is addressed under the coastal habitat resource).
Freshwater habitats	The Project is offshore, with no new onshore disturbance, so will not have any impact on freshwater habitats.
Marine Resources	
Aquatic plants	The marine aspects of the Project will occur in an area that is too deep to support vascular marine plants.
Physical Resources	
Vibration and radiation	The Project will not generate any vibration or radiation that is expected to impact resources/receptors. See Section 2.12, Materials, Emissions, Discharges, and Wastes, for a description of radiation sources that will be used by the Project, and the related procedures that will be employed to ensure protection of Project workers.

5.2.1 Assessment of Potential for Geological/Seismic Impacts

During the scoping process for the Payara EIA, the public indicated concern that the Project's offshore activities could potentially result in a seismic event and—as a result of such an event—inland flooding (e.g., from a tsunami). Based on consideration of the potential for Project activities to result in these types of events, the Consultants determined it was appropriate to exclude this potential impact from further consideration in the EIA. However, in light of the public's stated concerns, the following discussion is presented to elaborate on the justification for this exclusion.

5.2.1.1 Natural Disaster Risk Ratings for Guyana

In 2014, the United Nations International Strategy for Disaster Reduction (UNISDR) assessed natural hazard risk in Guyana as part of a global initiative to assess vulnerability to natural disasters. UNISDR's disaster risk profile for Guyana indicates that based on historical records, floods, droughts, and landslides pose the most significant risks to Guyana (UNISDR 2014). This assessment was based on a "look back" at the incidence of natural hazards that have occurred in the past, but did not indicate probability of hazards occurring in the future. However, the UNISDR also conducted a probabilistic assessment that used mathematical models to combine possible future hazard scenarios, information about exposed assets, and potential vulnerability to provide estimates of probable economic losses due to different categories of disasters. Unlike the "look back" assessment, the probabilistic risk assessment addressed the limitations associated with deriving risk from historical disaster loss data by accounting for all types of disasters that can occur in the future, including higher-intensity losses with long recurrence intervals (UNISDR 2014). This assessment indicated that floods pose, by far, the most significant risk to Guyana, followed by relatively minor risks from earthquakes. The risks posed by tsunamis were determined to be not significant enough to be reported in the economic analysis. The assessment indicated that the predicted recurrence interval of a tsunami in Guyana exceeded 1,500 years (UNISDR 2014).

Additionally, the World Bank Group's *ThinkHazard*! tool, an online, natural hazard risk database for emerging market countries, was queried to assess relative risk ratings for a suite of potential natural hazards for Guyana. The results of the assessment are generally consistent with the UNISDR assessment, ranking floods as high risk, tsunamis as medium risk, and earthquakes as very low risk for Guyana (World Bank 2019).

Additional information regarding earthquake and tsunami risks to Guyana is presented below.

5.2.1.2 Assessment of Earthquake Risks to Guyana

Seismic hazard refers to the risk associated with the potential occurrence of earthquakes in a particular area. Guyana is located within the craton[1] of the South American tectonic plate. Seismicity in the northern part of the continent of South America is largely controlled by plate boundary events occurring along the southern rim of the Caribbean Basin. Major earthquakes frequently occur along the Lesser Antilles subduction zone, where the South American Plate is subducting beneath the Caribbean Plate. The Payara PDA is located more than 280 kilometers (174 miles) from the boundary between the Caribbean and South American plates and more than 1,050 kilometers (652 miles) from the nearest area of active seismicity (in the vicinity of Puerto Rico).

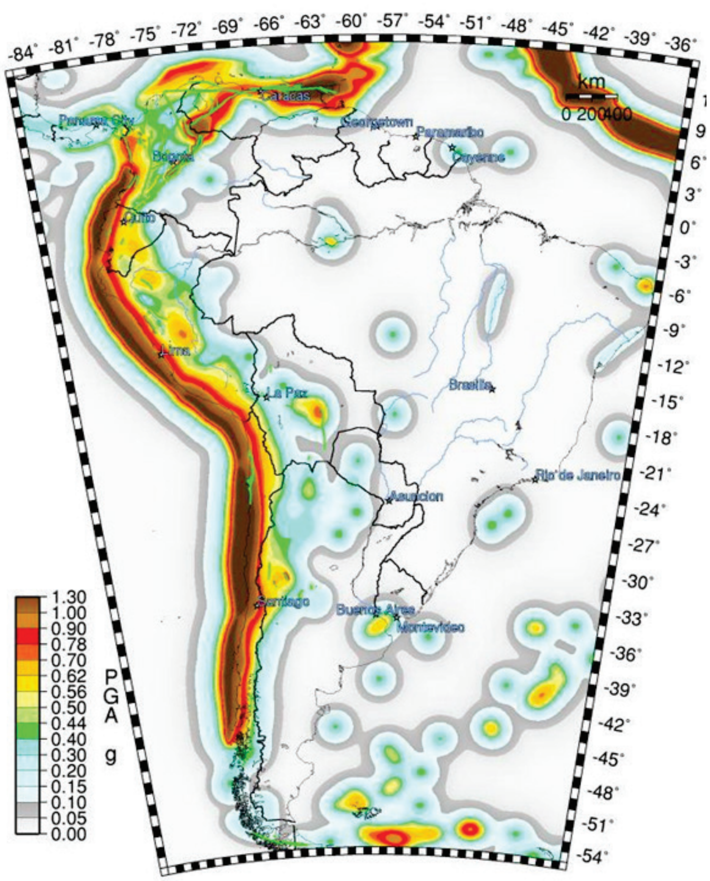
A seismic hazard map shows the relative seismic hazards in different areas. These maps are typically developed using information known about:

1. Past faults and earthquakes;
2. The behavior of seismic waves as they travel through different materials of the Earth's crust; and
3. The near-surface site conditions at specific locations of interest.

The U.S. Geological Survey (USGS) Hazard Mapping Program produces probabilistic seismic hazard maps that show the potential for ground motion, as measured by what is known as *peak ground acceleration*, which is expressed as a multiple of the acceleration of gravity (g), e.g., *0.1g*, meaning one-tenth the acceleration of gravity. Ground acceleration is the velocity of a particle on the ground that is recorded by a particular station during an earthquake and can be

[1] The stable interior portion of a continent characteristically composed of ancient crystalline basement rock

considered to reflect what a person might feel standing on the ground in an earthquake. Figure 5.2-1 shows the USGS's preliminary peak horizontal ground acceleration seismic hazard map for South America (USGS 2010). The map presents the peak ground accelerations with a 2 percent probability of being exceeded in a 50-year return period. As shown in the figure, the peak ground acceleration with a 2 percent probability of exceedance over a 50-year return period in the Payara PDA is between 0.00g and 0.05g. To put this into perspective, 0.001g is generally perceptible by people, 0.02g is the point where a person would typically lose their balance, and 0.5g results in severe shaking, with moderate damage to buildings. Therefore, this indicates that there is a 2 percent chance in a given 50-year period that a very small seismic event (which might not even be perceptible if someone were at the exact location of the event) would occur in the PDA. Referring to the map, the nearest area identified on the map as having an elevated seismic risk is approximately 280 kilometers [approximately 174 miles] away from the Payara PDA, at the boundary between the Caribbean and South American plates.



Source: USGS 2010

Note: Hazard map shows the peak ground acceleration with a 2 percent probability of being exceeded in a 50-year return period.

Figure 5.2-1: Preliminary Seismic Hazard Map for South America

5.2.1.3 Assessment of Tsunami Risks to Guyana

Guyana could experience tsunamis generated from seismic activity outside Guyana if such activity propagated waves of sufficient magnitude and in the required direction. Most of the available research on seismic risk in the region has focused on three potential locations where seismic activity could originate (see Figure 5.2-2):

- The Septentrional Fault Zone, north of the Dominican Republic;
- The Hispaniola Trench, north of the Dominican Republic; and
- The Puerto Rico Trench, which begins off the northeast coast of Hispaniola and extends along a generally east-west axis for more than 750 kilometers (approximately 466 miles) into the western Atlantic Ocean.

Source: WHOI 2005

Figure 5.2-2: Areas of Potential Seismic Risk

In 2005, the Woods Hole Oceanographic Institute reported that although all three of these features are capable of producing earthquakes large enough to induce tsunamis, the overall risk of such an event is small, and the greatest risk associated with earthquake-generated tsunamis in these locations would be to Hispaniola and Puerto Rico (WHOI 2005; Brink and Lin 2004).

In light of recent seismic events around the globe, such as the 2010 earthquake and tsunami in Haiti, ICG/CARIBE-EWS[2] established a permanent working group (WG2) with specific focus on the potential impacts of tsunamis across Caribbean communities, so that emergency planners can pursue risk mitigation and preparedness. To assess tsunami potential, WG2 conducted numerical simulations of 17 seismic sources associated with the Caribbean Plate and affecting northern Hispaniola, Honduras, southern Dominican Republic, and Central America using the numerical model Tsunami-HySEA (Macías et al. 2017). Figure 5.2-3 illustrates results from this exercise, showing the regions concluded to be at risk in terms of maximum wave height for the largest possible event in the list of 17 scenarios studied by WG2: a hypothetical Mw[3] 8.9 earthquake that simultaneously ruptures two faults, each 500 kilometers (310.7 miles) long, near the coast of South America at the Southern Caribbean Deformed Belt.

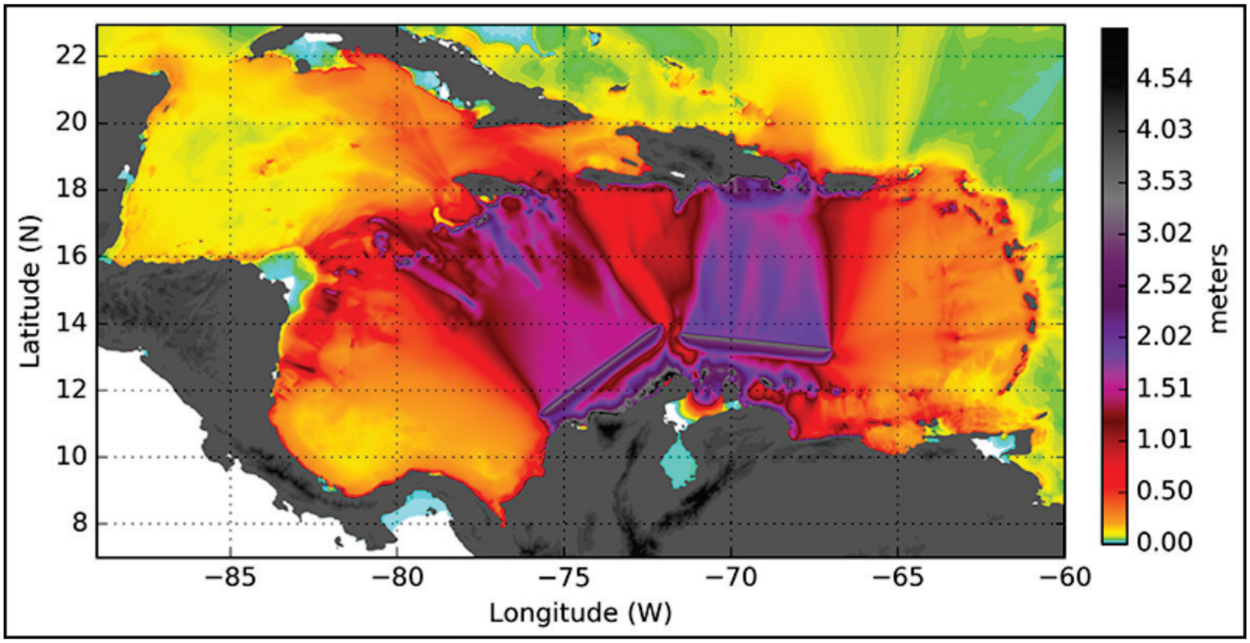
The WG2 work indicated that in the unlikely event of a tsunami generated at the Septentrional Fault Zone or the Hispaniola Trench, the risk to Guyana would be essentially zero because the land masses of Hispaniola, Puerto Rico, and the Lesser Antilles would shield Guyana from any tsunami that propagated in a southerly direction (López-Venegas et al. 2018) (Figure 5.2-3). The same would be true of seismic activity along the western portion of the Puerto Rico Trench. Guyana could theoretically be exposed to a tsunami that arose at the extreme eastern end of the Puerto Rico Trench and propagated southward; however, the Puerto Rico Trench is located approximately 1,050 kilometers (approximately 652 miles) away from the Payara PDA.

5.2.1.4 Assessment of Fault Presence in the Payara Project Development Area

Natural processes that modulate the spatial and temporal occurrence of earthquakes include tectonic stress changes, migration of fluids in the crust, Earth tides, surface loading and unloading, heavy precipitation, atmospheric pressure changes, and groundwater loss (Kundu et al. 2015). In rare cases, human-related activities may supplement natural tectonic processes and trigger earthquakes (Foulger et al. 2018). For oil and gas operations, these activities include injection, production, and stimulation. In all cases, the presence of critically stressed planes of weakness (e.g., faults) is required to host and accommodate seismic slip (Alt and Zoback 2016). There are no mapped faults at the Payara reservoir interval in the Payara PDA and, consequently, the likelihood of seismic slip in the PDA is anticipated to be extremely low.

[2] Intergovernmental Coordination Group of the Early Warning System for Tsunamis and Other Coastal Threats for the Caribbean Sea and Adjacent Regions

[3] Moment magnitude, which is based on the concept of seismic moment, a measure of the size of an earthquake based on the area of fault rupture, the average amount of slip, and the force required to overcome the friction sticking the rocks together that were offset by faulting



López-Venegas et al. 2018

Figure 5.2-3: Areas of Potential Tsunami Risk

5.2.1.5 Conclusion

The Project is considered to have a negligible potential to result in seismic risk, including risk of tsunamis reaching Guyana, for the following reasons:

- Guyana has a low risk of exposure to seismic risks in general.
- Guyana would be naturally buffered from the effects of a tsunami originating at most of the known seismically active zones in the region, even in the extremely unlikely event that such an event occurred.
- The Project's drilling activities would not have a reasonable potential to affect seismic stability at the areas identified in the region as active seismic areas (the nearest being approximately 280 kilometers [approximately 174 miles] away from the PDA).
- There are no mapped faults at the Payara reservoir interval in the Payara PDA, and, consequently, the likelihood of seismic slip that could be caused by injection, production, and stimulation of the reservoir in the PDA is anticipated to be extremely low.

Accordingly, potential seismic impacts have been scoped out of further assessment in the EIA.

6. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIES—PHYSICAL RESOURCES

For the purposes of this EIA, physical resources include non-biological natural resources.

6.1. AIR QUALITY AND CLIMATE

6.1.1. Administrative Framework—Air Quality and Climate

Table 6.1-1 summarizes the legislation, policies, treaty commitments, and industry practices that focus specifically on air quality and climate.

Table 6.1-1: Legislation, Policies, Treaty Commitments and Industry Practices—Air Quality and Climate

Title	Objective	Relevance to the Project
Legislation		
Environmental Protection Air Quality Regulations, 2000	Establishes that the EPA shall at any time after the commencement of the Regulation, establish limits for any of the contaminants specified in the regulation. Sets reporting requirements, penalties for violations of standards, and permitting requirements for stationary and mobile sources of air emissions.	Applicable to Project sources of air emissions (although no limits have yet been established by the EPA).
International Agreements Signed/Acceded by Guyana		
Paris Agreement (under the United Nations Framework Convention on Climate Change)	Promotes international cooperation to limit average temperature increases and resulting changes in climate, and international cooperation to adapt to these impacts.	Provides the framework for possible future controls on greenhouse gas (GHG) emissions within Guyana's territory (maritime and land), and the framework for establishing national policy regarding adaptation to climate change. Guyana's Intended Nationally Determined Contributions under the convention are focused on preserving the country's forests as a carbon sink and include avoiding deforestation, minimizing emissions from forestry and mining operations, expansion of renewable energy sources, and integrated water resource management (Guyana NDC 2016). Further, it favors more efficient technologies: "Implement awareness and incentive programmes to improve the efficiency of technologies and practices in the mining industry" (Guyana NDC 2016). The most recent national communication refers to a net sink of approximately 60,000 gigagrams of carbon dioxide-equivalent per year against emissions of approximately 2,000 gigagrams of carbon dioxide-equivalent per year.

Title	Objective	Relevance to the Project
Kyoto Protocol	Extends the United Nations Framework Convention on Climate Change and commits countries to reduce GHG emissions.	Establishes national GHG emission reduction targets. Guyana acceded in 2003. The Kyoto Protocol has been superseded by the Paris Agreement.
Vienna Convention on the Protection of the Ozone Layer	Provides a framework for the protection of the ozone layer.	Establishes measures for protecting the ozone layer. Guyana acceded in 1993.
Montreal Protocol on Substances that Deplete the Ozone Layer	A protocol to the Vienna Convention designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.	Prohibits the use of several groups of halogenated hydrocarbons that may deplete the ozone layer. Guyana acceded in 1993.

6.1.2. Existing Conditions—Air Quality and Climate

This section describes the existing air quality conditions and climate in the Project Area of Influence (AOI). Air quality in a geographic area is determined by the presence of background concentrations due to natural and distant sources, the type and amount of pollutants emitted locally into the atmosphere, the topography of the area, and the weather and climate conditions. The levels of pollutants and pollutant concentrations in the atmosphere are typically expressed in units of parts per million (ppm), parts per billion (ppb), or micrograms per cubic meter ($\mu g/m^3$), averaged over various periods of time.

6.1.2.1. Existing Conditions—Air Quality

This section describes the existing air quality conditions in the Project AOI. Existing air quality conditions are described for both the offshore environment in the vicinity of the Payara Project Development Area (PDA) and the onshore environment, where community receptors could potentially be impacted by pollutant emissions from the Project.

Existing Conditions—Offshore Air Quality

The PDA is located approximately 207 kilometers (approximately 128 miles) northeast of the coastline of Georgetown in the Atlantic Ocean, far removed from any anthropogenic sources of emissions other than intermittent marine traffic and oil and gas exploration and development activities. Therefore, offshore ambient air quality is determined primarily by regional influences rather than by local emission sources or topographic influences. Additionally, the prevalent wind direction is from the northeast (i.e., from the open ocean); therefore, ambient air quality within the PDA is expected to be undegraded. Nevertheless, to assess existing offshore air quality conditions in the PDA and its general vicinity, EEPGL has commissioned four offshore ambient air monitoring campaigns:

- From 3 October through 23 October 2016, air quality monitoring equipment was deployed on a research vessel and samples were collected within the Stabroek Block in the vicinity of the Liza Phase 1 PDA. Pollutants sampled included inhalable particulate matter (PM) (i.e., that fraction with aerodynamic diameter of less than 10 micrometers [PM_{10}]), carbon monoxide (CO), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), nitrogen dioxide (NO_2), and volatile organic compounds (VOCs).
- From 9 April through 16 April 2018, air quality monitoring equipment was deployed on a research vessel and samples were collected within the Stabroek Block in the vicinity of the Liza Phase 2 PDA. Pollutants sampled included PM_{10}, CO, SO_2, H_2S, NO_2, and VOCs.
- From 2 May through 13 May 2018, air quality monitoring equipment was deployed on a fishing trawler and additional samples were collected within the Stabroek Block in the vicinity of the Liza Phase 2 PDA. Pollutants sampled included PM with an aerodynamic diameter of less than 2.5 micrometers ($PM_{2.5}$), CO, SO_2, H_2S, NO_2, and VOCs.
- From 22 April through 26 April 2019, air quality monitoring equipment was deployed on an offshore support vessel and samples were collected within the vicinity of the Payara PDA. Pollutants sampled included PM_{10}, $PM_{2.5}$, CO, SO_2, H_2S, NO_2, and VOCs.

The offshore air quality monitoring report documenting the 2019 monitoring campaign is presented in Appendix C, Ambient Offshore Air Quality Monitoring Report. Reports documenting the 2016 and 2018 monitoring campaigns can be found in the Liza Phase 1 EIA and Liza Phase 2 EIA, respectively (ERM 2017; ERM et al. 2018).

Because the monitoring campaigns were all conducted in a relatively localized portion of the Stabroek Block (owing to the fact that the Liza Phase 1, Liza Phase 2, and Payara PDAs are relatively close together), the results from all four campaigns are considered to be relevant for the purpose of characterizing ambient offshore air quality in the vicinity of the Payara PDA. The measurements from all four campaigns found that ambient concentrations of constituents were generally below laboratory detection limits, with the exception of PM_{10} (measured concentrations ranging from non-detectable to 32 $\mu g/m^3$), $PM_{2.5}$ (measured concentrations ranging from non-detectable to 15 $\mu g/m^3$), and non-methane VOCs. During the first three offshore monitoring campaigns, the reported non-methane VOC concentrations for samples ranged from 2 to 290 parts per billion by volume (ppb(v)). For the 2019 monitoring program, reported non-methane concentrations were considerably higher, ranging from 83 to 4,533 ppb(v). While the 2019 VOC measurements were significantly higher than the measurements from previous campaigns, concentrations of those VOC species for which health guidelines have been established were all below their corresponding guideline concentrations.

For all four offshore monitoring campaigns, chemical analysis of the PM samples found that the most abundant elements in the collected particulate mass were sodium and chlorine—the most likely source of which is sea salt.

Laboratory-reported concentrations of CO, SO_2, H_2S, and NO_2 were all below laboratory reporting limits (i.e., non-detectable) for all four monitoring campaigns. The absence of detectable CO in any of the samples demonstrates that the monitoring campaigns were not significantly biased by the ships' engine emissions.

Existing Conditions—Onshore Air Quality

Given the scarcity of available information regarding onshore ambient air quality in Guyana, EEPGL commissioned an onshore ambient air-quality monitoring program in 2018. To date, monitoring has been conducted at three onshore sites (see Figure 6.1-1). The air quality monitoring report documenting the onshore ambient air quality monitoring conducted to date is included in Appendix D, Ambient Onshore Air Quality Monitoring Report.

The onshore monitoring sites and their rationale for selection are as follows:

- New Amsterdam (Rose Hall Estate), Berbice. The New Amsterdam site was selected to represent rural, near-coast conditions, upwind of the Georgetown urban area. Monitoring was performed at this site from 15 August 2018 through 3 October 2018.
- Carifesta, Georgetown. The Carifesta monitoring site was established adjacent to the Guyana Telephone & Telegraph, Carifesta Avenue location. This coastal site represents a more urban setting compared to the New Amsterdam site, but is still generally upwind of larger point source emission sources in the Georgetown urban area. This site was monitored twice—from 15 August 2018 through 3 October 2018, and from 11 December 2018 through 19 March 2019.
- New Guyana School. This monitoring site, near the east bank of the Demerara River, is generally downwind of the most densely populated and developed areas of Georgetown. It is thus expected to be representative of the higher ambient concentrations of pollutants that could be emitted from the Georgetown urban area. Monitoring commenced at this site on 12 April 2019 and continues to date. This EIA and the attached monitoring report documents measurements through 12 June 2019.

As with the offshore environment, the prevailing wind direction at all three of the onshore monitoring sites is overwhelmingly from the east and east-northeast.

The pollutants assessed at each site included PM_{10}, $PM_{2.5}$, CO, SO_2, H_2S, NO_2, and the VOC compounds benzene, toluene, ethylbenzene, and xylenes (BTEX). All seven parameters were measured continuously or semi-continuously during the referenced monitoring periods. At the New Amsterdam and Carifesta sites, local meteorological parameters were also monitored at collocated sites. At the New Guyana School site, wind speed and direction measurements were integrated with the air quality measurement system.

Figure 6.1-1: Onshore Ambient Air Quality Monitoring Sites

The onshore measurements of PM_{10}, $PM_{2.5}$, CO, SO_2, H_2S, NO_2, and BTEX at all three onshore monitoring sites are summarized in Tables 6.1-2 through 6.1-11. The relevant World Health Organization (WHO) or U.S. Environmental Protection Agency (USEPA) criteria are provided for comparison purposes. Guyana has not established specific ambient air quality standards; therefore, the guidelines used for reference in this assessment were those established by the *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide—Global Update 2005* (WHO 2005), except for toluene, CO, and H_2S, for which WHO guidelines were published in WHO's *Air Quality Guidelines for Europe, 2nd edition, 2000* (WHO 2000). While no WHO guidelines have been published for BTEX, criteria for these species have been established by the USEPA and these were used for the assessment of results (USEPA 1999).

As illustrated in the summary tables presented below, PM concentrations (both PM_{10} and $PM_{2.5}$) were near or exceeded WHO criteria at all three onshore monitoring sites.

PM_{10}, and to a lesser extent $PM_{2.5}$, is generated by physical operations such as grinding or cutting, burning, and resuspension of dust. It is likely that the elevated concentrations monitored at all three sites were significantly influenced by vehicle traffic (engine emissions, rubber tire dust, resuspended road dust) and open burning. The Carifesta site may have also received significant sea salt inputs due to its proximity to the coast. The sources of New Amsterdam PM_{10} ambient air impacts likely included agricultural emission sources (tilling, harvesting, and residue burning). While PM_{10} can be a respiratory irritant, it is not generally associated with adverse chronic health effects.

In most cases, the primary source of $PM_{2.5}$ is atmospheric chemical reaction of precursor gases that forms fine particles. Common precursor gases are SO_2 and NO_2 from fuel combustion, as well as ammonia from livestock operations. Combustion emissions from vehicle engines and open burning were also likely significant $PM_{2.5}$ emission sources impacting the three monitoring sites. $PM_{2.5}$ exposure has been found to pose significant health risk, potentially contributing to a broad range of respiratory and cardiovascular diseases.

While the monitoring period average concentrations for PM_{10} and $PM_{2.5}$ were above or near the annual average WHO Guideline Values at the three onshore sites, comparison between the monitoring period average values and the annual average WHO Guideline Values should be considered indicative rather than directly comparable, as the WHO Guideline Values are for annual average, and the monitoring duration at each of the three sites was less than 365 days. The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases.

The only measured exceedance of a gaseous pollutant criterion was the 24-hour average benzene levels at the Carifesta monitoring site. The high benzene values measured at the Carifesta site were not observed at the other two monitoring sites. It is likely that vehicle emissions (a common source of airborne benzene) were responsible for these high measurements, given that the Carifesta site is situated between two roadways that are often busy and sometimes congested. The sample inlet was located 34 meters (111.5 feet) from Carifesta Road and 69 meters (226.4 feet) from Seawall Public Road. The International Agency for Research on Cancer classifies benzene as “carcinogenic to humans.” Inhalation is the primary exposure pathway, with breathing cigarette smoke and contaminated air (such as from gasoline vapors and engine exhaust) as the most prevalent exposure routes. The WHO has not established a criterion for benzene, but the USEPA has set 9.4 ppb(v) as its reference concentration.

At sufficient concentrations, CO can be an asphyxiant or, over longer time periods, stress the cardiovascular system. The monitoring results for CO were all below the WHO Guideline Values.

NO_2 can lead to adverse health effects, contribute to the formation of tropospheric ozone (a respiratory irritant), and participate in formation of secondary $PM_{2.5}$. The monitoring results for NO_2 were all below WHO Guideline Values. The low concentrations limit the extent to which NO_2 would be likely to promote ozone or secondary $PM_{2.5}$ formation.

SO_2 can lead to adverse health effects and participate in the formation of secondary $PM_{2.5}$. The monitoring results for SO_2 concentrations are below the WHO Guideline Values. The low concentrations limit the extent to which SO_2 would be likely to promote secondary $PM_{2.5}$ formation.

At sufficiently high concentration, H_2S can cause a number of adverse health effects. WHO has established a 24-hour criterion of 107.6 ppb(v) as protective of human health. The monitoring results indicate that H_2S concentrations at the New Amsterdam and Carifesta sites were less than 2 percent of the WHO criterion. Measured New Guyana School H_2S measurements were higher, but still less than 20 percent of the WHO criterion. It is possible that the New Guyana School measurements may relate to sewage emissions. Under anaerobic conditions, sewer gas can contain significant H_2S concentrations, and may be the primary source of the measured H_2S.

Table 6.1-2: Summary of Onshore PM_{10} Monitoring Results

Location	Maximum 1-Hour Average (µg/m³)	Maximum 24-Hour Average (µg/m³)	Monitoring Period Average [a] (µg/m³)	Data Recovery	Valid Monitoring Days
Carifesta	266.7	154.2	27.9	94%	141
New Amsterdam	110.7	39.8	20.6	99%	50
New Guyana School	84.9	47.6	27.1	98%	61
Criterion	—	50 (WHO 24-hour)	20 (WHO Annual)		

[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high values.

Table 6.1-3: Summary of $PM_{2.5}$ Monitoring Results

Location	Maximum 1-Hour Average (µg/m^3)	Maximum 24-Hour Average (µg/m^3)	Monitoring Period Average [a] (µg/m^3)	Data Recovery	Valid Monitoring Days
Carifesta	92.7	53.1	10.8	94%	141
New Amsterdam	38.3	13.5	6.8	99%	50
New Guyana School	45.8	16.4	9.9	98%	61
Criterion	—	25 (WHO 24-hour)	10 (WHO Annual)		

[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high values.

Table 6.1-4: Summary of CO Monitoring Results

Location	Maximum 1-Hour Average (ppm)	Maximum 8-Hour Average (ppm)	Monitoring Period Average (ppm)	Data Recovery	Valid Monitoring Days
Carifesta	1.9	1.6	0.6	98%	147
New Amsterdam	1.1	0.7	0.4	98%	50
New Guyana School	1.2	1.1	0.4	98%	61
Criterion	26.2 (WHO 1-hour)	8.7 (WHO 8-hour)	—		

Table 6.1-5: Summary of NO_2 Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Monitoring Period Average [b] (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	15.0	4.6	98%	147
New Amsterdam	21.7	-1.4 [a]	79%	50
New Guyana School	12.2	4.2	98%	61
Criterion	106.4 (WHO 1-hour)	21.3 (WHO Annual)		

[a] Normal analyzer drift may result in reported negative concentrations where ambient levels are low. In conformance with standard quality assurance practice, these are reported without adjustment.
[b] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high values.

Table 6.1-6: Summary of SO_2 Monitoring Results

Location	Maximum Daily 1-hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	7.2	0.3	-0.4 [a]	98%	147
New Amsterdam	-0.1 [a]	-1.0 [a]	-1.3 [a]	95%	50
New Guyana School	11.7	1.7	0.9	98%	61
Criterion	75 (USEPA 1-hour)	7.6 (WHO 24-hour)	—		

[a] Normal analyzer drift may result in reported negative concentrations where ambient levels are low. In conformance with standard quality assurance practice, these are reported without adjustment.

Table 6.1-7: Summary of H_2S Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	20.0	1.9	0.2	98%	147
New Amsterdam	5.7	0.4	-0.1 [a]	95%	50
New Guyana School	71.8	16.0	4.8	98%	61
Criterion	—	107.6 (WHO 24-hour)	—		

[a] Normal analyzer drift may result in reported negative concentrations where ambient levels are low. In conformance with standard quality assurance practice, these are reported without adjustment.

Table 6.1-8: Summary of Benzene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	1,272.6	155.8	21.7	94%	47
New Amsterdam	7.9	0.4	0.0	99%	50
New Guyana School [a]	NA	0.7	NA	100%	4
Criterion	—	9.4 (USEPA 24-hour)	—		

NA = not applicable

[a] Data from integrated 24-hour Summa samples[1]

[1] Samples were collected in summa canisters, which are specially treated to make them chemically non-reactive with specific air pollutants so that collected whole air samples do not degrade significantly during the interval between sampling and analysis.

Table 6.1-9: Summary of Toluene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	1,134.6	169.5	20.7	94%	47
New Amsterdam	6.7	5.4	5.0	99%	50
New Guyana School [a]	NA	6.0	NA	100%	4
Criterion	—	—	59 (WHO 1-week)		

NA = not applicable
[a] Data from integrated 24-hour Summa samples

Table 6.1-10: Summary of Ethylbenzene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	31.6	3.3	0.08	94%	47
New Amsterdam	0.6	0.1	0.0	99%	50
New Guyana School [a]	NA	ND	ND	100%	4
Criterion	—	—	0.23 [b] (USEPA Annual)		

NA = not applicable; ND = below minimum laboratory reporting level of 0.14 ppb by volume
[a] Data from integrated 24-hour Summa samples
[b] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.

Table 6.1-11: Summary of Xylenes Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	137.1	12.3	0.4	94%	47
New Amsterdam	14.4	0.9	0.1	99%	50
New Guyana School [a]	NA	0.4	NA	100%	4
Criterion	—	100 (USEPA 24-hour)	—		

NA = not applicable
[a] Data from integrated 24-hour Summa samples

6.1.2.2. Existing Conditions—Climate

Guyana has a wet tropical climate characterized by two pronounced wet seasons and year-round warm temperatures. The bimodal wet/dry regime is caused by the annual migration of the Inter-Tropical Convergence Zone (ITCZ), which changes latitude based on the Earth's position and angle in relation to the sun. Northward movement of the ITCZ occurs as energy from the sun is strongest in the Northern Hemisphere during the Northern Hemisphere's summer, thereby increasing solar heating in that hemisphere. The relative change in solar heating slightly shifts the atmosphere's primary circulation cells, which causes the area of trade wind convergence closest to the Equator to migrate seasonally. In the areas closest to the ITCZ, one can expect increased thunderstorm activity and heavy rainfall between mid-April and the end of July, with peak rainfall in June. This period is known in Guyana as the primary wet season. The secondary wet season occurs during the southward migration of the ITCZ from mid-November to the end of January, with peak rainfall in December. The intervening periods (January to April and mid-August to mid-November) are relatively dry, but rain can occur at any time of the year. Average monthly rainfall totals range between approximately 100 millimeters and 300 millimeters (4 inches to 12 inches) (World Weather & Climate Information 2016). During El Niño years, Guyana's long dry season is often drier and warmer than normal, and La Niña years bring wetter and cooler conditions than normal during the long wet season (McSweeney et al. 2010).

Although the ITCZ moves seasonally, it is generally located between 5 degrees (°) North latitude and 5° South latitude. North and south of the ITCZ, atmospheric circulation and the Coriolis effect create global wind patterns including the Northern Hemisphere's trade winds and westerlies (NOAA 2008). Guyana's coastal zone is located approximately between 6° and 8° latitude, and the Stabroek Block is located between 7° and 8° latitude, both within the southern portion of the area impacted by the trade winds. The influence of the trade winds produces a strongly dominant northeast wind offshore of Guyana, which gives rise to the afternoon "sea breeze" that usually blows inland across coastal Guyana from the ocean.

Annual average temperatures in coastal Guyana are relatively constant, with an annual average daytime maximum temperature of 29.6 degrees Celsius (°C) (85.3 degrees Fahrenheit [°F]) and an annual average nighttime minimum temperature of 24.0 °C (75.2°F). The average daily temperature is approximately 27°C (81°F). Relative humidity is high at 80 percent or more year round in the coastal zone.

To develop more specific climate information regarding offshore conditions in the vicinity of the PDA, EEPGL commissioned deployment of a surface met buoy in the Stabroek Block to collect information on existing meteorological conditions. With respect to atmospheric conditions, the instrument measured and logged the following:

- Air temperature
- Water temperature
- Atmospheric pressure
- Relative humidity
- Solar radiation
- Precipitation
- Wind speed
- Wind direction
- Gust speed

The above information for the five deployments of the surface met buoy between March 2016 and April 2018 is included as Appendix E, Onshore and Offshore Meteorological Data.

To develop more specific climate information regarding onshore climate conditions, EEPGL commissioned deployment of a meteorological station at two of the three ambient onshore monitoring air quality sites discussed above (Carifesta and New Amsterdam). The instrument measured and logged the following:

- Air temperature
- Relative humidity
- Atmospheric pressure
- Solar radiation
- Precipitation
- Wind speed
- Wind direction
- Gust speed

The above information for the meteorological station deployments between December 2017 and April 2019 is included as Appendix E, Onshore and Offshore Meteorological Data.

6.1.3. Impact Assessment—Air Quality and Climate

This section addresses potential impacts on air quality due to emissions resulting from planned Project activities. Additionally, while potential climate impacts are more of a global concern from cumulative worldwide greenhouse gas (GHG) emissions, this section addresses potential impacts on climate due to GHG emissions resulting from planned Project activities. The key potential impacts assessed include increases in ambient concentrations of pollutants as a result of stationary and mobile combustion sources associated with planned Project activities, and GHG emissions from these same sources.

6.1.3.1. Relevant Project Activities and Potential Impacts

Emissions generated by the Project generally emanate from two source categories: (1) specific point sources such as the power-generating units and diesel engines on drill ships and on the Floating Production, Storage, and Offloading (FPSO) vessel, flares used (non-routinely) to combust produced gas when not consumed as fuel gas on the FPSO or re-injected back into the reservoir, and vents; and (2) general area sources such as support vessels, construction vessels, tug boats, and helicopters. Such emissions contribute to increases in the ambient air concentrations of certain pollutants and will also increase Guyana’s national GHG emissions inventory.

Depending on the magnitude and extent of the increases in ambient air pollutant concentrations relative to the location of potential human receptors onshore in Guyana, the increases from Project activities may contribute to health impacts. Because potential air quality-related health effects for Project workers will be addressed through standard occupational exposure guidelines, this air quality impact assessment was limited to consideration of potential onshore community receptors.

Table 6.1-12 summarizes the Project stages and activities that could result in potential Project impacts on air quality and climate.

**Table 6.1-12: Summary of Relevant Project Activities and Key Potential Impacts—
Air Quality and Climate**

Stage	Project Activity	Resource	Key Potential Impacts
Development Well Drilling FPSO and SURF Installation Decommissioning	Operation of drill ships (power generation and engines), marine support and installation vessels, and support aircraft	Air quality (onshore population as receptors)	Increased concentrations of pollutants in ambient air, potentially contributing to health impacts for onshore receptors
		Climate	Increased emissions of GHGs may increase the concentrations of GHGs in the atmosphere
Production Operations	Operation of FPSO (power generation and engines), marine support vessels, and support aircraft; temporary, non-routine flaring of gas when not re-injected	Air quality (onshore population as receptors)	Increased concentrations of pollutants in ambient air, potentially contributing to health impacts for onshore receptors
		Climate	Increased emissions of GHGs may increase the concentrations of GHGs in the atmosphere

SURF = Subsea, Umbilicals, Risers, and Flowlines

6.1.3.2. Emissions of Air Quality Pollutants

Emissions of air quality pollutants from the Project have been estimated based on a number of factors, including activity levels, fuel types, equipment capacities, and standard emission factors that are published by the USEPA in the publication *AP-42: Compilation of Air Pollutant Emission Factors* (USEPA 2018). As described in AP-42, an emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., milligrams of nitrogen oxides emitted per cubic meter of natural gas combusted). In most cases, these factors are averages of available data of an acceptable quality, and are generally assumed to be representative of long-term averages for a particular type of source.

Embedded Controls

The Project has been inherently designed to incorporate a number of embedded controls that will serve to reduce air pollutant emissions (as well as GHG emissions—discussed further below) from Project sources. Table 6.1-13 includes a summary of these embedded controls.

Table 6.1-13: Embedded Controls Contributing to Reductions in Atmospheric Emissions

Embedded Controls
If well testing is performed, implement the following measures: • Flow only the minimum volume of hydrocarbons required for the test and reduce the test duration to the extent practical; • Use an efficient test-flare burner head equipped with an appropriate combustion enhancement system to minimize incomplete combustion, black smoke, and hydrocarbon fallout[2] to the sea; • Record volumes of hydrocarbons flared and make available to the EPA upon request;

[2] Hydrocarbons that are deposited on the ocean surface due to both wet and dry deposition processes

Embedded Controls
• Provide adequate gas sensors that are appropriately located during testing operations, to ensure all sources of gas can be detected; • Monitor pipes and joints on a daily basis for leakages and fugitive emissions. Burn all collected gaseous streams in high-efficiency flares, and implement and maintain a leak detection and repair program; • Keep the well test to the minimum practical time, in keeping with a pre-approved schedule with the EPA. Notify the EPA immediately in case of any deviation/variation to the well test; and • Provide sufficient compressed to the oil burner for efficient flaring assignment.
Use aero-derivative turbines instead of industrial turbines on the FPSO.
Install waste heat recovery units (WHRUs) on turbine generators to reduce the demand of more power generation or fired heaters, thus decreasing fuel gas consumption. Two WHRUs provide sufficient heat for the entire FPSO, but the Project is designed to use WHRUs on three of the four turbine generators, which adds spare capacity to ensure achieving maximum uptime and reducing flaring.
Use a crude–crude exchanger to recover heat from the dead crude to heat up live crude, instead of using a fired heater.
Use a large power plant and maximize the use of mechanical driven equipment that is more energy efficient. Use a gas turbine to drive the compressor directly, allowing savings in fuel versus using a gas turbine to generate electricity, and then using an electric motor to drive the compressor—reducing motor losses and power generation losses.
Use large, high-voltage motors, which are more efficient than industry standard machines.
Use the same gas turbines for the main generators, designed slightly larger than the need for the compressor such that when one compressor trips, the second unit still can meet 60 percent of production and thus reduce flaring.
Implement an FPSO topsides leak detection and repair program to reduce fugitive emissions.
Instead of continuous flaring, re-inject produced gas that is not used as fuel gas on the FPSO into the reservoir, to avoid routine flaring.
Adopt highly efficient combustion equipment using recovery heat systems as part of the heat and power production.
With respect to non-routine flaring, the following measures will be implemented: • Ensure flare equipment is properly inspected, well maintained, monitored, certified, and function-tested prior to and throughout operations; • Install the flare at a safe distance from storage tanks containing flammable liquids or vapors and accommodation units; • Ensure combustion equipment is designed and built to appropriate engineering codes and standards; • Do not operate the flare outside design operating ranges; • Use efficient flare tips and optimize the size and number of burning nozzles; • Minimize risk of pilot blowout by ensuring sufficient exit velocity and provision of wind guards; • Use a reliable pilot ignition system; • Install high-reliability instrument pressure protection systems, as appropriate, to reduce overpressure events and avoid or reduce flaring situations; • Operate the flare to control odor and visible smoke emissions; • Record volumes of hydrocarbons flared and submit a copy of the record to the EPA annually; • Maximize efficiency of flaring through flare tip design to ensure correct ratio of fuel and air are present to support efficient combustion • Implement burner maintenance and replacement programs to ensure continuous maximum flare efficiency; • Minimize liquid carryover and entrainment in the gas flare stream with a suitable liquid separation system, with sufficient holding capacity for liquids that may accumulate, and which is designed in accordance with good engineering practice; • Equip liquid separation system (e.g., knockout drum) with high-level facility shutdown or high-level alarms and empty as needed to increase flare combustion efficiency; • Implement source gas reduction measures (i.e., gas re-injection into reservoir) to the extent possible to avoid or reduce flaring from FPSO;

Embedded Controls
• Minimize flaring from purges and pilots without compromising safety through measures such as installation of purge gas reduction devices, vapor recovery units, inert purge gas, and soft seat-valve technology where appropriate, and installation of conservation pilots; and • Minimize flame lift off and/or flame lick.
Develop equipment strategies and execute a maintenance program to minimize equipment breakdowns and plant upsets that could result in flaring, and make provisions for equipment sparing and plant turn-down protocols where practical.
Implement inspection, maintenance, and surveillance programs to identify and prevent unplanned emissions to atmosphere onboard the FPSO.
In the event of an emergency or equipment breakdown on the FPSO, or when facility upset conditions arise, excess gas should not be vented but rather should be sent to an efficient flare gas system, where practical and operationally safe.
Notify the EPA via email, correspondence, and/or telephone within 24 hours after process upset events or unplanned maintenance occur that result in a flaring event on the FPSO sustaining a volume of at least 10 million standard cubic feet per day. Capture volumes from minor flaring events not requiring notification in aggregate in annual emissions reporting.
Avoid routine venting (excludes tank flashing emissions, standing/ working/breathing losses) except during safety and emergency conditions.
Avoid use of chlorofluorocarbons and polychlorinated biphenyls on the FPSO.
Use low-sulfur fuels for major Project vessels, where available and commercially viable.
Use dust-suppression measures at the shorebases to reduce impacts on air quality.
Operate incinerators in accordance with the manufacturers' operating manuals and Waste Management Plan. Ensure that the incinerators are operated only by trained personnel.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' specifications and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Maximize efficiency of flaring by controlling and optimizing flare fuel, air, and stream flowrates to ensure the correct ratio of assist stream to flare stream.
Regularly inspect and service shorebase cranes and construction equipment to mitigate the potential for spills and to reduce air emissions to the extent reasonably practicable.
Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.
Implement a chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment;

As noted in Table 6.1-13, several of the embedded controls relate to minimization of flaring from the Project's FPSO production operations. To support this embedded control, EEPGL has developed a Flaring Minimization Plan to document the design measures and operational practices that minimize flaring resulting from Project FPSO operations. The following sub-section provides an overview of the Flaring Minimization Plan:

Flare Minimization Plan Overview

Guiding Principles

It is ExxonMobil's (EEPGL's parent organization) and its affiliates' policy to conduct its business in a manner that is compatible with the balanced environmental and economic needs of the communities in which it operates. ExxonMobil is committed to continuous efforts to improve environmental performance throughout its operations.

Further, it is ExxonMobil's corporate environmental policy to:

- *Comply* with all applicable laws and regulations and apply responsible standards where laws and regulations do not exist;
- *Encourage* concern and respect for the environment, and foster appropriate operating practices and training;
- *Prevent* incidents and control emissions and wastes to below harmful levels;
- *Respond* quickly and effectively to incidents.

Flaring is an integral part of safe operations for any production facility. The flare provides a consistent, dependable utility for safely managing hydrocarbons that may be released during overpressure events on process vessels. Combining technologies, procedures, and work practices with comprehensive flare management can result in significant flare reduction from operations.

Operating in a safe and environmentally sound manner is an essential part of the ExxonMobil philosophy and efforts will be made to minimize flaring emissions during maintenance, commissioning/start-up, and shutdown operations to the extent practical.

Flaring Process Description

The purpose of the flare system is to provide for the collection and safe disposition of produced hydrocarbons resulting from unplanned, non-routine relief and blowdown events. Relief events occur to prevent overpressure scenarios in the process equipment. Blowdown events occur to depressure the facilities in a controlled manner as a result of emergency shutdown events. In addition, temporary, non-routine flaring will occur during equipment maintenance, process upsets, and commissioning/start-up. The flare system will include both a high-pressure and low-pressure flare sharing a common flare tower. The flare tower has elevated flare tips for both high and low pressure flares, which provides for the safe ignition of hydrocarbon gases. Both flares will support high-efficiency combustion and will use pilots that have minimal emissions.

Flare Minimization Practices

The FPSO is designed, constructed, and operated to avoid routine flaring. For events where flaring is the only viable solution, such as maintenance, commissioning/start-ups, and shutdowns, the below measures, practices, and technologies will be used to minimize flaring.

Flaring emissions are reduced through the facility design. ExxonMobil internal environmental standards establish a design approach to reduce flaring emissions, which mandates that facilities should be designed to avoid routine flaring of associated gas and include an evaluation for the most beneficial use alternatives for associated gas that would otherwise be flared.

Three primary alternatives were considered for addressing associated gas produced during operations: gas re-injection, continuous flaring, and gas export. Continuous flaring of gas on a routine basis is not preferred, primarily due to the associated air emissions (pollutants including GHGs). Gas re-injection was determined to be feasible, and it also provides benefits in terms of reservoir management by helping to maintain pressure in the reservoir (thereby increasing the amount of crude oil that can be recovered over time) and reduced air emissions (as compared to continuous flaring).

The FPSO is designed to recover associated gas to be used as fuel on the FPSO and re-inject the produced gas back into the reservoir, except during times of injection system unavailability, which may require temporary, non-routine flaring. Through using associated gas as fuel on the FPSO and re-injecting the remaining volumes, flaring emissions have been minimized.

In addition, the flare systems onboard the FPSO is designed and built to appropriate engineering codes, including:

- Use of efficient flare tips and optimized size and number of burning nozzles;
- Reduce risk of pilot blowout through ensuring sufficient exit velocity and provision of wind guards;
- Use of a reliable pilot ignition system;
- Use of a high-integrity instrument pressure protection systems, where appropriate, to reduce overpressure events and avoid or reduce flaring situations;
- Use of a suitable liquid separation system, with sufficient holding capacity for liquids that may accumulate, in order to minimize liquid carryover and entrainment in the gas flare stream; and
- Use of a high-level facility shutdown or high-level alarms on the liquid separation system.

<u>Maintenance Programs</u>

Proactive and preventative maintenance and testing programs will reduce flaring by minimizing downtime from equipment failure and ensure continuous maximum flare efficiency. The key aspects of these programs include preventative maintenance, corrective maintenance, and capacity enhancements, which can increase reliability and reduce unplanned downtime. A robust facility preventative maintenance program can reduce the number of unavoidable events. The FPSO will use a computerized maintenance management system to schedule efficient use of maintenance time and to ensure that the proper equipment inventory is maintained. The maintenance events that are routinely conducted are entered into this system, which notifies the appropriate personnel of required maintenance. In addition, a facility integrity management system will be in place, which is a primary driver for inspections of vessels, piping, and equipment that cannot be completed while the facility is online. Preventative maintenance is the key technique to reduce the probability of equipment failure. When maintenance is managed correctly and efficiently, emissions can be minimized. Good maintenance practices can reduce the number of unavoidable events and increase safety.

Procedures

Additional measures are in place to minimize flaring through procedural activities. Operations will follow specifically developed procedures for starting up and shutting down equipment. By following these procedures, flaring emissions will be minimized.

Prior to any major maintenance or turnaround event, a specific plan will be developed in advance that includes a review of potential flaring and evaluation of possible mitigations to minimize any flaring.

During maintenance and shutdown events, operations will take the following measures to avoid or reduce flaring:

- When feasible, perform maintenance on one area without impacting other operations on site. This will allow other operations to continue normally without the need to flare excess gas.
- Curtail oil production or throttle back equipment during planned shutdowns.
- Plan maintenance activities during optimal periods. Scheduling maintenance during periods of minimum capacity needs and/or following planned process unit shutdowns has the potential of minimizing flaring activities.
- Optimize planned shutdowns for major maintenance. There will be times when the FPSO has to shut down and flare process gas to conduct major maintenance work; this is known as a turnaround. The following procedures will be used to minimize flaring during FPSO turnarounds:
  - Prior to turnaround, identify critical equipment to be serviced to avoid downtime and associated flaring.
  - Phase equipment and process unit shutdowns to minimize fuel gas imbalances that may result in additional flaring.
  - Phase equipment and process unit start-ups to minimize start-up duration and the flaring associated with these transitional operations.

Monitoring

Twenty-four-hour coverage of the facility will be provided to manage operational events that may cause flaring.

Operators will conduct routine rounds on the FPSOs to visually monitor equipment, including the flare system. It is important that equipment be visually inspected and monitored to ensure that remote instrumentation are operating correctly and to confirm that no abnormalities are present.

Additionally, the FPSOs will maintain and operate instrumentation to continuously monitor and record process and flare parameters. Monitoring and control of the FPSO production operations will be performed by an Integrated Control and Safety System. The system will include primary process control, monitoring, and data acquisition, shutdown functions, operator graphics/consoles, and visual alarm notifications. This system will allow operators to visualize what is happening in the process and help identify situations that could result in flaring events. Deviations from set parameters will cause an alarm, driving operations to intervene to prevent or mitigate an event. The alarm will be followed by an automatic trip if the deviation reaches a certain threshold.

If flaring does occur, consideration will be given to the expected flaring rate, expected flaring duration, and year-to-date flaring performance to determine if production should be curtailed to reduce flared volumes relative to predicted volumes in the EIA.

Reporting

The following core reporting components will support the application of this flare minimization plan, and will drive improvement initiatives by tracking overall flare performance.

- The volumes of gas flared will be recorded on a daily basis.
- Any flaring event resulting from upset events or unplanned maintenance that sustains a volume and/or duration exceeding limits imposed by the permit conditions will be reported to the EPA.
- EEPGL will report flaring volumes on an annual basis to the EPA.

Mitigation Measures

In addition to the embedded controls discussed above, the Project design incorporates a number of additional mitigation measures that are anticipated to further reduce energy usage and therefore further reduce the air pollutant emissions from Project sources. Table 6.1-14 includes a summary of these additional mitigation measures.

Table 6.1-14: Additional Mitigation Measures Contributing to Reduced Energy Consumption and Atmospheric Emissions

Mitigation Measures
Use an increased inlet pressure to decrease the overall compression requirements, which leads to a reduction in power demand and fuel consumption.
Install VOC recovery on the FPSO cargo tanks, which results in a reduction in FPSO cargo tank emissions.
Optimize gas turbine maintenance to ensure that gas turbines are not overhauled more often than needed, and also to ensure overhauls are completed at the right time, in alignment with other FPSO maintenance activities to reduce the need to flare.
Implement trip-reduction initiatives for the gas turbines to improve reliability/ availability to reduce flaring.
Quantify and report direct greenhouse gas emissions from Project offshore facilities and from offshore and onshore Project activities conducted by EEPGL and its dedicated contractors on an annual basis in accordance with internationally recognized methodologies.

Project Emissions Inventory

To support modeling of Project emissions of air pollutants (discussed further below), the Project emissions inventory used as input for modeling considered all of the embedded controls and mitigation measures described above. Table 6.1-15 provides a summary of expected annual emissions from various planned Project activities for three time periods: 2020–2022 (development well drilling; Subsea, Umbilicals, Risers, and Flowlines [SURF] installation and commissioning; FPSO installation; and operation of related support vessels); 2023–2025 (continued development well drilling; operation of related support vessels; FPSO startup and associated temporary, non-routine flaring; beginning of production operations; and tanker loading); and 2026–2044 (production operations following cessation of drilling, including temporary, non-routine flaring; operation of related support vessels; and tanker loading). For each of the time periods, the annual emissions presented for each pollutant in Table 6.1-13 represents the maximum anticipated annual emissions for that pollutant for any of the years during the indicated time period. While there are some differences in emissions for different years within the time periods, they are relatively minor and the use of maximum emissions for the impact assessment provides a degree of conservatism in the results.

Table 6.1-15: Annual Air Pollutant Emissions Summary—Payara Project

Pollutant	Source Category	Annual Emissions (tonnes)		
		2020–2022	2023–2025	2026–2044
Nitrogen Oxides	FPSO	0	2,730	2,635
	FPSO Flaring (temporary, non-routine)	0	865	165
	Tanker Loading	0	290	230
	Area Sources	3,110	3,365	1,670
	Drill Ships	1,675	1,675	0
	Total	4,785	8,925	4,700
SO_2	FPSO	0	140	140
	FPSO Flaring (temporary, non-routine)	0	150	30
	Tanker Loading	0	50	40
	Area Sources	110	120	60
	Drill Ships	60	60	0
	Total	170	520	270
PM	FPSO	0	65	60
	FPSO Flaring (temporary, non-routine)	0	25	5
	Tanker Loading	0	25	20
	Area Sources	220	240	120
	Drill Ships	120	120	0
	Total	340	475	205

Pollutant	Source Category	Annual Emissions (tonnes)		
		2020–2022	2023–2025	2026–2044
CO	FPSO	0	695	675
	FPSO Flaring (temporary, non-routine)	0	4,685	880
	Tanker Loading	0	65	50
	Area Sources	650	705	350
	Drill Ships	350	350	0
	Total	1,000	6,500	1,955
H_2S	FPSO Flaring (temporary, non-routine)	NA (no emissions)	<5	<1
VOCs	All Sources	125	6,825	2,775

NA = not applicable
Notes:

1. The annual estimated totals generally reflect the current preliminary Project schedule and remain subject to adjustment.
2. VOCs and GHG emissions are shown in this table but were not included in the impact assessment modeling, as no Guyana-specific ambient air quality criteria have been established for these substances.
3. PM emissions represent total PM; for the purpose of the impact assessment, the results from modeling of total PM values were used for comparison to both PM_{10} standards and $PM_{2.5}$ standards (a conservative assumption).
4. The emission rates in this table reflect annual totals. In some cases, the activities generating the emissions are not continuous during the year, or do not operate at full capacity throughout the year. For these sources, the annual emissions reflect this non-continuous operation over the year. However, for the purpose of modeling conducted to compare with short-term (up to 24-hour) guidelines, activities were assumed to be operating at full capacity for the simulated period, to reflect maximum possible short-term emission rates.
5. Area Sources are mobile equipment such as aviation and marine support vessels (besides the FPSO and drill ships) used during drilling, installation, production operations, and decommissioning.

6.1.3.3. Characterization of Potential Impacts—Air Quality

This section presents the assessment of potential Project impacts on air quality based on the Project emissions inventory presented above.

Ambient Air Quality Guidelines and Concentrations

Ambient air quality guidelines are concentration levels in air that are established to protect human health in locations where exposure can potentially occur. These generally include a margin of safety to ensure that individuals with a higher sensitivity to air pollutants are also protected. Guyana has not established specific ambient air quality standards; therefore, the guidelines used for reference in this assessment were those established by WHO. The WHO guidelines are summarized in Table 6.1-16). These guidelines were published in *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide—Global Update 2005* (WHO 2005) except for CO and H_2S, for which guidelines were published in WHO's *Air Quality Guidelines for Europe, 2nd edition, 2000* (WHO 2000).

Table 6.1-16: WHO Ambient Air Quality Guidelines

Pollutant	Averaging Period	Guideline Concentration (µg/m^3)
NO_2	1-hour	200
	Annual	40
SO_2	10-minute	500
	24-hour	20
PM_{10}	24-hour	50
	Annual	20
$PM_{2.5}$	24-hour	25
	Annual	10
CO	1-hour	30,000
	8-hour	10,000
H_2S	30-minute	7

Source WHO 2000; WHO 2005

Air Quality Dispersion Modeling

Air dispersion modeling was carried out to assess air quality impacts for onshore human receptors. The key elements of the modeling are discussed below, including receptors, source inputs, model selection, and meteorological data.

Receptors: A grid of potential receptor points was established for onshore areas in the Project AOI, with a denser grid used in coastal areas (closer to Project sources) and a coarser grid used in inland regions. For each pollutant, dispersion modeling was used to predict the maximum concentration at any time at any one of the onshore grid points; these maximum predicted concentrations were then compared to concentrations that may potentially result in significant impacts. Under this conservative approach, if the maximum predicted concentrations are determined to be not significant (i.e., less than the reference concentration), it follows that potential air quality impacts at any specific onshore receptor location also would be not significant. For this reason, specific locations of sensitive receptors were not identified at the onset of modeling.

Sources: With regard to source characteristics, point sources were modeled with fixed stack parameters, including physical dimensions and exhaust characteristics. Flares were also modeled as stacks, with adjustments made to account for and maintain thermal buoyancy associated with the high temperature of the flare. All of the emissions sources on the FPSO were conservatively modeled at a single location (representing the highest predicted ambient air concentration scenario). Area sources (i.e., mobile sources without fixed locations) were modeled in a fashion to represent their transit across planned travel areas. For example, support vessels and helicopters were assumed to operate and generate emissions within the PDA and also to transit between Georgetown and the PDA. There is a potential that additional support vessels for some stages of the Project may transit between Trinidad and Tobago and the PDA; however, based on the low level of emissions contributed by support vessel/helicopter traffic, relative to emissions from sources in the PDA, and the expectation that most support vessel/helicopter traffic will originate from Guyana shorebase facilities, modeling of support vessel area sources was limited to vessels transiting between Guyana and the PDA.

Figure 6.1-2 shows the modeling domain used in this analysis, the locations of the main Project point sources (the FPSO and Drill Center 5), and the boundary of Project-related area sources (including support vessels, construction vessels, and other sources without a fixed location), as configured for the modeling. Onshore terrain elevations used in the modeling are also depicted on this figure. The figure also shows the locations of other (non-Project) air pollutant emissions sources that were used for modeling of cumulative impacts, as described in Chapter 10, Cumulative Impact Assessment.

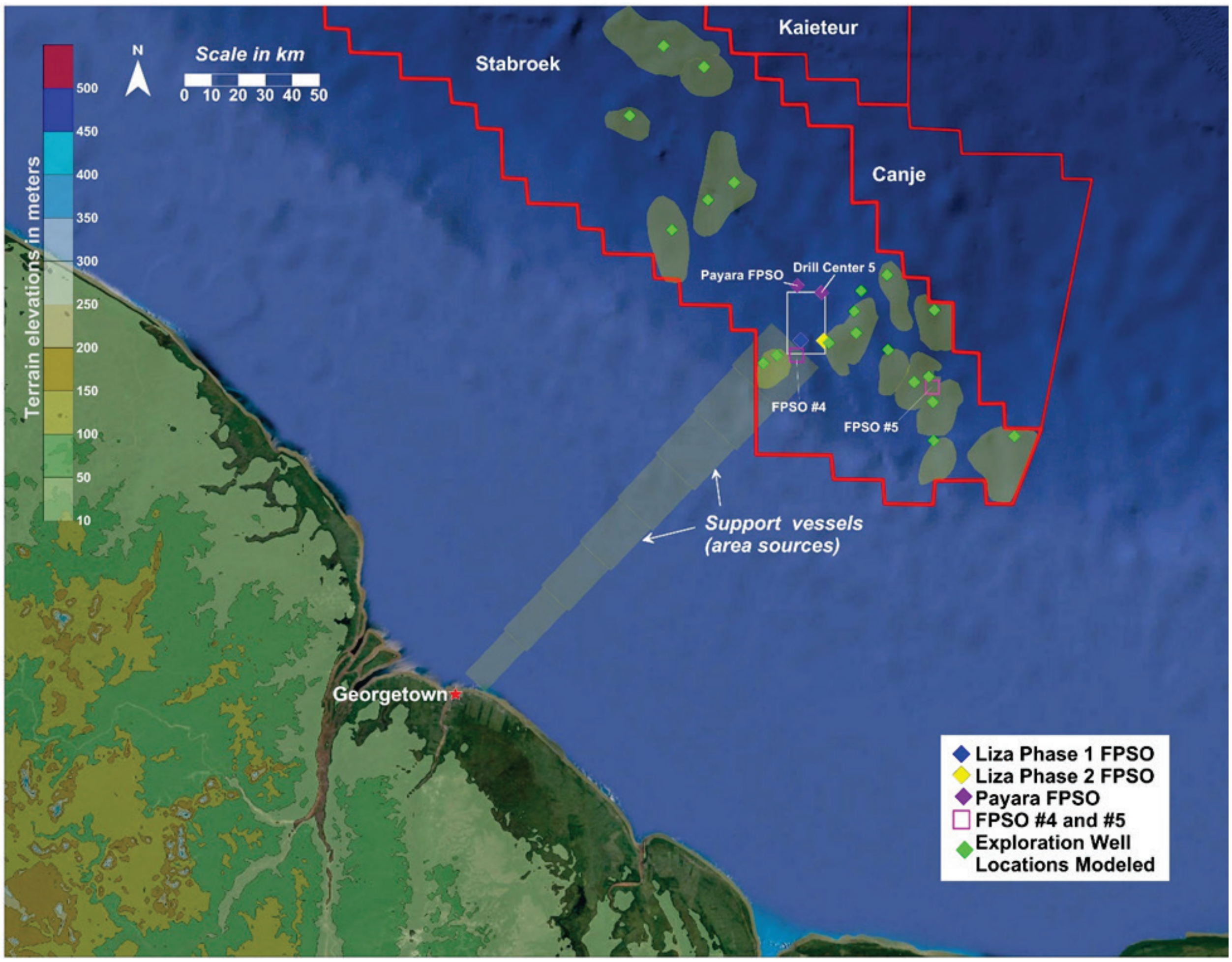


Figure 6.1-2: Air Quality Modeling Domain

Model Selection: The CALPUFF model (Version 7.2.1, level 150618) used in the assessment is a non-steady-state model used in the United States and around the globe for long-range transport and complex wind modeling. CALPUFF is a Lagrangian "puff" model that treats a plume of emissions as a series of puffs that it tracks as the wind carries the plume toward potential receptor locations. The selection of CALPUFF was based on the relatively large distance between the Project Development Area and the potential onshore receptors. The distance from the Project Development Area to the coastline of Georgetown is approximately 207 kilometers (128 miles). At this distance, emission plumes released from the point sources modeled would travel for approximately 10 hours, assuming an average wind speed of 5 meters (16.4 feet) per second (typical for the area). During this transport time, winds can change direction and speed. Accordingly, prediction of plume dispersion is most appropriately accomplished with a non-steady state model.

Meteorological Data: The Weather Research and Forecasting model was used to develop hourly meteorology inputs for CALPUFF for 3 years—calendar years 2014, 2015, and 2016. The Weather Research and Forecasting model is a prognostic meteorological model that creates profiles of winds and temperature at grid points across a domain. The grid spacing chosen for this analysis was 12 kilometers (7.5 miles), so that a two-dimensional profile of hourly winds and temperature was developed every 12 kilometers (7.5 miles) within the modeling domain. The profiles were used by CALPUFF to simulate the transport and dispersion of emission plumes from Project sources, allowing the model to calculate ambient constituent concentrations at potential receptor locations, accounting for changes in meteorology as the plumes travel downwind.

Predicted Ambient Air Concentrations

Using the methodology described above, modeling was conducted with CALPUFF to predict maximum onshore ground-level concentrations of each pollutant as a result of emissions from Project sources. Model results were developed for each modeled pollutant, for each averaging period with an associated WHO guideline concentration (Table 6.1-16). Results are summarized in Table 6.1-17.

Table 6.1-17: Summary of Modeling Results—Maximum Predicted Project Impact at Onshore Locations

Pollutant	Averaging Period	WHO Guideline Concentration (µg/m^3)	Maximum Predicted Onshore Concentration (µg/m^3)			Percent of WHO Guideline		
			2020–2022	2023–2025	2026–2044	2020–2022	2023–2025	2026–2044
NO_2	1-hour	200	1.6	3.3	2.2	0.8%	1.7%	1.1%
	Annual	40	0.15	0.27	0.15	0.37%	0.68%	0.36%
SO_2	10-minute	500	0.14	0.63	0.44	0.03%	0.13%	0.09%
	24-hour	20	0.03	0.13	0.09	0.13%	0.65%	0.45%
PM_{10}	24-hour	50	0.06	0.08	0.04	0.11%	0.16%	0.09%
	Annual	20	0.01	0.02	0.01	0.07%	0.09%	0.04%
$PM_{2.5}$	24-hour	25	0.06	0.08	0.04	0.22%	0.33%	0.18%
	Annual	10	0.01	0.02	0.01	0.14%	0.18%	0.07%
CO	1-hour	30,000	0.42	1.86	0.87	0.001%	0.006%	0.003%
	8-hour	10,000	0.31	1.12	0.55	0.003%	0.011%	0.005%
H_2S	30-minute	7	n/a	0.0010	0.0005	n/a	0.015%	0.0065%

n/a = no emissions of this pollutant during the indicated timeframe

Magnitude of Impact—Air Quality

The magnitude rating for potential air quality impacts is determined on the basis of two factors:

- The increase in pollutant concentrations in air as a result of the Project (Project Contribution—“PC”); and
- The total air pollutant concentrations arising as a result of the PC added to the existing conditions (the Predicted Environmental Concentration—“PEC”).

The PC and PEC are considered in the context of the relevant WHO air quality guidelines. Once the PC and PEC have been estimated, there are a number of approaches that may be used to determine the magnitude of impact. In jurisdictions such as Guyana that do not have specified approaches, the approach taken for the EIA is based on guidance from the International Finance Corporation (IFC 2007), and is shown on Figure 6.1-3.

Magnitude of Impacts

	Undegraded Airshed (Baseline < AQS)	Degraded Airshed (Baseline >AQS)
Negligible	PC < 25% of AQS	PC <10% of AQS
Small	PC >25% of AQS, <50% of AQS, and PEC <100% of AQS	PC >10% of AQS, <15% of AQS
Medium	PC >25% of AQS, <50% of AQS, and PEC >100% of AQS; or PC >50% of AQS, <100% of AQS, and PEC <100% of AQS	PC >15% of AQS, <25% of AQS
Large	PC >50% of AQS, <100% of AQS, and PEC >100%; or PC >100% of AQS	PC >25% of AQS

Source: IFC 2007

AQS = air quality standard; undegraded airshed = environmental conditions where no existing concentrations exceed a specific air quality guideline.

Figure 6.1-3: Definitions for Magnitude Ratings for Potential Impacts on Air Quality

Existing offshore air quality in the vicinity of the Payara PDA and existing onshore air quality in the Georgetown area are discussed in Section 6.1.2, Existing Conditions—Air Quality and Climate. Based on a comparison of measured ambient offshore concentrations of pollutants and measured ambient onshore concentrations to WHO standards, it was concluded that the offshore airshed in the vicinity of the Payara PDA can be considered an *undegraded airshed*. Based on the fact that measured onshore ambient PM_{10} and $PM_{2.5}$ concentrations exceeded WHO Guideline Values, the onshore airshed in the Georgetown area was considered a *degraded* airshed for the purpose of this assessment.

As shown in Table 6.1-17, for all the modeled pollutants, the maximum onshore concentrations predicted to result from planned Project activities are all less than 2 percent of the respective WHO ambient air quality guidelines. Accordingly, the magnitude of potential impacts on air quality is considered **Negligible**.

Sensitivity of Receptors—Air Quality

The standard approach taken in air quality impact assessment assumes that the sensitivity to air pollutant-related health impacts for receptors within the general population is **Medium**. This is on the basis that, as air quality standards are set to protect the most vulnerable individuals in society, there is inherently a margin of safety within air quality standards. There are a small number of specific cases where receptor sensitivity may be defined as **High**; these cases include where there are particularly vulnerable individuals (e.g., a hospital where there are intensive care wards and high-dependency wards where patients will be particularly sensitive to air pollution).

As such, the sensitivity of most potential onshore receptors is considered **Medium**, with the potential for some receptors to have a **High** sensitivity.

Impact Significance—Air Quality

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on air quality for all receptors is **Negligible**.

6.1.3.4. Characterization of Potential Impacts—Climate

Potential climate impacts are a global concern and stem from cumulative worldwide GHG emissions. The models used to predict climate impacts from global emissions are built around emissions on a global scale, and thus are not capable of modeling impacts from the GHG emissions contribution from a single project. Additionally, there are no Guyanese regulatory criteria to which Project GHG emissions can be compared. For these reasons, while it is possible to quantify the total GHG emissions from the Project, it is difficult to assign a magnitude rating (as is done for other resources assessed in this EIA). Accordingly, the assessment of potential impact significance for the Project's contribution to global climate change is conducted differently from the assessment for other resources.

The approach taken to assign a significance rating for potential Project impacts on global climate change is to assign a significance rating directly, based on the following factors:

- Comparison of Project GHG emissions to those of Guyana (i.e., without the Project); and
- Comparison of Project GHG emissions to those of the global oil and gas industry.

As discussed above in relation to air quality, the Project has elected to avoid routine flaring of associated gas. This represents a significant reduction in annual Project emissions compared to routine flaring. Additionally, the Project design includes a series of embedded controls that serve to further reduce emissions of atmospheric pollutants (see Table 6.1-13). Many of these embedded controls also serve to decrease GHG emissions.

Table 6.1-18 summarizes the estimated peak annual GHG emissions that would be associated with the Project if routine flaring were used and if none of the embedded controls were adopted. The table summarizes the reductions in GHG emissions resulting from avoidance of routine flaring and the additional reductions in GHG emissions resulting from adoption of the listed embedded controls.

The primary sources of GHG emissions are the combustion turbines and flares on the FPSO, with smaller amounts from other fuel combustion sources. GHG emissions were calculated in three parts: the quantity of carbon dioxide (CO_2) in the fuel that is emitted directly as CO_2; products of combustion of various fuel components based on the potential for each component to contribute to GHG emissions; and the CO_2-equivalent (CO_2e) emissions of other emitted compounds such as methane and nitrous oxides. Emission factors from the AP-42 document noted above were used to calculate the combustion-related GHG emissions.

Table 6.1-18: Estimated Peak Annual Project GHG Emissions (Pre-Mitigation)

	Estimated Peak Annual GHG Emissions (kilotonnes CO_2e) [a]		
	2020-2022	2023-2025	2026-2044
All Project Activities (combined)—no avoidance of routine flaring, no embedded controls, and no mitigation measures considered	249	9,160	7,443
Reduction due to avoidance of routine flaring	—	5,727	5,727
	—	62%	77%
All Project Activities (combined)—considering avoidance of routine flaring, but not considering embedded controls	249	3,433	1,716
Additional reduction due to embedded controls	—	257	257
	—	7%	15%
All Project Activities (combined)—considering avoidance of routine flaring and use of embedded controls	249	3,176	1,459

[a] The annual estimated totals generally reflect the current preliminary Project schedule (see Section 2.2, Project Schedule), which could change.

As shown in Table 6.1-18, GHG emissions will occur during all three of the time periods considered for atmospheric emissions. In the first time period (characterized by drilling and installation activities), GHG emissions will be relatively low. In the second time period, drilling will still be ongoing, production start-up will occur, and production operations will begin; the combined activities result in this time period exhibiting the peak annual GHG emissions for the Project life cycle (at least 20 years); however, this is only an approximately 3-year period (and the peak value is only relevant for one of those years). In the last time period, production operations without drilling will last for at least another 18 years and will be characterized by a relatively steady level of emissions, at 1.46 million tonnes of CO_2e emissions per year; this annual GHG emission rate during the production operations stage is the focus for the remainder of this assessment. GHG emissions during the decommissioning stage will be relatively low, comprising emissions principally from decommissioning vessels.

Guyana published its Second National Communication on Climate Change in 2012 (Government of Guyana 2012) and it reported in this communication to be a net sink of GHGs (meaning its national "removals" exceeded its national emissions). The reported net annual removals for Guyana were approximately 58 million tonnes of CO_2e, comprising total removals of approximately 60 million tonnes of CO_2e and total emissions of approximately 2 million tonnes of CO_2e. Considering these figures, although the overall emissions at a country level would be increased by approximately 73 percent as a result of pre-mitigation Project GHG emissions, net country-level removals would decrease only slightly from 58 million tonnes of CO_2e to 56.5 million tonnes of CO_2e (i.e., an approximately 2.5 percent decrease).

Project pre-mitigation GHG emissions were also compared to GHG emissions typical of the global oil and gas sector as a whole. In a paper published in 2008, the average value for GHG emissions per barrel was greater than 30 kilograms CO_2e per barrel oil for combined emissions across four global oil and gas operators (Stockman et al. 2009). On a more recent basis, a Stanford University paper published in 2018 (Garthwaite 2018) cites an average value for oil production globally of 10.3 grams CO_2e per megajoule (MJ) of crude oil. Converting Project pre-mitigation GHG emissions to this same basis yields a value of 2.33 grams CO_2e/MJ of crude for the Project, almost 4 times smaller than the reported global industry value.

Climate change has a high importance as a global concern. The Project represents an increase in GHG emissions, specifically in terms of the percentage increase of national Guyana GHG emissions that the Project's pre-mitigation GHG emissions would represent. However, this is balanced against the relatively small percentage decrease of Guyana's net removals represented by the Project's pre-mitigation GHG emissions and the fact that the pre-mitigation Project GHG performance factor is significantly better than the global industry average. Balancing these factors, a pre-mitigation significance rating of **Moderate** is assigned for the production operations stage. Based on the relatively low GHG emissions prior to and following cessation of production operations, pre-mitigation significance ratings of **Negligible** are assigned for the drilling and installation and decommissioning stages.

6.1.4. Mitigation Measures—Air Quality and Climate

Based on the **Negligible** significance of potential air quality, no additional mitigation measures are considered warranted. However, a number of embedded controls and mitigation measures technologies incorporated into the Project are anticipated to aid in reducing emissions of pollutants to the atmosphere (see Tables 6.1-13 and 6.1-14).

In addition to the above-referenced embedded controls—most of which will serve to mitigate emissions of GHGs—the design elements incorporated as additional mitigation measures to reduce energy consumption (and therefore to reduce GHG emissions) by the Project (see Table 6.1-14) were considered for the purpose of assigning a residual impact significance level for potential impacts on climate.

The residual significance of potential Project impacts on global climate is assessed on the basis of predicted Project GHG emissions considering the decision to avoid routine flaring, the embedded controls presented in Table 6.1-13, and the additional mitigation measures presented in Table 6.1-14. Table 6.1-19 summarizes the estimated peak annual residual GHG emissions for the Project (considering avoidance of routine flaring, adoption of embedded controls, and adoption of mitigation measures).

Table 6.1-19: Estimated Peak Annual Project GHG Emissions (Residual, i.e., with Mitigation Measures)

	Estimated Peak Annual GHG Emissions (kilotonnes CO_2e) [a]		
	2020-2022	**2023-2025**	**2026-2044**
All Project Activities (combined)—considering avoidance of routine flaring and embedded controls, but no mitigation measures	249	3,176	1,459
Additional reduction due to mitigation measures	—	108	108
	—	3%	7%
All Project Activities (combined)—considering avoidance of routine flaring, embedded controls, and mitigation measures [b]	250	3,070	1,355

[a] The annual estimated totals generally reflect the current preliminary Project schedule (see Section 2.2, Project Schedule), which could change.

[b] Values rounded up to next multiple of 5 kilotonnes CO_2e

Considering these predicted emissions, overall emissions at a country level would be increased by approximately 68 percent as a result of mitigated Project GHG emissions, and country-level net removals would decrease from 58 million tonnes of CO_2e to 56.6 million tonnes of CO_2e (i.e., an approximately 2.4 percent decrease).

The mitigated GHG emissions will equate to a performance factor of 13.7 kilograms CO_2e per barrel of oil for the Project (46 percent of the average value GHG emissions from the Stockman et al. [2009] paper) or 2.16 grams CO_2e/MJ for the Project (4 times smaller than the reported global industry value from Garthwaite 2018).

Adoption of the stated additional mitigation measures are anticipated to result in a substantial decrease in Project GHG emissions, but the Project still represents an increase of national Guyana GHG emissions. The mitigation emissions represent an even smaller percentage decrease of Guyana's net removals and translate to a Project GHG performance factor far better than the global industry average. The Project has applied technologies aligned with Good International Oil Field Practice (GIOFP) to reduce GHG emissions; this suggests that it is appropriate to reduce the significance rating. However, in view of the fact that climate change is an issue of global importance, the significance rating of **Moderate** is maintained for the production operations stage.

Consistent with GIOFP, EEPGL will annually quantify direct Project GHG emissions from the dedicated Project facilities and equipment used within the Project AOI.

Table 6.1-20 summarizes the monitoring measures relevant to this resource.

Table 6.1-20: List of Monitoring Measures

Monitoring Measures
Monitor on an ongoing basis the volume of fuel used by all combustion sources and equipment on FPSO and other marine vessels.
Monitor volume of fuel used for helicopter operation.
Keep records of non-routine flaring of produced gas.
An air emissions inventory report will be prepared annually.
Monitor flare performance to maximize efficiency of flaring operation.

Table 6.1-21 summarizes the assessment of potential pre-mitigation and residual Project impacts on air quality and climate. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the air quality-specific methodology described in Sections 6.1.3.2, Emissions of Air Quality Pollutants, and 6.1.3.3, Characterization of Impacts—Air Quality.

Table 6.1-21: Summary of Potential Pre-Mitigation and Residual Impacts—Air Quality and Climate

Stage	Resource/Receptor—Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Ambient air quality—increased concentrations of pollutants in ambient air, potentially contributing to health impacts for onshore human receptors	Negligible	Medium (most of population) High (more sensitive receptors)	Negligible	Embedded controls listed in Table 6.1-13 and mitigation measures listed in Table 6.1-14	Negligible
Drilling and Installation Decommissioning	Climate—GHG emissions, resulting in increases in Guyana's national GHG emissions	—	—	Negligible	Embedded controls listed in Table 6.1-13 and additional mitigation measures listed in Table 6.1-14	Negligible
Production Operations	Climate—GHG emissions, resulting in increases in Guyana's national GHG emissions	—	—	Moderate	Embedded controls listed in Table 6.1-13 and additional mitigation measures listed in Table 6.1-14	Moderate

6.2. SOUND

6.2.1. Administrative Framework—Sound

Table 6.2-1 summarizes the legislation, policies, treaty commitments, and industry practices that focus specifically on sound.

Table 6.2-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Sound

Title	Objective	Relevance to the Project
Legislation		
Environmental Protection Noise Management Regulations, 2000	Establishes general provisions for noise avoidance and restrictions from multiple commercial and industrial sources, including sound making devices, equipment, tools, and construction activities. Authorizes EPA to set specific permissible noise levels in the future. Includes reporting requirements, penalties for violations of standards, and permitting requirements for operations that emit noise.	Regulated facilities include any offshore installation and any other installation, whether floating or resting on the seabed.
Guyana Standard, Guidelines for Noise Emission into the Environment, 2010	Establishes standard used for monitoring of noise emission into the environment; sets permissible noise levels for residential, commercial, industrial, institutional, educational, construction, transportation, and recreational receptors (day and night).	Relevant to Project-related noise levels that could be perceived by receptors (onshore or nearshore activities)
Joint Nature Conservation Committee (JNCC) Guidelines for Minimising the Risk of Injury and Disturbance to Marine Mammals from Seismic Surveys, 2017	Reduces the risk of injury to marine mammals from geophysical survey activities.	Although the JNCC guidelines are voluntary, they are widely recognized as a global best practice in the oil and gas industry for managing the potential adverse effects of seismic surveys on marine mammals, and will be applicable to vertical seismic profiles conducted on any of the development wells.

6.2.2. Existing Conditions—Sound

This section includes a summary of the desktop review of existing underwater sound conditions in the Project AOI. It also describes the different metrics commonly used to represent underwater acoustic fields. A discussion of the modeling study used to predict underwater sound levels associated with Project activities in the PDA is provided in Section 7.5, Marine Mammals.

The characterization of existing sound conditions and the analysis of predicted sound levels associated with Project activities are limited to underwater sound because the Project is located approximately 207 kilometers (128 miles) northeast of the coastline of Georgetown. Accordingly, airborne sound and ground-borne vibration from Project activities in the PDA will occur too far from the coast to impact noise-sensitive receptors on land. Offshore, the principal airborne sound receptors will be the workforce on the Project vessels, who will be provided with appropriate personal protective equipment (PPE), including ear protection (when engineered controls must be augmented to manage sound exposure). The Project is not expected to result in significant changes to existing sound or vibration levels at the shorebases, pipe yards, and warehouse locations, as such facilities have existing industrial operations. Therefore, airborne sound and ground-borne vibration are not discussed further in this section.

6.2.2.1. Underwater Acoustic Metrics

Underwater sound amplitude is measured in decibels (dB) relative to a fixed reference pressure (p_0 = 1 micro Pascal [µPa])[3] or reference energy level (1 μPa^2•s). The following are three common acoustic metrics used to characterize underwater sound levels:

- Peak Sound Pressure Level (PK, measured in dB re 1 µPa);
- Root Mean Square Sound Pressure Level (SPL, measured in dB re 1 µPa); and
- Sound Exposure Level (SEL, measured in dB re 1 μPa^2•s).

The PK metric is the maximum instantaneous SPL in a stated frequency band attained by an acoustic event. This peak metric is commonly used to characterize impulsive sounds, but does not describe the duration or bandwidth of the sound. At higher intensities, the peak SPL can be a valid criterion for assessing whether a sound may have the potential to result in auditory injury impacts on a marine receptor.

The SPL is a measure of the average pressure or the "effective pressure" over the duration of an acoustic event, such as the emission of one acoustic pulse from a seismic source (e.g., vertical seismic profiler). SPL is often used to assess whether an acoustic event may have the potential to result in behavioral disturbance on a marine receptor.

The SEL is a measure of the total acoustic energy contained in one or more acoustic events and is often used as an indication of the sound energy dose over a specific event or time period. The SEL metric measures the total sound energy to which a receptor would be exposed over the associated period of time, and can be used to assess the potential for auditory injury impacts. When assessing the potential for auditory damage using the SEL metric, the predicted noise levels are frequency-weighted to mirror the expected hearing ability of a receptor across the frequency range.

More information on the underwater acoustic metrics described above, including the analytical formulation of these metrics, is provided in the document Underwater Sound Associated with Liza Phase 1 Project Activities, prepared by JASCO Applied Sciences in December 2016, included as Appendix G, Underwater Sound Modeling Report, to this EIA.

[3] Sound levels expressed in dB in water are not the same as sound levels expressed in dB in air due to differences in the reference level and impedance of the two media. For sounds in water, the reference level is expressed as "dB re 1 µPa," referring to the relative amplitude of a sound wave to a reference pressure of 1 µPa (the reference level for sounds in water) (IAGC 2014).

6.2.2.2. Methodology for Characterizing Existing Conditions in the PDA

Ambient underwater sound levels were characterized based on literature values. With the exception of localized or short-term events that may result in rises in sound levels (e.g., passage of a ship, intense rain events, whale vocalizations, etc.) underwater sound levels do not vary much in the open ocean (MacDonald et al. 2008; University of Rhode Island and Inner Space Center Undated). Non-Project related human activities are minimal in the PDA (principally related to commercial fishing and transit of other ocean-going vessels). Therefore, literature values for the open ocean are expected to be a reasonable representation of underwater sound conditions in the PDA.

Ambient underwater sound levels can serve as the context in which to measure potential disturbance impacts associated with Project activities. Sound in the ocean is the result of both natural and anthropogenic sources. Natural contributions include sources such as wind-driven waves and rainfall. A generalized model for deep-water ocean ambient sound was presented by Hildebrand (2009) and characterizes ambient sound levels at a depth of 1,000 meters, taking into account natural sources of sound (e.g., wind, sea state) as well as what the author characterized as "modern shipping noise." The model predicts ambient sound ranging across a frequency spectrum from 20 hertz (Hz) to more than 70 kilohertz (kHz). Across this spectrum, predicted sound levels decrease from a high of approximately 60 to 80 dB re 1 $\mu Pa^2 Hz^{-1}$ (at 20 Hz), to approximately 30 to 46 dB re 1 $\mu Pa^2 Hz^{-1}$ (at 20 kHz). Predicted sound levels decrease sharply between 20 kHz and 70 kHz (Hildebrand 2009). It is noted that where a noise spectrum is presented in this way, the noise has been filtered into 1 Hz bandwidths and the noise levels are presented as dB re 1 $\mu Pa^2 Hz^{-1}$ to reflect this.

Other than the ongoing EEPGL exploration activities and the development well drilling for the Liza Phase 1 and Liza Phase 2 Development Projects and sporadic transits of commercial fishing vessels and other ocean-going vessels in the vicinity of the PDA, there are currently no notable sources of mechanical or human-generated background underwater sound in the PDA. Considering the spectral noise levels described above, and based on frequencies from approximately 20 Hz up to approximately 20 kHz, this suggests a total broadband sound level (excluding periodic sound levels associated with exploration and Liza Phase 1 and Liza Phase 2 development well drilling) of approximately 100 to 120 dB re 1 μPa [SPL].

6.2.3. Impact Assessment—Sound

As indicated above, the only receptors of airborne sound from Project activities in the PDA will be workers on board the FPSO, drill ships, and other Project-associated vessels. EEPGL will use industry-standard engineering and administrative controls for sound mitigation, will periodically monitor sound levels, and will provide appropriate hearing-protection PPE for workers, as needed. With respect to airborne sound from Project activities at the shorebases or other onshore infrastructure, the shorebase owners/operators of these facilities will manage sound levels from Project-related activities so as to not cause exceedances of the applicable levels contained in their environmental permits and/or the Guyana Standard, Guidelines for Noise Emission into the

Environment, 2010. Therefore, the Project's potential impacts from airborne sound and ground-borne vibration are not assessed further in this EIA.

Potential impacts from Project-related underwater sound are discussed in the sections relating to potential marine life receptors (Sections 7.5.3, Impact Assessment—Marine Mammals; 7.7.3, Impact Assessment—Marine Turtles; and 7.8.3, Impact Assessment—Marine Fish).

6.2.4. Mitigation Measures—Sound

As potential impacts from airborne sound and ground-borne vibration are not assessed further in this EIA, no mitigation measures are proposed.

Mitigation measures to address potential impacts from Project-related underwater sound are discussed in the sections relating to potential marine life receptors (Sections 7.5.4, Mitigation Measures—Marine Mammals; 7.7.4, Mitigation Measures—Marine Turtles; and 7.8.4, Mitigation Measures—Marine Fish).

6.3. Marine Geology and Sediments

6.3.1. Administrative Framework—Marine Geology and Sediments

The Consultants have not identified any legislation, policies, or treaty commitments that focus specifically on marine geology and sediments.

6.3.2. Existing Conditions—Marine Geology and Sediments

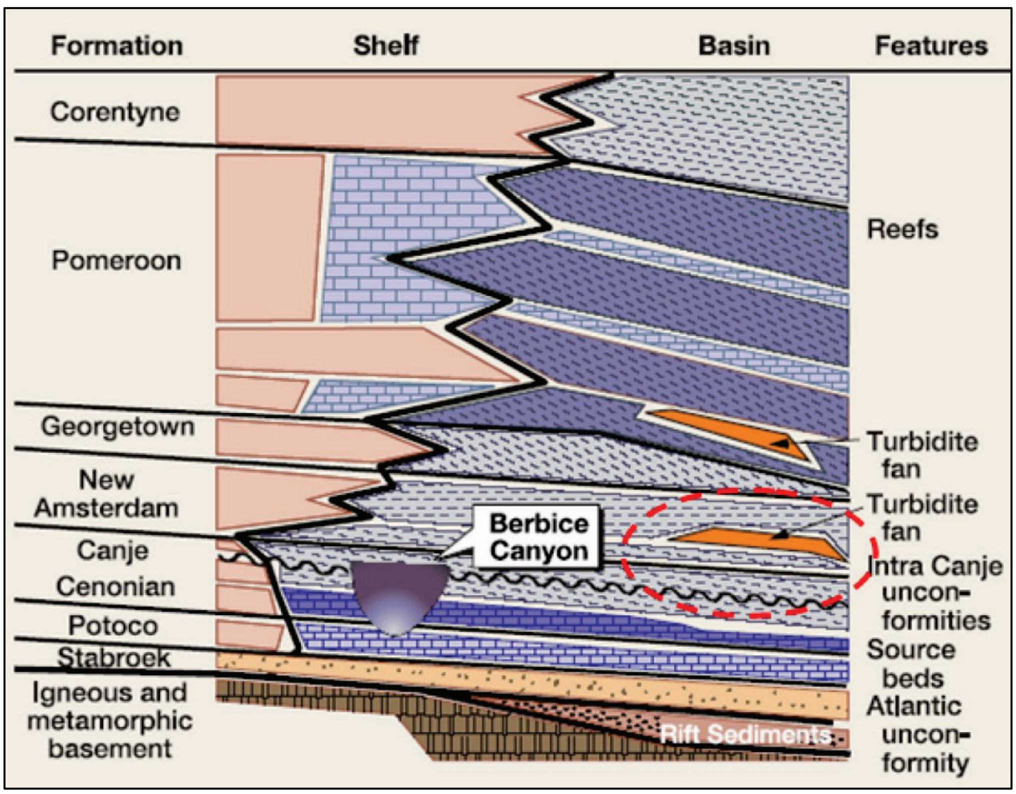
6.3.2.1. Coastal Geology

Guyana's continental shelf occupies an area of 48,666 square kilometers (km^2) (18,790 square miles [mi^2]). The average width of the continental shelf is approximately 113 kilometers (approximately 70 miles) (NDS 1997). The shelf is widest near the borders of Suriname and Venezuela, and slightly narrower near the center of Guyana's coastline. Guyana's coastline is approximately 431 kilometers (approximately 268 miles) long (NDS 1997). The Guyana coast is a sedimentary plain that has formed from successive deposits of alluvial sediment with a series of coastal ridges crossing the coast from east to west. The alluvial sediments are primarily clays swept out to sea by the Amazon River, carried north by ocean currents, and deposited on Guyanese shores. The coastal ridges are connected with submarine features that move across the shallow continental shelf in a northward direction, driven by the nearshore current.

6.3.2.2. Marine Stratigraphy

Subsurface Stratigraphy

The Guyana Basin has been described as a passive margin basin[4] associated with the rifting and opening of the equatorial Atlantic Ocean. Part of the Guyana Basin is onshore, but most of it occurs offshore. Figure 6.3-1 depicts the basin stratigraphy and Table 6.3-1 summarizes the age and composition of the major geologic formations (listed in descending order from ground surface) that comprise the Guyana Basin (Workman 2000; CGX 2009). The Stabroek formation is Cretaceous-Barremian in age and is dominated by continental shales and sands. Overlying the Stabroek is the Aptian-aged Potoco formation, which is dominated by carbonates. The Santonian to Turonian-aged interval contains the Canje formation, which is dominated by shales and sandstones. Similarly, the Lower Tertiary to Maastrichtian formation contains the New Amsterdam and Georgetown formations, dominated by sandstones, shales, and carbonates. The Pomeroon and Corentyne formations are of Pleistocene-Pliocene and Miocene-Eocene age and are also dominated by shales and sandstones.



Source: From Workman and Birnie 2015; modified by the Consultants

Figure 6.3-1: Stratigraphic Chart of Guyana Basin

[4] A passive margin is an area where continents have rifted apart to become separated by an ocean. Passive margins are found at every ocean and continent boundary that is not marked by a strike-slip fault or a subduction zone.

Table 6.3-1: Major Geologic Formations of the Guyana Basin

Formation	Age	Composition
Corentyne	Pleistocene-Pliocene	Sandstone and shale
Pomeroon	Miocene-Eocene	Carbonate sandstone and shale
Georgetown	Maastrichtian	Sandstone, shale and carbonate
New Amsterdam	Lower Tertiary to Maastrichtian	Sandstone and shale
Canje and Cenonian	Santonian to Turonian	Organic shale, non-organic shale, and sandstone
Potoco Formation	Aptian	Carbonates
Stabroek Formation	Cretaceous–Barremian	Basal shales and sandstones of continental origin
Precambrian Basement	Proterozoic-Hadean	Igneous/Metamorphic rocks [a]

[a] The igneous/metamorphic basement in Figure 6.3-1 is of Precambrian age.

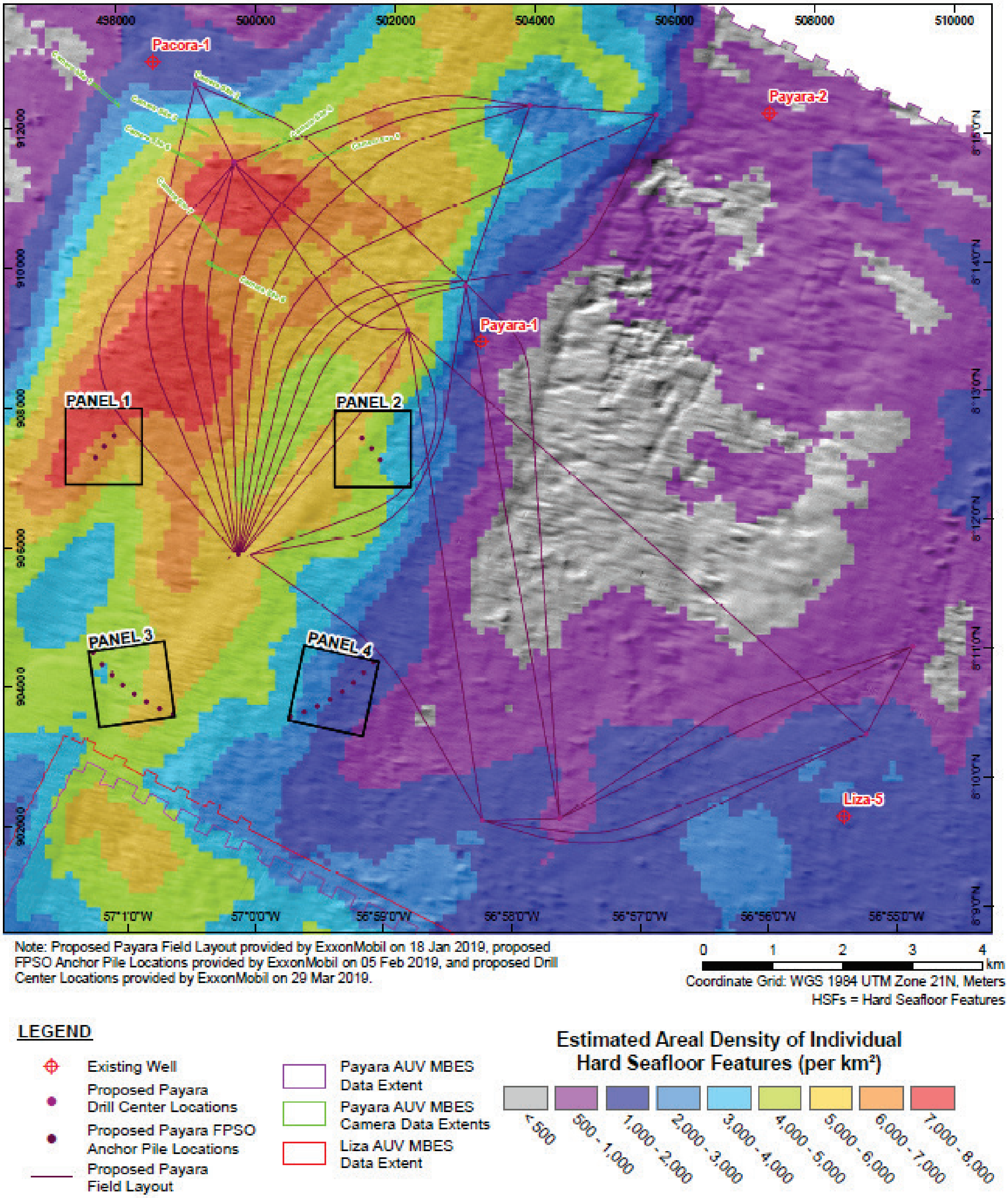
Near-Surface Stratigraphy

In 2019, Fugro prepared a report describing a category of anomalous seabed features that occur throughout the Payara PDA (Appendix H, Hard Seafloor Features Report). These features, referred to by Fugro as *hard seafloor features* (HSFs)[5] are generally small (1.1 to 1.4 meters [3.6 to 4.6 feet] in mean diameter), generally circular features with a flat or gently rounded surface (maximum seafloor relief estimated to be less than 50 centimeters [20.7 inches]). A box core sample collected from one of these HSFs indicates that they consist of a thin, stratified "crust" on the seafloor. Based on this analysis, Fugro interpreted the HSFs as fluid expulsion features resulting from dewatering and/or degassing of buried turbidites[6] and mass transport deposits[7] (Fugro 2019a). Figure 6.3-2 depicts a vertically sectioned portion of the HSF that was retained in the above-mentioned box core sample, and clearly shows the stratified nature of the HSF.

[5] Investigations have determined that the HSFs (i.e., thin, stratified crust layers) have a relatively low strength and are fragile.
[6] Turbidites are sea-bottom deposits formed by rivers flowing into the ocean that deposit sediments on the continental shelf and slope. When these deposits experience slope failure in response to excessive sedimentation load, they slide down to the ocean bottom to create a turbidite.
[7] Mass transport deposits are the sedimentary remains of submarine "landslides" and are distinctive due to their large size, distinctive morphology, and chaotic internal composition.

Figure 6.3-2: Box Core Sample of a Hard Seafloor Feature

HSFs are numerous within and around the Payara PDA, but in aggregate they account for a very small proportion of the seafloor surface within the PDA. Fugro estimated that the total number of HSFs within a 417 km^2 (161 mi^2) study area (which included the Subsea PDA and the immediate surrounding seafloor) exceeds 1.1 million individual HSFs, but that HSFs in aggregate cover less than 1 percent of the seafloor within the entire study area (FUGRO 2019c). Fugro estimates HSF coverage is slightly higher within the Subsea PDA, as compared to surrounding areas, and that HSFs cover roughly 2 percent of the seafloor within the most intensely impacted portion of the Subsea PDA, corresponding to an estimated maximum density of 7,000 to 8,000 HSFs per square kilometer in the western portion of the Payara PDA. Densities of HSFs within the Payara PDA and immediate surroundings are depicted in Figure 6.3-3.

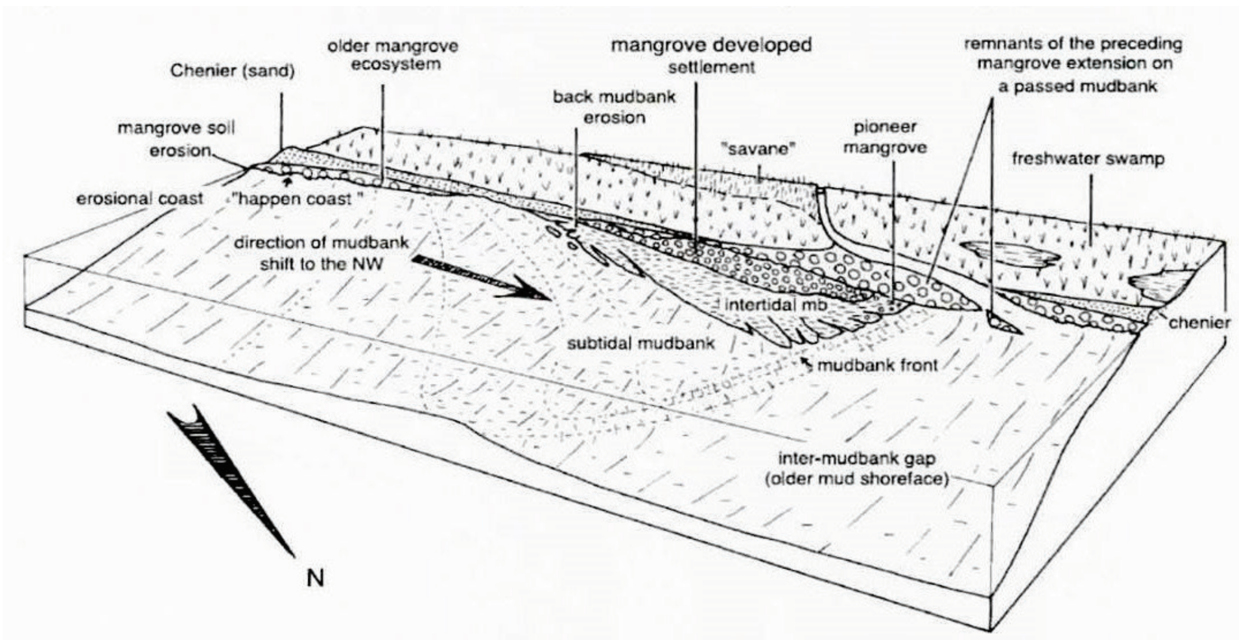


FUGRO 2019c

Figure 6.3-3: Estimated HSF Areal Densities in and Around the Payara PDA

6.3.2.3. Marine Sedimentology

Fine clay and mud sediment are transported north from the mouth of the Amazon River and are deposited approximately 21 to 60 kilometers (approximately 13 to 37 miles) offshore, to an average thickness of approximately 20 meters (approximately 65 feet) along Guyana's continental shelf (CGX 2009). Moving further out to sea (i.e., toward the edge of the continental shelf), sand gradually becomes the dominant sediment layer. The bathymetric profile of the continental shelf forms a generally smooth, gradual slope from nearshore to shelf edge, but a series of low mud ridges or mudbanks are located approximately 21 to 60 kilometers (13 to 37 miles) offshore (Figure 6.3-4).



Source: Royal Haskoning 2004

Figure 6.3-4: Typical Distribution of Mudbanks on Guyana's Coast

Although the Essequibo River and several other smaller rivers (e.g., the Demerara, Corentyne, and Berbice rivers) discharge large quantities of fine sediment, which are subsequently transported seaward and westward across the continental shelf, analysis of the humic content, nutrient composition, and ratio of surface area to mass of Guyanese marine sediments indicates that they are nearly identical to Amazonian sediments and unlike continental Guyanese sediments (Eisma and van der Marel 1971). This evidence strongly indicates that from a sedimentary perspective, the Guyanese continental shelf functions as a marine extension of the Amazonian delta system. At greater depths, calcarenite (coral fragment) substrates become more prevalent (Strømme and Sætersdal 1989). The Stabroek Block occupies the transition area between the Amazonian-influenced zone and the older, deeper calcarenite zones.

In the PDA, the seabed sediments are comprised primarily of coarse silt (with sand and shell fragments). The gravel and sand content averaged 55.4 percent across the samples collected as part of a 2019 geotechnical survey in the PDA (FUGRO 2019b). Based on photographic evidence collected by remotely operated vehicles (ROVs), the surfaces of the HSFs are generally comprised of rocky and gravelly material (FUGRO 2019a).

Sediment samples were collected from the Stabroek Block offshore Guyana as part of environmental baseline surveys (EBS) conducted in 2014 (Maxon and TDI-Brooks 2014), 2016 (FUGRO 2016), 2017 (ESL 2018), and 2018 (FUGRO 2019b). The 2018 EBS was focused on the Payara PDA. The full 2014, 2016, and 2017 EBS reports were provided as Appendices G, H, and I of the Liza Phase 2 Development Project EIA. The full 2018 EBS report is provided as Appendix I, 2018 Environmental Baseline Survey Report, to this EIA. As the EBS events were all conducted in the eastern part of the Stabroek Block, the data from all four EBS are relevant to describe sediment quality in the vicinity of the PDA and the data from all four EBS events are therefore discussed herein.

Sediment samples were collected from 10 sampling stations during the 2014 survey, 25 sampling stations during the 2016 survey, 10 sampling stations during the 2017 survey, and 8 sampling stations during the 2018 survey (these locations are collectively referred to as the Study Area in this section). The stations included locations within the PDA as well as locations outside the PDA, within the southeastern portion of the Stabroek Block, and along the continental shelf. A discussion of the results from all four surveys is provided below. Summaries of the results for reported metals and hydrocarbon concentrations in the sampled sediments are presented in Table 6.3-2 and Table 6.3-3, respectively. Figure 6.3-5 shows the sediment sampling locations for the four EBS events described above.

Table 6.3-2 includes the U.S. National Oceanic and Atmospheric Administration (NOAA) Effect Range Low (ERL) and Effects Range Median (ERM) values. ERL and ERM are measures of toxicity in marine sediment and are used to evaluate whether a concentration of a contaminant in sediment might have toxicological effects. The ERL indicates the concentration below which toxic effects are scarcely observed or predicted; the ERM indicates the concentration above which effects are generally or always observed (Long et al. 1995). They are not regulatory criteria, but define a benchmark as a concentration that, when exceeded, has the potential to cause harm or significant risk to organisms in the environment[8].

[8] NOAA screening values are commonly used for comparison when in-country values are not available.

Table 6.3-2: Summary of Metal Concentrations Reported for Sediment Samples (µg/g dry weight)

Parameter	Mean	Minimum	Maximum	Mean Background [a]	Effects Range Low [b]	Effects Range Median [c]
2014 EBS (n=10)						
Aluminum	11,495	8,100	15,000	77,440	—	—
Arsenic	6.1	4.5	11.4	2	8.2	70
Barium	98.9	57.4	159	668	—	—
Cadmium	0.125	0.102	0.165	0.102	1.2	9.6
Chromium	14.9	8.6	21.1	35	81	370
Copper	13.1	9.9	16.5	14.3	34	270
Iron	19,130	13,500	25,300	30,890	—	—
Lead	11.6	8.3	15.6	17	46.7	218
Mercury	0.042	0.026	0.062	0.056	0.15	0.71
Nickel	21.4	14.1	32.3	18.6	20.9	51.6
Vanadium	23.5	18.1	28.3	53	—	—
Zinc	45.5	26.9	63.7	52	150	410
2016 EBS (n=25)						
Aluminum	43,432	13,900	66,600	77,440	—	—
Arsenic	11.6	6.1	97.1	2	8.2	70
Barium	175	44	272	668	—	—
Cadmium	0.120	0.073	0.255	0.102	1.2	9.6
Chromium	36.1	14.5	53.4	35	81	370
Copper	20.2	6.9	30.5	14.3	34	270
Iron	30,364	12,100	98,100	30,890	—	—
Mercury	0.029	0.016	0.042	0.056	0.15	0.71
Selenium	0.22	0.05	0.75	0.083	—	—
Lead	15.5	9.9	27.5	17	46.7	218
Nickel	27.0	10.8	51.5	18.6	20.9	51.6
Zinc	69.7	32.5	101.0	52	150	410
2017 EBS (n=10)						
Aluminum (total)	6,510	2,900	13,000	77,440	—	—
Arsenic (total)	15	3.6	50	2	8.2	70
Barium (total)	7.5	3.5	16	668	—	—
Cadmium (total)	BDL	BDL	BDL	0.102	1.2	9.6
Chromium (total)	15	7.7	24	35	81	370
Copper (total)	3.1	BDL	6.7	14.3	34	270
Iron (total)	20,720	8,900	35,000	30,890	—	—
Mercury (total)	BDL	BDL	BDL	0.056	0.15	0.71
Selenium (total)	BDL	BDL	BDL	0.083	—	—
Lead (total)	7.8	3.8	15	17	46.7	218
Nickel (total)	8.6	3.8	15	18.6	20.9	51.6

Parameter	Mean	Minimum	Maximum	Mean Background [a]	Effects Range Low [b]	Effects Range Median [c]
Zinc (total)	29	11	55	52	150	410
2018 EBS (n=8)						
Aluminum (total)	36,400	29,800	45,100	77,440	—	—
Arsenic (total)	37.8	6.62	250	2	8.2	70
Barium (total)	165	132	240	668	—	—
Cadmium (total)	BDL	BDL	BDL	0.102	1.2	9.6
Chromium (total)	30.3	24.5	38.9	35	81	370
Copper (total)	15.1	12.5	17.4	14.3	34	270
Iron (total)	33,700	17,700	122,000	30,890	—	—
Mercury (total)	0.0236	0.0206	0.027	0.056	0.15	0.71
Selenium (total)	0.63	0.50	1.53	0.083	—	—
Lead (total)	12.3	10.4	14.7	17	46.7	218
Nickel (total)	20	16.8	26.1	18.6	20.9	51.6
Zinc (total)	60.5	42.6	112	52	150	410

µg/g = microgram per gram; BDL = below detection limit; "—" = no ERL/ERM available
Note: One-half of the detection limit was used for non-detect results in all statistical calculations.
[a] Mean concentration in upper continental crust (Wedepohl 1995)
[b] NOAA ERL (Macdonald et al. 1996)
[c] NOAA ERM (Macdonald et al. 1996)

Table 6.3-3: Summary of Hydrocarbon Concentrations Reported for Sediment Samples

Parameter		Mean	Minimum	Maximum	Background [a]
2014 EBS (n=10)					
Total Saturated Hydrocarbon (SHC) (µg/g)		10.64	8	14	NA
Total Unresolved SHC (µg/g)		6.97	3	12	NA
Total Resolved SHC (µg/g)		3.68	2	8.9	NA
Carbon Preference Index (CPI)		1.97	1.47	3.27	NA
Pristane (µg/g)		0.007	0.004	0.012	NA
Phytane (µg/g)		0.005	0.003	0.010	NA
Pristane/Phytane Ratio		1.34	0.67	1.8	NA
$nC_{16}/(nC_{15}+nC_{17})$		0.40	0.24	0.51	NA
Total Polycyclic Aromatic Hydrocarbons (PAHs) (µg/g)		0.03861	0.02458	0.05336	NA
Petrogenic/Pyrogenic Ratio		3.36	2.14	4.65	NA
2016 EBS (n=25)					
Total Hydrocarbons (THC) (µg/g)		2.8	1.5	4.8	0.2-5
Unresolved Complex Mixture (UCM) (µg/g)		1.8	0.9	2.8	NA
n-alkanes	nC_{12-20} (µg/g)	0.06	0.02	0.13	NA
	nC_{21-36} (µg/g)	0.21	0.1	0.38	NA
	nC_{12-36} (µg/g)	0.27	0.12	0.5	NA
CPI	nC_{12-20}	1.29	1.1	2.41	NA
	nC_{21-36}	2.62	2.09	2.99	NA
	nC_{12-36}	2.22	1.83	2.7	NA

Parameter		Mean	Minimum	Maximum	Background [a]
Pristane (µg/g)		0.002	0.001	0.013	NA
Phytane (µg/g)		0.003	0.001	0.012	NA
Pristane/Phytane Ratio		1.28	0.13	2.27	NA
Total PAH (Sum of 2-6 Rings) (µg/g)		0.048	0.016	0.239	NA
Sum of 2-3 Rings (NPD) (µg/g)		0.016	0.006	0.082	NA
Sum of 4-6 Rings (µg/g)		0.032	0.010	0.157	NA
NPD/4-6 Ring		0.54	0.35	0.82	NA
2017 EBS (n=10) (detected constituents only)					
n-Dotriacontane (µg/g)		0.213	0.17	0.26	NA
n-Hexatriacontane (µg/g)		0.194	0.14	0.28	NA
n-Octadecane (µg/g)		0.14	BDL	1.4	NA
n-Triacontane (µg/g)		0.22	0.17	0.31	NA
Total Extractable Hydrocarbons		7.1	4.9	10	NA
2018 EBS (n=8)					
THC (µg/g)		0.7	0.6	0.8	0.2-5
UCM (µg/g)		0.4	0.4	0.5	NA
n-alkanes	nC_{12-20} (µg/g)	0.7	0.6	0.8	NA
	nC_{21-36} (µg/g)	0.4	0.4	0.5	NA
	nC_{12-36} (µg/g)	0.08	0.06	0.1	NA
CPI	nC_{12-20}	1.13	1.04	1.2	NA
	nC_{21-36}	2.71	2.45	2.92	NA
	nC_{12-36}	2.22	2.02	2.4	NA
Pristane (µg/g)		0.0007	0.0006	0.0009	NA
Phytane (µg/g)		0.0003	0.0002	0.0004	NA
Pristane/Phytane Ratio		2.42	2.06	3.17	NA
Total PAHs (Sum of 2-6 Rings) (µg/g) [b]		0.004	0.002	0.007	NA
Sum of 2-3 Rings (NPD) (µg/g)		0.001	BDL	0.002	NA
Sum of 4-6 Rings (µg/g)		0.003	-	0.005	NA
NPD/4-6 Ring		0.33	BDL	0.40	NA

µg/g = microgram per gram; BDL = below detection limit; CPI = carbon preference index (the ratio of odd-number carbon chain n-alkanes to even-numbered carbon chain n-alkanes); NA = not applicable; NPD = naphthalene, phenanthrene, anthracene, and dibenzothiophene (2 ring and 3-ring PAHs) SHC = saturated and aliphatic hydrocarbons

Notes:

Petrogenic/Pyrogenic = Ratio of the sum of combustion-related PAHs (fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene) divided by the sum of petrogenic PAHs (naphthalene, acenaphthene, acenaphthalene, fluorene, phenanthrene, dibenzothiophenes, chrysenes, and fluoranthenes/pyrenes).

2-6 Ring PAH = Total 2- to 6-ring polycyclic aromatic hydrocarbons

nC_{12-20} = alkanes ranging from carbon numbers 12 to 20

nC_{21-36} = alkanes ranging from carbon numbers 21 to 36

nC_{12-36} = alkanes ranging from carbon numbers 12 to 36

[a] Typical THC levels (i.e., “background”) in sediments remote from anthropogenic activities (North Sea Task Force 1993)

[b] NOAA suggested ERL and ERM values for total PAHs of 4.022 µg/g and 44.792 µg/g, respectively (Long et al. 1995)

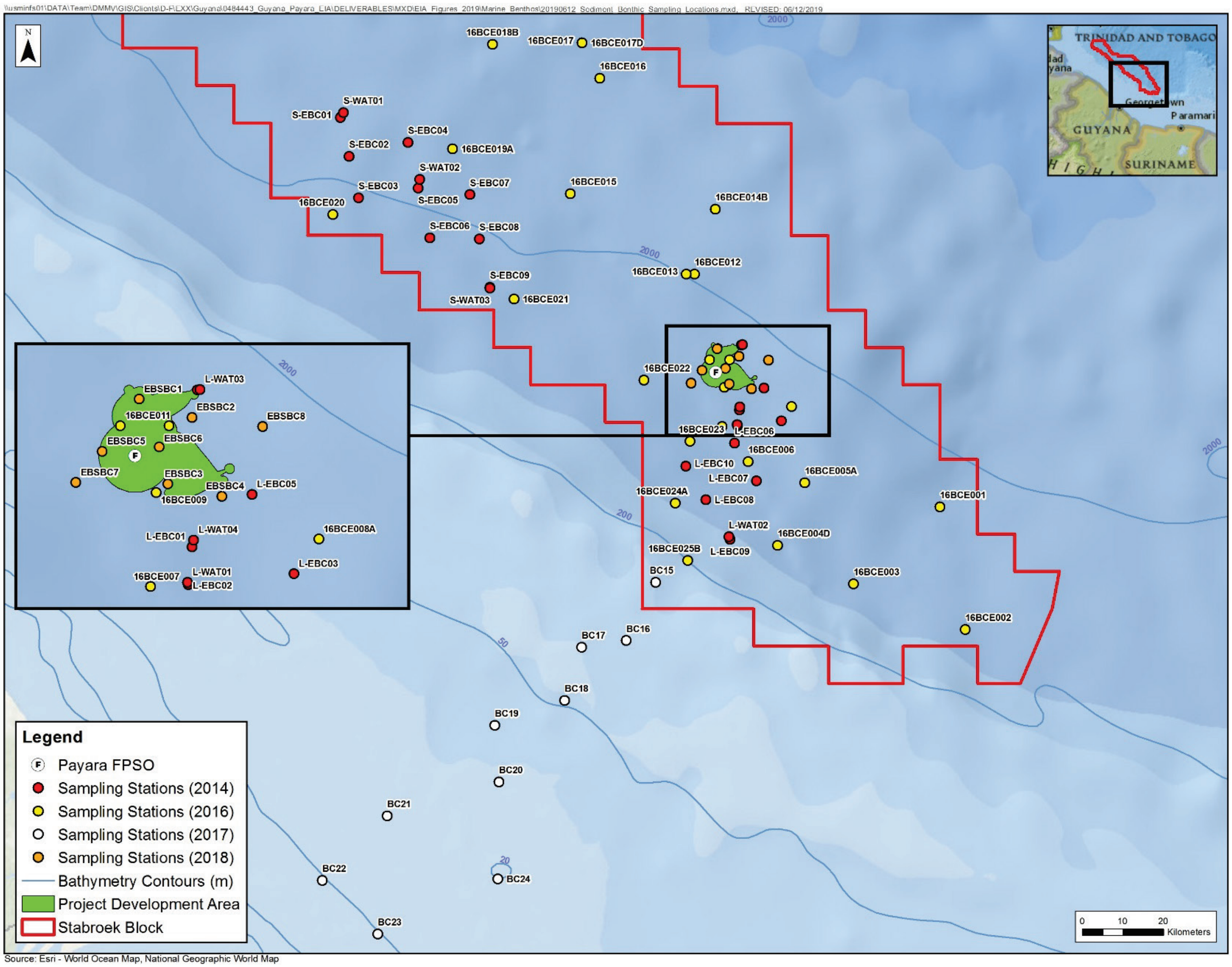


Figure 6.3-5: Sediment Sampling Locations for EBS Events Conducted to Date in and Shoreward of Stabroek Block

2014 Survey

During the 2014 survey (TDI-Brooks 2014), sediment samples were analyzed for the following parameters:

- Total organic carbon (TOC)
- Metals
- Hydrocarbons

Total Organic Carbon

Concentrations of TOC were less than 1 percent at all survey stations. Higher concentrations of TOC were found in the southwest portion of the survey area, which is closer to shore.

Metals

Twelve metals were analyzed to assess general patterns of distribution across the Study Area. Of the 12 metals analyzed, 10 metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, vanadium, and zinc) were used as indicators of anthropogenic sources; the remaining 2 metals (aluminum and iron) were used to provide geological source information. All of the ten anthropogenic-indicator metals had concentrations similar to those reported for the upper continental crust (Wedepohl 1995), with the exception of arsenic, for which reported concentrations were slightly elevated (average of 6.1 micrograms per gram (µg/g) compared to an upper continental crust mean background concentration of 2 µg/g). However, all average concentrations were at or below the NOAA ERL values.

Hydrocarbons

Hydrocarbons are divided into two classes of compounds: aliphatic compounds and aromatic compounds. The hydrocarbon analysis consisted of the analysis of saturated and other aliphatic hydrocarbons (SHC)—including selected isoprenoids, and the analysis of polycyclic aromatic hydrocarbons (PAHs).

Aliphatic compounds can be “saturated” (alkanes with carbon atoms joined by single bonds), or “unsaturated” (alkenes with carbons joined by double bonds). The study measured concentrations of total SHC that encompass light and heavy fractions of petroleum (i.e., alkanes nC_{9-40}) and selected isoprenoids (branched chain unsaturated hydrocarbons), including pristane and phytane. Concentrations of total SHC ranged from 8 µg/g to 14 µg/g. The unresolved portion of the SHC analysis (i.e., SHCs that cannot be identified through the use of standard analytical methods) ranged from 3 µg/g to 12 µg/g, with an average of 7 µg/g, which makes up approximately 66 percent of the reported average total SHC concentration.

Several SHC-based parameters and ratios were used to distinguish between biogenic and petroleum-derived sources. These parameters and ratios are listed below, along with a general discussion of their relevance in determining the source of the hydrocarbons:

- Carbon Preference Index (CPI): The total odd-chain hydrocarbons divided by the total even-chain hydrocarbons. A value of 2 to 4 indicates input from plants. As petroleum is added, the value decreases, approaching 1.
- Pristane/Phytane Ratio: The source of phytane is mainly petroleum, whereas pristane is derived from both biological matter and petroleum. In environmental samples with no petroleum contribution, this ratio is greater than 1 and it decreases as petroleum is added.
- Hexadecane (nC_{16})/(pentadecane [nC_{15}] + heptadecane [nC_{17}]) ratio: At "background" levels, hydrocarbons nC_{15} and nC_{17} can be used as indicators of plankton hydrocarbon inputs. As plankton productivity increases, this ratio decreases. If the ratio were to increase over time or within the data set, the rationale would be that it is related to anthropogenic sources. Hexadecane (nC_{16}) is rarely found in biolipids (Thompson and Eglinton 1978); paraffins of nC_{15}, nC_{17}, or nC_{19} have been found to be predominant in benthic algae (Clark and Blumer 1967; Youngblood et al. 1971).

The results of the sediment samples exhibited a predominance of odd-chain hydrocarbons as compared to even-chain hydrocarbons, with an average CPI value of approximately 2; this indicates a primarily biogenic source of hydrocarbons. This result is reasonable given the volume of land runoff from the Essequibo and Demerara rivers.

The average pristane/phytane ratio of 1.34 reflects a predominance of pristane over phytane in the sediments, also indicating a predominantly biogenic source of hydrocarbons.

The low ratio (less than 1) of nC_{16} over the sum of $nC_{15} + nC_{17}$ for all samples also indicates relatively higher concentrations of plankton-related hydrocarbons, as compared to hydrocarbons from anthropogenic sources.

PAHs are composed of aromatic rings. PAHs analyzed included 20 parent (i.e., unalkylated) compounds and 23 alkylated homologues, consisting of 2- to 6-ring PAH compounds. Concentrations of total PAHs (all 43 analytes combined) ranged from 0.02458 μg/g to 0.05336 μg/g.

The sample distribution of individual PAHs provided information for a range of hydrocarbon sources. The petrogenic/pyrogenic distribution ratio listed below is useful to distinguish between petroleum-derived hydrocarbons and those derived from combustion of fossil fuels. The ratio increases as inputs from petroleum increase.

- Petrogenic/Pyrogenic Ratio—The ratio of the sum of petrogenic PAHs divided by the sum of pyrogenic (i.e., combustion-related) PAHs, where:
  - Petrogenic PAHs include naphthalene, acenaphthene, acenaphthalene, fluorene, phenanthrenes, and dibenzothiophenes, as well as the daughter compounds of the chrysenes and fluoranthenes/pyrenes; and

- Pyrogenic PAHs include the parent compounds of fluoranthene, pyrene, and chrysene, as well as benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

In general, sample distributions of PAHs were dominated by the low molecular weight PAHs—naphthalenes and anthracene-phenanthrenes. The petrogenic/pyrogenic ratios of greater than 1 indicate hydrocarbons are from biogenic or natural material (potentially including petroleum-derived) rather than combustion-related compounds. High concentrations of perylene relative to other PAHs were also observed. Perylene is a biogenic compound linked to plant pigments from terrestrial runoff and is not indicative of either petrogenic or pyrogenic sources (FUGRO 2016). Both total PAHs and total SHC exhibited strong positive correlations with TOC, further supporting biogenic origins of the trace hydrocarbons.

Overall, the 2014 survey results indicate that biogenic or natural materials are the primary source of the low-level hydrocarbon concentrations measured during the survey. Biogenic hydrocarbon sources most likely consist of terrestrial plant and humic material transported to the survey area via river inputs.

2016 Survey

During the 2016 survey (FUGRO 2016), sediment samples were analyzed for the following parameters:

- TOC
- Metals
- Hydrocarbons

TOC

Similar to the 2014 results, concentrations of TOC ranged from below the reporting limit to 1.1 percent. TOC concentrations were found to be higher at sampling locations with a greater proportion of fine sediments, indicating a negative correlation between grain size and organic content (logical given that smaller grain sizes have a greater surface area and thus more ability to adsorb organic matter).

Metals

Twelve metals were measured to determine general patterns of distribution across the survey area. Of the 12 metals analyzed, 10 metals (i.e., arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, vanadium, and zinc) were used as indicators of anthropogenic sources and 2 metals (i.e., aluminum and iron) were used to provide geological source information. The maximum concentrations of the individual metals measured during the 2016 survey were consistently higher than those from the 2014 survey; this is possibly a result of the different acids used by the 2014 and 2016 laboratories for extraction, or of greater variability in the data set due to the significantly larger sample area covered by the 2016 survey, as compared to that of the 2014 survey. Average concentrations of anthropogenic-indicator metals arsenic and nickel exceeded their respective NOAA ERL values. While this may reflect the composition of source material, there may be some contribution from terrestrial runoff contaminated from mining or other industries, as carried to the Guyana Basin via riverine inputs from Brazil and the Guiana Shield.

Hydrocarbons

The hydrocarbon analyses included measurements of total hydrocarbons (THC) and PAHs.

THC concentrations ranged from 1.5 µg/g to 4.8 µg/g. THC showed positive correlations with metals concentrations, with the exception of copper and arsenic, as well as with TOC concentrations. The unresolved complex mixture (UCM; i.e., fraction of THC that cannot be resolved/identified) concentrations ranged from 0.9 µg/g to 2.8 µg/g, and the average was 1.8 µg/g, which makes up 64 percent of the average THC concentration. Concentrations of alkanes (nC_{12-36}) ranged from 0.12 µg/g to 0.50 µg/g. Reported concentrations of short-chain alkanes (nC_{12-20}) were consistently lower than those of long-chain alkanes (nC_{21-36}).

Several THC-based parameters and ratios were used to distinguish between biogenic and petroleum-derived sources. CPI values for the total range of alkanes (nC_{12-36}) ranged from 1.83 µg/g to 2.27 µg/g. These results display a predominance of odd-chain hydrocarbons over even-chain hydrocarbons, with an average CPI value greater than 2, indicating primarily biogenic sources of hydrocarbons. The average pristane/phytane ratio was 1.28, meaning a predominance of pristane over phytane exists in the samples, indicating the primary source of the hydrocarbons is likely biological.

Concentrations of total PAHs ranged from 0.016 µg/g to 0.239 µg/g. The ratio of the sum of naphthalene, phenanthrene, anthracene, and dibenzothiophene (NPD; petrogenic indicators) divided by the sum of 4 to 6 ring PAHs (pyrogenic indicators) is useful to determine the relative contributions of pyrogenic and petrogenic hydrocarbons. The ratio increases as inputs from petroleum increase. In general, samples showed a predominance of 4- to 6-ring PAHs (i.e., NPD/4- to 6-ring ratios of less than 1), indicating predominantly pyrogenic sources of hydrocarbons, as opposed to petrogenic sources. However, high concentrations of perylene (a biogenic compound linked to plant pigments from terrestrial runoff and not indicative of either petrogenic or pyrogenic sources) relative to other PAHs were also observed.

Overall, the 2016 survey results indicate that the low levels of hydrocarbons measured in the Study Area could have derived from biogenic or natural materials as well as combustion-related compounds. Biogenic hydrocarbon sources most likely consist of terrestrial plant and humic material transported to the survey area via river inputs, while combustion-related emissions could arise from multiple natural or anthropogenic sources.

2017 Survey

During the 2017 survey (ESL 2018), sediment samples were analyzed for the following parameters:

- TOC
- Moisture content
- Oxidation-reduction (redox) potential
- Metals (total and bioavailable)
- Hydrocarbons

TOC

Consistent in general with the 2014 and 2016 surveys, concentrations of TOC were less than 1 percent in all ten samples. TOC concentrations tended to be higher in samples with higher clay content.

Moisture Content

Sediment moisture content is an important fundamental physical property that may be highly variable. Its value is dependent upon particle size and type, organic matter content, as well as physico-chemistry of the sediment. Temporal and special changes may occur in sediment porosity that also affect water content (Bennett et al. 1990). Sediment moisture content ranged from 22.1 percent to 38.6 percent, with an average value of 27.4 percent. There was limited variability among the samples; the highest value was measured at a station located 20 meters (66 feet) from the shoreline and the lowest was measured at a station 67 meters (220 feet) from the shoreline, suggesting no correlation between depth and sediment moisture content.

Redox Potential

The redox state of sediment is the result of the combined effect of biological and chemical processes of a reversible and/or irreversible nature (Bågander 1978). Redox reactions control organic-matter oxidation and element cycling in aquatic ecosystems (Schlesinger and Bernhardt 2013). Redox conditions in surface sediments depend on the degree of organic enrichment (Zobell 1946). Organic enrichment of sediments usually leads to reduced conditions that equate to “poor” sediment quality (i.e., low dissolved oxygen and elevated ammonia or sulfide concentrations), wherein natural benthic communities undergo substantial changes (ECASA 2004). Negative redox potential values are therefore associated with anoxic conditions, in which the degradation of organic matter is performed by anaerobic bacteria (ECASA 2004). The values detected in all ten samples were positive, indicating oxic conditions within the sediment at the time of sampling.

Metals

Twelve metals were measured to determine general patterns of distribution across the survey area. Of the 12 metals analyzed, 10 metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc) were used as indicators of anthropogenic sources and two metals (aluminum and iron) were used to provide geological source information. Samples were analyzed both for total concentrations of metals as well as bioavailable concentrations of metals. The average concentrations and ranges of concentrations for all metals were comparable to those observed during the 2014 and 2016 surveys.

The average concentration of one anthropogenic indicator metal (arsenic) exceeded the NOAA ERL value. When the 2016 survey results for total arsenic and iron were taken into consideration, it was observed that almost all the values showed a strong positive correlation. A comparison of the 2017 arsenic/iron correlation to that of the 2016 data further revealed that seven of the ten detected values of 2017 were consistent with the background levels recorded in 2016. Thus, the observed variation in total arsenic concentrations at most of the 2017 sampling stations likely reflect natural background concentrations associated with variation in sediment geochemistry. For the remaining three stations, the higher arsenic to iron ratios are likely indicative of anthropogenic inputs.

The bioavailable concentrations of metals were below detection levels for most of the metals in most samples. The exceptions were two detections of bioavailable aluminum (14 µg/g and 20 µg/g) and one detection of bioavailable arsenic (1.3 µg/g).

Hydrocarbons

All ten samples were analyzed for the full suite of saturated hydrocarbons, which constituted a total of 39 individual analytes. Five of the 39 analytes were detected at one or more stations, while the remaining 34 analytes (87 percent) were not detected above their respective detection levels at all ten stations. Only two of the five detected hydrocarbon analytes were detected at all ten stations. Where detected, saturated hydrocarbons ranged from 0.14 to 10.0 milligrams per kilogram, with n-dotriacontane concentrations consistent across the ten stations, while n-hexatriacontane concentrations varied with distance from the shoreline.

2018 Survey

During the 2018 survey (FUGRO 2019b), sediment samples were analyzed for the following parameters:

- TOC
- Metals
- Hydrocarbons

TOC

TOC concentrations were generally consistent with those of the 2014, 2016, and 2017 surveys. Concentrations of TOC were less than 1 percent in all eight samples, with values ranging from 0.27 percent to 0.36 percent. The mean TOC value is comparable to the mean from the 2016 survey (0.32 percent; FUGRO 2016). The TOC concentrations tended to be higher in samples with higher clay content.

Metals

As described previously, 12 metals were measured to determine general patterns of distribution across the survey area. The sediment levels of arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, vanadium, and zinc were used as indicators of anthropogenic sources, and levels of aluminum and iron were used to provide geological source information. In general, all of the anthropogenic indicator metals were reported at average concentrations below or similar to those reported for the upper continental crust (Wedepohl 1995), with the exception of arsenic and selenium. Selenium was detected in only one sample and the concentration was above the mean concentration in the upper continental crust. With the exception of arsenic, all average concentrations were at or below their respective NOAA ERL values. While the level of arsenic may reflect the composition of source material, there may be some contribution from terrestrial runoff contaminated from mining or other industries, as carried to the Guyana Basin via riverine inputs from Brazil and the Guiana Shield.

The average concentrations of aluminum and iron were consistent with those reported for the upper continental crust.

Hydrocarbons

The hydrocarbon analyses for the 2018 study include the measurement of concentrations of THC and PAHs. The concentrations of THC ranged from 0.6 to 0.8 µg/g with an average concentration of 0.7 µg/g. The concentrations of THC across all sampled stations were lower than the average from the 2016 study. No spatial trends in THC were apparent with any variation between stations likely to be a result of natural small-scale heterogeneity in sediment characteristics and associated THC concentrations. The concentration of UCM of THC that cannot be resolved/identified ranged from 0.4 µg/g to 0.5 µg/g. The average was 0.4 µg/g, which makes up 57 percent of the average THC concentration.

Several THC-based parameters and ratios were used to distinguish between biogenic and petroleum-derived sources. CPI values for the total range of alkanes (nC12-36) ranged from 2.02 µg/g to 2.4 µg/g. These results display a predominance of odd-chain hydrocarbons over even-chain hydrocarbons, with an average CPI value greater than 2, indicating primarily biogenic sources of hydrocarbons. The average pristane/phytane ratio of 2.42 reflects a predominance of pristane over phytane in the sediments, also indicating a predominantly biogenic source of hydrocarbons.

Concentrations of total PAHs ranged from 0.002 µg/g to 0.007 µg/g. The ratio of the sum of NPD (petrogenic indicators) divided by the sum of 4- to 6-ring PAHs (pyrogenic indicators) is useful to determine the relative contributions of pyrogenic and petrogenic hydrocarbons. The ratio increases as inputs from petroleum increase. In general, samples showed a predominance of 4- to 6-ring PAHs (i.e., NPD/4- to 6-ring ratios of less than 1), indicating predominantly pyrogenic sources of hydrocarbons, as opposed to petrogenic sources.

Overall, as in the case of 2016 survey, the 2018 survey results indicate that the low levels of hydrocarbons measured in the PDA could have derived from biogenic or natural materials as well as combustion-related compounds. Biogenic hydrocarbon sources most likely consist of terrestrial plant and humic material transported to the survey area via river inputs, while combustion-related emissions could arise from multiple natural or anthropogenic sources.

6.3.3. Impact Assessment—Marine Geology and Sediments

This section addresses potential impacts on marine geology and sediments resulting from planned Project activities. The potential impacts assessed include changes to seafloor morphology from accumulation of discharged drill cuttings on the seafloor and changes to sediment quality from the residual hydrocarbon contained on the discharged drill cuttings.

During installation of the FPSO and SURF components, there will be some localized disturbance of sediments in a limited area; however, this potential impact on seafloor morphology will not be significant. The installation of suction piles or driven piles and flowlines on the seafloor may result in localized disturbance of the top-most seabed sediment, but without introducing any foreign material. Given the largely cohesive nature of the seafloor material (i.e., sediments classified as coarse silts with a large proportion of fines—on the order of 44.5 percent; see Section 6.3.2.3, Marine Sedimentology), the seafloor is expected to be largely resilient to scour. In coarse sediment areas with a high proportion of fines, usually greater than 10 percent, the coarse particles are subjected to the cohesive forces of the fines (FUGRO 2011) and are less likely to be easily scoured.

In terms of the potential for stability of the substrate to be affected by FPSO and SURF installation activities, Table 6.3-4 summarizes relevant results from geotechnical studies conducted as part of the Project design:

Table 6.3-4: Summary of Assessment of Potential for Seabed Stability Effects from FPSO/ SURF Installation Activities

Project Component	Assessment of Potential for Seabed Stability Effects
FPSO Anchor Clusters	The anchor piles will be installed into the substrate using suction pressure. There is no energy transmission to the soil material outside the anchor pile, as in the case of driven piles. Therefore, given the low permeability of the soft clays encountered in the Payara PDA, there will be no effect on the shear strength, porosity, or compressibility of the substrate. The seafloor material in the PDA is classified as very soft high plastic clay. Based on the soil behavior of such clays, the seafloor is not susceptible to erosion or scour. Therefore, there is no risk of increased erosion. In the region where the mooring chains interact with the seafloor—from the pile padeye at depth (approximately 16 to 17 meters [53 to 56 feet] below the mudline) to the seafloor surface roughly 25 to 30 meters (82 to 98 feet) away from the suction pile centerline in the direction towards the FPSO, the repeated movement of the chain induced from the movement of the FPSO may create a trench feature approximately 25 to 30 meters (82 to 98 feet) in front of the suction pile, about 6 meters (20 feet) in width and up to the padeye depth. This trench is expected to be created with years of FPSO operations, and remain present throughout the life of the FPSO. The impact of the trench is accounted for and included in the anchor pile design.
Drill Center	The piles at the drill centers will be installed into the substrate using suction pressure, similar to those installed at the FPSO anchor clusters. As with the FPSO anchor clusters, there is no energy transmission to the soil material outside the anchor pile, as in the case of driven piles. Therefore, given the low permeability of the soft clays encountered in the Payara PDA, there

Project Component	Assessment of Potential for Seabed Stability Effects
	will be no effect on the shear strength, porosity, or compressibility of the substrate. The seafloor material in the PDA is classified as very soft high plastic clay. Based on the soil behavior of such clays, the seafloor is not susceptible to erosion or scour. Therefore, there is no risk of increased erosion. Due to the absence of a mooring chain, the drill center piles are primarily vertically loaded. Trenching is therefore absent at the drill centers, as seen at other suction piles installed in other offshore settings. Additionally, selected subsea infrastructure may be founded on mudmats with skirts. The mudmats are designed to have a larger contact surface with the seafloor than the subsea infrastructure itself, thereby reducing the contact pressure exertion onto the seafloor. Therefore, there is minimal stress/pressure applied onto the seafloor, and there is almost no change in porosity and compressibility. As part of detailed design, the stability of the mudmats is checked against vertical, horizontal, and rotations forces (and combinations thereof).
Flowlines/Umbilicals	The flowlines and umbilicals will be laid in place onto the seafloor. Due to the very soft nature of the seafloor, there will be some amount of self-weight penetration of the flowlines and umbilicals, although the self-weight penetration is expected to be <0.3 meter (1 foot). Detailed calculations will be performed to determine the self-weight penetration, as well as the pipe-soil interaction curves (spring curves) developed specific to the flowline/umbilical configurations. There is some amount of consolidation as a consequence of the self-weight penetration, but this is expected to have minimal changes on shear strengths, porosities, and compressibility. The seafloor material in the Payara PDA is classified as very soft high-plastic clay. Based on the soil behavior of such clays, the seafloor is not susceptible to erosion or scour. Therefore, there is no risk of increased erosion.
Riser Touchdown points	The riser will contact the seafloor and cyclically interact with the seafloor, as a consequence of the FPSO’s movement due to metocean forces. The motion will remold the soil within the touchdown zone and will decrease the shear strength (to a fraction of the undisturbed shear strength). The remolded strength is determined based on the soil sensitivity from laboratory testing to be performed from samples collected. The remolding is expected to also locally impact the porosity and compressibility. This is typical of riser touchdown points and the effects (if any) are analyzed during detailed design. The remolding does not impact the soft clays’ susceptibility to erosion or scour. Therefore, there is no risk of increased erosion.

No impacts on marine geology and sediments are expected as a result of activities associated with production operations or decommissioning.

Impacts on marine geology and sediments as a result of drilling development wells are discussed below. Additional detailed discussion regarding potential impacts on marine benthos from accumulation of discharged drill cuttings on the seafloor and changes to sediment quality from the residual hydrocarbon contained on the discharged drill cuttings is provided in Section 7.9.3, Impact Assessment—Marine Benthos.

6.3.3.1. Relevant Project Activities and Potential Impacts

The process of drilling development wells will produce drill cuttings that will be discharged either directly to the seafloor (in open-hole sections drilled riserless and with seawater) or from the drill ship (after treatment including solids control and processing through a centrifugal cuttings dryer system) into the ocean (in sections drilled with a riser). The planned development drilling program and its cuttings management approach is consistent with industry practices. For each well, approximately 4,400 barrels (bbl) of cuttings for the riserless sections will be discharged directly to the seafloor per standard industry practice, as these sections will be drilled using water-based drilling fluids (WBDF) instead of non-aqueous drilling fluid (NADF). For sections drilled with a riser, approximately 2,500 bbl of cuttings (per well) will be treated to remove associated drilling fluids to acceptable discharge thresholds before discharge from the drill ship into the ocean (refer to Chapter 2, Description of the Project, for a description of the drilling process). Planned discharges of drill cuttings and fluids will potentially impact the marine sediment layer locally as a result of accumulation of cuttings on the seafloor. Cuttings will accumulate on the seafloor around the well locations, with the distribution of cuttings determined by oceanographic conditions.

Table 6.3-5 summarizes the Project stages and activities that could result in potential Project impacts on marine geology and sediments.

Table 6.3-5: Summary of Relevant Project Activities and Key Potential Impacts—Marine Geology and Sediments

Stage	Project Activity	Key Potential Impacts
Development Well Drilling	Discharge of drill cuttings during drilling of wells, and resulting deposition of cuttings on the seafloor	• Changes to seafloor morphology from accumulated drill cuttings • Impacts on sediment quality from deposition of residual hydrocarbon on discharged cuttings

6.3.3.2. Characterization of Impacts—Changes to Seafloor Morphology

Magnitude of Impact—Changes to Seafloor Morphology

To aid in assessing the magnitude of predicted changes to seafloor morphology from discharge of drill cuttings, modeling of cuttings deposition was performed using the Generalized Environmental Modeling System for Surfacewaters (GEMSS) model. This three-dimensional, particle-based model uses Lagrangian[9] algorithms in conjunction with currents, specified mass load rates, release times and locations, particle-size distributions, settling velocities, and shear stress values to calculate the fate and transport of discharged drill cuttings. Model outputs provide estimates of the thickness of deposits on the seafloor, and the mass distribution of base hydrocarbon (adhered to the cuttings) across the seafloor.

A total of eight drill cuttings deposition scenarios were modeled: two different scenarios for a production well at Drill Center PY1-P (the shallowest of the Project drill centers) and two different scenarios for an injection well at Drill Center PY3-I (the deepest of the Project drill centers), each under two current conditions: the minimum and the maximum of the monthly averaged and depth-averaged current speeds. These current speeds were derived from the SAT-OCEAN ocean circulation model. As described below, the modeled deposition scenarios reflect combinations of top-hole section drilling (containing WBDF); with cuttings discharged at

[9] A gridless model in which pollutant particles move according to the wind field, buoyancy, and turbulence effects. Term is often used to differentiate such models from Eulerian models, which use a gridded model domain.

the seafloor and bottom-hole drilling (containing NADF cuttings; with cuttings discharged overboard from the drill ship prior to treatment, per standard industry practice) for multiple wells within a single drill center cluster.

Table 6.3-6 summarizes the results of the modeling for the above-referenced drill cuttings discharge scenarios.

Table 6.3-6: Summary of Modeling Results for Drill Cuttings Discharge Scenarios

Drill Center	Scenario [a]	Maximum Predicted Thickness (cm)	Total Area (m^2) with Predicted Thickness > 5 cm
PY1-P	1-Minimum Currents	185.7	3,571
	1-Maximum Currents	238.8	2,874
	2-Minimum Currents	116.8	1,976
	2-Maximum Currents	178.3	1,636
PY3-I	1-Minimum Currents	214.2	2,932
	1-Maximum Currents	255.5	2,739
	2-Minimum Currents	138.2	1,663
	2-Maximum Currents	179.1	1,455

cm = centimeter; m^2 = square meters
[a] Scenario 1 reflects seabed discharges from sequential jetting/drilling of four top-hole sections at a drill center (sections 1 and 2) using WBDF. Scenario 2 reflects seabed discharges from sequential jetting/drilling of top holes sections (sections 1 and 2) from two wells using WBDF followed by overboard discharges from drilling of bottom-hole sections (sections 3 and 4) of the second well with NADF.

Modeling of cuttings discharge and deposition indicates the maximum depositional thickness of cuttings on the seafloor is predicted to be between 116.8 and 255.5 centimeters (46 and 101 inches), depending on currents, drill center location, and scenario. From a change in seafloor morphology standpoint, a depositional thickness of 255 centimeters (100 inches) is only 0.13 percent of the total water column depth of approximately 1,900 meters (6,234 feet) within the PDA, and thus changes to the regional seafloor topography from cuttings deposition would be insignificant.

The cuttings for the initial open-hole sections settle relatively close to the well, as they are discharged at the seafloor. In contrast, the cuttings for the lower well sections are subjected to greater dispersion, as they are distributed by the currents during their settling.

A literature-based deposition threshold rate of 5 centimeters (2 inches) per month (Ellis and Heim 1985; MarLIN 2011) was used to assess the extent of the area with the potential to impact benthic organisms via smothering (an indirect impact resulting from impacts on marine sediment morphology, further discussed in Section 7.9.3, Impact Assessment—Marine Benthos). This threshold represents the accumulation rate above which benthic organisms would be expected to be unable to overcome the rate of deposition and become smothered, thereby limiting their mobility and access to oxygen.

While the above results are expressed in terms of total depositional thickness at completion of drilling of the well, it is appropriate to compare these total thicknesses to the deposition threshold *rate* of 5 centimeters (2 inches) per month. This is based on the fact that the scenarios selected for modeling were designed to simulate drilling activities with the potential to result in the greatest combined deposition at a given location within a 30-day period. Additional detail regarding the drill cuttings deposition modeling is presented in Appendix J, Water Quality Modeling Report.

In terms of magnitude, the potential impact of drill cuttings deposition on sediment morphology was viewed in the context of the resource's overall functionality with respect to providing a habitat for benthic organisms. In this sense, the magnitude rating is expressed based on the fraction of the overall resource being impacted at any one time by the Project. If it is conservatively assumed that up to two drill ships are active simultaneously on Payara drill centers and are both undertaking drilling that matches the simulated scenarios, the conservative approach is therefore to double the affected area results from Table 6.3-6 to reflect the largest area predicted to be subjected to a cuttings deposition rate greater than 5 centimeters (2 inches) per month at any one time. This results in a predicted area of approximately 7,100 square meters (m^2) (approximately 76, 400 square feet [ft^2]), which represents approximately 0.01 percent of the area of the Subsea PDA (which itself covers approximately 0.3 percent of the Stabroek Block). Further, the currents are expected to redistribute the cuttings away from their initial deposition sites over time, gradually reducing their thickness on the seafloor at these locations.

It would not be feasible to calculate the exact number of HSFs that would be impacted by the Project because the exact number of HSFs is unknown; however, it is possible to conservatively estimate the number and the proportion of the total suspected HSFs that would be impacted based on the size of the cuttings deposition zone, the maximum density of HSFs—as estimated by Fugro, and Fugro's estimate of the total number of HSFs within the study area. The cuttings deposition zone described in the preceding paragraph accounts for approximately 0.7 percent of a square kilometer. Assuming a mean density of 7,500 HSFs per square kilometer (the median of the highest density category in Fugro's study) across the entire cuttings deposition zone, approximately 53 HSFs would be covered by cuttings at a rate in excess of 5 centimeters (2 inches) per month. This represents less than 0.005 percent of the more than 1.1 million HSFs that Fugro estimates to exist within the study area.

The assessment of the Project's magnitude of potential impacts on seafloor morphology is determined based on consideration of geographic extent, intensity, frequency, and duration. The intensity of potential impacts on changes to seafloor morphology is defined according to the definitions provided in Table 6.3-7. Although the scientific community has broadly accepted the North Brazil Shelf Large Marine Ecosystem (LME) as the relevant regional ecological unit to assess and manage ecological functions (see Section 7.10.2, Existing Conditions—Ecological Balance and Ecosystems), the Consultants determined that the North Brazil Shelf LME was too large an area to use to assess the geographic extent element of the intensity rating. Therefore, and to ensure an element of conservatism in the analysis, the Consultants used smaller geographic areas to determine intensity of impacts on marine geology and sediments. The following paragraphs discuss the characteristics of the potential impact on seafloor morphology and the resultant magnitude rating.

Table 6.3-7: Definitions for Intensity Ratings for Potential Impacts on Seafloor Morphology

Criterion	Definition
Intensity	Negligible: No changes to overall functionality with respect to providing a habitat for benthic organisms.
	Low: Changes to overall functionality with respect to providing a habitat for benthic organisms, but limited to a very localized area.
	Medium: Changes to overall functionality with respect to providing a habitat for benthic organisms over a moderately sized area.
	High: Widespread changes to overall functionality with respect to providing a habitat for benthic organisms.

As deposition above the 5 centimeters (2 inches) threshold will occur over a localized area in the immediate vicinity of the drill centers, the intensity of impact associated with changes in the seafloor morphology is considered **Low**. While there will be periods curing the drilling stage when cuttings deposition will not occur, the impact will be present throughout the drilling stage, yielding a **Continuous** frequency rating. Drilling for the Project is expected to occur over multiple years, so the duration is considered **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of impact on sediment morphology from drill cutting deposition is considered **Small** (see Table 6.3-8).

Table 6.3-8: Magnitude Ratings for Potential Impacts on Changes to Sediment Morphology

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Development Well Drilling	Change of seafloor morphology (habitat functionality)	Direct AOI (PDA)	Low	Continuous	Long-term	Negligible

Sensitivity of Resource—Changes to Seafloor Morphology

Table 6.3-9 provides the definitions used to assign ratings for the sensitivity of marine sediments to changes in morphology.

Table 6.3-9: Definitions for Sensitivity Ratings for Potential Impacts on Seafloor Morphology

Criterion	Definition
Sensitivity	Low: Affected habitat does not support any unique or otherwise critically important species.
	Medium: Affected habitat supports unique or critically important species, but represents only a small portion of the habitat on which these species depend.
	High: Affected habitat supports unique or critically important species, and represents a substantial portion of the habitat on which these species depend.

As discussed in Section 7.9.2.3, the HSFs are not biologically unique, nor do they present any unique sensitivities that would exceed the general sensitivities of other ubiquitous deep marine benthic communities. As discussed in that section, the marine sponges that dominate the HSF communities would be highly sensitive to smothering effects at an individual level, but are not unique or critically important from a conservation perspective. They are also believed to occur widely outside the impacted area (FUGRO 2019a).

As discussed in Section 6.3.2, Existing Conditions—Marine Geology and Sediments, Guyana's mudbanks are critically important as feeding zones for birds, nursery areas for fish, and habitat for a variety of invertebrates. This subset of marine sediments would thus warrant a higher sensitivity rating if they were to be experience potential impacts from the Project. However, they are located on the nearshore portion of the continental shelf, well outside the area that modeling indicates will be affected by drill cuttings deposition. Accordingly, they are not discussed further in this section, and the sensitivity rating is focused on marine sediments other than mudbanks.

Based on the definitions above, the sensitivity of the overall marine sediment resource to potential changes in morphology from drill cuttings deposition is considered **Low**, as the deepwater sediments on which drill cuttings will settle do not support high densities of unique marine species; this was corroborated by the EBS events, deepwater fish surveys, and ROV surveys that have been carried out in the Stabroek Block. These ecological communities are discussed further in Section 7.8, Marine Fish, and Section 7.9, Marine Benthos.

Impact Significance—Changes to Seafloor Morphology

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance of potential impacts on sediment morphology from discharge of drill cuttings is considered **Negligible**.

6.3.3.3. Characterization of Impacts—Sediment Quality Changes

Magnitude of Impact—Sediment Quality Changes

The embedded controls in the Project design that will reduce the potential impact of drilling discharges on sediment quality include: (1) use of WBDF to the extent reasonably practicable (for drilling of initial open-hole well sections), and (2) use of International Association of Oil and Gas Producers (IOGP) Group III NADF in all other cases. WBDF contains no hydrocarbons; accordingly, no treatment of WBDF-based cuttings is required and there will be no impacts on sediment quality as a result of drill cuttings deposition from these sections of the wells. When NADF is used for bottom-hole sections, the discharge of treated cuttings will be controlled such that residual base fluid content on discharged cuttings will average no more than 6.9 percent (wet weight). The NADF will be IOGP Group III, with low to negligible aromatic content, reducing the potential that changes in sediment quality as a result of discharge of the treated cuttings will lead to potential toxicological impacts on benthic fauna.

The assessment of the Project's magnitude of potential impacts on sediment quality is determined based on consideration of geographic extent, intensity, frequency, and duration. The intensity of potential impacts on sediment quality is defined according to the definitions provided in Table 6.3-10. The following paragraphs discuss the characteristics of the impact on sediment quality and the resultant magnitude rating. This is summarized in Table 6.3-10.

Table 6.3-10: Definitions for Intensity Ratings for Potential Impacts on Sediment Quality

Criterion	Definition
Intensity	Negligible: No measureable changes in sediment quality.
	Low: Measureable but minor changes to sediment quality, limited to a very localized area.
	Medium: Minor changes to sediment quality over a moderately-sized area; or Moderate changes over a localized area.
	High: Significant changes to sediment quality or moderate changes over a widespread area.

While the magnitude rating assigned for sediment quality was not based on a quantitative calculation, as was the case for sediment morphology, the calculation presented for sediment morphology illustrates the extremely low proportion of the Subsea PDA that could be potentially impacted by drill cuttings deposition. Based on these factors described above, and considering the embedded controls that will reduce the mass of residual hydrocarbon contained in discharged cuttings, the intensity of impact associated with drill cuttings discharges' impact on sediment quality is considered **Low**. While there will be periods during the drilling stage when cuttings deposition will not occur, the impact will be present throughout the drilling stage, yielding a **Continuous** frequency rating. Drilling for the Project is expected to occur over multiple years, so the duration is considered **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of impact on sediment morphology from drill cutting deposition is considered **Small** (see Table 6.3-11).

Table 6.3-11: Magnitude Ratings for Potential Impacts on Sediment Quality

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Development	Sediment quality	Direct AOI	Small	Continuous	Long term	Small

Sensitivity of Resource—Sediment Quality Changes

Designation of the sensitivity of marine sediments with respect to sediment quality changes was conducted using the same definitions presented for potential sediment morphology impacts from drill cuttings deposition (Table 6.3-9). Accordingly, the sensitivity of marine sediments to sediment quality impacts from drill cuttings deposition is considered **Low**.

Impact Significance—Sediment Quality Changes

Based on the magnitude of impact and resource sensitivity ratings, the pre-mitigation significance of potential impacts on marine sediment quality as a result of drill cuttings deposition is considered **Negligible**.

6.3.4. Mitigation Measures—Marine Geology and Sediments

Based on the **Negligible** significance of potential marine geology and sediment impacts, no mitigation measures are proposed. It is noted, however, that the limited significance of potential marine geology and sediment impacts is supported by a suite of embedded controls related to discharge management (see summary in Chapter 13, Recommendations). Table 6.3-12 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 6.3-12: List of Embedded Controls and Monitoring Measures

Embedded Controls
When NADF is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
Implement a chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
Ensure wastewater released from the onboard sewage treatment plant complies with aquatic discharge standards in accordance with International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.
Ensure there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge.
Treat bilge water in accordance with MARPOL 73/78 to ensure compliance with an oil in water content of less than 15 ppm as applicable.
Monitoring Measures
Monitor daily during drilling to ensure that end of well maximum weighted mass ratio averaged over all well sections drilled using NABF shall not exceed 6.9 percent wet weight base fluid retained on cuttings.

Table 6.3-13 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine geology and sediments. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, and the marine geology and sediment-specific methodology described in Sections 6.3.3.2 and 6.3.3.3.

Table 6.3-13: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Geology and Sediments

Stage	Resource - Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling	Sediment morphology—changes from drill cuttings deposition (habitat functionality)	Small	Low	Negligible	None	Negligible
	Sediment quality—impacts from residual NABF on deposited drill cuttings	Small	Low	Negligible	None	Negligible

6.4. Marine Water Quality

6.4.1. Administrative Framework—Marine Water Quality

Table 6.4-1 summarizes the legislation, policies, treaty commitments, and industry practices that focus specifically on water quality.

Table 6.4-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Water Quality

Title	Objective	Relevance to the Project
Legislation		
Environmental Protection Water Quality Regulations, 2000	Focused on setting effluent standards, reporting requirements, penalties for violations of standards, and permitting requirements for discharges.	Regulates discharges of listed substances, which could include substances used as part of the Project.
International Agreements Signed/Acceded by Guyana		
International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)	Regulates various forms of marine pollution, including oil and fuel, noxious liquid, hazardous substances, sewage, garbage, air emissions, and ballast water.	Applies to the handling and disposition of controlled substances from the drill ships, FPSO, and support vessels. Guyana acceded in 1997.

6.4.2. Existing Conditions—Marine Water Quality

6.4.2.1. Oceanographic Conditions

Guyana's marine environment is bounded, and heavily influenced, by the Orinoco and Amazon rivers in Venezuela and Brazil, respectively. During the rainy season, Guyana's coastal marine waters receive large volumes of freshwater discharges from these major rivers, as well as from Guyana's own Essequibo, Demerara, and Berbice rivers (FAO 2005).

Guyana’s surficial marine waters are crossed by the Guiana Current, which is part of the northern limb of the North Atlantic Meridional Overturning Circulation (MOC). The North Atlantic MOC circulates water between the subtropics and polar region. The Guiana Current derives from the North Brazil Current (NBC) flowing north along the northeastern coast of South America from northern Brazil toward the southeastern Caribbean Sea. As it reaches French Guiana, part of the NBC separates from the coast to join the North Equatorial Counter Current (NECC), while the rest continues flowing northwest to form the Guiana Current. Figure 6.4-1 illustrates the proximity of the Guiana Current, NBC, and NECC to the Stabroek Block.

Several times a year, the NBC turns back on itself to create closed circulation and form regions of strong eddies (circular currents). These eddies can separate the NBC and NECC and travel northwest along the South American coast. The eddies may range from approximately 145 to 400 kilometers (approximately 90 to 250 miles) in diameter and current magnitude within the eddies can vary significantly depending on the depth.

During the spring, the Guiana Current can extend as far as 300 nautical miles offshore to cover Guyana’s entire continental shelf. Its highest velocities tend to occur along the edge of the continental shelf (i.e., in Guyana just shoreward of the Stabroek Block). Fluctuations in the ITCZ and the trade winds lead to significant variation in the strength of the Guiana Current and the extent of its influence offshore, but maximum speeds generally occur from April to May, while minimum speeds commonly occur in September (Gyory et al. 2013).

The Guiana Current primarily influences the upper portion[10] of the water column, while the deeper portion of the water column in the Stabroek Block is strongly influenced by the North Atlantic Deep Western Boundary Current (DWBC), which is the southward limb of the North Atlantic MOC. The North Atlantic DWBC returns colder, denser water from polar regions to the subtropics at intermediate and deep levels.

[10] There is limited information documenting the depths at which the Guiana Current and North Atlantic Deep Western Boundary Current (DWBC) exert an influence, but metocean data collected by EEPGL (Figure 6.4-3) suggests the Guiana Current exerts an influence in at least the top 200 meters (approximately 656 feet) and the North Atlantic DWBC exerts an influence at depths of more than 800 meters (approximately 2,625 feet). The strength of the Guiana Current will also likely dictate how deep its influence extends at a given time, as it weakens/strengthens depending on the winds and Amazon River flows.

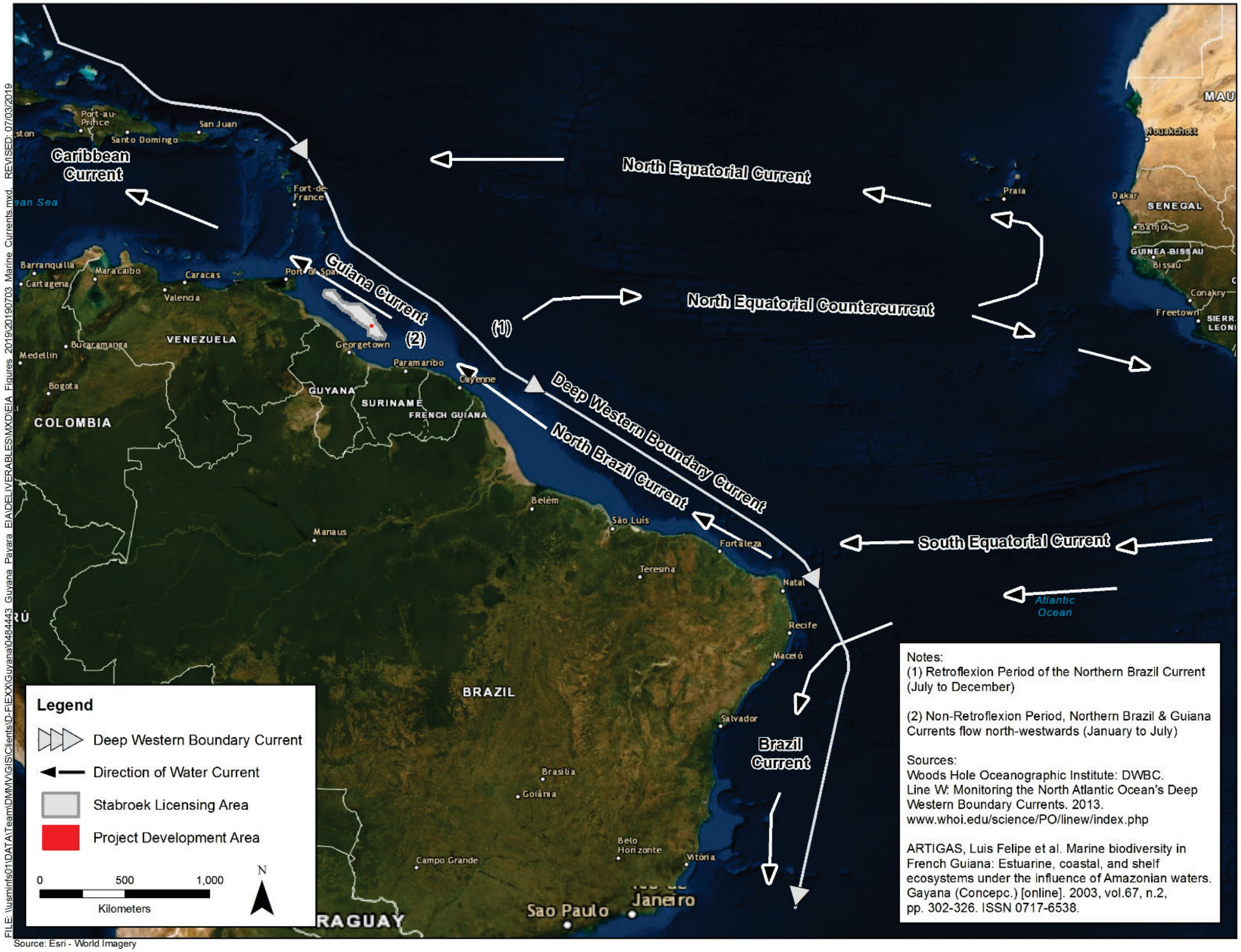
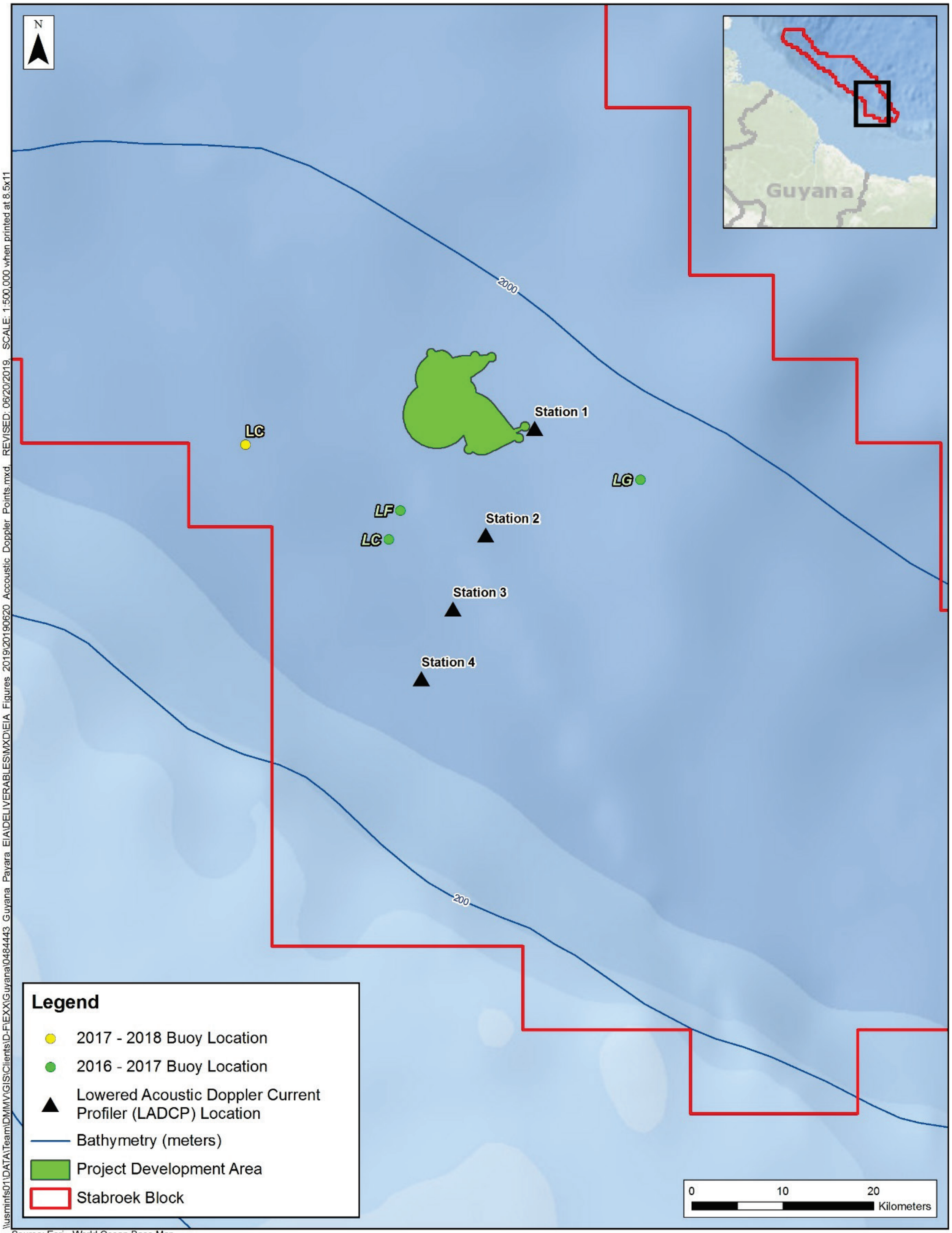


Figure 6.4-1: Marine Currents in the Vicinity of the Project Development Area

In May 2014, EEPGL commissioned a Lowered Acoustic Doppler Current Profiler (LADCP) survey of four stations along a transect in the central portion of the Stabroek Block to support Project design development. The LADCPs were placed at depths ranging from approximately 970 to 1,100 meters (3,182 to 3,609 feet). To supplement the above data, in March 2016, an EEPGL contractor deployed and maintained a series of four deepwater current profile mooring buoys and one surface met station buoy (RPS 2016; 2017a, b, c; 2018b). Two of the mooring buoys were deployed in the Liza field along with a surface met station buoy, and the remaining two mooring buoys were deployed northwest of the Liza field. During the deployment in September 2017, the two Liza field mooring buoys were installed at the same locations, but the met station buoy was relocated. Figure 6.4-2 shows the locations of the LADCPs (shown as "Station 1" through "Station 4"), the two Liza field mooring buoys (shown as "LF" and "LG"), and the surface met station buoy (shown as "LC").

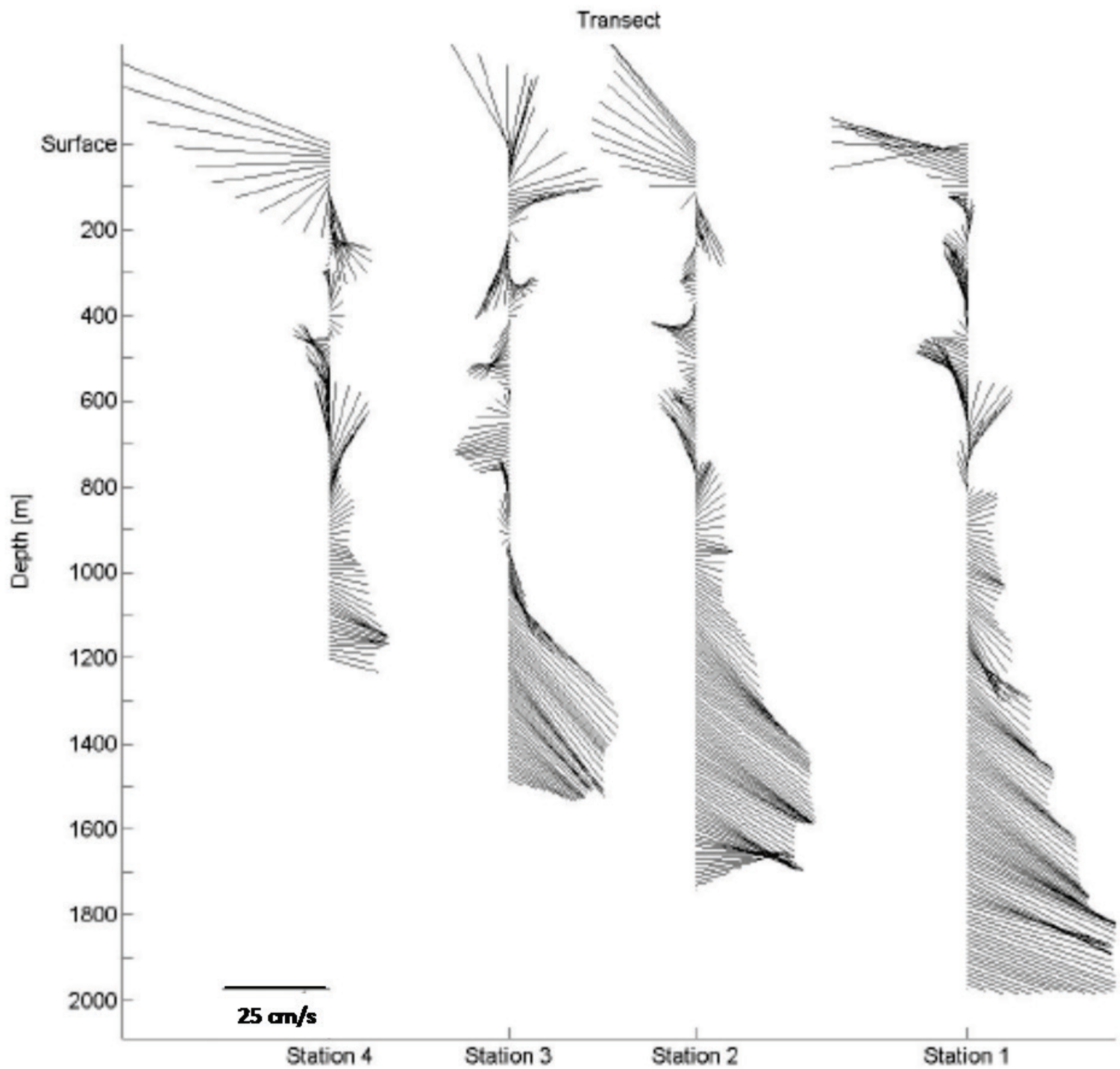
The LADCP data indicate the presence of both the Guiana Current and the North Atlantic DWBC. Figure 6.4-3 shows vector stick plots from the four stations along the LADCP transect. The three deepest stations (Stations 1, 2, and 3) showed similar vertical current structure (i.e., a north-westward surface flow influenced by the Guiana Current and a south-eastward deep flow influenced by the North Atlantic DWBC). The shallowest station (Station 4) showed a similar layered structure, but the speed of the north-westward surface current was significantly greater at this station than at the others (TDI-Brooks 2014).

Processed final datasets from the mooring buoys were available for buoy deployments spanning March 2016 through April 2018, including the fifth deployment that spanned from mid-September 2017 to early April 2018. In addition to confirming the overall circulation pattern off the coast of Guyana as measured in 2014, these moorings also helped identify regional current phenomena. For example, the data showed the existence of a northwest/north-northwest (NW-NNW) current that is characteristic of the NBC current at this location (see data from "LF" mooring buoy on Figure 6.4-4). The currents shown on the plot are directed toward the NW-NNW with a strong magnitude starting around 19 February 2017. The NBC is an aperiodic current, and Figure 6.4-4 shows the onset of the leading edge of this current reaching the LF mooring buoy location. The vector stick plot (Figure 6.4-3) shows a point in time when the NBC ring was present at the LADCPs. The most recent dataset (RPS 2018b) showed four significant pulses of surface currents during early to mid-October, early to mid-January, late February, and early April. All four of these events were toward the NW-W, characteristic of the general direction of the Guiana Current. The near-bottom current magnitudes averaged from 18 to 20 centimeters per second (cm/s) at the LF buoy location and from 24 to 28 cm/s at the LG buoy location, representative of the south-eastward deep flow influenced by the North Atlantic DWBC.



Source: Esri - World Ocean Base Map

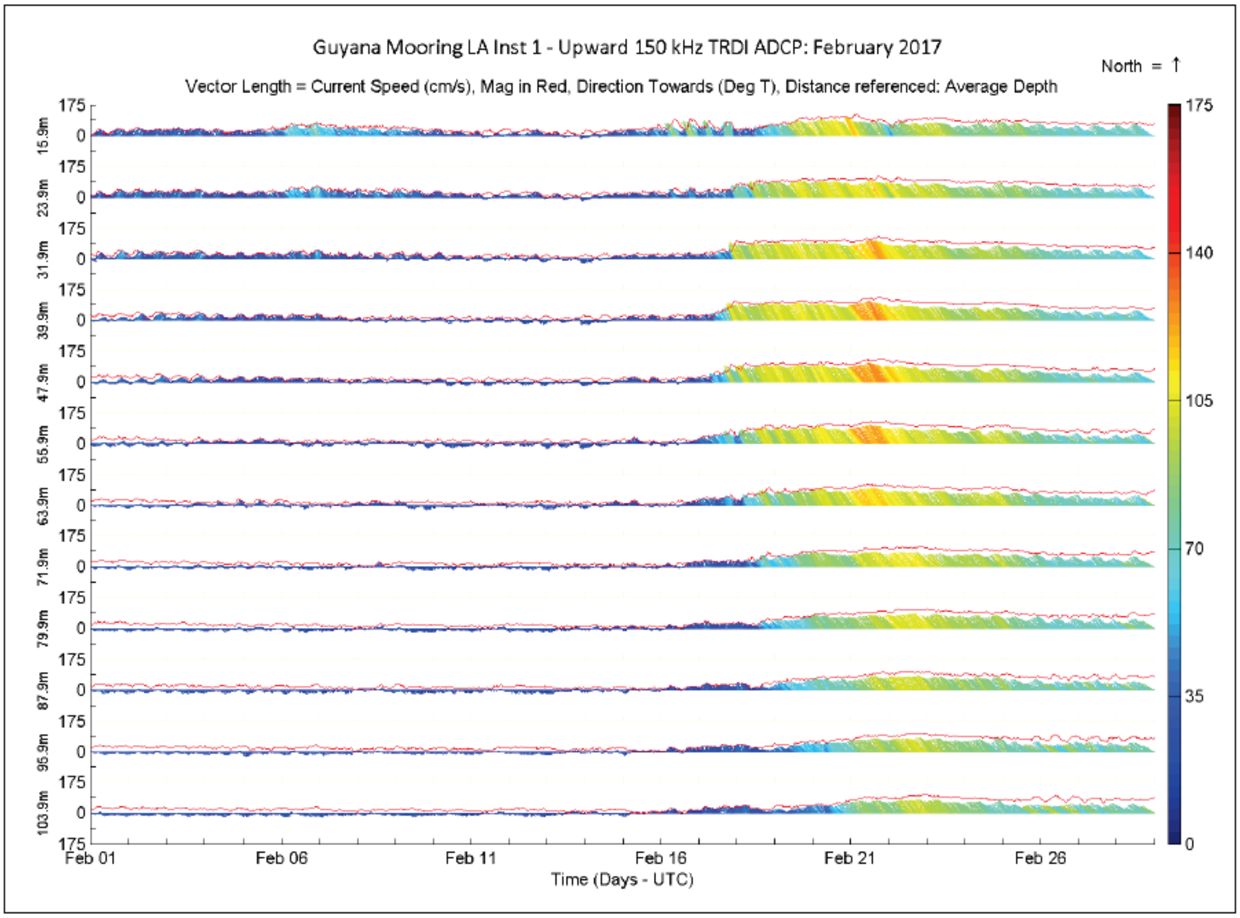
Figure 6.4-2: LADCP and Buoy Locations



Source: TDI-Brooks 2014

m= meters. Note: Each "stick" (also called a vector) describes the direction, speed, and depth of a discrete measurement. The length of the vector is directly proportional to its speed (a scale is provided at the bottom of the plot). The depth of each measurement is provided on the y-axis. The direction of the vector points in the compass direction of the current flow (north corresponding to "up" on the plot). The horizontal distance between stations on the x-axis is to scale.

Figure 6.4-3: Vector Stick Plot for Stations on the Stabroek Block LADCP Transect



Source: RPS 2018a

ADCP = Acoustic Doppler Current Profile; kHz = kilohertz; Mag = magnitude; m = meters

Figure 6.4-4: Near Surface Currents at LF Mooring Buoy, Showing the Onset of the Strong NW-NNW Currents related to the NBC

6.4.2.2. Marine Water Quality

Regional Water Quality Influences

The hydrographic[11] and isohaline[12] conditions in Guyana's coastal marine waters are greatly impacted by the outflow of the coastal rivers in the region, as described in Section 6.4.2.1, Oceanographic Conditions. The large amount of freshwater discharge affects ocean salinity and temperature. Oceanic water is relatively heavy, cold, and saline compared to the lighter, warmer, and fresher water of the Amazon and Orinoco plumes that converge offshore of Guyana. These convergences form oceanic fronts offshore of Guyana. Freshwater lenses[13] generated by the Amazon and Orinoco rivers are transported across Guyana's continental shelf to points north and west. These lenses persist for months and have been detected as far away as Barbados and Trinidad (Sherman and Hempel 2009).

Of the several coastal rivers that influence the Guyana offshore marine environment, the Amazon River, with an average discharge of 180,000 cubic meters per second (Nittrouer and De Master 1987), is the most prominent factor in terms of marine water quality. Analysis of the Amazonian plume has shown there is little seasonal variation in the plume's nutrient content (e.g., silicates of 144 micromoles per kilogram [µmol/kg], phosphates of 0.7 µmol/kg, and nitrates of 16 µmol/kg) (De Master and Pope 1996). It has been estimated that 40 to 50 percent of the annual Amazon run-off transits along the coast of Guyana (Nittrouer and De Master 1987).

The entire region offshore of Guyana is considered part of the North Brazil LME. The ocean temperature in the North Brazil Shelf LME has alternately warmed and cooled over the last few decades. A period of cooling lasted from the mid-1970s through the mid-1990s; since the mid-1990s, the LME has consistently warmed (Sherman and Hempel 2009). The net change in LME water temperature since 1957 equates to an average increase of more than 0.22˚C over 50 years (Sherman and Hempel 2009).

Characterization of Water Quality in the Stabroek Block

EEPGL has collected water quality samples from the Stabroek Block as part of four EBS events in 2014, 2016, 2017, and 2018. The full reports for the 2014, 2016, and 2017 EBS events were attached to the Liza Phase 2 Development EIA as appendices. The full report for the 2018 EBS event is provided as Appendix I, 2018 Environmental Baseline Survey Report to this EIA. Figure 6.4-5 displays the combined water quality sampling locations for the four EBS events. Descriptions of the sampling program for each survey and summaries of the results are provided below.

[11] Relating to the characteristic features (such as flow or depth) of bodies of water

[12] Isohalines are areas in the aquatic systems that have the same salinity.

[13] Freshwater lenses are formed near the surface of a marine environment when fresh (non-saline) water from rivers or rainfall enters a marine/saline waterbody. Freshwater is lighter and floats to the top of the saline water column, creating a layer (lens) of fresh, lower-salinity water.

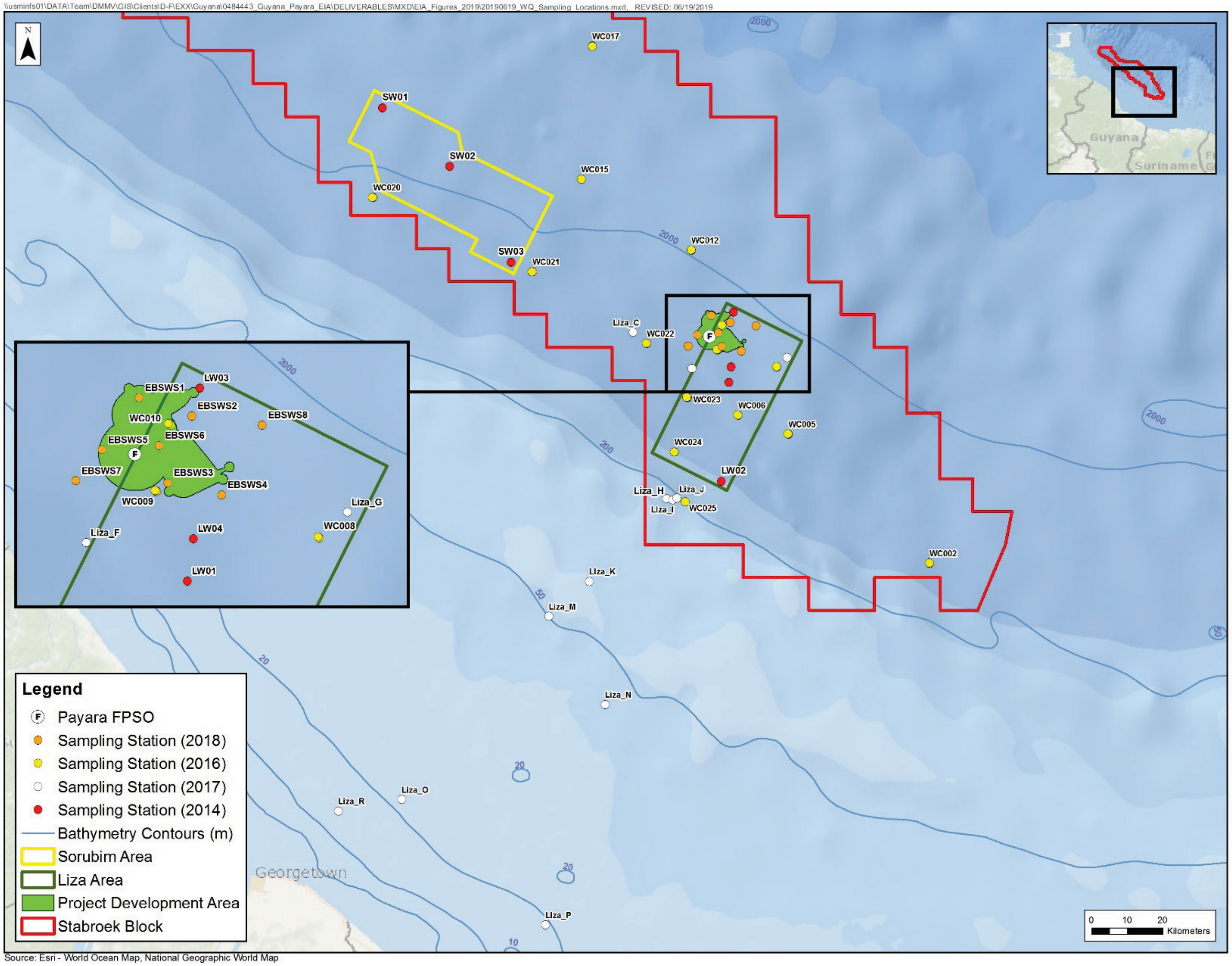


Figure 6.4-5: Combined Water Quality Sampling Locations—2014, 2016, 2017, and 2018 Surveys

2014 Survey

In the 2014 survey (Maxon and TDI Brooks 2014), water quality sampling was conducted at four stations in the Liza field and three samples at a location approximately 100 kilometers (62 miles) northwest of the Liza field (referred to in the survey as the Sorubim area). Three discrete water samples were collected at each station from the near-surface (5- to 10-meter [16.4- to 33-foot] depth), from the mixed layer (around 25-meter [82-foot] depth), and from approximately 5 to 10 meters (16.4 to 33 feet) above the seafloor, resulting in a total of 21 water samples. All samples were analyzed for total suspended solids (TSS), TOC, SHC, PAHs, and metals. Additionally, at each station, a vertical profile of water quality was determined with a conductivity-temperature-depth (CTD) meter, augmented with additional sensors for dissolved oxygen and turbidity.

Water-column profiling depicted a steep halocline, reaching a maximum salinity of 37 percent at 100-meter (328-foot) depth. Water temperature dropped from 28°C at the surface to 3°C around 2,000 meters (6,562 feet). The water column was highly stratified, likely limiting nutrient flux into surface waters from below the mixed layer. The permanent (non-seasonal) pycnocline[14] extends down to approximately 200 meters (656 feet), below which density increases slowly with depth. The water column was relatively clear, with light transmittance through the 25-centimeter (10-inch) path length typically greater than 95 percent. Dissolved oxygen was consistently high, ranging from roughly 6 milligrams per liter (mg/L) near the surface to greater than 8 mg/L in near-bottom waters.

Average TOC concentrations were 0.81 mg/L for both the Liza and Sorubim areas. Average TSS concentrations were 4.3 mg/L and 4.8 mg/L for the Liza and Sorubim areas, respectively.

Barium was the only metal detected in all samples. Copper, mercury, and zinc were the only other metals detected, with mercury concentrations (detected in 2 out of 21 samples) at less than 1 part per trillion. Arsenic, cadmium, chromium, and lead were not detected in any of the samples. Concentrations of all metals were well below those considered harmful to aquatic organisms in marine waters.

Total PAH concentrations (for 43 compounds) were extremely low in all samples (≤50 nanograms per liter [ng/L]). The majority of detected PAH compounds were naphthalene, and C1- and C2-naphthalenes, suggesting the potential for trace-level introduction from the analytical laboratory (these compounds are ubiquitous laboratory contaminants). Total SHCs were detected in only 4 out of 21 samples, with the highest reported concentration at 230 micrograms per liter (µg/L) (Maxon and TDI Brooks 2014).

2016 Survey

The 2016 survey provided additional data from an area covering 247 mi² (approximately 64,000 hectares). Water quality samples were collected at 15 locations in the Stabroek Block; at each location, samples were collected at top, middle, and bottom depths and samples were

[14] A layer in a body of water in which water density increases rapidly with depth

analyzed for TOC, TSS, hydrocarbons, PAHs, and metals. Additionally, the water column was profiled at each station with a CTD meter, augmented with additional sensors for dissolved oxygen, pH, and turbidity.

Water profiling at all sampling stations identified a generally stratified water column, with depth of thermocline[15], halocline[16], and oxygen boundary[17] increasing with water depth. At all 15 stations, temperature, salinity, and dissolved oxygen displayed a strong thermocline, halocline, and oxygen boundary. Salinity exhibited a narrow range, with a maximum value of 37.05 parts per thousand (ppt). Surface temperatures were relatively consistent across stations, but the lower water column temperatures decreased proportionally with water depth. The mean surface temperature was 27.8°C and the mean bottom temperatures ranged from 2.7°C (deepest site) to 11.2°C (shallowest site). Turbidity within the water column remained reasonably constant throughout the entire length of all water profiles, with mean values equal to or less than 2.9 formazine turbidity units. At all stations, the pH (which ranged between 8.18 and 8.47) increased gradually with increasing depth, and pH profiles were very similar between stations.

TOC and TSS were generally low at all stations, with TOC increasing slightly overall with depth from a mean surface concentration of 2.3 mg/L to a mean bottom concentration of 1.8 mg/L. TSS exhibited a similar profile, with a mean surface concentration of 6.7 mg/L and a mean bottom concentration of 3.4 mg/L.

Total hydrocarbon (THC) concentrations and PAH concentrations were generally at low levels across the survey area, with little variation between samples (highest reported THC concentration of 35.9 µg/L and highest reported total PAH concentration of 20.6 ng/L). All levels were below the USEPA water quality guidelines published in Burgess et al. 2013. Gas chromatography traces exhibited only small spikes in individual long-chain n-alkanes at all stations.

Reported metal concentrations were low in all water samples and did not vary substantially between stations or with depth. Metals reported above detection limits included cadmium, chromium, copper, lead, zinc, and arsenic. Concentrations of all metals were below their respective USEPA Saltwater Quality Standards thresholds (USEPA 2016), where these are available (Fugro EMU Limited 2016).

2017 Survey

The 2017 survey included sampling at 12 additional locations along the continental shelf, along the continental slope, and within the Stabroek Block. Samples were collected at surface,

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[15] A thermocline is the location within a stratified water column where a steep gradient of temperature exists. Typically, a thermocline marks a transition layer between a warmer (and mixed) surface layer and a cooler deep layer.

[16] Similar to a thermocline, a halocline is the location within a stratified water column where a steep gradient of salinity exists. Typically, a halocline marks the transition layer between a fresher surface layer and more saline deep layer.

[17] An oxygen boundary develops due to the presence of a thermocline and/or halocline, which reduce oxygen transport across these transition layers. Across the oxygen boundary, a sharp gradient in dissolved oxygen exists where the layer near the surface is typically well mixed and near saturation due to re-aeration, whereas the layer below reaches anoxic (very low dissolved oxygen) conditions.

mid-depth, and bottom, for a total of 72 samples (duplicates of each were collected). Samples were analyzed for TOC, TSS, total dissolved solids (TDS), chemical oxygen demand (COD), SHCs, metals, cyanide, and ammonia. Additionally, the water column was profiled at each station with a CTD meter, augmented with additional sensors for dissolved oxygen and turbidity.

Depths profiled for temperature and salinity revealed the presence of a thermocline and halocline at the deepwater stations (1,705 to 2,006 meters [5,594 to 6,581 feet]) and well-mixed conditions at the continental shelf stations (14 to 26 meters [46 to 85 feet]) and continental slope stations (134 to 215 meters [440 to 705 feet]). The strengths (gradient) of these profiles were consistent with the data collected in 2014 and 2016. The range of temperatures observed near the surface was also consistent with previous observations. Dissolved oxygen ranged from 6.21 mg/L to 6.86 mg/L at shelf stations, 6.23 mg/L to 8.05 mg/L at slope stations, and 6.28 mg/L to 10.56 mg/L at deepwater stations.

TDS, TSS, TOC, and COD showed decreases in concentrations at deeper locations. In general, TDS concentrations were highest at the top of the water column and lowest at the middle. The average level of TDS decreased with increasing distance from the shore. TOC concentrations were similar but tended to decrease with increasing depth, ranging between 1.3 mg/L and 2.1 mg/L at the surface and between 1.1 mg/L and 1.9 mg/L in the bottom depths. TSS concentrations also generally decreased with increasing depth, ranging between 2.8 mg/L and 28 mg/L near the surface and between 3.3 mg/L and 10.6 mg/L in the bottom depths. COD concentrations also generally decreased with increasing depth, with the average values at the top being approximately 1.5 times higher than the average values at the bottom.

Total cyanide and all analyzed metals were reported to be not detected in all samples. SHCs were detected at all of the slope and shelf locations, but not at the deepwater stations. Reported detections ranged from 210 to 580 µg/L. Ammonia was detected only at shelf locations, with reported detections ranging from 0.01 mg/L to 0.02 mg/L (ESL 2018).

2018 Survey

The 2018 survey included sampling at eight additional locations within the Payara PDA. Samples were collected at the surface (10 meters [33 feet]), below the thermocline (approximately 200 meters [656 feet] below surface), and near the bottom of the water column (20 meters [66 feet] above seabed), for a total of 24 samples. Samples were analyzed for TSS, TOC, hydrocarbons, and metals. Additionally, the water column was profiled at each station with a CTD meter, augmented with additional sensors for dissolved oxygen, pH, and turbidity.

Depths profiled for temperature and salinity revealed the presence of a thermocline and halocline at these stations. The strengths (gradient) of these profiles were consistent with the data collected at deeper stations in 2014 and 2016. The range of temperatures observed near the surface was also consistent with previous observations where surface temperatures were around 29.3ºC near surface and around 3.7ºC near seabed. Salinity ranged from 34.6 ppt to 36.9 ppt, with a mean of 35.0 ppt. Dissolved oxygen was reported as percentage of saturation and ranged from 33.2 percent to 105 percent, with a mean of 49.1 percent. pH showed alkaline conditions throughout the survey area, with a range of 7.60 to 8.43, and a mean of 7.77.

Reported TSS concentrations did not exhibit any significant variation with depth. In surface samples, TSS ranged from 22.9 mg/L to 56.1 mg/L; in mid-depth samples, concentrations ranged from 25.0 mg/L to 58.6 mg/L; and in the bottom-depth samples, concentrations ranged from 25.4 mg/L to 49.6 mg/L. All TOC values were below the minimum reporting value of 0.5 mg/L, lower than for previously sampled stations.

Reported THC concentrations were below the minimum reporting value of 10 µg/L at all stations except for one (bottom), which had a reported concentration of 21 µg/L. This value of 21 µg/L was higher than the mean THC reported for previous surveys. Arsenic concentrations ranged from 1.42 µg/L to 2.19 µg/L, with a mean concentration of 1.7 µg/L (comparable to previous surveys). All other metals were also found to be within the same range as previously sampled.

6.4.3. Impact Assessment—Marine Water Quality

This section addresses potential impacts on marine water quality resulting from planned Project activities. The potential impacts assessed include changes to marine water quality physico-chemical conditions as a result of the various effluent discharges associated with the Project. The following sections describe the various discharges for which potential marine water quality impacts were assessed, the application of computational models for impact magnitude quantification, and a discussion of the significance of potential impacts.

6.4.3.1. Relevant Project Activities and Potential Impacts

Planned discharges of drill cuttings and fluids may have a localized impact on marine water quality as a result of increased TSS concentrations in the water column. Cuttings and fluids released at the seafloor during jetting and drilling of the initial sections of the well will increase TSS concentrations around the well near the seafloor. Cuttings discharged overboard from the drill ships will increase TSS concentrations in the photic zone (the upper portion of the water column). These increases in TSS may clog fish gills or—in the photic zone—cause light inhibition for photosynthetic organisms.

During installation and commissioning of SURF equipment, hydrotesting fluids containing biocides, oxygen scavengers, and corrosion inhibitors, as well as hydrate inhibiting fluid (such as methanol or ethylene glycol), will be discharged to the sea, resulting in localized changes to water quality.

The FPSO will have several discharges related to its operation and maintenance during production operations. The potential impacts from these discharges include localized changes to water quality from effluent discharges during production operations, and localized changes to water temperature from discharge of cooling water effluent and treated produced water.

Table 6.4-2 summarizes the Project stages and activities that could result in potential Project impacts on marine water quality.

Table 6.4-2: Summary of Relevant Project Activities and Key Potential Impacts—Marine Water Quality

Resource/Receptor	Stage	Project Activity	Key Potential Impacts
Marine water quality (marine fauna as receptors)	Development Well Drilling FPSO/SURF Installation	Discharge of drill cuttings, resulting in increased TSS concentrations in water column Discharge of liquid effluents from drill ships and marine installation and support vessels (chemical substances) Discharge of hydrotesting fluids	• Increased TSS concentrations in water column, potentially contributing to health impacts on marine fauna • Increased chemical concentrations in water column, potentially contributing to health impacts on marine fauna
	Production Operations	Discharge of liquid effluents from FPSO and marine support vessels (chemical substances, and elevated temperature streams)	• Increased chemical concentrations in water column, potentially contributing to health impacts on marine fauna • Increased temperature in water column, potentially leading to avoidance of the area by marine fauna
	Decommissioning	Discharge of liquid effluents from marine support vessels (chemical substances)	• Increased chemical concentrations in water column, potentially contributing to health impacts on marine fauna

6.4.3.2. Characterization of Impacts—Increased TSS from Drill Cuttings Discharge

Magnitude of Impact—Increased TSS Concentrations from Drill Cuttings Discharge

The assessment of the Project’s magnitude of potential impacts from the increase of TSS concentrations from drill cuttings discharge is determined based on consideration of geographic extent, intensity, frequency, and duration. The intensity of potential impacts on water quality related to changes in TSS concentration is defined according to the definitions provided in Table 6.4-3.

Table 6.4-3: Definitions for Intensity Ratings for Potential Impacts on Water Quality from Increases in TSS Concentrations

Criterion	Definition
Intensity	Negligible: No TSS concentrations above levels with potential to contribute to health impacts on marine fauna
	Low: TSS concentrations above levels with potential to contribute to health impacts on marine fauna, but limited to a very localized area
	Medium: TSS concentrations above levels with potential to contribute to health impacts on marine fauna over a moderately-sized area
	High: TSS concentrations above levels with potential to contribute to health impacts on marine fauna, affecting a widespread area

As described in Appendix J, Water Quality Modeling Report, modeling of discharge and deposition of cuttings was performed using the GEMSS model. This three-dimensional particle-based model uses Lagrangian algorithms in conjunction with currents, specified mass load rates, release times and locations, particle sizes, settling velocities, and shear stress values to calculate the fate and transport of discharged drill cuttings. Model outputs provide estimates of the water column TSS concentrations resulting from the planned drilling operations.

For the purpose of modeling TSS concentrations, a total of eight drill cuttings deposition scenarios were modeled: two different scenarios for a production well at Drill Center PY1-P (the shallowest of the Project drill centers) and two different scenarios for an injection well at Drill Center PY3-I (the deepest of the Project drill centers). Each scenario was modeled under two current conditions: the minimum and the maximum of the monthly averaged and depth-averaged current speeds. These current speeds were derived from the SAT-OCEAN ocean circulation model. The modeled deposition scenarios reflect combinations of top-hole section drilling (containing WBDF; with cuttings discharged at the seafloor) and bottom-hole drilling (containing NADF cuttings; with cuttings discharged overboard from the drill ship prior to treatment, per standard industry practice) for multiple wells within a single drill center cluster.

As was assumed with drill cutting deposition modeling (Section 6.3.3, Impact Assessment—Marine Geology and Sediments), modeling of increases in water-column TSS concentrations was conducted assuming cuttings from the open-hole sections (containing WBDF) will be discharged at the seafloor (as noted above, these cuttings may alternatively be discharged from the drill ship prior to treatment, per standard industry practice). This was confirmed to be a conservative assumption, as modeling indicated the highest predicted TSS concentration increases are associated with discharge of cuttings at the seafloor (see results discussion below).

Modeling of cuttings discharge and deposition predicts the maximum TSS concentrations at the seafloor during drilling of the initial sections of the well will be between approximately 12,711 mg/L and 51,164 mg/L, depending on currents and drilling scenario (top-hole sections only or top-hole sections followed by a bottom-hole section). These concentrations correspond to only the initial sections of the well, where WBDF and cuttings are discharged directly from the casing. In contrast, modeling indicates the maximum TSS concentrations in the upper portion of the water column to be between approximately 23.6 mg/L and 52.8 mg/L, depending on currents and drilling scenario (top-hole sections only or top-hole sections followed by a bottom-hole section). These predicted concentrations are much lower because drill cuttings and fluids from bottom-hole sections that are released near the surface will be processed on the drill ship to remove a substantial amount of the drilling fluid prior to discharge. Additionally, discharges near the surface are also subjected to greater mixing from the higher current speeds at the shallower depths.

A TSS threshold of 35 mg/L is recommended by the International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) (IMO 2006) for discharges of effluent from marine vessels. This threshold was used to assess the extent of the area with the potential to contribute to health impacts on marine fauna, either through gill fouling or through inhibited photosynthesis via a reduction in light penetration (a potential indirect impact resulting from increased TSS concentrations in the water column). Table 6.4-4 summarizes the results of the modeling for the drill cuttings discharge scenarios described above.

Modeling predicts that TSS concentrations above the 35 mg/L threshold will occur mostly during drilling of the initial well sections, and these instances are confined to within a relatively small area around the well locations, near the seafloor. It is noted that these water depths are too great to allow for light penetration, so potential photosynthesis impacts at these depths are not a concern. In the case of bottom-hole well sections involving overboard cuttings discharges, only slight exceedances above the TSS threshold of 35 mg/L occurred near the surface, over a very localized area.

Table 6.4-4: Summary of TSS Concentration Modeling Results for Drill Cuttings Discharge Scenarios

Simulation	Maximum TSS (mg/L) Bottom / Surface	Area (km²) with TSS > 35 mg/L Threshold Bottom / Surface
Scenario 1—PY1-P Minimum Currents	42,796	0.362 / NA
Scenario 1—PY1-P Maximum Currents	36,859	0.621 / NA
Scenario 1—PY3-I Minimum Currents	51,120	0.170 / NA
Scenario 1—PY3-I Maximum Currents	51,164	1.339 / NA
Scenario 2—PY1-P Minimum Currents	18,520 / 23.6	0.288 / 0
Scenario 2—PY1-P Maximum Currents	26,149 / 52.8	0.160 / 0.0065
Scenario 2—PY3-I Minimum Currents	12,711 / 23.7	0.259 / 0
Scenario 2—PY3-I Maximum Currents	45,302 / 52.4	0.202 / 0.0065

cm = centimeters; g/m^2 = grams per square meter; NA = not applicable (no surface discharges for Scenario 1)

Considering the results of the modeling discussed above, the impacts will be limited to the portion of the **Direct AOI** in the immediate vicinity of the drill centers. While TSS concentrations for discharges at the seafloor will result in conditions exceeding the threshold, modeling indicates TSS concentrations will be reduced to below the threshold through settling and dispersion within approximately 12 hours of cessation of drilling for each well section (0.5 to 1.5 days, with approximately 1-day breaks in discharge between sections). TSS concentrations will be reduced to below the threshold within approximately 2 hours of cessation of drilling for bottom-hole sections. While this illustrates the intermittent nature of the impact, drilling operations will occur on a relatively continual basis throughout the drilling stage. Based on this, the frequency designation is **Continuous** for the drilling stage. The impact itself will persist for less than a year in aggregate, yielding a duration rating of **Medium-term**. Furthermore, with respect to inhibition of photosynthetic impacts, these are less relevant to the area near the seafloor, which is well below the photic zone. While there will be exceedances of the threshold, most of the area experiencing an exceedance of the 35 mg/L threshold will be near the bottom, where photosynthesis impacts are not relevant. The impacted portion of the photic zone near the surface covers a very small area (up to 0.007 km^2). Considering these factors, the intensity of the impact is considered **Low**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of impact on water quality from increases in TSS concentrations is therefore considered **Small** (see Table 6.4-5)**.**

Table 6.4-5: Magnitude Ratings for Potential Impacts on Water Quality from Increased TSS Concentrations

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Development well drilling	Marine water quality (marine fauna) – elevated TSS concentrations	Direct AOI	Low	Continuous	Medium-term	Small

Sensitivity of Resource—Increased TSS Concentrations from Drill Cuttings Discharge

The definitions used to designate sensitivity of receptors (marine fauna) to increases in TSS concentrations are shown in Table 6.4-6.

Table 6.4-6: Definitions for Receptor Sensitivity Ratings for Potential Impacts of Increased TSS Concentrations

Criterion	Definition
Sensitivity	Low: Affected portion of water column does not support any unique, biologically vulnerable, or otherwise critically important species.
	Medium: Affected portion of water column supports unique, biologically vulnerable, or critically important species, but represents only a small portion of the area on which these species depend.
	High: Affected portion of the water column supports unique, biologically vulnerable, or critically important species, and represents a substantial portion of the area on which these species depend.

Most of the marine environment is considered to be relatively resilient to TSS concentrations at the scale predicted by the modeling described above; however, an investigation of anomalous HSFs in and around the Payara PDA conducted in 2018 confirmed the existence of a community dominated by filter-feeding organisms (predominantly marine sponges) (FUGRO 2019). These organisms are vulnerable to elevated suspended sediments in the water column because of their immobile adult life forms and their feeding strategy. Based on their importance to the HSF biological community and their known vulnerability to TSS-related impacts, the sensitivity of the marine environment to increased TSS concentrations is conservatively designated as **Medium**.

Impact Significance—Increased TSS Concentrations from Drill Cuttings Discharge

Based on the magnitude of impact and resource sensitivity ratings, the significance of potential impacts on marine water quality from increased TSS concentrations resulting from drill cuttings discharge is considered **Minor**.

6.4.3.3. Characterization of Impacts—Changes to Water Quality and Temperature

Magnitude of Impact—Changes to Water Quality and Temperature

The assessment of the Project's magnitude of potential impacts on changes to water quality and temperature is determined based on consideration of geographic extent, intensity, frequency, and duration. The intensity of potential impacts on water quality is defined according to the definitions provided in Table 6.4-7. The following paragraphs discuss the intensity of the impact on changes to water quality and temperature, and the resultant magnitude rating.

Table 6.4-7: Definitions for Intensity Ratings for Potential Impacts from Changes to Water Quality and Temperature

Criterion	Definition
Intensity	Negligible: No concentrations or temperature increases above levels with potential to contribute to health impacts on marine fauna
	Low: Concentrations or temperature increases above levels with potential to contribute to health impacts on marine fauna, but limited to a very localized area
	Medium: Concentrations or temperature increases above levels with potential to contribute to health impacts on marine fauna over a moderately-sized area
	High: Concentrations or temperature increases above levels with potential to contribute to health impacts on marine fauna, affecting a widespread area

Project Discharges

The Project will include several discharges with the potential to change water quality and temperature. These discharges, based on the preliminary Project design information, are listed in Table 6.4-8.

Table 6.4-8: Summary of Project-Related Discharges

Type of Discharge and Effluent Characteristics	Expected Discharge Volume/Rate	Discharge Criteria	Treatment Required to Meet Criteria?
SURF and FPSO Installation/Commissioning Discharges			
Ballast water (FPSO initial deballasting)	≤ 550,000 bbl total	1) Perform in accordance with IMO requirements 2) No visible oil sheen on receiving water	No
Hydrostatic test water • Biocide: ≤ 500 ppm • Oxygen scavenger ≤ 100 ppm • Corrosion inhibitor ≤ 200 ppm	65,000 bbl (total volume for all flowlines and risers, occurring throughout SURF commissioning phase)	No visible oil sheen on receiving water	No
Gas injection line commissioning Fluids • Hydrate inhibitor (e.g. methanol or ethylene glycol)	1,400 bbl total	None	NA
Production Discharges			
Produced water • Oil and grease • Temperature (55°C at point of discharge) • Residual production and water treatment chemicals: – Scale Inhibitor ≤100 ppm – Corrosion Inhibitor ≤200 ppm	≤ 300,000 BPD	Oil in water content: 29 mg/L (monthly average); 42 mg/L (daily maximum) Temperature rise <3°C at 100 meters from discharge	Yes
Cooling water • Hypochlorite: ≤ 5 ppm • Temperature (50°C at point of discharge)	≤ 1,600,000 BPD	No visible oil sheen on receiving water Temperature rise <3°C at 100 meters from discharge	No
Sulfate removal and potable water processing brines • Hypochlorite: ≤ 1 ppm • Electrolyte: ≤ 1 ppm • Biocide: ≤ 5 ppm • Oxygen scavenger: ≤ 10 ppm • Scale inhibitor: ≤ 5 ppm	≤ 265,000 BPD	None	NA
Subsea hydraulic fluid discharge • Water soluble, low-toxicity	≤ 5 BPD	None	NA
FPSO bilge water	1,800 BPD	Oil in water content: <15 mg/L	Yes
Inert gas generator cooling water	Negligible	None	NA
FPSO slop tank water (includes off-specification oil from process and deck drainage)	Rainfall-dependent, but expected to be negligible [a]	Oil in water content: 29 mg/L (monthly average); 42 mg/L (daily maximum)	Yes
Miscellaneous discharges including boiler blowdown, desalinization blowdown, lab sink drainage	<10 BPD	None	NA

Type of Discharge and Effluent Characteristics	Expected Discharge Volume/Rate	Discharge Criteria	Treatment Required to Meet Criteria?
Tanker ballast water	Maximum 1,200,000 bbl total (at each tanker crude loading)	1) Perform in accordance with IMO requirements 2) No visible oil sheen on receiving water	No
BOP system testing water-soluble low toxicity hydraulic fluid	30 bbl every 2 weeks	None	NA
Gray water	250 BPD	None	NA
Black water (sewage)	70 BPD	Total residual chlorine as low as practical but not less than 1 ppm	Yes
Food preparation wastes	<40 BPD	Macerated to <25 millimeters diameter	Yes

BPD = barrels per day; IMO = International Maritime Organization; NA = not applicable
[a] FPSO slop tank water includes deck drainage in addition to off specification oil from the process. While the expected volume of off-specification oil will be negligible, if it rains significantly, the expected discharge volume for this stream will be increased (though the increase would be entirely rainwater).

Based on the estimated discharge rates in Table 6.4-8, cooling water, produced water, and brines from the Sulfate Removal Unit and freshwater reverse osmosis system (all associated with the production operations stage) are the operational discharges that are significant enough to require assessment, and thus these were the focus of modeling to assess the nature and extent of potential marine water quality impacts. Additionally, although the discharge of hydrotest water and commissioning fluids will occur over only a short time period during the SURF installation and commissioning stage, they were also included in the offshore discharge modeling as a conservative measure. Potential impacts from the other effluent discharges listed above were considered to be insignificant. There may be localized toxic effects on fish, crustacean, plankton, and benthos from some of the chemicals in the low volume of subsea hydraulic fluid discharge, but the chemicals used will be of low toxicity and will dilute and disperse rapidly.

The constituents considered for each of these modeled discharges are listed in Table 6.4-9. The constituents are associated with potential indirect impacts on marine aquatic life, as indicated in the table.

Table 6.4-9: Summary of Modeled Discharges and Considered Constituents for Production Operations and SURF Hydrotesting

Modeled Discharge	Considered Constituents	Potential Indirect Impacts on Marine Aquatic Life
Cooling Water	• Temperature • Residual chlorine	Temperature increase and associated avoidance impacts on marine species Increased residual chlorine concentrations and associated toxicity impacts on marine species
Produced Water	• Oil and grease • Temperature • Residual production-related and water treatment chemicals (e.g., scale and corrosion inhibitors)	Increased concentrations of oil and grease and production-related and water treatment chemicals, and associated toxicity impacts on marine species
Sulfate Removal and Potable Water Processing Brines	• Hypochlorite • Electrolyte • Biocide • Oxygen scavenger • Scale Inhibitor	Increased chemical concentrations and associated toxicity impacts on marine species
Hydrotest Water	• Biocides • Oxygen scavenger • Corrosion inhibitor	Increased chemical concentrations and associated toxicity impacts on marine species
Gas Injection Line Commissioning Fluid	• Hydrate inhibitor (e.g., methanol or monoethylene glycol)	Increased chemical concentrations and associated toxicity impacts on marine species

The cooling water discharge is the return flow associated with a routine operational process used to cool selected machinery onboard the FPSO. The cooling water discharge will have an elevated temperature (relative to the ambient water temperature for the marine environment) and will contain a limited amount of hypochlorite (generated from seawater and added as an anti-biofouling agent). Aquatic species may be indirectly impacted by the elevated temperature and residual chlorine in the discharge. Elevated temperatures may result in aquatic species avoiding regions close to the discharge. Residual chlorine may interact with naturally occurring organic matter, resulting in chlorinated byproducts with the potential to result in indirect toxicity impacts on aquatic species. There are no regulatory limits for residual chlorine in marine discharges in Guyana. Residual chlorine toxicity depends not only on exposure (concentration and duration), but also on individual species' sensitivity. This makes defining a single impact threshold for residual chlorine exposure difficult. If the discharge is designed such that the exposure is reduced to the extent reasonably practicable, the potential for resulting impacts should be limited and can be managed.

Discharge of produced water containing oil and grease and residual quantities of certain production-related and water treatment chemicals can result in localized increases in concentrations of chemical constituents in the marine environment. Discharge of sulfate removal and potable water processing brines can also result in localized increases in concentrations of chemical constituents in the marine environment. Depending on the specific constituent concentrations in these discharges, some aquatic species may experience indirect toxicity impacts from these constituents. Additionally, the produced water discharge will have an elevated temperature (relative to the ambient water temperature for the marine environment).

Hydrotest water discharges may contain biocides, oxygen scavengers, and corrosion inhibitors, which can result in locally increased concentrations of chemical constituents and associated potential for indirect toxicity impacts on aquatic species. The hydrotest discharge and hydrate inhibitor discharge will occur only during a limited time period during SURF installation and commissioning activities, unlike the discharge of cooling water, produced water, and sulfate removal and potable water processing brines discharge, all of which will occur continuously during production operations.

Water Quality Modeling

The USEPA-approved CORMIX[18] dilution model was used to predict the nature and extent of discharge plumes from the various modeled discharges. CORMIX is a design tool routinely used by regulatory agencies to estimate mixing zones resulting from water discharges. Understanding the mixing characteristics of the various discharges and assessing impacts requires understanding the properties of the discharged effluent (e.g., temperature), the properties of the receiving (ambient) water, and the method by which the discharge stream enters the ambient water (e.g., pipe, diffusers). Collectively, these factors control the near-field mixing and dilution of the discharge.

Discharge velocity, an important determinant of the mixing characteristics of a discharge, is directly related to the discharge pipe diameter. At a given discharge flow rate, smaller pipe diameters result in higher exit velocities, which facilitate increased mixing. However, engineering constraints may limit the degree to which the pipe diameter can be reduced. Similarly, the location of the discharge pipe (submerged or above water) can significantly influence the near-field mixing. An above-surface discharge accelerates under gravity to reach increased velocities before entering the sea, a desirable outcome that can be achieved if further reductions in pipe diameter are not practicable. As the detailed design for the Project has not been finalized, conservative assumptions were used for the modeled discharge pipe diameters. Pipe diameters that are smaller than those considered in the modeling will result in increased mixing (and lower concentrations at the edge of mixing zone, relative to those predicted by modeling).

For the receiving environment, the ambient currents selected for modeling consisted of bounding cases (5th and 95th percentile for the range of current velocities identified) as well as a typical case (50th percentile for the range of current velocities identified). Ambient temperatures selected for modeling also consisted of bounding cases (1st and 99th percentiles) and a typical case (50th percentile).

The modeling of potential impacts from these discharges found that even under the most conservative bounding case for each discharge modeling scenario, the discharges were subject to

[18] CORnell MIXing Zone; http://www.cormix.info/

rapid mixing and, consequently, experienced substantial reductions in constituent concentrations within a relatively small distance from the point of discharge.

Guyana has not established a specific thermal discharge limit; therefore, a 3°C maximum temperature rise at a distance of 100 meters (328 feet) from the discharge point was used as a reference point for cooling water and produced water discharges, consistent with recognized international benchmarks (IFC 2015). Table 6.4-10 summarizes the results of the modeling of discharges for the most conservative bounding cases, including percent reduction in constituent concentrations at the 100-meter (328-foot) reference distance from the source. International standards and guidelines and established regulatory requirements provide appropriate discharge benchmarks for oil and grease content in produced water, and MARPOL 73/78 specifies limits on oil and grease in bilge water. There are no prescribed limits for the constituents contained in the other discharge streams.

Table 6.4-10: Summary of Modeling Results for Most Conservative Bounding Case Conditions (Predicted Results at 100-Meter Reference Distance)

Discharge	Most Conservative Bounding Case Conditions	Modeled Parameters/ Constituents	Modeled Results at 100 Meters
Cooling Water (Thermal)	Minimum ambient temperature, maximum ambient current	Temperature rise [a]	Ambient temperature rise <3°C
Cooling Water (Hypochlorite)	Minimum ambient temperature, maximum ambient current	Residual chlorine	97.8% reduction (0.11 mg/L)
Produced Water	Maximum ambient current	• Oil and grease [b] • Temperature rise • Residual production chemicals	Ambient temperature rise <3°C 98.6% reduction in oil and grease and other residual production chemicals
Sulfate Removal and Potable Water Processing Brines	Maximum ambient current	• Hypochlorite • Electrolytes • Biocide • Oxygen scavenger • Scale inhibitor	98.9% reduction
Hydrotest Water	Minimum ambient current	• Biocide • Oxygen scavenger • Corrosion inhibitor	98.9% reduction
Hydrate Control Fluid (Gas Injection Line Commissioning Fluid)	Minimum ambient current (ethylene glycol); high ambient current (methanol)	Hydrate inhibitor (either methanol or ethylene glycol)	99.6% reduction in ethylene glycol or 99.9% reduction in methanol

[a] Design specifications for the cooling water discharge port were not finalized at the time of the EIA; modeling was conducted to ensure the most probable design will result in a temperature rise less than 3°C at the edge of the 100-meter (328-foot) mixing zone.
[b] Discharges will adhere to a limit of 42 mg/L oil and grease (daily maximum) and 29 mg/L (monthly average) at the point of discharge (consistent with recognized international benchmarks).

Magnitude Ratings

Considering the results of the modeling discussed above, the impacts will be limited to a small portion of the **Direct AOI** (i.e., within the immediate vicinity of the FPSO discharge). The various operational discharges will occur continuously throughout the operational stage of the Project life cycle (at least 20 years). Based on this, the frequency designation is **Continuous** for the operational stage, with a duration of **Long-term** for all discharges. In terms of the intensity of the potential impacts on marine water quality from production operations and hydrotesting discharges, Table 6.4-11 summarizes the assigned intensity designations for the various discharge types, based on consideration of the modeling results and the definitions of the intensity ratings presented in Table 6.4-7.

Table 6.4-11: Intensity Ratings Summary for Modeled Production Operations and Hydrotesting Discharges

Discharge Type	Intensity Rating	Rationale for the Intensity Rating Assigned
Cooling Water	Negligible	Modeling indicates the temperature rise in the water column will reduce to no greater than the reference benchmark of 3°C at the edge of the recommended 100-meter (328-foot) mixing zone (i.e., within recommended limits). At this same distance, chlorine concentrations are predicted to decrease by 97.8 percent to a concentration of 0.11 mg/L.
Produced Water	Negligible	At the 100-meter (328-foot) reference distance, concentrations of oil and grease and residual production-related and water treatment chemicals are predicted to decrease by 98.6 percent, and temperature rise is predicted to be less than 3°C.
Sulfate Removal and Potable Water Processing Brines	Negligible	At the 100-meter (328-foot) reference distance, concentrations of hypochlorite, electrolyte, biocide, oxygen scavenger, and scale inhibitor are predicted to decrease by 98.9 percent.
Hydrotest Water	Negligible	At the 100-meter (328-foot) reference distance, concentrations of biocide, oxygen scavenger, and corrosion inhibitor are predicted to decrease by 98.9 to 99.6 percent, depending on pipe diameter. Additionally, each release event will be short-term in nature (approximately 60 minutes or less).
Hydrate Inhibitor (Gas Injection Line Commissioning Fluid)	Negligible	At the 100-meter (328-foot) reference distance, the concentration of hydrate control fluid (methanol or monoethylene glycol) is predicted to decrease by 99.6 to 99.9 percent, depending on the fluid selected. Additionally, the release event will be short-term in nature (a matter of hours).

Based on the limited area impacted, the magnitude of impacts on marine water quality from production operations and hydrotesting discharges is considered **Negligible** for all of the discharges assessed (see Table 6.4-12).

Table 6.4-12: Magnitude Ratings for Potential Impacts from Production, Operations, and Hydrotesting Discharges

Stage	Receptor—Impact	Discharge Type	Geographic Extent	Intensity	Frequency	Duration	Magnitude
All stages of the Project	Marine Water Quality	Cooling Water	Direct AOI	Negligible	Continuous	Long-term	Negligible
		Produced Water	Direct AOI	Negligible	Continuous	Long-term	Negligible
		Sulfate Removal and Potable Water Processing Brines	Direct AOI	Negligible	Continuous	Long-term	Negligible
		Hydrotest Water	Direct AOI	Negligible	Continuous	Long-term	Negligible
		Hydrate Inhibitor (Gas Injection Line Commissioning Fluid)	Direct AOI	Negligible	Continuous	Long-term	Negligible

Sensitivity of Resource—Changes to Water Quality and Temperature

As described in Section 7.8.3, Impact Assessment—Marine Fish, elevated temperature is known to have several physiological lethal and sub-lethal impacts on fish including reduced reproductive success, reduced early life stage survivorship, and increased metabolic stress. Thermal thresholds for such impacts vary widely by species, but thresholds from the scientific literature range from about +1.5 ˚C to +6 ˚C (Donelson et al. 2014; Pankhurst and Munday 2011). Most of the research on thermal thresholds for these types of impacts has focused on reef or structure-oriented species that spend their entire adult lives in a small area rather than the open-ocean pelagic species that will occur near the surface in the PDA. Pelagic species are much more likely to move away from a thermal mixing zone that exceeds their optimum range than structure-oriented species, so the species that occur within the PDA will also be resilient to these thermal impacts based on their propensity to actively avoid suboptimal water temperatures.

Similar to temperature increases, chlorine can also induce a range of negative impacts in fish, including disruption of cardiac function, respiration, and growth. Chlorine toxicity depends not only on dosage (concentration and exposure time) but also on individual species’ sensitivity to chlorine. The combined impact of increased temperature and chlorine concentrations will make the localized mixing zone inhospitable to some species. However, unless they are physically confined or otherwise prevented from escaping lethal water quality conditions, or water quality conditions decline so quickly that escape is impossible, fish are usually capable of detecting and avoiding harmful water quality conditions. This is especially true of water quality conditions that cause discomfort or are otherwise physically apparent at sub-lethal levels like chlorine, and is also especially true of the pelagic species that move throughout their lives and will be in the most direct contact with elevated temperatures and chlorine concentrations. Considering these factors, the definitions used for sensitivity ratings are presented in Table 6.4-13.

Table 6.4-13: Definitions for Receptor Sensitivity Ratings for Potential Impacts from Production Operation and Hydrotest Discharges

Criterion	Definition
Sensitivity	Low: Sufficient mobility to avoid regions of elevated concentrations to avoid lethal or toxic effects; high tolerance to exposure concentrations
	Medium: Limited mobility to avoid regions of elevated concentrations; moderate tolerance to exposure concentrations
	High: Confined to regions of elevated concentrations; low tolerance to exposure concentrations

On the basis of consideration of potential marine fauna that could be impacted in the PDA, the sensitivity of the marine environment to elevated constituent concentrations and increased temperature is considered **Low**.

Impact Significance—Changes to Water Quality and Temperature

Based on the magnitude of impact and resource sensitivity ratings, the significance of potential impacts on marine water quality from changes in water quality and temperature resulting from production operations and hydrotesting discharges is considered **Negligible**.

6.4.4. Mitigation Measures—Marine Water Quality

While no mitigation measures are proposed, potential marine water quality impacts are addressed by a suite of embedded controls related to water quality management (see summary in Chapter 13, Recommendations). Table 6.4-14 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 6.4-14: List of Embedded Controls and Monitoring Measures

Embedded Controls
When NADF is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with International Maritime Organization/ MARPOL 73/78 requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 mg/L on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals.
Measure residual chlorine concentration of sewage discharges form the FPSO monthly to ensure it is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to ensure that there are no floating solids or discoloration of the surrounding waters.

Embedded Controls
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' specifications and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Implement a chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
Ensure wastewater released from the onboard sewage treatment plant complies with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.
Ensure there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge.
Treat bilge water in accordance with MARPOL to ensure compliance with an oil in water content of less than 15 ppm as applicable.
Monitoring Measures
Prior to and post-drilling, an ROV will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to ensure that end of well maximum weighted mass ratio averaged over all well sections drilled using NABF shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C at 100 meters (approximately 328 feet) from point of discharge.
Utilize load monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Monitor chlorine concentration of treated sewage discharges.
Perform daily visual inspection of discharge points to ensure absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to ensure compliance with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 6.4-15 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine water quality. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine water quality-specific methodology described in Sections 6.4.3.2 and 6.4.3.3.

Table 6.4-15: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Water Quality

Stage	Resource - Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling	Marine water quality (marine fauna)—increased TSS concentrations and potential health impacts	Small	Medium	Minor	None	Minor
SURF/FPSO Installation Production Operations	Marine water quality (marine fauna)—changes to water quality and temperature	Small	Low	Negligible	None	Negligible

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7. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIES—BIOLOGICAL RESOURCES

7.1. PROTECTED AREAS AND SPECIAL STATUS SPECIES

7.1.1. Administrative Framework—Protected Areas and Special Status Species

Table 7.1-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on protected areas and special status species.

Table 7.1-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Protected Areas and Special Status Species

Title	Objective	Relevance to the Project
Legislation		
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora.	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a supportive mechanism cognizant of the national goals for wildlife protection, conservation, management, sustainable use, and external trade.
Protected Areas Act, 2011 (also discussed in Chapter 3)	Provides for protection and conservation of Guyana's natural heritage and natural capital through a national network of protected areas. This act also allowed for the creation of the Protected Areas Commission to oversee the management of this network. It highlights the importance of maintaining ecosystem services of national and global importance and public participation in the conservation of protected areas. It establishes a protected-areas trust fund to ensure adequate financial support for maintenance of the network. Other functions of this act include promoting national pride in and encouraging stewardship of Guyana's natural heritage; recognizing the conservation efforts and achievements of Amerindian villages and Amerindian communities; and promoting the recovery and rehabilitation of vulnerable, threatened, and endangered species.	Shell Beach, which is a coastal area subject to potential impact from a Project unplanned event (i.e., oil spill), was identified as one of the five priority areas for establishment of protected areas in Guyana and was designated a protected area with the passage of the Protected Areas Act in 2011.

Title	Objective	Relevance to the Project
International Agreements Signed/Acceded by Guyana		
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection for the marine environment, especially from possible pollution. Acceded and ratified in 2010.
Protocol on Specially Protected Areas and Wildlife	Protocol supplementing and supporting the Cartagena Convention. Requires signatories to adopt an ecosystem approach to conservation. Provides mechanism for compliance with the Convention on Biological Diversity.	Elaborates on the wildlife goals established in the Cartagena Convention and Convention on Biological Diversity. Guyana acceded and ratified in 2010.
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Signed in 1992, ratified in 1994.
Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)	Protects endangered plants and animals from international trade.	Restricts collection and trade of endangered species. Guyana acceded in 1977.

7.1.2. Existing Conditions—Protected Areas and Special Status Species

7.1.2.1. Protected Areas

Formerly, the EPA was Guyana's focal point for the Convention on Biological Diversity, and the agency coordinated the National Protected Areas System (EPA undated), which included five protected areas. In 2011, Guyana enacted the Protected Areas Act, which established a Protected Areas Commission to oversee and manage protected areas. This legislation established a list of prohibited activities, including unlawfully entering or remaining within a protected area; disturbing or destroying the vegetation (common or endangered); removing or exterminating wildlife species (common or endangered); damaging archaeological finds or sites; and mining. If any prohibited activities occur, fines range from $50,000 to $500,000 (Guyanese dollars [GYD]; $240 to $2,400 U.S. dollars [USD]) (Protected Areas Act 2011). Guyana's National Biodiversity Strategy and Action Plan (EPA and MoNRE 2015) describes the overall importance of biodiversity's role within the country:

> "Guyana's biodiversity provides an important basis for climate regulation, poverty reduction, provisioning of fresh water and hydropower, economic growth and development in areas such as agriculture, forestry and fisheries, payment for forest climate services, community based economies, particularly in hinterland communities and biodiversity-related education, scientific research and recreation. Loss of biodiversity and any disruption in the provision of ecosystem services would impact negatively on the economy and more particularly on the quality of life in the hinterland and indigenous communities."

The 2011 legislation also established Shell Beach and the Kanuku Mountains as Guyana's newest nationally protected areas. This increased the total number of protected areas in Guyana to seven and increased the total land area protected to approximately 1.8 million hectares, or about 9 percent of Guyana's land area, as summarized in Table 7.1-2. Figure 7.1-1 illustrates the locations of Guyana's protected areas. There are currently no designated marine protected areas in Guyana.

Table 7.1-2: Protected Areas in Guyana

Protected Area	Area (hectares)
Kaieteur National Park	63,000
Iwokrama Forest	371,000
Kanashen (Community Owned Conservation Area)	625,000
Kanuku Mountains	611,000
Shell Beach Nature Reserve	200,000
Moraballi Forest Reserve	11,000
Mabura Hill Forest Reserve	2,000

Source: IUCN and UNEP-WCMC 2016

Of the seven protected areas, Shell Beach Protected Area (SBPA) is the only one located on Guyana's coast, and is most pertinent to the assessment of potential impacts from the Project. SBPA includes Guyana's coastline but does not extend into the Atlantic Ocean; however, the ecology of the coastal zone and Shell Beach are inextricably connected to the coastal marine ecosystem. The SBPA is managed by the Protected Areas Commission; the management framework for the protected area is described in the Shell Beach Protected Area Management Plan 2015-2019 (PAC 2014).

Figure 7.1-2 provides a detailed map of SBPA, the beaches it incorporates, and the surrounding area. It is located in northern Guyana and extends for almost 140 kilometers (approximately 87 miles), and is bordered by the Waini, Baramani, and Moruka rivers and the Atlantic Ocean. The Project Development Area (PDA) is located 202 kilometers (125 miles) northeast of the southernmost (closest) point of SBPA.

Shell Beach, which derived its name from the fact that its entire stretch of coastline is comprised mainly of pulverized crustacean shells (EPA et al. 2004), is a dynamic area. Its landscape constantly changes due to the competing impacts of erosion and accretion along the shoreline. The area is 70 percent forested; the rest is made up of mostly swamp (less than 30 percent) and sandy beaches (less than 1 percent) (Kandaswamy 2014). Shell Beach supports numerous plant species, including coconut, papaya, and palm trees (GMTCS 2011; Bovell 2011).

The vegetative community has changed little in recent history apart from limited clearing to accommodate a few dispersed encampments and farmsteads. The rivers bordering the SBPA discharge nutrients through the protected area's mudflats and mangroves. These high nutrient levels contribute to the productivity of the marine ecosystem. Fish, prawns, and crabs from the nearshore marine area use the mangrove covered coastlines as nursery habitat.

Figure 7.1-1: Protected Areas of Guyana

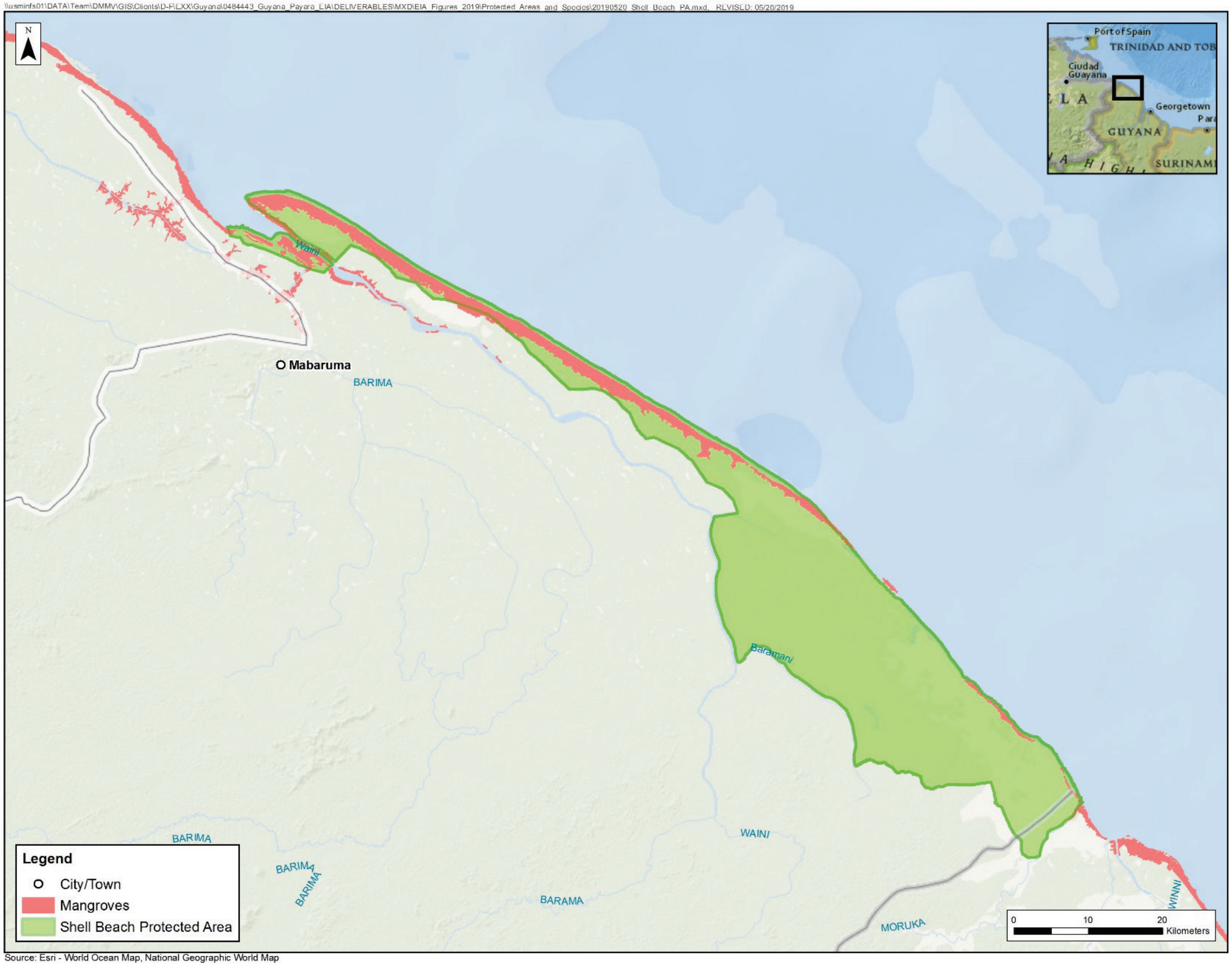


Figure 7.1-2: Shell Beach Protected Area

Shell Beach is best known as a marine turtle nesting site. The composition of the substrate at Shell Beach, its geographical location, and the low anthropogenic activity makes it an ideal nesting site for marine turtles. Most nesting beaches in Guyana are used by only one or two species of marine turtles, but four species (leatherback turtle [*Dermochelys coriacea*], hawksbill turtle [*Eretmochelys imbricata*], olive ridley turtle [*Lepidochelys olivacea*], and green turtle [*Chelonia mydas*]) nest at Shell Beach (Pritchard 2001). In addition to marine turtles, there are also at least four other species of turtles present within the SBPA, including yellow-footed tortoise (*Geochelone denticulata*), scorpion mud turtle (*Kinosternon scorpioides*), giant river turtle (*Podocnemis expansa*), and mata mata (*Chelus fimbriata*).

The SBPA also supports rich bird, herpetofauna (reptiles and amphibians), and mammal communities. The 2004 Rapid Biodiversity Assessment (EPA et al. 2004) documented 170 species of birds, 20 species of mammals, and 31 species of herpetofauna. The 170 species of birds represent one of the richest populations in Guyana and include well known species such as Scarlet Ibis (*Eudocimus ruber*), Roseate Spoonbill (*Platalea ajaja*), and Caribbean Flamingo (*Phoenicopterus ruber*), Orange-winged Amazon Parrot (*Amazona amazonica),* and several species of macaws.

Sixteen herpetofauna species (other than turtles) are known to inhabit the Shell Beach area. These include Ameiva lizard (*Ameiva ameiva*), rainbow whiptail lizard (*Cnemidorphous lemniscatus*), water labaria (*Helicops angulatus)*, cane toad (*Rhinella marina*), paradoxical frog (*Pseudis paradoxa*), and numerous tree frogs (*Hyla* spp.) (EPA et al. 2004).

Resources within protected areas are a key factor in supporting local communities (see Section 8.9, Ecosystem Services, for additional information). Areas within and near Shell Beach have been inhabited for 10,000 years by Amerindian groups from the Warao, Carib, and Arawak tribes (Charles et al. 2004). Most of the current indigenous residents of the Shell Beach area are concentrated in a community known as Almond Beach, near the northern end of the SBPA. Other communities included within the boundary of the SBPA, as delineated in 2011, include Father's Beach and Assakata. The remainder of the SBPA is sparsely populated, if at all.

Indigenous communities have historically used the Shell Beach area for subsistence fishing, crabbing, trapping, farming, logging, and palm harvesting. The important crab species that are used by the locals include blue sheriga (*Callinectes bocourti*), sheriga (*Portunas spinimamus*), bunderi (*Cardiosoma guanhumi*), and buck-crab (*Ucides cordatus*) (EPA et al. 2004). They have also historically engaged in marine turtle trapping and egg harvesting. While these activities have declined in recent years as emphasis on conservation and sustainability has increased, illegal catching of turtles may still occur (Charles et al. 2004).

Increasing human activity in proximity to Shell Beach has led to increasing exploitation of natural resources and has the potential to lead to additional ecological harm. In 1997, a fire caused by human activity extensively damaged an area of mangroves (Pritchard 2001). Throughout the past few decades, there have also been various industrial proposals for Shell Beach. These include proposals to extract shell material from the beaches as feedstock for fertilizer production and to develop a luxury tourist outpost (Charles et al. 2004). Amerindian communities in the area have also expressed interest in developing ecotourism in the area (Charles et al. 2004).

7.1.2.2. Special Status Species

The International Union for the Conservation of Nature (IUCN) Red List is the definitive authority on global species conservation status. In addition to the global IUCN Red List, many countries have a National Red List that assesses species status at a national or smaller scale. Guyana does not have a National Red List (NRL 2018) so the IUCN Red List is used herein. For the purposes of this assessment, special status species are defined as those that are listed as: (1) Near Threatened (NT), Vulnerable (VU), Endangered (EN), or Critically Endangered (CR) on the IUCN Red List Version 2019.1 (IUCN 2019). Table 7.1-3 summarizes the IUCN Red List categories. Species categorized as CR, EN, and VU are collectively considered to be internationally "threatened," while NT species are considered to be close to qualifying as "threatened." Conversely, Least Concern (LC) species are considered internationally widespread and abundant. Species listed as Data Deficient (DD) are poorly understood, so their conservation status and extinction risk is unknown.

Table 7.1-3: Definitions of IUCN Red List Categories of Extinction Risk

IUCN Red List Status	Definition
Extinct (EX)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), and throughout its historical range have failed to record an individual.
Critically Endangered (CR)	A taxon is Critically Endangered when the best available evidence (severe population decline, very small population, very small geographic area occupied, or a probability of extinction in the next 10 years of >50%) indicates that it is facing an extremely high risk of extinction in the wild.
Endangered (EN)	A taxon is Endangered when the best available evidence (large population decline, small population, small geographic area occupied, or a probability of extinction in the next 20 years of >20%) indicates that it is facing a very high risk of extinction in the wild.
Vulnerable (VU)	A taxon is Vulnerable when the best available evidence (substantial population decline, small population, fairly small geographic area occupied, or a probability of extinction in the next 100 years is >10%) indicates that it is considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered, or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
Least Concern (LC)	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable, or Near Threatened. Taxa that are widespread and abundant are included in this category.
Data Deficient (DD)	A taxon is Data Deficient when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status.

Source: IUCN 2012

There are 296 species known to occur in the coastal or marine habitats in Guyana that are on the IUCN Red List. Seventy-four of these coastal or marine species are ranked NT or higher (i.e., NT, VU, EN, or CR). Table 7.1-4 lists the 74 species with elevated conservation status (ranked NT or higher), their current Red List status, and their primary habitat association. An additional 37 species known to occur in the coastal or marine habitats in Guyana are listed by IUCN as DD (Appendix K, IUCN-Listed Coastal and Marine Species Known from Guyana with Red List Status Classified as Data Deficient). The 74 species with an elevated conservation status include 54 fish, 11 birds, 4 marine turtles, 1 terrestrial turtle, and 4 mammals (1 marine mammal and 3 coastal/riverine mammal species). The vast majority of the species ranked NT or higher are fish, including highly migratory species such as tunas and sharks, bentho-pelagic species including certain groupers, and demersal species including species of skates and rays. As noted in Section 8.1.2, Existing Conditions—Socioeconomic Conditions, many of these fish species are also targeted by the Guyanese commercial fishing industry. According to the IUCN's classification scheme, these species currently face a credible threat of extinction. All but 2 of these 74 species have been observed in the Stabroek Block, along the Guyana coast, or between the coast and the Stabroek Block during the following EEPGL-commissioned survey and monitoring activities conducted over the past several years:

- Marine and coastal bird surveys of the area between Georgetown and the Stabroek Block and within the Stabroek Block (five sampling events): October 2017 (ERM 2018a), April 2018 (ERM 2018b), October 2018, January 2019, and April 2019. See Appendix L, Marine Bird Survey Reports, and Appendix M, Coastal Bird Survey Reports, for the results of the October 2018, January 2019, and April 2019 sampling events.
- Marine and coastal fish surveys (five sampling events): October 2017 and April 2018 (ERM 2018c), and November-December 2018, January 2019, and April/May 2019. See Appendix N, Nearshore and Offshore Fisheries Study Summary Report—Dry Season 2018–2019, for the results of the November/December 2018, January 2019, and April/May 2019 sampling events).
- Protected species observer monitoring (paired observer and passive acoustic monitoring) conducted during EEPGL seismic programs from 2015 through 2019. Data from 2015 through 2018 are reported in RPS (2018); see Appendix O, Protected Species Observer Summary Report, for data collected since 2018.
- Harbor mammal surveys conducted between the mouth of the Demerara River and the Demerara Harbour Bridge (two sampling events): April 2019 and May 2019 (see Section 7.6, Riverine Mammals).
- Marine benthos surveys (five sampling events): 2014 (Maxon and TDI Brooks 2014), 2016 (Fugro 2016), 2017 (ESL 2018), and 2018 and 2019 (see Appendix I, 2018 Environmental Baseline Survey Report, for data collected since 2018).

The two species not observed during EEPGL-commissioned surveys include the giant otter (*Pteronura brasiliensis*) and the yellow-footed tortoise (*Geochelone denticulate*), both of which are most commonly found in inland habitats rather than along the coast. Figures 7.1-3, 7.1-4, and

7.1-5 are photographs of some of the IUCN Red List species observed during EEPGL-commissioned surveys.

Table 7.1-4: IUCN-Listed Coastal and Marine Species Known to Occur in Guyana with Red List Status of NT or Higher

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana
Birds			
Agamia agami	Agami Heron	VU	Coastal lowland forest and marsh
Buteogallus aequinoctialis	Rufous Crab Hawk	NT	Coastal mangrove
Calidris canutus	Red Knot	NT	Coastal mudflat and beach; marine during migration
Calidris pusilla	Semipalmated Sandpiper	NT	Coastal mudflat and beach; marine during migration
Conirostrum bicolor	Bicolored Conebill	NT	Coastal mangrove
Harpia harpyja	Harpy Eagle	NT	Coastal mangrove
Oceanodroma leucorhoa	Leach's Storm-Petrel	VU	Marine
Patagioenas subvinacea	Ruddy Pigeon	VU	Coastal and inland forest
Picumnus spilogaster	White-bellied Piculet	VU	Coastal mangrove
Pterodroma hasitata	Black-capped Petrel	EN	Marine
Ramphastos tucanus	White-throated Toucan	VU	Coastal and riverine forest
Mammals			
Lontra longicaudis	Neotropical otter	NT	Coastal and riverine forests, swamps, and rocky shorelines
Pteronura brasiliensis	Giant otter	EN	Rivers and swamps (inland)
Physeter macrocephalus	Sperm whale	VU	Marine
Trichechus manatus	West Indian manatee	VU	Coastal and riverine
Marine and Terrestrial Turtles			
Chelonia mydas	Green turtle	EN	Marine and coastal
Dermochelys coriacea	Leatherback sea turtle	VU	Marine and coastal
Eretmochelys imbricata	Hawksbill sea turtle	CR	Marine and coastal
Geochelone denticulata	Yellow-footed tortoise	VU	Riverine and interior forest
Lepidochelys olivacea	Olive ridley sea turtle	VU	Marine and coastal
Fishes			
Aetobatus narinari	Spotted eagle ray	NT	Offshore and coastal pelagic
Albula vulpes	Bonefish	NT	Coastal demersal
Alopias vulpinus	Common thresher shark	VU	Offshore and coastal pelagic
Balistes capriscus	Gray triggerfish	VU	Coastal demersal
Balistes vetula	Queen triggerfish	NT	Coastal demersal
Carcharhinus acronotus	Blacknose shark	NT	Coastal pelagic
Carcharhinus brevipinna	Spinner shark	NT	Coastal pelagic
Carcharhinus falciformis	Silky shark	VU	Offshore pelagic
Carcharhinus leucas	Bull shark	NT	Coastal pelagic
Carcharhinus limbatus	Blacktip shark	NT	Coastal pelagic
Carcharhinus longimanus	Oceanic whitetip shark	VU	Offshore and coastal pelagic
Carcharhinus obscurus	Dusky shark	VU	Offshore and coastal pelagic

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana
Carcharhinus perezi	Caribbean reef shark	NT	Offshore and coastal pelagic
Carcharhinus signatus	Night shark	VU	Offshore pelagic
Dermatolepis inermis	Sickelfish grouper	NT	Coastal demersal
Diplobatis pictus	Variegated electric ray	VU	Offshore and coastal demersal
Epinephelus itajara	Atlantic goliath grouper	CR	Coastal demersal
Epinephelus morio	Red grouper	NT	Coastal demersal
Epinephelus striatus	Nassau grouper	EN	Coastal demersal
Fontitrygon geijskesi	Sharpsnout stingray	NT	Offshore and coastal demersal
Galeocerdo cuvier	Tiger shark	NT	Offshore and coastal pelagic
Gymnura altavela	Spiny butterfly ray	VU	Coastal demersal
Hyporthodus flavolimbatus	Poey's grouper	VU	Coastal demersal
Hyporthodus niveatus	Snowy grouper	VU	Coastal demersal
Isogomphodon oxyrhynchus	Daggernose shark	CR	Coastal pelagic
Isurus oxyrinchus	Shortfin mako	VU	Coastal pelagic
Kajikia albida	White marlin	VU	Offshore pelagic
Lachnolaimus maximus	Hogfish	VU	Coastal demersal
Lopholatilus chamaeleonticeps	Golden tilefish	EN	Offshore and coastal demersal
Lutjanus analis	Mutton snapper	NT	Coastal demersal
Lutjanus cyanopterus	Cubera snapper	VU	Coastal demersal
Lutjanus synagris	Lane snapper	NT	Coastal demersal
Manta birostris	Giant manta ray	VU	Offshore and coastal pelagic
Megalops atlanticus	Tarpon	VU	Coastal pelagic
Mola mola	Ocean sunfish	VU	Offshore pelagic
Mycteroperca bonaci	Black grouper	NT	Coastal demersal
Mycteroperca venenosa	Yellowfin grouper	NT	Coastal demersal
Narcine bancroftii	Caribbean electric ray	CR	Coastal demersal
Negaprion brevirostris	Lemon shark	NT	Coastal pelagic
Prionace glauca	Blue shark	NT	Offshore and coastal pelagic
Pristis pristis	Largetooth sawfish	CR	Coastal demersal
Pseudobatos percellens	Chola guitarfish	NT	Offshore and coastal demersal
Raja cervigoni	Venezuela skate	NT	Coastal demersal
Rhincodon typus	Whale shark	EN	Offshore and coastal pelagic
Rhinobatos percellens	Southern guitarfish	NT	Coastal demersal
Rhinoptera bonasus	Cownose ray	NT	Offshore and coastal demersal
Sciades parkeri	Gillbacker sea catfish	VU	Coastal demersal
Sphyrna lewini	Scalloped hammerhead shark	EN	Offshore and coastal pelagic
Sphyrna mokarran	Squat-headed hammerhead shark	EN	Offshore and coastal pelagic
Sphyrna tudes	Smalleye hammerhead shark	VU	Coastal pelagic
Thunnus alalunga	Albacore tuna	NT	Offshore pelagic
Thunnus albacares	Yellowfin tuna	NT	Offshore pelagic
Thunnus obesus	Bigeye tuna	VU	Offshore pelagic
Thunnus thynnus	Atlantic bluefin tuna	EN	Offshore pelagic

Source: IUCN 2019

Photo credit: Waldyke Prince

Figure 7.1-3: Bicolored Conebill (*Conirostrum bicolor*), IUCN Red List Near Threatened, at the Maida Seaside, January 2019

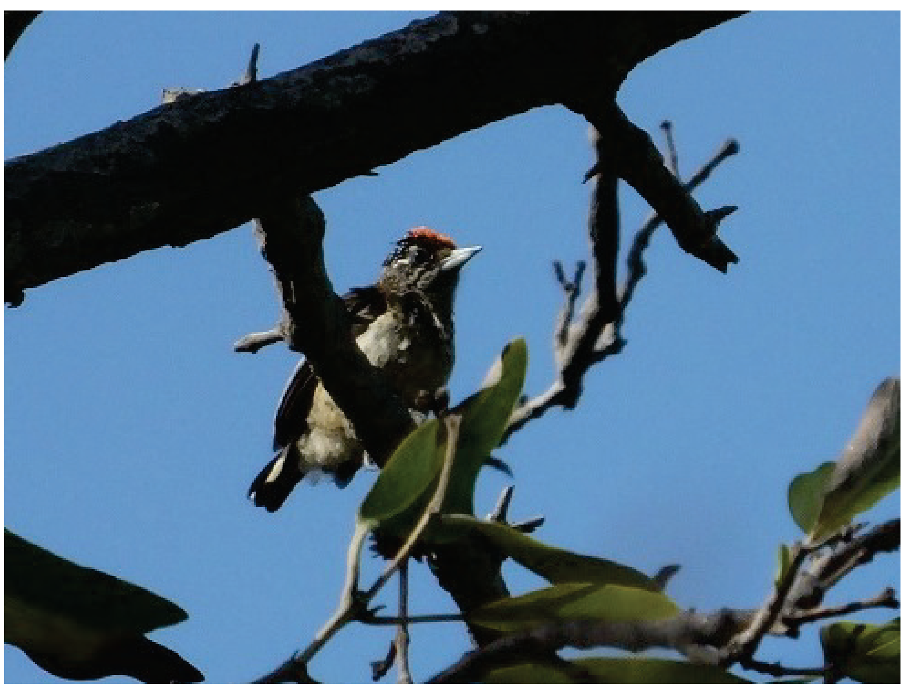


Photo credit: Waldyke Prince

Figure 7.1-4: White-bellied Piculet (*Picumnus spilogaster*), IUCN Red List Vulnerable, at Alness Seaside in Region 6, April 2019

Collected during January 2019 Fish Survey

Figure 7.1-5: Gillbacker Sea Catfish (*Sciades parkeri*), IUCN Red List Vulnerable

7.1.3. Impact Assessment—Protected Areas and Special Status Species

This section describes the assessment of potential impacts on protected areas and special status species.

7.1.3.1. Protected Areas

The planned Project activities, the bulk of which will occur approximately 207 kilometers (128 miles) northeast of the coastline of Georgetown, will not impact SBPA, which is Guyana's only designated protected area within the Project Area of Influence (AOI). The Project's only potential impacts on SBPA would be as a result of an unplanned event (i.e., an oil spill), which is discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

7.1.3.2. Special Status Species

For the purposes of this assessment, special status species are defined as those listed on the IUCN Red List as NT, VU, EN, or CR on the IUCN Red List Version 2019.1 (IUCN 2019) that are known or expected to occur in the Project AOI (see Section 7.1.2, Existing Conditions—Protected Areas and Special Status Species).

Relevant Project Activities and Potential Impacts—Special Status Species

Of the 74 special status species known or expected to occur in the Project AOI, 38 will not be impacted by planned Project activities (Section 7.3.3, Impact Assessment—Coastal Wildlife). They would only potentially be affected by an unplanned event, the impacts of which are discussed in Sections 9.7, Coastal Wildlife, and Section 9.10, Riverine Mammals. Table 7.1-5 presents the distribution of the remaining (non-coastal/inland) special status species, according to taxonomic group and IUCN Red List status, that could experience potential impacts from planned Project activities.

Table 7.1-5: Number of Special Status Species Potentially Affected by Planned Project Activities, Categorized by Taxonomic Group and IUCN Red List Status

Taxonomic Group	Number of Non-Coastal/Inland Special Status Species Known or Expected to Occur within Project AOI (IUCN Red List Status)
Marine turtles	4 (1 CR, 1 EN, 2 VU)
Riverine mammals	2 (1 NT, 1 VU)
Marine mammals	1 (VU)
Marine fish	24 (5 EN, 10 VU, 9 NT)
Seabirds [a] and other migratory birds that occur offshore Guyana in the Stabroek Block	4 (1 EN, 2 NT, 1 VU)

[a] For the purposes of this special status species assessment, the term "special status seabirds" includes two true seabird species (Black-capped Petrel [*Pterodroma hasitata*] and Leach's Storm-Petrel [*Oceanodroma leucorhoa*]) and two migratory shorebird species that have been documented offshore Guyana in the Stabroek Block: Red Knot (*Calidris canutus*) and Semipalmated Sandpiper (*Calidris pusilla*).

Potential impacts from planned Project activities on special status species are the same as those described in the resource-specific impact sections of this EIA (Section 7.7.3, Impact Assessment—Marine Turtles; Section 7.5.3, Impact Assessment—Marine Mammals; Section 7.6.3, Impact Assessment—Riverine Mammals; Section 7.8.3, Impact Assessment—Marine Fish; and Section 7.4.3, Impact Assessment—Seabirds). As discussed in more detail in these resource-specific impact assessment sections, planned Project activities could result in a number of potential impacts on these resources, including: localized changes in the distribution of marine species as a result of altered water quality; acoustic disturbance impacts from Project-induced underwater sound; localized changes in distribution and habitat usage due to disturbance from sound, lighting, vessel traffic, human activity, or the presence of Project infrastructure; entrainment in water intakes; and potential attraction to lighting from the Floating Production, Storage, and Offloading (FPSO) vessel, drill ships, and major installation vessels.

Potential impacts on these groups of resources from unplanned events, including oil spills, discharges of untreated wastewater from the FPSO, contact with the FPSO flare or heat plume, and vessel and helicopter collisions with animals, are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Magnitude of Impacts—Special Status Species

The impact magnitude rating describes the degree of change that the impact is likely to impart on the resource, without regard to resource sensitivity (see Section 4.6, Assessment of Impacts and Identification of Mitigation Measures). Impact magnitude is the same for special status and non-special status species, because the rating describes the impact itself and the change it is likely to cause to the resource.

With the exception of the Black-capped Petrel (*Pterodroma hasitata*), the special status seabirds will have the same exposure to potential impacts as non-special status seabirds because their habitat use, behavior patterns, and biology are similar; accordingly, the magnitude ratings for special status species seabirds were not changed from those used for non-special status seabirds (Section 7.4). All of these species occur seasonally offshore Guyana and the broader Caribbean region, primarily during the non-breeding and migratory periods. For Black-capped Petrel, the magnitude of potential impacts from attraction to offshore Project facilities and light and sound disturbance from offshore Project activities was considered **Negligible** due to the rarity of this species in the PDA and this the very low likelihood that this species would be exposed to these types of potential impacts from the Project. As described in Section 7.4.3.2, Magnitude of Impacts—Seabirds, the magnitude of impacts for the other special status seabird ranges from **Negligible** to **Small** depending on the impact and the Project stage during which the impact occurs.

The 24 species of special status fishes will have the same exposure to potential impacts as non-special status fishes because their habitat use, behavior patterns, and biology are similar; accordingly, the magnitude ratings for special status species fishes were not changed from those used for non-special status fishes (Section 7.8). As described in Section 7.8.3.2, Magnitude and Sensitivity Definitions for Potential Impacts on Marine Fish, the magnitude of impacts ranges from **Negligible** to **Small** depending on the impact and the Project stage during which the impact occurs.

Sections 7.4 through 7.8 provide the details for the basis of the magnitude ratings for all taxonomic groups; the magnitude ratings assigned for each impact and conservation status are provided below.

Sensitivity of Receptor—Special Status Species

The sensitivity of special status species to impacts is considered to be higher than that of non-special status species because special status species are assumed to have a diminished capacity to recover from impacts due to their elevated conservation status. With the exception described below, the designation of sensitivity ratings for special status species is based on the definitions provided in Table 7.1-6.

Table 7.1-6: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Special Status Species

Criterion	Definition
Sensitivity	Negligible: Species with no specific value or importance attached to them.
	Low: Species and sub-species listed as LC on the IUCN Red List (or not meeting criteria for higher IUCN listing status), or without specific anatomical, behavioral, or ecological susceptibilities to potential Project-related impacts.
	Medium: Species listed as VU or NT on the IUCN Red List; species protected under national legislation; nationally restricted range species; regionally important numbers of migratory or congregatory species; species not meeting rating criteria as EN or CR; and species vital to the survival of a medium value species.
	High: Species on IUCN Red List categorized as CR or EN. Species having a locally restricted range, low number of sites where they occur, or highly fragmented population (i.e., endemic species to a site, or found globally at fewer than 10 sites, fauna having a distribution range less than 50,000 square kilometers), internationally important numbers of migratory or congregatory species, species exhibiting or undergoing key evolutionary processes, and species vital to the survival of high value species.

In the case of the resource-specific assessments for marine mammals (Section 7.5) and marine turtles (Section 7.7), the assessments of impact significance assume the affected receptors are all special status species, so the sensitivities for special status marine mammals and marine turtles are identical to those presented in Sections 7.5 and 7.7. In the case of seabirds and marine fish, the resource-specific assessments presented in Section 7.4, Seabirds, and Section 7.8, Marine Fish, are not conducted on the basis of an assumed special status for the receptors. Accordingly, additional review of the sensitivity ratings assigned in Section 7.4 for seabirds and Section 7.8 for marine fish was warranted.

Contrary to other potential impacts, anthropogenic disturbance of turtles at sea (the only potential impact on marine turtles from planned Project activities with a magnitude higher than **Negligible**) is not known to be a major contributor to declines in listed turtle species. Accordingly, the sensitivity rating for this particular impact was not defined based on marine turtles' listing status, but rather on the basis of their anticipated propensity to adapt to occasional disturbance. Increased activity in the PDA and between the PDA and shorebases could cause turtles approaching nesting beaches from the northeast to deviate from their normal migration route, but marine turtles are not known to be particularly sensitive to human activity while at sea and no publicly available research suggests that turtles would be more susceptible to disturbance in the nearshore environment when approaching nesting beaches. Deviation from normal movement patterns would likely be temporary during the disturbance period and would not be expected to result in a significant effect on nesting. On this basis, receptor sensitivity for marine turtles is considered **Low** for this potential impact.

Impact Significance—Special Status Species

As summarized in Table 7.1-8, based on the ranges of magnitudes for potential impacts and the receptor sensitivity ratings applicable for the various IUCN listing levels, the pre-mitigation significance ratings for potential impacts on special status species range from **Negligible** to **Moderate**.

7.1.4. Mitigation Measures—Protected Areas and Special Status Species

The embedded controls integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on marine fish, marine mammals, seabirds, and marine turtles. The same applies for members of these taxonomic groups that carry a special status designation. Table 7.1-7 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.1-7: List of Embedded Controls and Monitoring Measures

Embedded Controls
When non-aqueous drilling fluid (NADF) is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
Employ trained Marine Mammal Observers during the conduct of seismic-related activities.
Conduct a continuous observation of a mitigation zone (500 meters [1,640 feet] around the sound source) to verify whether it is clear of marine mammals and marine turtles before commencing sound producing seismic operations. Do not commence sound-producing seismic operations (including soft starts) if marine mammals or turtles are sighted within the mitigation zone during the 30 minutes prior to commencing sound-producing operations in water depths less than 200 meters (656 feet), or 60 minutes prior to commencing sound-producing operations in water depths greater than 200 meters.
Where practicable, ensure that sound-making devices or equipment are equipped with silencers or mufflers and are enclosed, and/or use soft-start procedures (e.g., for pile driving, vertical seismic profiling, etc.) to reduce noise to levels that do not cause material harm or injury to marine species.
Adhere to the JNCC Guidelines (2017) during the conduct of seismic-related activities.
During pile-driving activities, gradually increase the intensity of hammer energy to allow sensitive marine organisms to vacate the area before injury occurs (i.e., soft starts).
Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with International Maritime Organization/International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 mg/L on a daily basis or 29 milligrams per liter (mg/L) on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals
Measure residual chlorine concentration of sewage discharges form the FPSO monthly to ensure it is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to ensure that there are no floating solids or discoloration of the surrounding waters.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' specifications and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.

Implement a chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
Ensure wastewater released from the onboard sewage treatment plant complies with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.
Ensure there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge.
Treat bilge water in accordance with MARPOL 73/78 to ensure compliance with an oil in water content of less than 15 parts per million as applicable.
Where practicable, direct lighting on FPSO and major Project vessels to required operational areas rather than at the sea surface or skyward. Ensure lighting on vessels adheres to maritime safety regulations/standards.
Provide screening for seawater intakes, if safe and practical, to avoid entrainment and impingement of marine flora and fauna.
Monitoring Measures
Monitor on an ongoing basis visual detections of marine mammals, riverine mammals, and marine turtles.
Prior to and post-drilling, a remotely operated vehicle will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to ensure that end of well maximum weighted mass ratio averaged over all well sections drilled using non-aqueous base fluid shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C at 100 meters (approximately 328 feet) from point of discharge.
Utilize load monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Monitor chlorine concentration of treated sewage discharges.
Perform daily visual inspection of discharge points to ensure absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to ensure compliance with 15 parts per million MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.1-8 summarizes the assessment of potential pre-mitigation and residual Project impacts on special status species. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the special status species-specific methodology described in Section 7.1.3.2 and the resource-specific methodologies described in Sections 7.4, Seabirds; 7.5, Marine Mammals; 7.7, Marine Turtles; and 7.8, Marine Fish.

Table 7.1-8: Summary of Potential Pre-Mitigation and Residual Impacts—Special Status Species

Group	IUCN Designation	Range of Magnitude Ratings [a]	Sensitivity Rating	Range of Pre-Mitigation Significance Ratings	Proposed Mitigation Measures	Range of Residual Significance Ratings
Marine Turtles	CR, EN	Negligible to Small	Low to High [b]	Negligible	None	Negligible
	VU	Negligible to Small	Low to Medium [b]	Negligible	None	Negligible
Marine Mammals	VU	Negligible to Medium	Medium	Negligible to Moderate	None	Negligible to Moderate
Riverine Mammals	VU	Small	Medium	Minor	None	Minor
	NT	Small	Medium	Minor	None	Minor
Marine Fish (Offshore)	EN	Negligible to Small	High	Negligible to Moderate	None	Negligible to Moderate
	VU	Negligible to Small	Medium	Negligible to Minor	None	Negligible to Minor
	NT	Negligible to Small	Medium	Negligible to Minor	None	Negligible to Minor
Marine Fish (Coastal)	CR	Negligible	High	Negligible	None	Negligible
	EN	Negligible	High	Negligible	None	Negligible
	VU	Negligible	Medium	Negligible	None	Negligible
	NT	Negligible	Medium	Negligible	None	Negligible
Seabirds	EN	Negligible	High	Negligible to Minor [c]	None	Negligible to Minor
	VU	Negligible to Small	Medium	Negligible to Minor	None	Negligible to Minor
	NT	Negligible to Small	Medium	Negligible to Minor	None	Negligible to Minor

[a] Magnitude ratings referenced from resource-specific sections (Sections 7.4, Seabirds; 7.5, Marine Mammals; 7.6, Riverine Mammals; 7.7, Marine Turtles; and 7.8, Marine Fish) unless otherwise indicated
[b] Sensitivity rating of Low for potential impacts related to disturbance at sea; IUCN designation-based sensitivity ratings were used for other potential impacts
[c] Although the impact assessment methodology indicates an impact significance rating of Negligible (based on magnitude and sensitivity), a rating of Minor was assigned for attraction-related impacts during the production operations phase of the Project based on the small size and declining population trend of this species (Black-capped Petrel) and the duration of the production operations stage of the Project (20 years) (see Section 7.4, Seabirds).

7.2. Coastal Habitats

7.2.1. Administrative Framework—Coastal Habitats

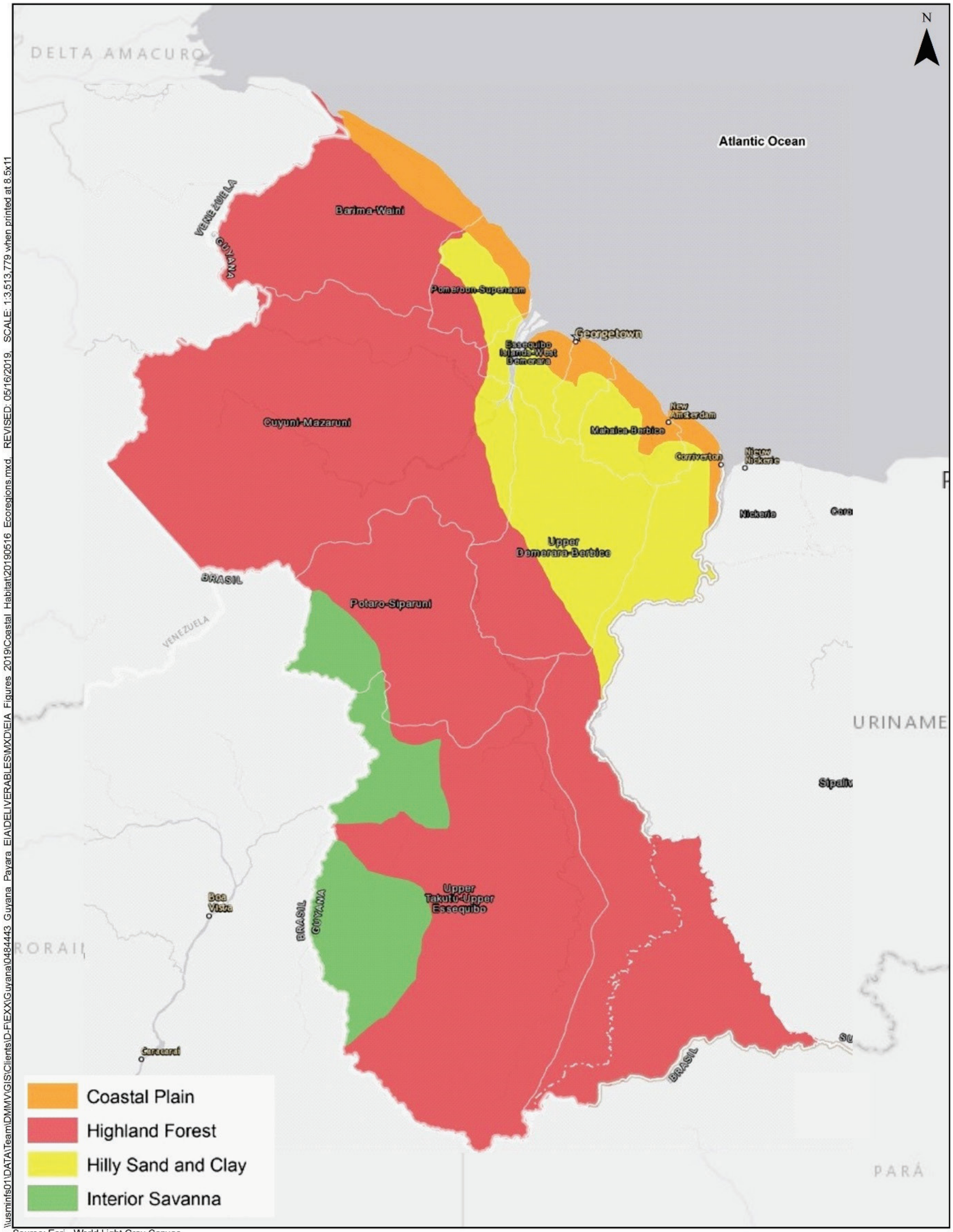
Table 7.2-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on coastal habitats.

Table 7.2-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Coastal Habitats

Title	Objective	Relevance to the Project
Legislation		
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora.	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a supportive mechanism cognizant of the national goals for wildlife protection, conservation, management, sustainable use, and external trade.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.
Protocol on Specially Protected Areas and Wildlife	Protocol supplementing and supporting the Cartagena Convention. Requires signatories to adopt an ecosystem approach to conservation. Provides mechanism for compliance with the Convention on Biological Diversity.	Elaborates on the wildlife goals established in the Cartagena Convention and Convention on Biological Diversity. Acceded and Ratified in 2010.

7.2.2. Existing Conditions—Coastal Habitats

There are four ecoregions in Guyana (Figure 7.2-1): coastal plain, interior savannas, hilly sand and clay, and highland forest (EPA and MoNRE 2015). Neither the planned activities of the Project nor the unplanned events considered in relation to the Project will have an impact on the interior savannas, hilly sand and clay, or highland forest; accordingly, this section focuses on habitats of the coastal plain (note that the only potential impacts on the coastal plain would be those associated with unplanned events [i.e., an oil spill]).



Source: Esri - World Light Gray Canvas

Figure 7.2-1: Guyana's Ecoregions

The coastal plain is a narrow belt of sediments with riverine and marine clays and silts stretching along Guyana's coastline. It occupies approximately 7 percent of the country's total area and extends along the entire length of the coastline—approximately 400 kilometers (approximately 250 miles)—of the Atlantic coast, varying in width from approximately 16 to 64 kilometers (approximately 10 to 40 miles) (Kalamandeen and Da Silva 2002) and in elevation from sea level to approximately 3 meters (approximately 10 feet) above sea level (EPA and MoNRE 2015). The coastal plain is a highly productive and sensitive environment that is subjected to marine and terrestrial influences. Guyana's coastal plain includes a network of plains and low hills, including mangroves, salt to brackish lagoons, brackish herbaceous swamps, and swamp forests. Guyana's coastal plain contains some of the world's most productive ecosystems, with rich biological diversity (Kalamandeen and Da Silva 2002). The swamps are an important source of freshwater to mangroves and other flora and fauna (WWF 2016).

Along the Guyana shoreline, which is the portion of the coastal plain with the most potential to be impacted by an unplanned event associated with the Project, the principal habitats are:

- Mangroves
- Beaches
- Mudbanks
- Tidal flats, including mudflats and sandflats
- Vegetated low banks
- Salt and brackish marshes
- Riprap and exposed solid manmade structures

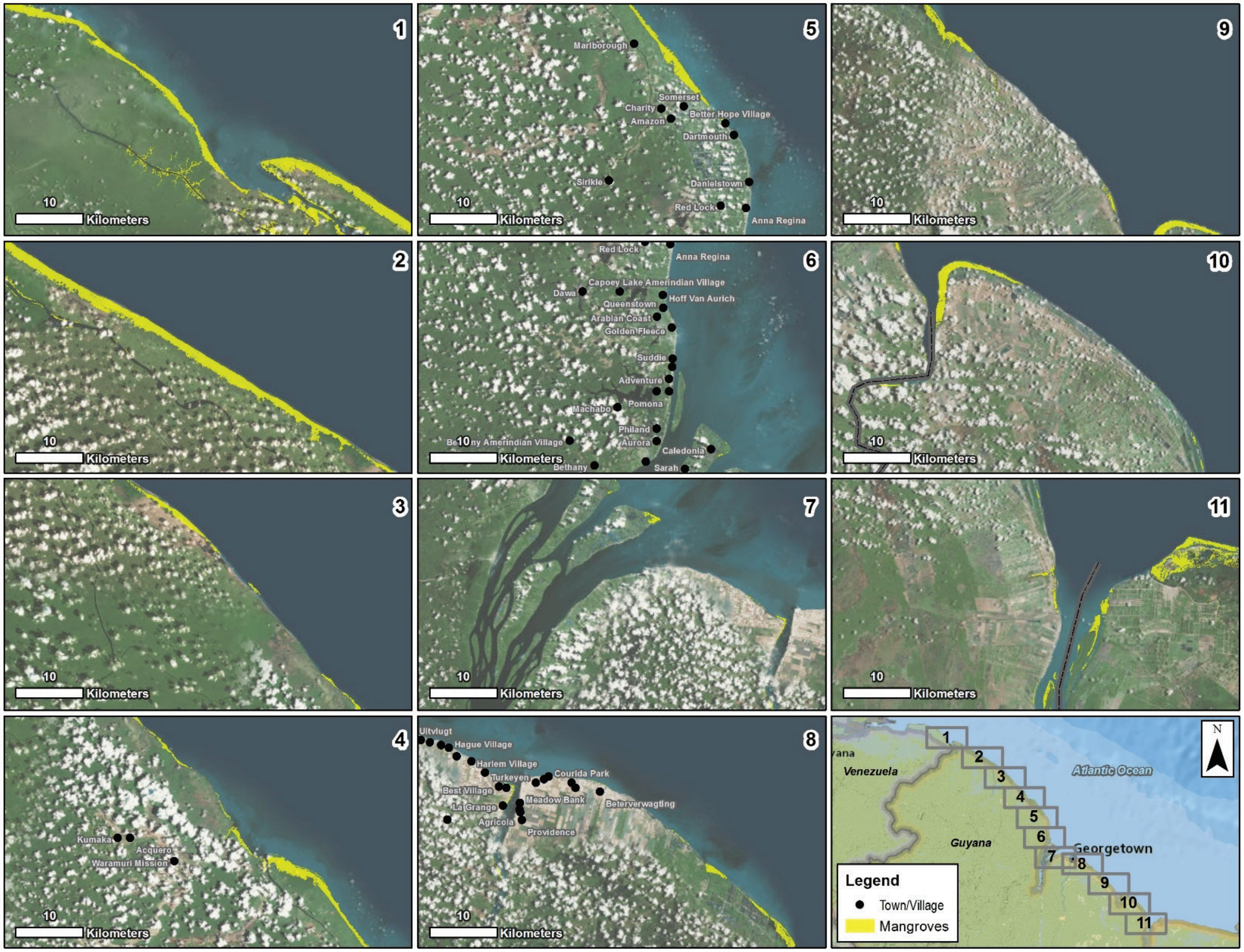
These habitats are described in the sections below.

7.2.2.1. Mangroves

Mangroves are regarded as one of the most important ecosystems for the security of the biodiversity of the entire Guyana coast, as they protect coastlines from wave action and shoreline erosion (see Section 6.3.2, Existing Conditions—Marine Geology and Sediments). A 2008 Smithsonian report stated that mangroves occupied more than 81,000 hectares (approximately 200,155 acres) of Guyana's coast, in 6 of Guyana's 10 geopolitical regions. The Guyana Mangrove Restoration Project estimates that 75 percent of the country's mangroves are concentrated in Regions 1 and 2 (GMRP 2010), which are located along the northern part of the Guyana coast and include the SBPA.

Figure 7.2-2 shows the distribution of coastal mangrove resources in Regions 1 through 6, based on interpretation of satellite imagery[1] and fieldwork conducted in November 2017 and April 2018.

[1] Sentinel 2 multispectral imagery from 2017; and Google Earth imagery ranging from 2009 to 2017. Sentinel 2 is a European Space Agency mission composed of two satellites that provide wide-swath, high-resolution, multi-spectral imaging. Google Earth aggregates imagery from a variety of publicly available sources.



Note: Yellow shading indicates mangroves.

Figure 7.2-2: Guyana's Coastal Mangrove Distribution

The fieldwork was conducted for all coastal mangroves not blocked by barrier islands (collectively, "the Mangrove Study Area") as part of a broader effort to field-verify the major features of the coastal sensitivity maps (Appendix P, Coastal Sensitivity Maps) that have been developed for the Project. Although the 2017-2018 fieldwork did not include riverine mangroves, the study did support the conclusion that coastal mangroves are heavily concentrated in the northern portion of the Guyana coastline within Regions 1 and 2. Table 7.2-2 and Figure 7.2-3 summarize the estimated area covered by coastal mangroves in Regions 1 through 6 based on the results of the coastal mapping field verification effort.

Table 7.2-2: Distribution of Coastal Mangroves in Regions 1 through 6

Region	Area Covered by Mangroves (hectares)	Percentage of Area of All Mangroves in Mangrove Study Area
Region 1	43,170	80.1
Region 2	5,242	9.7
Region 3	1,055	2.0
Region 4	380	0.7
Region 5	1,841	3.4
Region 6	2,215	4.1
TOTAL	53,904	100

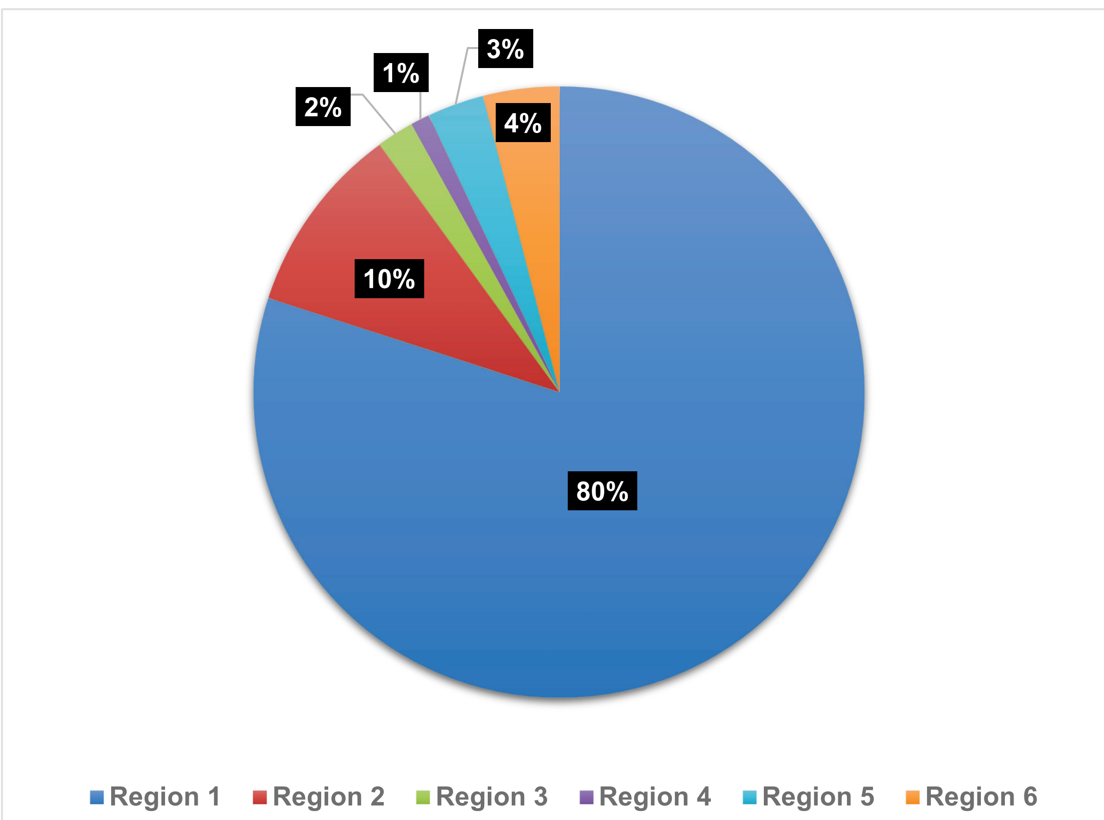


Figure 7.2-3: Distribution of Mangroves in Regions 1 to 6

This study classified mangroves in one of five categories of "sensitivity"[2] based on a combination of relative biomass, mangrove age, and stability (whether it was eroding, stable, or expanding). Table 7.2-3 and Figure 7.2-4 summarize the results of the mangrove sensitivity assessment in Regions 1 through 6. Figure 7.2-5 is a mosaic of photographs taken during the field verification process showing examples of the five ratings of mangrove sensitivity.

Table 7.2-3: Mangrove Sensitivity Classifications for Regions 1 through 6

Sensitivity Rating	Total Area for Sensitivity Rating (hectares)	Percentage of Area of All Mangroves in Mangrove Study Area
Critical Sensitivity	6,478	12.0
Very High Sensitivity	312	0.6
High Sensitivity	26,122	48.5
Medium Sensitivity	20,000	37.1
Low Sensitivity	992	1.8
TOTAL	53,904	100

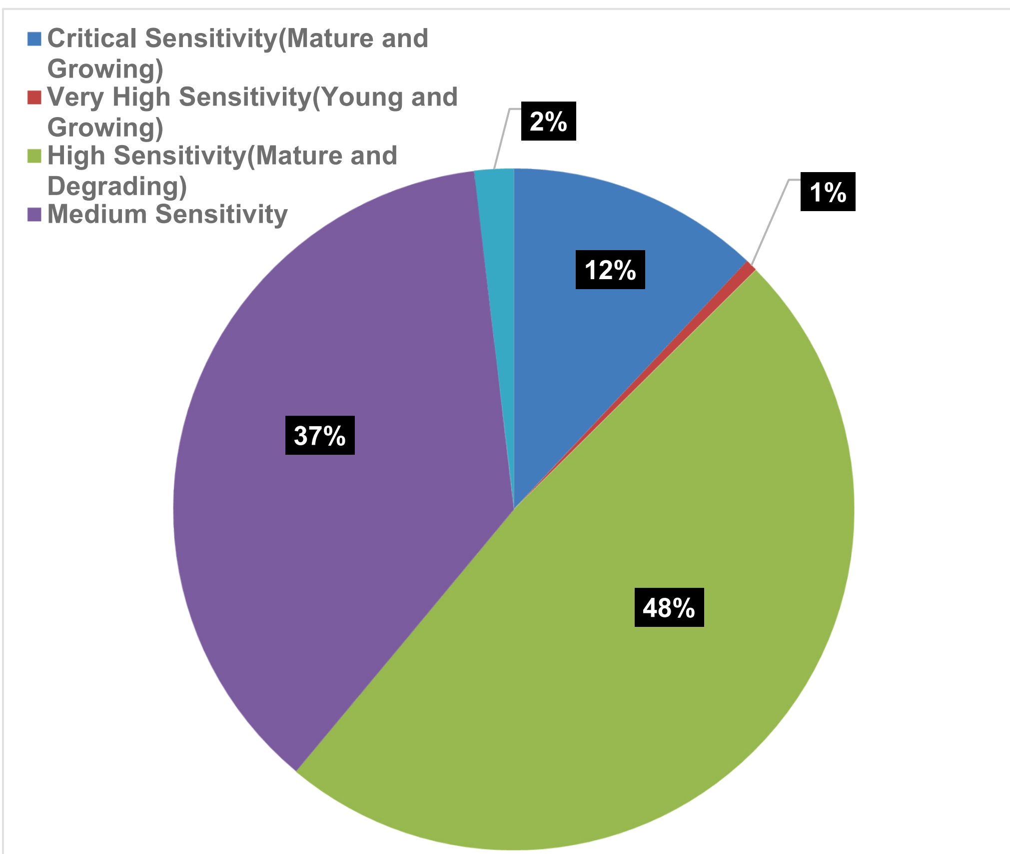


Figure 7.2-4: Sensitivity Ratings for Coastal Mangroves in Regions 1 to 6

2 The study was conducted in the context of mapping coastal "sensitivities" but with respect to mangroves, the "sensitivity" classification was equivalent to ecological value of the mangroves.

Sensitivity Class	Representative Photograph
Critical Sensitivity (high biomass, mature, expanding)	
Very High Sensitivity (high biomass, young, growing/expanding)	

Sensitivity Class	Representative Photograph
High Sensitivity (high biomass, mature, static or degrading)	
Medium Sensitivity (medium biomass, all age classes, static or degrading)	

Sensitivity Class	Representative Photograph
Low Sensitivity (low biomass, all age classes, degrading or eroding)	

Source: ERM 2018

Figure 7.2-5: Examples of the Five Ratings of Mangrove Sensitivity

There are currently three species of mangrove in Guyana: red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Laguncularia racemosa*). Mangroves in Guyana have a unique distribution pattern that is different from the norm in most other countries. The National Agricultural Research and Extension Institute (NAREI 2014) noted that in Guyana black mangroves typically colonize the coastal shorelines, while red mangroves establish further inland along rivers. There is some overlap in the typical distribution of these species elsewhere, but in general the pattern in other countries is for red mangroves to establish along the shoreline, black mangroves to establish farther inland, and white mangroves to establish the farthest inland.

Like most coastal habitats, mangroves are dynamic habitats that are capable of rapid changes over time. As part of the coastal sensitivity verification study, the Consultants analyzed historical imagery to identify areas where mangroves have been lost along the coast. The analysis documented the loss of approximately 1,460 hectares (approximately 3,608 acres) of mangroves since 1980, based on comparison of imagery from 1980 against imagery from 2017. This represents a loss equivalent to 3 percent of the total estimated coastal mangrove coverage in Guyana over a period of slightly less than four decades.

Mangrove ecosystems are known to be among the most productive ecosystems in the world (Mann 1982), serving major habitats while providing shelter and feeding sites for many faunal species (Mestre et al. 2007). Coastal mangroves are vital to Guyana's biodiversity, physical security, and economy (WWF 2016; GMRP 2010; Ilieva undated). Many invertebrate inhabitants of mangrove ecosystems in Guyana, including snails, barnacles, tunicates, mollusks, polychaete worms, oligochaete worms, shrimp, crabs, sponges, jellyfish, amphipods, and isopods, live either on or in close proximity to mangrove roots and/or the bottom substrate. These small organisms provide forage for birds, mammals, reptiles, amphibians, and fish. Herons, egrets, and ibises are the most conspicuous group of bird species found in mangroves, due to the abundant food sources in a relatively safe habitat (Da Silva 2014).

7.2.2.2. Beaches

Guyana has relatively few beaches and the largest expanse of beaches in the country lies within the SBPA. The SBPA beaches are critically important nesting habitats for marine turtles. They also provide habitat used by a variety of avian, herptile, and mammalian species (see Figure 7.1-2 for the locations of beaches in the SBPA; see Figure 7.2-6 for a representative photograph of an expanse of beach in Region 2).

Figure 7.2-6: Beach Habitat in Region 2 near the Border with Region 1

7.2.2.3. Mudbanks

“Mudbanks” generally refer to the submerged mud features below the low tide line, as distinct from the intertidal “mudflats” (see Section 6.3.2, Existing Conditions—Marine Geology and Sediments, for a description of the physical attributes and location of Guyana’s mudbanks). According to a recent study by Anthony et al. (2013), accretion of muddy sediments discharged from the Amazon River is the most significant natural phenomenon controlling the shape of the coast of South America between the Amazon and Orinoco rivers. About 15 to 20 percent of this muddy discharge forms coastal mudbanks that migrate towards the mouth of the Orinoco River. These mudbanks are characterized by extremely large spatio-temporal geomorphic variability resulting from intense wave-reworking of the migrating banks, mangrove colonization and destruction, and erosion in interbank areas.

No targeted biological surveys of Guyana’s mudbanks have been conducted to date, but coastal mudbank habitats typically support burrowing invertebrates such as marine worms, mollusks, crustaceans, amphipods, and copepods. This invertebrate community provides important forage for bottom-feeding fishes such as grunts, catfishes, and snappers (particularly during their early life stages).

7.2.2.4. Tidal Flats

There are two main types of tidal flat habitats along Guyana’s coastline—mudflats and sandflats. Both of these tidal flat habitats occur in the intertidal zone, so they are submerged under water and exposed twice daily with the tides. The flats are formed by the deposition of mud or sand as a result of the tides. As suggested by their names, mudflats and sandflats are primarily differentiated from one another by their substrates: mudflats have a mud substrate and sandflats have a sand substrate, although due to regular tidal action, these habitats are highly dynamic and there is a continuous gradation between them. The plant and animal communities that are associated with these habitats vary depending on the type and stability of the substrate.

Mudflats

Mudflats are usually barren (without any vegetation) and the mud can range from very soft (almost liquid) to highly compact. Mudflats protect inland landforms from erosion and they are a highly productive and important ecosystem. Mudflats are often associated with coastal mangroves and salt marshes and these areas together constitute an ecologically important ecosystem for fish and invertebrates, which provide an essential food base for birds, particularly migratory shorebirds that stop-over in Guyana during their bi-annual northward and southward migrations. Each year during spring and fall migration, hundreds (and sometimes thousands) of individual birds stop to feed in Guyana’s most extensive mudflats located at Exmouth seaside, Walton Hall seaside, Anna Regina seaside, Ogle seaside, Enmore seaside, Maida seaside and Bush Lot seaside (see Figure 7.2-7, Figure 7.2-8, and Section 7.3, Coastal Wildlife). These mudflats (some with adjacent mangrove habitats) can be termed as Important Bird Habitat (IBH) sites due to their importance for migratory shorebirds and resident coastal birds.

Figure 7.2-7: Mudflat at Bush Lot Seaside—Important Bird Habitat

Source: Esri - World Oceans Map

Figure 7.2-8: Locations of Important Tidal Flats in Coastal Guyana

Sandflats

Sandflats are similar to mudflats except they are composed primarily of sand rather than mud. They are usually associated with another shoreline type on the landward side of the flat, though they can occur as separate shoals, and they are commonly associated with tidal inlets. When mud accretes on sandflats, a rapid change in the physical structure of the sandflat can occur. Compaction of the sand and mud over time facilitates rapid growth of vegetation, with complete vegetation coverage of the sandflat in potentially less than 1 year. For example, Affiance Seaside in Region 2 changed from an unvegetated sandflat in August 2017 to a fully vegetated sandflat in April 2018 and vegetation cover persists in April 2019 (see Figure 7.2-9). Vegetated sandflats are ecologically important habitats because they provide food for marine turtles and attract juvenile fish and invertebrates, which are important food sources for birds.

Figure 7.2-9: Vegetated Sandflat at Affiance Seaside in April 2019

7.2.2.5. Vegetated Low Banks

Vegetated low banks are low banks that are covered in grasses, shrubs, or trees with the roots regularly exposed to the water through tides (see Figure 7.2-10).

Note: Tiger Island is in the photo background.

Figure 7.2-10: Vegetated Low Bank along the Region 2 Shoreline

7.2.2.6. Salt and Brackish Marshes

Salt and brackish marshes are intertidal wetlands that consist of emergent, herbaceous vegetation. Depending on inter-annual variations in the amount and location of rainfall and runoff, associated vegetation may include species tolerant of or adapted to salt, brackish, or tidal freshwater conditions. Salt and brackish marshes are often formed in a sheltered area or behind a structure, such as a seawall or groin where water movement slows down - allowing for deposition of mud and growth of vegetation (see Figure 7.2-11). The marsh width may vary widely, from a narrow fringe to an extensive area. Sediments are composed of rich, organic mud except on the margins of islands. Wildlife in saltmarsh and brackish marsh habitats can be abundant and diverse. A wide variety of invertebrates inhabit the mud substrate and fish and shrimp use the vegetation for foraging, sheltering, and laying their eggs. Birds forage on the invertebrates and fish and nest and roost in the vegetation.

Figure 7.2-11: Saltmarsh Habitat in Region 2 that Developed after the Installation of a Groin

7.2.2.7. Riprap and Exposed Solid Manmade Structures

Riprap structures are composed of cobble to boulder-sized blocks of rock, concrete, and similar materials and are usually used as revetments and groins for shoreline protection and breakwater and jetties around inlets and marinas (see Figure 7.2-12). Exposed solid manmade structures include seawalls, groins, revetments, piers, and port facilities constructed of concrete, wood, or metal. Most of the structures are designed to protect a single lot, thus their composition, design, and condition are highly variable along the coastline. Some biota (primarily macroinvertebrates and aquatic plants) attach themselves to the riprap and other manmade structures, particularly in the lower intertidal zone that receives regular tidal inundation.

Sea Defense Work is taking place involving the placement of riprap in front of the seawall.

Figure 7.2-12: Boulder Riprap at Met-Meer-Zorg in Region 3 in April 2019

7.2.3. Impact Assessment—Coastal Habitats

The planned Project activities, the bulk of which will occur approximately 207 kilometers (128 miles) northeast of the coastline of Georgetown, will not impact any coastal habitats. Operation of the existing Guyana shorebases on the east side of the Demerara River will have little to no impact on coastal habitat. Additional onshore facilities may be utilized by other companies; any such additional onshore facilities will be owned/operated by others and will not be dedicated to the Project. Should any new or expanded shorebases or onshore support facilities be utilized, the construction/expansion and any required dredging of such facilities, as well as the associated environmental authorization, would be the responsibility of the owner/operator, and such work scope is therefore not included in the scope of the Project EIA.

The Project's only potential impact on coastal habitats would be as a result of an unplanned event (i.e., an oil spill), which is discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

7.2.4. Mitigation Measures—Coastal Habitats

As the planned activities of the Project are not anticipated to impact any coastal habitats, no mitigation measures associated with planned activities are proposed. Mitigation measures to address potential impacts on coastal habitats from an unplanned event are discussed in Chapter 9.

7.3. Coastal Wildlife

7.3.1. Administrative Framework—Coastal Wildlife

Table 7.3-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on coastal wildlife.

Table 7.3-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Coastal Wildlife

Title	Objective	Relevance to the Project
Legislation		
Wild Birds Protection Act, 1987	Protects listed wild birds in Guyana.	Sections 3 and 6 prohibit knowingly wounding or killing wild birds listed in the First and Second Schedule of the Act, and establishes penalties.
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora.	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a supportive mechanism cognizant of the national goals for wildlife protection, conservation, management, sustainable use, and external trade.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Signed in 1992, ratified in 1994.

7.3.2. Existing Conditions—Coastal Wildlife

Guyana occupies the west-central portion of the Guianan mangrove ecoregion, which extends from southeastern Venezuela southeast to French Guiana between the Orinoco River Deltas and the Oyapok River Delta in French Guiana. The ecoregion is a bio-geographical, rather than geopolitical, region and was designated as a distinct ecoregion by the World Wildlife Fund as part of their Terrestrial Ecosystems of the World project (Olson et al. 2001). Despite supporting over 90 percent of the country's human population, Guyana's coastal region supports a diverse fauna. This section briefly describes bird, mammal, and herpetofauna (reptile and amphibian) species that are representative of Guyana's coastal region.

7.3.2.1. Coastal Mammals and Herpetofauna

Numerous mammal and herpetofauna species occur in Guyana's coastal mangroves, agricultural areas, and forests. There are over 50 species of mammals present, including opossums; bats; primates such as capuchin monkey (*Cebus apella*), squirrel monkey (*Saimira sciureus*), howler monkey (*Alouatta seniculus*) and Guianan saki (*Pithecia pithecia*); giant anteater (*Myrmecophaga triactyla*); several species of cats including jaguar (*Panthera onca*), puma (*Puma concolor*), and ocelot (*Leopardus pardalis*); ungulates; and rodents including the capybara (*Hydrochaeris hydrochaeris*), paca (*Agouti paca)*, and red-rumped agouti (*Dasyprocta leporina*); red and grey brocket deer (*Mazama* sp.); giant river otter (*Pteronura brasiliensis*), which is a freshwater species; and neotropical otter (*Lontra longicaudi*s), which is found in both freshwater and estuarine habitats (Figure 7.3-1). Reptiles that frequent this ecoregion are the green iguana (*Iguana iguana*), spectacled caiman (*Caiman crocodilus)*, and green anaconda (*Eunectes murinus*). Amphibians are generally less common along the coast than in the interior, especially due to saline influence in the mangroves, but some of the species that occur along the coast include several species of tree frogs (*Hyla* sp.), the paradoxical frog (*Pseudis paradoxa*), cane toad (*Rhinella marina*), and pipa frog (*Pipa pipa*).

No comprehensive, targeted surveys for mammals or herpertofauna along Guyana's coast have been conducted. Two biodiversity surveys have been undertaken within and around the SBPA over roughly the past decade and these surveys included documentation of 27 mammal and 41 herpetofauna (28 reptile and 13 amphibian) species, including many of those listed above (Mendonca et al. 2006; EPA et al. 2004; see Appendix Q, Flora and Fauna of Shell Beach). Incidental observations of mammals documented during EEPGL-commissioned coastal bird surveys in 2017, 2018, and 2019 (see Section 7.3.2.2, Coastal Birds, for a detailed description of these surveys) documented some of the species above and also Guianan red howler monkey (*Aloutta macconnelli*), wedge-capped capuchin monkey (*Cebus albifrons*), Indian grey mongoose (*Herpestes edwardsi*), and crab-eating raccoon (*Procyon cancrivorus*) (Figure 7.3-2). EEPGL commissioned a targeted survey of riverine mammals in early 2019 in the area between the Demerara Harbour Bridge and the mouth of the Demerara River. Two surveys have been conducted to date, each yielding a single observation of West Indian manatee (*Trichechus manatus*).

Figure 7.3-1: Puma (*Puma concolor*) Swimming across Baramanni Creek, Region 1

Photo credit: Waldyke Prince

Figure 7.3-2: Crab-eating Raccoon (*Procyon cancrivorus*) Observed at Phillipe Seaside in Region 6, April 2019

7.3.2.2. Coastal Birds

Historical Data

Guyana's coastal bird community is abundant and diverse, with over 200 recorded species within 21 families representing multiple bird groups, including parrots and macaws, passerines, waterfowl, colonial waterbirds, shorebirds, and raptors. The bird groups that are most strongly affiliated with the coast are waterfowl, shorebirds, and colonial waterbirds. Waterfowl are species of birds that are ecologically dependent upon wetlands or waterbodies for their survival (e.g., ducks, geese, etc.). Shorebirds are found mainly on beaches and mudflats between the low and high water marks and are typically migratory, utilizing Guyana's coastline during the course of their bi-annual migrations. Colonial waterbirds are birds that live near water and nest in colonies or groups (e.g., gulls, terns, ibis, herons, etc.).

Braun et al. (2007) developed a comprehensive checklist of the 814 bird species within 11 habitats documented in Guyana. The coastal habitats surveyed include mangrove forests (47 species documented within 18 families) and mudflats (38 species documented within 8 families; Braun et al. 2007). Another coastal bird survey conducted along the coast in the Georgetown region by Bayney and Da Silva (2005) documented 32 coastal bird species, 20 of which are migrants. The most abundant species documented in the survey were shorebirds including Least Sandpiper (*Calidris minutilla*), Spotted Sandpiper (*Actitis malcularia*), Ruddy Turnstone (*Arenaria interpres*), and Semipalmated Plover (*Charadrius semipalmatus*). Waterbird species including Cattle Egret (*Bulbulcis ibis*) and Snowy Egret (*Egretta thula*) were also abundant. A more recent bird survey within coastal mangrove habitats in southeast Guyana identified 37 species within 14 families (Da Silva 2014). In this 2014 survey, the most abundant species recorded were the Great Egret (*Ardea alba*), Greater Kiskadee (*Pitangus sulphuratus*), Pied Water Tyrant (*Fluvicola pica*), Rufous Crab-hawk (*Buteogallus aequinoctialis*), and Scarlet Ibis (*Eudocimus ruber*) (Da Silva 2014).

Two biodiversity surveys undertaken within SBPA over roughly the past decade documented over 200 bird species in the Shell Beach area, including many forest interior species that occur in the inland habitats of Shell Beach (Mendonca et al. 2006; EPA et al. 2004) (Appendix Q, Flora and Fauna of Shell Beach). Many of the over 200 species documented are migrants, traveling from United States and Canada to spend the winter season in Guyana, primarily following the Atlantic and Central Flyways to South America. The most abundant coastal species recorded at and around Shell Beach during the two surveys included Black-bellied Whistling-duck (*Dendrocyna autumnalis*),[3] Laughing Gull (*Larus atricilla*), Least Tern (*Sterna antillarum*), Spotted Sandpiper, Lesser Yellowlegs (*Tringa flavipes*), Scarlet Ibis, and Yellow-billed Tern (*Sterna superciliaris*) (Mendonca et al. 2006; EPA et al. 2004).

Collectively, species accounts from all these reports document the presence of 95 species of coastal birds from 32 families in Guyana. Another 113 species of non-coastal birds have been documented in inland habitats of the SBPA (Mendonca et al. 2006; EPA et al. 2004). These

[3] Recorded as a freshwater species in Braun et al. 2007

113 species occasionally occur in coastal areas as transients, but are not expected to occur there regularly, so are not considered coastal birds.

Coastal Bird Survey Data Collected from 2017 to 2019

EEPGL commissioned a series of seasonal coastal bird surveys along the Guyana coast between 2017 and 2019 (ERM 2018 and Appendix M, Coastal Bird Survey Reports, Interim Reports). Surveys of coastal birds were conducted across six regions by teams of international and Guyanese bird specialists in the following time periods and locations:

- Fall 2017 Survey: Occurred 23–27 September 2017 and 19–22 October 2017 at coastal sites in Regions 2-5 and the Essequibo Islands
- Spring 2018 Survey: Occurred 3–13 April 2018 and 16–24 April 2018 at coastal sites in Regions 1-6 and the Essequibo Islands
- Fall 2018 Survey: Occurred 14–15 September 2018 and 30 September to 3 October 2018 at coastal sites in Regions 2–6 and the Essequibo Islands
- Winter 2019 Survey: Occurred 22 January to 2 February 2019 at coastal sites in Regions 2–6 and the Essequibo Islands
- Spring 2019 Survey: Occurred 27 March to 4 April 2019 at coastal sites in Regions 2–6 and the Essequibo Islands

A total of 117 sites were surveyed throughout Regions 1 to 6 during the EEPGL-commissioned coastal bird surveys (Figure 7.3-3 and Table 7.3-2). Some sites were not sampled in 2017 because the scope of the surveys in 2017 only included Regions 2 through 5. Also, additional survey sites were added in 2018 and 2019 in Regions 2 and 6 and in 2019 the number of Essequibo Island survey points was reduced to optimize survey coverage of these areas.

The 2017-2019 coastal bird surveys documented a total of 230 species and 69,713 birds across all regions and survey sites. Coastal sites accounted for 212 species and island sites accounted for 140 species, with 121 species found at both coastal and island sites. Appendix M, Coastal Bird Survey Reports, lists all of the species observed in each region during the EEPGL-commissioned surveys conducted to date. All of the species documented during the 2017–2019 surveys have been previously recorded in Guyana, although many species were newly documented in the coastal regions of the country. These new occurrences are likely due to the lack of documented comprehensive surveys of coastal birds along the Guyana coast prior to these surveys.

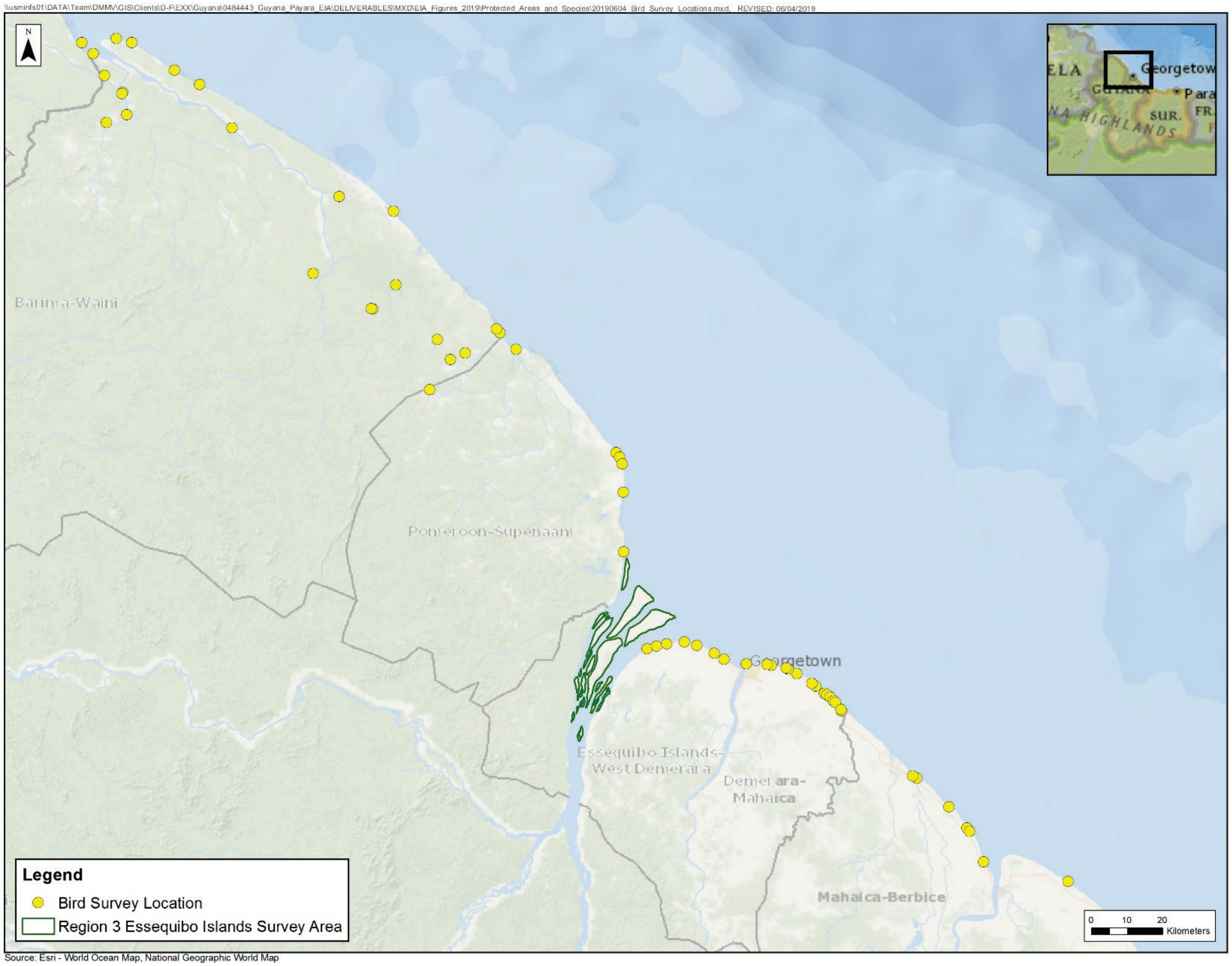


Figure 7.3-3: Coastal Bird Survey Sites Surveyed in 2017–2019

Table 7.3-2: Number of Coastal Bird Sampling Sites by Region for each Sampling Period (2017–2019)

Region	September/ October 2017	April 2018	September/ October 2018	January/ February 2019	March/ April 2019	Total [a]
1	NS	18	NS	NS	NS	18
2	5	6	6	6	6	6
3 (Coastal)	3	3	7	7	7	7
3 (Essequibo Islands)	32	50	52	51	27	52
4	20	20	16	16	16	20
5	6	6	6	6	6	6
6	NS	5	5	5	8	8
Total	66	108	92	91	70	117

NS = not sampled
[a] Total unique sites surveyed from all surveys conducted between September 2017 and April 2019

Further, while these surveys documented many more species than previously recorded in Guyana's coastal habitats (230 versus 208), some species previously known to occur along the Guyana coast, based on historical records, were not documented during the 2017-2019 surveys; therefore, the coastal bird community likely has even higher bird species richness (number of species) than documented in the 2017-2019 surveys. The most common shorebirds observed during the 2017-2019 surveys (more than 500 individuals each) were Semipalmated Sandpiper (*Calidris pusilla*), White-rumped Sandpiper (*Calidris fuscicollis*), Lesser Yellowlegs, Sanderling (*Calidris alba*), and Greater Yellowlegs (*Tringa melanoleuca*). The most common colonial waterbirds were Snowy Egret, Great Egret, Little Blue Heron (*Egretta caerulea*), Scarlet Ibis, Semipalmated Plover, and Tricolored Heron (*Egretta tricolor*). Bird diversity and abundance at the survey points were highly variable and influenced primarily by time of day (for forest birds) and tidal stage (for shorebirds). Twenty-one species of migratory shorebirds (Charadriidae and Scolopacidae families) were documented across all surveys. Figures 7.3-4, 7.3-5, and 7.3-6 include photographs of birds taken during the coastal bird surveys in 2019 (see Appendix M, Coastal Bird Survey Reports, for additional photographs).

The coastal habitat types that were surveyed included mangrove (riverine and coastal), mudflats, and sandy beaches. Mudflats had the highest average species richness (17 species per site) and bird abundance (330 birds per site). Mangrove habitat sites had the second highest average richness (12 species per site), but sandy beach sites had the second highest abundance (264 birds per site). Several sites contain multiple habitat types, so abundance and richness estimates are not completely exclusive between habitats.

Photo Credit: Waldyke Prince

Figure 7.3-4: Crested Caracara (*Caracara cheriway*) Observed at 63 Beach in Region 6, April 2019

Photo credit: Waldyke Prince

Figure 7.3-5: Lesser Yellowlegs (*Tringa flavipes*) at No. 57 Village Seaside in Region 6, April 2019

Photo credit: Waldyke Prince

Figure 7.3-6: Scarlet Ibis (*Eudocimus ruber*) Foraging in the Mangroves in Region 6, February 2019

Survey effort varied by region, so bird abundance and species richness are averaged by survey effort. Across all of the surveys, Region 6 had the greatest average abundance (772 birds per site) followed by Region 5 (608 birds per site) and Region 2 (335 birds per site; Table 7.3-3; Figure 7.3-7). Region 1 had the greatest average species richness (23 species per site) followed by Region 5 and Region 2 (17 species per site, respectively; Table 7.3-4, Figure 7.3-8).

Table 7.3-3: Average Per-Site Bird Abundance for 2017–2019 Surveys by Region

Region	September/ October 2017	April 2018	September/ October 2018	January/ February 2019	March/ April 2019	Overall Average Abundance
1	NS	144	NS	NS	NS	144
2	402	298	546	171	271	335
3—Coastal	41	21	62	105	69	68
3—Islands	43	27	18	14	10	40
4	218	134	206	256	145	190
5	160	990	778	605	522	608
6	NS	363	2047	710	268	772

NS = not sampled
[a] Data for 2018 island surveys were provided by island sites as a group rather than individual survey points.

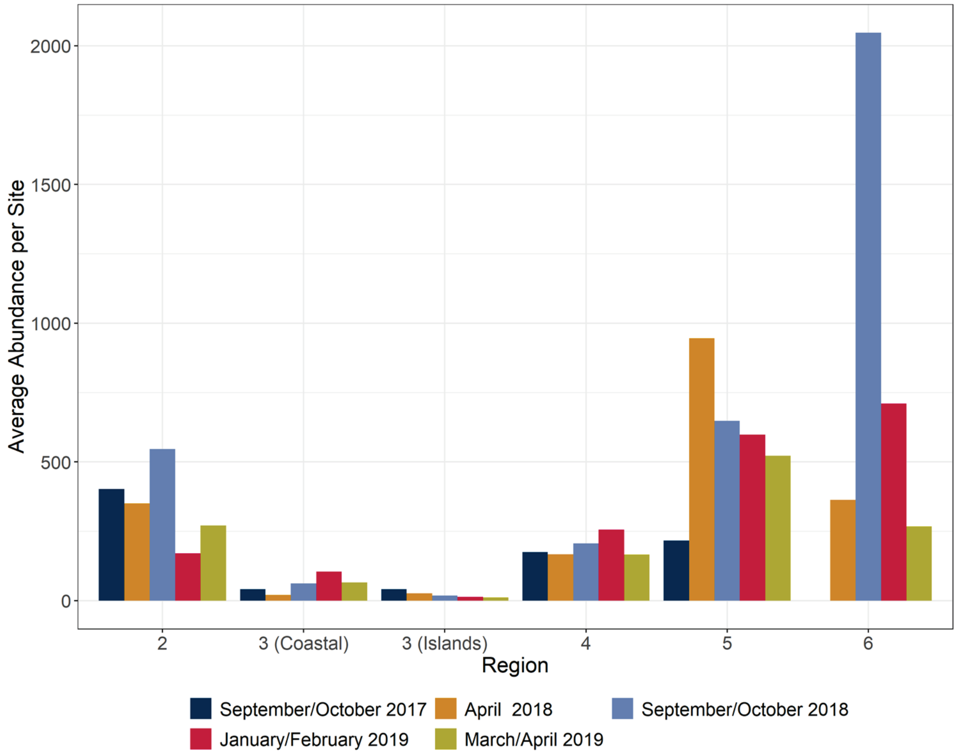


Figure 7.3-7: Average Bird Abundance per Site, by Region and Survey Period

Table 7.3-4: Average Per-Site Species Richness for 2017–2019 Surveys by Region

Region	**September/ October 2017**	**April 2018**	**September/ October 2018**	**January/ February 2019**	**March/ April 2019**	**Overall Average Richness**
1	NS	23	NS	NS	NS	23
2	19	19	20	13	14	17
3—Coastal	20	12	14	16	13	15
3—Islands	10	11	13	5	5	9
4	17	13	16	9	13	14
5	18	15	18	18	17	17
6	NS	13	16	15	16	15

NS = not sampled

[a] Data for 2018 island surveys were provided by island sites as a group rather than individual survey points.

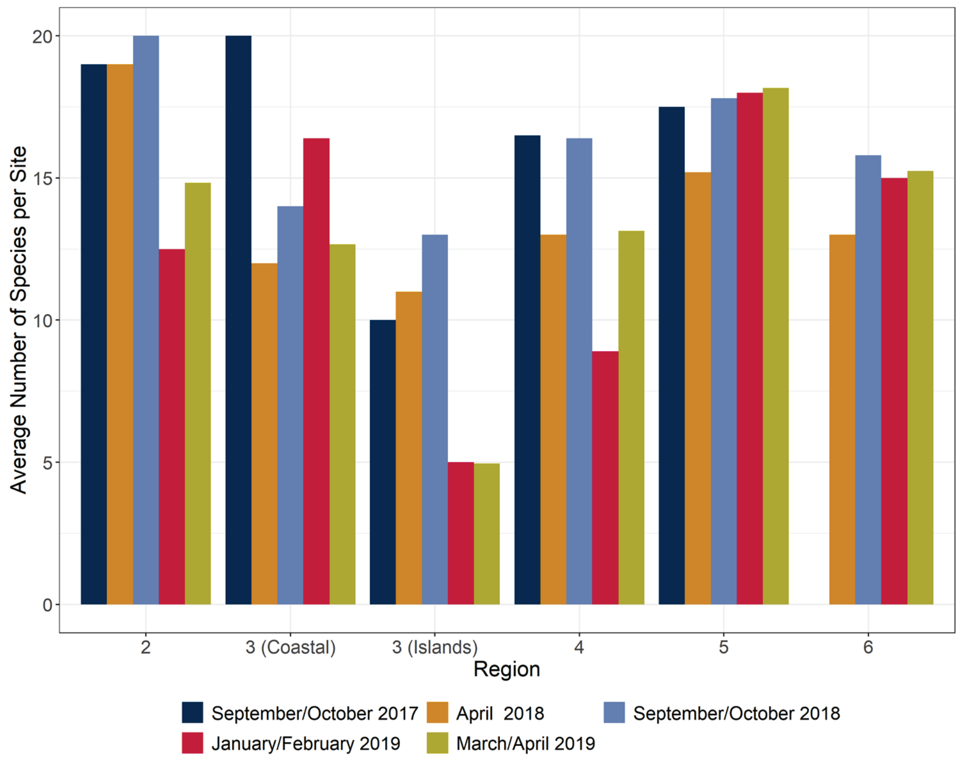


Figure 7.3-8: Average Species Richness per Site, by Region and Survey Period

The high average species richness in Region 1 is likely due to the survey area covering a greater diversity of habitats, including more inland habitats than the other regions (i.e., riverine mangroves, wetlands, and riverine forests, which are not present in the coastal survey sites in Regions 2-6). Although the Region 3 Essequibo Islands sites had some of the lowest average richness and abundance (9 species and 40 birds per site), this is due to the number of sites surveyed along the entire coast on each island; there were typically around 50 island sites surveyed during each period, resulting in more sites with few or no birds at the time of survey, often as a byproduct of tide or other conditions.

Overall, abundance and richness varied between survey events. One survey event of note is the September/October 2018 survey, which likely coincided with peak migration given the consistently high bird abundance across regions; Region 6 had over 2,000 birds per site, on average (Table 7.3-3, Figure 7.3-7).

7.3.2.3. Important Bird Habitats for Coastal Birds

BirdLife International (2016) has designated several Important Bird Areas (IBAs) in the neighboring countries of Suriname, Trinidad and Tobago, and Venezuela. These IBAs provide foraging, breeding, and nesting habitats similar to those found along Guyana's coastline. While no IBAs have been designated in Guyana, several areas along the Guyana coastline meet the definition of a 'threshold site' by BirdsCaribbean (www.birdscaribbean.org) for high abundance (criterion for threshold site is more than 3,000 individuals), which is consistent during coastal bird migration periods (ERM Personal Communication 25).

Fourteen coastal IBH sites were identified within Regions 1 to 6 in 2018, based on the EEPGL-commissioned coastal bird surveys in 2017 and 2018 (ERM 2018) as well as other available data from historical or ongoing surveys, and local bird specialists' knowledge (Figures 7.3-9, Figure 7.3-10, and Table 7.3-5). These IBH sites support one or more of the following: (1) predictable congregations of migratory shorebirds, including 'threshold sites'; (2) concentrations of roosting and/or nesting wading birds; (3) unique habitat that supports large numbers of riverine forest- and mangrove-dependent species; and (4) important nesting sites for regional endemic species of conservation interest.

Data from the ongoing EEPGL-commissioned coastal bird surveys that occurred after the initial designation of the 14 IBH sites validate their designation, as all previously identified IBH sites consistently had higher average bird abundance and species richness per site than other survey locations. Coastal IBH sites had an average abundance of 890 birds and 21 species per site across all surveys conducted to date, more than double that of non-IBH sites.

Photo credit: Waldyke Prince

Figure 7.3-9: Wading Birds and Shorebirds Feeding on Mudflat Habitat at the Exmouth Seaside Important Bird Habitat, January 2019

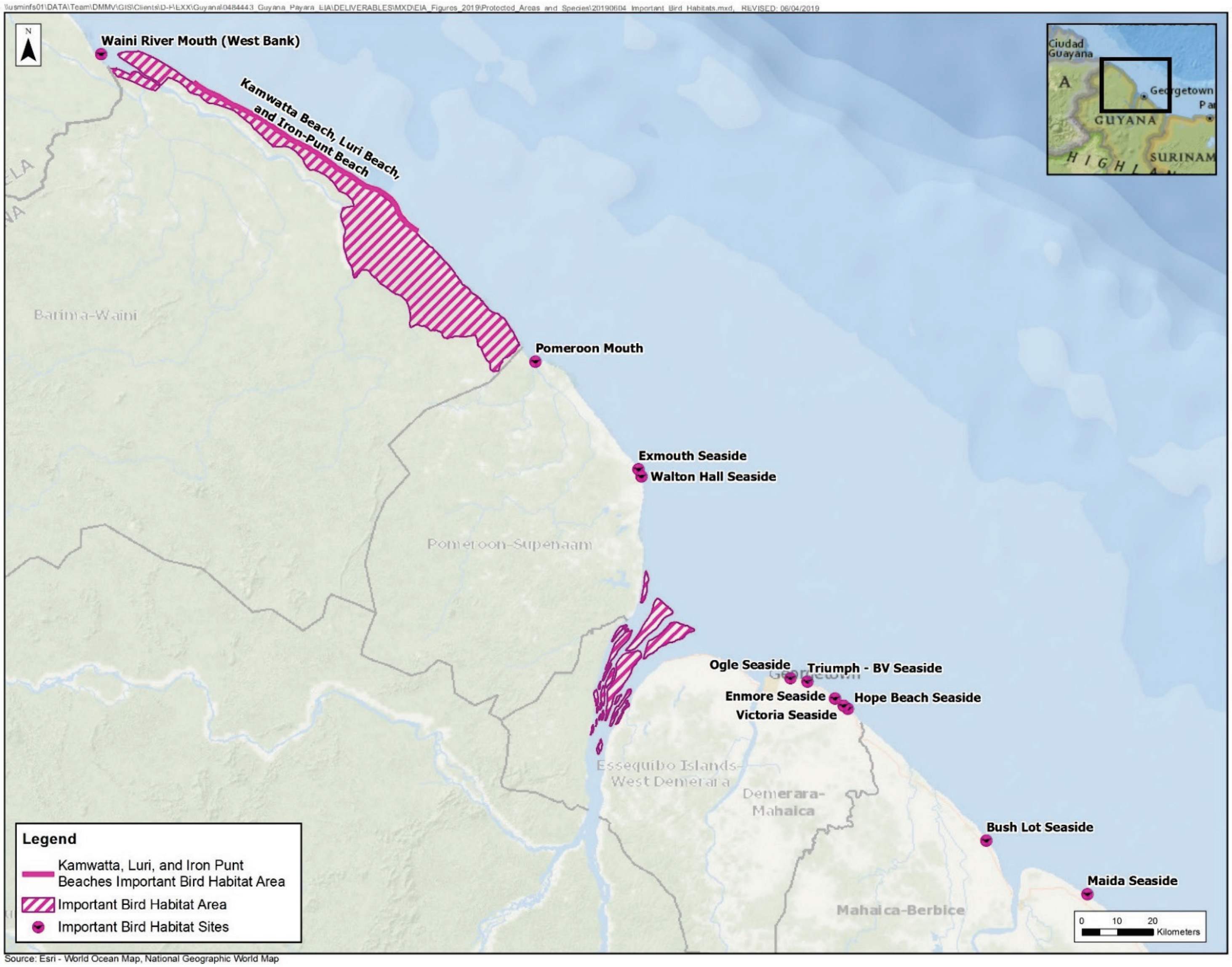


Figure 7.3-10: Locations of Important Bird Habitats—Regions 1 to 6

Table 7.3-5: Important Bird Habitats Identified in Regions 1 through 6

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Shell Beach Protected Area	1	Sandy beach, mudflat, mangrove	SBPA contains critically important nesting and foraging habitats for over 200 species of waterbirds and land birds, including several globally threatened species.	
Pomeroon River Mouth	1	Mudflat, mangrove	Extensive tidal mudflat that is an important congregation and foraging site for shorebirds and wading birds. Thousands of wading birds roost in the mangroves in this area.	
Kamwatta Beach, Iron Punt Beach, and Luri Beach	1	Sandy beach, mudflat, mangrove	These beaches host hundreds of flamingos (multiple species) and thousands of other colonial waterbirds (ERM Personal Communication 26) for nesting and feeding. The photo depicts Luri Creek, which is located just inland from Luri Beach and is the location of the colonial waterbird roosting and nesting site.	

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Waini River Mouth (west bank)	1	Mangrove	Pristine mangrove forest supporting large congregations of colonially roosting and nesting wading birds (herons, egrets, ibis, etc.).	
Exmouth Seaside	2	Mudflat	Extensive tidal mudflat that is an important congregation and foraging site for shorebirds and wading birds, including over 3,000 shorebirds (*Calidris* sp.) at a time, qualifying it as a Threshold Site[4] during the migratory season.	
Walton Hall Seaside	2	Mudflats and mangrove	Tidal mudflats and mangroves supporting large congregations of shorebirds and wading birds.	

[4] BirdLife International's definition of a Threshold Site for migratory birds is one that is known or thought to hold congregations that are equal to or more than 1 percent of the global population of one or more species (including species group or family) on a regular or predictable basis (BirdLife International 2011).

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Essequibo Island Complex	3	Mangrove	Unique transition zone between riverine forest and mangrove ecosystems that provides important roosting and nesting habitat for riverine birds and wading birds.	
Ogle Seaside	4	Mudflat	Extensive mudflat that is heavily populated with foraging shorebirds (over 3,000 individuals at a time, qualifying it as a Threshold Site for *Calidris* sp.) during the migratory season.	
Triumph-BV Seaside	4	Mudflat and mangrove	Extensive mudflat and natural revegetation of mangroves that supports large numbers of migratory shorebirds and waterbirds and is also considered very important as a nesting site for Snail Kite (*Rostrhamus sociabilis*).	

Important Bird Habitat	**Region**	**Primary Bird Habitat**	**Rationale for Designation as Important Bird Habitat**	**Photograph**
Enmore Seaside	4	Mudflat and mangrove	Tidal mudflats and mangroves that host large congregations of shorebirds and wading birds, and serve as nesting site for Snail Kite (*Rostrhamus sociabilis*) and other mangrove-dependent species including conebills	
Hope Beach Seaside	4	Vegetated sand flat	Fine sand flats overlain with compact mud at low tide that host large congregations of shorebirds and wading birds (including Scarlet Ibis [*Eudocimus ruber*]) and mangroves that support large numbers of nesting and roosting wading birds	
Victoria Seaside	4	Mangrove and brackish marsh	Extensive mangrove and brackish marsh along the shoreline and inland that provides important roosting and breeding site for shorebirds and waterbirds, particularly Scarlet Ibis (*Eudocimus ruber*) and mangrove-dependent species	

Important Bird Habitat	**Region**	**Primary Bird Habitat**	**Rationale for Designation as Important Bird Habitat**	**Photograph**
Bush Lot Seaside	5	Mudflat and mangrove	Extensive mudflats used by thousands of shorebirds during migration (threshold site for *Calidris* sp.) and waterbirds throughout the year	
Mangroves between Maida and Phillipe	6	Mangrove	Important roosting and breeding area for thousands of colonial waterbirds	

7.3.2.4. Conservation Status of Guyana Coastal Wildlife Species

Of the coastal wildlife species known to occur in coastal Guyana based on historical data and the 2017–2019 survey records, most are currently listed on the IUCN Red List as Least Concern (LC), which means that the population status of the species does not meet the IUCN criteria for a Threatened or Near Threatened designation (IUCN 2019; see Section 7.1.2, Existing Conditions—Protected Areas and Special Status Species). Twelve of the wildlife species known to occur in coastal Guyana have elevated conservation status, as they are classified as Vulnerable (VU), Near Threatened, (NT), or Endangered (EN) per the IUCN Red List (Table 7.3-6). These species include three mammal species and nine bird species (Figures 7.3-11 and 7.3-12).

In addition, three bird species of local conservation interest[5] have been recorded along the Guyana coast during the EEPGL-commissioned coastal bird surveys between 2017 and 2019. The Silvered Antbird (*Sclateria naevia*) was recorded in January/February 2019, while the Gray-headed Kite (*Leptodon cayennensis*) and the subspecies *fumosus* of Fuscous Flycatcher (*Cnemotriccus fuscatus*) were observed on the Essequibo Islands during the September/October 2017 survey.

Table 7.3-6: Coastal Wildlife Species with Elevated Conservation Status Known to Occur in Coastal Guyana[6]

Species	Common Name	IUCN Red List Status
Mammals		
Pteronura brasiliensis	Giant otter	EN
Lontra longicaudis	Neotropical otter	NT
Trichechus manatus	West Indian manatee	VU
Birds		
Agamia agami	Agami Heron	VU
Conirostrum bicolor	Bicolored Conebill	NT
Harpia harpyja	Harpy Eagle	NT
Calidris canutus	Red Knot	NT
Calidris pusilla	Semipalmated Sandpiper	NT
Patagioenas subvinacea	Ruddy Pigeon	VU
Buteogallus aequinoctialis	Rufous Crab-hawk	NT
Picumnus spilogaster	White-bellied Piculet	VU
Ramphastos tucanus	White-throated Toucan	VU

[5] Species of local conservation interest are species that are considered by Guyanese and international bird specialists to be rare and/or declining in Guyana or have very limited distribution in Guyana but are not species of global conservation concern based on their IUCN Red List status.

[6] Excludes marine mammals, marine turtles, and fishes, which are discussed in Sections 7.5, 7.7, and 7.8

Photo Credit: Waldyke Prince

Figure 7.3-11: Rufous Crab-Hawk (*Buteogallus aequinoctialis*), a Non-Migrant Coastal Endemic Species that Occurs in Mangroves and Other Wetland Areas, Observed at Ruimzeight Seaside in 2017

Photo credit: Waldyke Prince

Figure 7.3-12: Bicolored Conebill (*Conirostrum bicolor*), a Coastal Mangrove Specialist, Observed at the Maida Seaside Region 6, January 2019

7.3.3. Impact Assessment—Coastal Wildlife

The planned Project activities, the bulk of which will occur approximately 207 kilometers (128 miles) northeast of the coastline of Georgetown, will not impact coastal wildlife. The Project will not involve any direct disturbance of coastal wildlife species or their habitats. The shorebases are expected to be located in existing developed areas, so their ongoing use will have little to no impact on coastal wildlife species, other than possible disturbance to common generalist species[7] that are adapted to living in developed areas. The Project's only potential impact on coastal wildlife would be as a result of an unplanned event (i.e., an oil spill), which is discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

7.4. SEABIRDS

7.4.1. Administrative Framework—Seabirds

Table 7.4-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on seabirds.

Table 7.4-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Seabirds

Title	Objective	Relevance to the Project
Legislation		
Wild Birds Protection Act, 1987	Protects listed wild birds in Guyana.	Sections 3 and 6 prohibit knowingly wounding or killing wild birds listed in the First and Second Schedule of the act, and establishes penalties.
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora.	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a supportive mechanism to achieve the national goals for wildlife protection, conservation, management, sustainable use, and external trade.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.

[7] Generalist species are species that live in a wide range of habitat types and conditions and that do not have specialized habitat requirements or preferences.

7.4.2. Existing Conditions—Seabirds

7.4.2.1. Background

Seabirds are birds that spend extensive time in nearshore and/or offshore marine environments away from land, except when they are nesting. Types or groups of seabirds prevalent in this region include frigatebirds, pelicans, petrels, shearwaters, storm-petrels, jaegers, tropicbirds, boobies, gulls, and terns.

Birds in the Stabroek Block typically fit one or more of three characterizations: (1) birds that spend extensive time in waters of the Caribbean away from land or other structures (commonly referred to as pelagic birds or marine birds); (2) birds engaged in seasonal, usually latitudinal, migrations through the area (migratory birds); and (3) birds that have wandered outside their normal ranges, including birds affected by severe weather events, including seasonal storms. The primary focus of this section is on pelagic seabirds since they are the dominant bird type to occur in the Stabroek Block and they spend the most time of any birds within offshore Guyana.

Seabirds feed on fish and other marine organisms that concentrate on or near the surface of the water, either by surface feeding (from flight or swimming) or by diving. As such, the presence and availability of seabird prey in a given area, which is strongly influenced by the ocean's currents, is a major determinant in the occurrence of seabirds. Further, water clarity can impact a seabird's foraging success and some studies have suggested that seabirds in the Caribbean prefer areas with clear water where they can more easily see their prey (Schreiber 2001).

Seabirds in the PDA area are likely to be transients, moving opportunistically with schools of fish, oceanic arthropods, plankton, and other prey. The marine environment within the PDA is heavily influenced by the Guiana Current, which is a strong surface current that directs surface flows northwestward, drawing water from near Africa and feeding the Gulf Stream across the northern Caribbean. No slower-moving or circular currents or areas of upwelling that could concentrate marine biota are known to occur in the PDA (see Section 6.4.2.1, Oceanographic Conditions). Further, no islands or near-surface submarine ridges that would be an attractant to foraging seabirds occur in the PDA. While a variety of fish occur in the PDA, including schooling fish such as tuna and mahi-mahi, and flying fish (Exocoetidae), which are an important prey for both, no evidence suggests that large concentrations of fish consistently occur in the PDA to the extent that they would promote regular use by foraging seabirds. The turbid conditions in the Stabroek Block further reduce the likelihood that the area has significant importance for foraging seabirds.

Over 100 bird species have populations that migrate between North America and South America, and most of these nest in the north and reside in the southern range until the next nesting season. Many of these birds fly over the Caribbean, and in some cases the Stabroek Block, during migration. Although migration routes are well-defined for some bird species, the routes and timing of migration can vary markedly depending on climate and storms (McGrady et al. 2006).

7.4.2.2. Historical Data

Twenty-two species of seabirds are historically known to breed in the Caribbean and dozens more occur as migrants through the region. Seabird data specific to Guyana are extremely limited and no comprehensive survey of seabirds has ever been conducted in Guyana (BirdLife International 2019a). The authoritative, historical list for bird species present in Guyana, published by the Smithsonian Institution, lists 25 seabird species (Braun et al. 2007). BirdLife International lists 21 species of seabirds for Guyana (BirdLife International 2019a). The eBird-arbitrated observation list[8] for offshore Guyana contains 25 seabird species (eBird 2019a). Combining all of these sources, a total of 28 seabird species are reported to occur in Guyana (Table 7.4-2).

Table 7.4-2: Seabird Species Known to Occur in Guyana Based on Historical Data

Common Name	**Scientific Name**
Great Shearwater [a,b]	*Ardenna gravis*
Cory's Shearwater [a]	*Calonectris borealis*
Barolo Shearwater [c]	*Puffinus baroli*
Audubon's Shearwater [a,b]	*Puffinus lherminieri*
Wilson's Storm-Petrel [a,b]	*Oceanites oceanicus*
Leach's Storm-Petrel [a,b]	*Oceanodrama leucorhoa*
Brown Pelican [a,b]	*Pelecanus occidentalis*
Brown Booby [a,b,c]	*Sula leucogaster*
Masked Booby [c]	*Sula dactylatra*
Red-footed Booby [c]	*Sula sula*
Magnificent Frigatebird [a,b,c]	*Fregata magnificens*
White-tailed Tropicbird [c]	*Phaethon lepturus*
Parasitic Jaeger [b,c,d]	*Stercorarius parasiticus*
Pomarine Jaeger [a,b,c]	*Stercorarius pomarinus*
Great Skua [a,b]	*Stercorarius skua*
Lesser Black-backed Gull [c,d]	*Larus fuscus*
Laughing Gull [a,b,c]	*Leucophaeus atricilla*
Brown Noddy [a,c]	*Anous stolidus*
Black Tern [b,c,d]	*Chlidonias niger*
Gull-billed Tern [a,c]	*Gelochelidon nilotica*
Bridled Tern [c]	*Onychoprion anaethetus*
Sooty Tern [a]	*Onychoprion fuscatus*
Black Skimmer [a,c]	*Rynchops niger*
Roseate Tern [a,c]	*Sterna dougalli*

[8] eBird is a real-time, online database of bird observations through user-submitted checklists, eBird documents the presence or absence of species, as well as bird abundance. Country records in eBird are arbitrated by a team of local experts who are unpaid volunteers managed by eBird. This arbitration process is conducted to ensure data quality and avoid erroneous records. Only the arbitrated country record list is considered scientifically valid.

Common Name	Scientific Name
Common Tern [a,b,c]	*Sterna hirundo*
Royal Tern [a,b,c]	*Thalasseus maximus*
Arctic Tern [c]	*Sterna paradisaea*
Sandwich Tern [c,d]	*Thalasseus sandvicensis*

[a] Braun et al. 2007
[b] BirdLife International 2019a
[c] eBird 2019a
[d] Sight record only (Braun et al. 2007)

This number is consistent with other countries in the region. For example, 32 and 29 species of seabirds are documented in Trinidad and Tobago and Venezuela, respectively (BirdLife International 2019a). Any of the species could occur in the PDA at some time during the year (specific timing of occurrence is dependent on the species and environmental conditions).

Based on eBird reporting, an additional 29 species of seabirds are known to inhabit the southern Caribbean, but have not been reported in Guyana (eBird 2019a). These species and others could also occur in Guyanese offshore waters. Thus, the number of species that occur offshore Guyana is likely to be higher than 28, as documented through EEPGL-commissioned marine bird survey work conducted in the Stabroek Block between 2017 and 2019 (Section 7.4.2.3, Seabird Survey Data within and near Stabroek Block).

7.4.2.3. Seabird Survey Data within and near Stabroek Block

EEPGL-Commissioned Marine Bird Surveys

Survey Overview

EEPGL commissioned a series of marine bird surveys within the Stabroek Block and in the area between the Stabroek Block and the Guyana coast in 2017, 2018, and 2019. The surveys were conducted by teams of international and Guyanese bird specialists aboard vessels conducting various types of work between the Stabroek Block and Georgetown or within the Stabroek Block. Nine survey events encompassing more than 500 survey hours have been conducted to date. Table 7.4-3 summarizes information about each of these surveys and Figure 7.4-1 depicts the locations of the surveys and bird sightings. Of all survey events, the third survey event during the 2018 Fall Survey (Survey 1c) spent the most time in the Stabroek Block; approximately 160 survey hours were conducted in the block during this survey.

Table 7.4-3: Summary of EEPGL-Commissioned Marine Bird Surveys Conducted within the Stabroek Block and between the Stabroek Block and Georgetown, Guyana (2017–2019)

Survey Name	Number of Survey Events per Survey	Survey Date	Survey Area	Mobile or Stationary Survey Vessel [a]	Survey Hours
Fall 2017 Survey	1	30 September 2017–7 October 2017	Between Georgetown and the Stabroek Block	Mobile	46
Spring 2018 Survey	2				
Survey 1a	—	9 April 2018–15 April 2018	Within Stabroek Block	Mobile	60.2
Survey 1b	—	9 April 2018–16 April 2018	Between Georgetown and the Stabroek Block	Mobile	52.8
Fall 2018 Survey	3				
Survey 1a	—	15 September 2018–25 September 2018	Between Georgetown and Stabroek Block, and within Stabroek and Canje Blocks	Mobile	49.5
Survey 1b	—	1 October 2018–6 October 2018	Between Georgetown and Stabroek Block and within Stabroek Block	Mobile	23.5
Survey 1c	—	17 September 2018–1 October 2018	Within Stabroek Block	Stationary	159.8
Winter 2019 Survey	1	28 January 2019–4 February 2019	Within Stabroek Block	Stationary	36.5
Spring 2019 Survey	2				
Survey 1a	—	18 April 2019–23 April 2019	Within Stabroek Block and between Stabroek Block and Guyana coast	Mobile	52
Survey 1b	—	20 April 2019–26 April 2019	Within Stabroek Block and between Stabroek Block and Georgetown	Mobile	29.2

[a] Refers to whether the survey occurred aboard a stationary or mobile vessel. The stationary vessels were drill ships and the mobile vessels were various types of drill ship support vessels or sampling vessels.

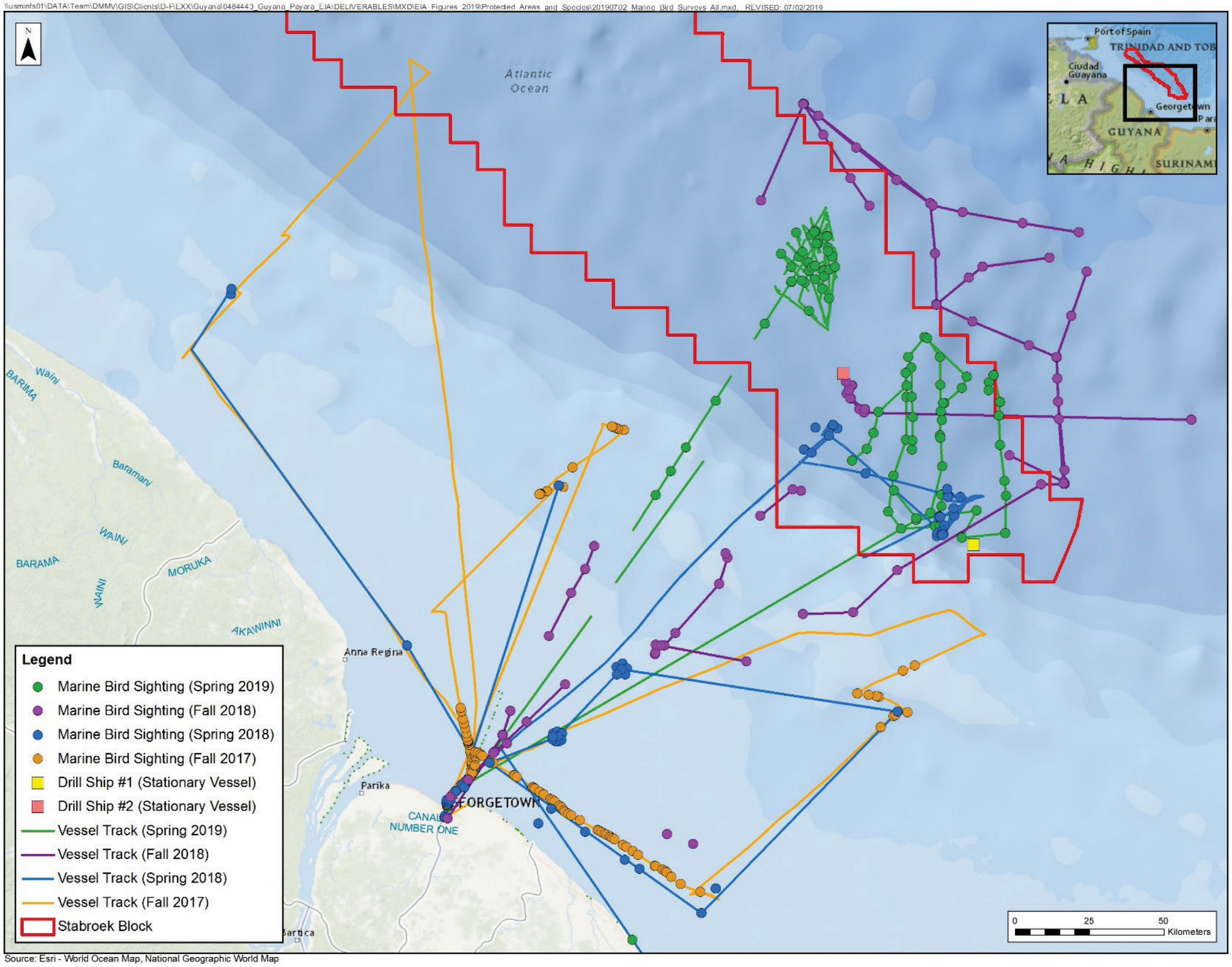


Figure 7.4-1: Map of Marine Bird Survey Locations within the Stabroek Block and between the Stabroek Block and Georgetown, 2017–2019

Species Assemblage

The nine EEPGL-commissioned marine bird surveys conducted to date yielded 1,837 bird observations representing 69[9] bird species within the Stabroek Block and the area between Georgetown and the Stabroek Block (Table 7.4-4). Fewer than half of the species observed during the surveys are classified as seabirds[10] (33 of 69 species). The other species are shorebirds or landbirds that fly over the Caribbean during migration, coastal birds on long-distance offshore foraging trips, or regional (short-distance) movements between breeding and non-breeding areas. Specifically, the 69 bird species observed encompass several types of birds that are differentiated by distinct life histories and habitat use patterns including: landbirds (16 species), shorebirds (9 species), coastal birds (11 species), and seabirds (33 species, including 13 nearshore species and 20 pelagic species).

Twenty-four of the 69 species observed during the EEPGL-commissioned marine bird surveys have been documented offshore Guyana based on historical data. Only four species historically known to occur offshore Guyana were not observed during the EEPGL-commissioned marine bird surveys: Great Skua (*Stercorarius skua*), Lesser Black-backed Gull (*Larus fuscus*), Gull-billed Tern (*Gelochelidon nilotica*), and Barolo Shearwater (*Puffinus baroli*)[11]. The 45 new species occurrences offshore documented during this survey are likely attributable to the lack of documented comprehensive surveys of marine birds offshore Guyana prior to these surveys.

The EEPGL-commissioned marine bird surveys yielded seven new records for Guyana (based on available documentation, these species had not been observed in the country previously), increasing the number of seabird species known to occur offshore Guyana from 28 to 35. The new records registered for Guyana are Bridled Tern (*Onychoprion anaethetus*), Manx Shearwater (*Puffinus puffinus*), Red-billed Tropicbird (*Phaethon aethereus)*, Bulwer's Petrel (*Bulweria bulwerii)*, Band-rumped Storm-Petrel (*Oceanodroma castro)*, Long-tailed Jaeger (*Stercorarius longicaudus*), and Great Black-backed Gull (*Larus marinus*). Two unconfirmed species, Black-browed Albatross (*Thalassarche melanophrys)* and Northern Gannet (*Morus bassanus)* may be additional new records for Guyana, but these species require field or photographic confirmation before they are added to the definitive species list. Figures 7.4-2 and 7.4-3 provide photographs from the EEPGL-commissioned marine bird surveys of two of the newly documented seabird species in Guyana.

[9] The species count includes only individuals confirmed to species; it does not include species identified to only genus (i.e., unknown tern).

[10] Includes species categorized as Pelagic or Nearshore Marine in Table 7.4-4.

[11] Barolo Shearwater was provisionally identified during the EEPGL-commissioned marine bird surveys, but the sighting lacked photographic documentation and expert confirmation - so the species was not included in the species tally for the EEPGL-commissioned marine bird surveys.

New country record for Guyana; observed within the Stabroek Block, April 2019

Figure 7.4-2: Long-tailed Jaeger (*Stercorarius longicaudus*)

New country record for Guyana; observed in the Stabroek Block, April 2019

Figure 7.4-3: Red-billed Tropicbird (*Phaethon aethereus*)

Table 7.4-4: Bird Species Observed during EEPGL-Commissioned Marine Bird Surveys Conducted in the Stabroek Block and between the Stabroek Block and Georgetown, 2017–2019

Common Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring
Leach's Storm-Petrel	*Oceanodrama leucorhoa*	Pelagic		X			X
Arctic Tern	*Sterna paradisaea*	Pelagic					X
Brown Noddy	*Anous stolidus*	Pelagic	X		X	X	
Sooty Tern	*Onychoprion fuscatus*	Pelagic					X
Band-rumped Storm-Petrel	*Oceanodroma castro*	Pelagic		X			
Wilson's Storm-Petrel	*Oceanites oceanicus*	Pelagic		X			X
Red-billed Tropicbird	*Phaethon aethereus*	Pelagic		X			X
White-tailed Tropicbird	*Phaethon lepturus*	Pelagic					X
Audubon's Shearwater	*Puffinus lherminieri*	Pelagic					X
Manx Shearwater	*Puffinus puffinus*	Pelagic					X
Bulwer's Petrel	*Bulweria bulwerii*	Pelagic		X	X		
Cory's Shearwater	*Calonectris borealis*	Pelagic					X
Great Shearwater	*Ardenna gravis*	Pelagic			X		X
Sooty Shearwater	*Ardenna grisea*	Pelagic				X	
Long-tailed Jaeger	*Stercorarius longicaudus*	Pelagic					X
Parasitic Jaeger	*Stercorarius parasiticus*	Pelagic		X			
Pomarine Jaeger	*Stercorarius pomarinus*	Pelagic	X	X		X	X
Brown Booby	*Sula leucogaster*	Pelagic	X	X	X		X
Masked Booby	*Sula dactylatra*	Pelagic		X	X	X	X
Red-footed Booby	*Sula sula*	Pelagic	X	X	X	X	
Magnificent Frigatebird	*Fregata magnificens*	Nearshore marine	X	X	X	X	X
Black Skimmer	*Rynchops niger*	Nearshore marine	X				X
Black Tern	*Chlidonias niger*	Nearshore marine			X		
Bridled Tern	*Onychoprion anaethetus*	Nearshore marine	X		X		
Cayenne Tern	*Thalasseus eurygnatha*	Nearshore marine	X				
Common Tern	*Sterna hirundo*	Nearshore marine	X	X	X		X

Common Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring
Laughing Gull	*Leucophaeus atricilla*	Nearshore marine	X	X	X		X
Least Tern	*Sternula antillarum*	Nearshore marine			X		
Roseate Tern	*Sterna dougalli*	Nearshore marine			X		
Royal Tern	*Thalasseus maximus*	Nearshore marine	X	X	X		X
Sandwich Tern	*Thalasseus sandvicensis*	Nearshore marine	X		X		
Great Black-backed Gull	*Larus marinus*	Nearshore marine				X	
Brown Pelican	*Pelecanus occidentalis*	Nearshore marine	X		X		
Large-billed Tern	*Phaetusa simplex*	Coastal	X				
Black-crowned Night-Heron	*Nycticorax nycticorax*	Coastal		X			
Cattle Egret	*Bubulcus ibis*	Coastal	X		X		
Great Egret	*Ardea alba*	Coastal		X			
Little Blue Heron	*Egretta caerulea*	Coastal	X		X		
Snowy Egret	*Egretta thula*	Coastal	X	X	X		
Tricolored Heron	*Egretta tricolor*	Coastal	X		X		
Yellow-crowned Night-Heron	*Nyctanassa violacea*	Coastal	X				
Yellow-headed Caracara	*Milvago chimachima*	Coastal	X				
Neotropic Cormorant	*Phalacrocorax brasilianus*	Coastal		X			
Scarlet Ibis	*Eudocimus ruber*	Coastal	X				
Black-bellied Plover	*Pluvialis squatarola*	Shorebird			X		
Semipalmated Plover	*Charadrius semipalmatus*	Shorebird					X
Least Sandpiper	*Calidris minutilla*	Shorebird			X		
Pectoral Sandpiper	*Calidris melanotos*	Shorebird	X				
Semipalmated Sandpiper	*Calidris pusilla*	Shorebird	X		X		
Spotted Sandpiper	*Actitis macularius*	Shorebird	X				
Lesser Yellowlegs	*Tringa flavipes*	Shorebird			X		
Ruddy Turnstone	*Arenaria interpres*	Shorebird		X	X		
Whimbrel	*Numenius phaeopus*	Shorebird	X				X
Barn Swallow	*Hirundo rustica*	Migratory landbird	X		X		
Purple Martin	*Progne subis*	Migratory landbird			X		

Common Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring
Bobolink	*Dolichonyx oryzivorus*	Migratory landbird			X		
Cliff Swallow	*Petrochelidon pyrrhonota*	Migratory landbird			X		
Snail Kite	*Rostrhamus sociabilis*	Non-migratory landbird			X		
Ruddy Ground-Dove	*Columba talpacoti*	Non-migratory landbird			X		
Gray-breasted Martin	*Progne chalybea*	Non-migratory landbird	X		X		
Great Kiskadee	*Pitangus sulphuratus*	Non-migratory landbird	X	X	X		
Lesser Kiskadee	*Pitangus lictor*	Non-migratory landbird			X		
Tropical Kingbird	*Tyrannus melancholicus*	Non-migratory landbird			X		
Short-tailed Swift	*Chaetura brachyura*	Non-migratory landbird			X		
Eurasian Collared Dove	*Streptopelia decaocto*	Non-migratory landbird			X		
Homing Pigeon	*Columba livia domestica*	Non-migratory landbird			X		
Rock Pigeon—feral	*Columba livia*	Non-migratory landbird	X		X		
White-winged Swallow	*Tachycineta albiventer*	Non-migratory landbird	X		X		
House Wren	*Troglodytes aedon*	Non-migratory landbird			X		

Bird Abundance

The data collected during the 2017–2019 EEPGL-commissioned marine bird surveys indicate that seabird abundance offshore is generally low and decreases with greater distance to shore. The bird detection rate across all surveys ranged widely from 0.7 to 7.7 birds per hour of observation, with a mean detection rate of 3.7 birds per hour of observation. During all of the 2017–2019 surveys, bird abundance decreased with distance to shore. Bird abundance was consistently highest in the area between 1 and 25 kilometers (0.62 and 15.5 miles) from shore and steadily decreased with increased distance to shore, with the fewest number of birds in areas more than 100 kilometers (62 miles) from shore.

For all surveys conducted to date, the greatest abundance of birds was observed during the fall surveys, specifically Fall 2018 Surveys 1a and 1b and Fall 2017 surveys (listed by greatest abundance) (Figure 7.4-4). The Fall 2017, Fall 2018 Survey 1b, and Fall 2018 Survey 1a events also had the greatest abundance per survey effort: (listed by greatest abundance per survey effort).

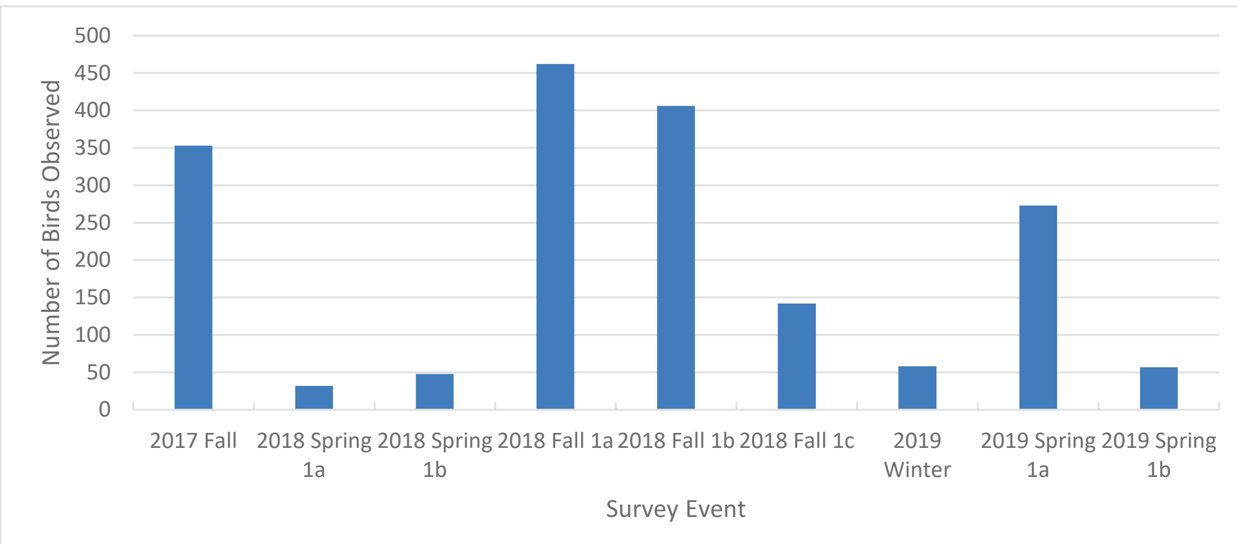


Figure 7.4-4: Overall Bird Abundance Documented per Survey Event during EEPGL-Commissioned Marine Bird Surveys, 2017–2019 (All Surveys)

The higher bird abundance observed during the Fall 2017 and Fall 2018 survey events is mostly attributable to the number of migrating shorebirds and landbirds moving through the area during those periods (Table 7.4-4). The spring surveys conducted in 2018 and 2019 also documented higher bird abundance than the Winter 2019 survey (the only survey conducted to date outside of the fall and spring migratory periods) and the species assemblage during that survey also included numerous migratory birds.

For all survey events combined, the most commonly observed bird species in and near the Stabroek Block were the Magnificent Frigatebird (*Fregata magnificens*), Common Tern

(*Sterna hirundo*), Rock Pigeon—feral (*Columba livia*)[12], Laughing Gull (*Leucophaeus atricilla*), and Masked Booby (*Sula dactylatra*). Figure 7.4-5 depicts the total abundance (all surveys combined) for the dominant species observed (species with at least 10 observations during the 2017 through 2019 survey period).

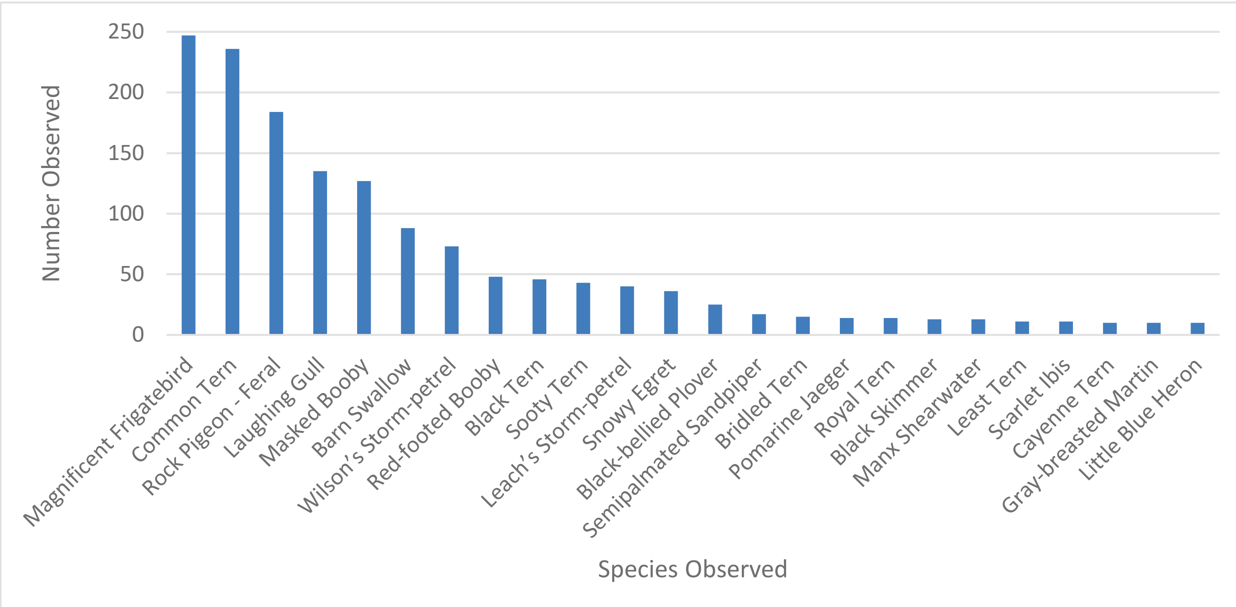


Figure 7.4-5: Most Frequently Observed Bird Species during the EEPGL-commissioned Marine Bird Surveys, 2017–2019 (All Surveys)

Figure 7.4-6 illustrates the most frequently observed species for each of the five seasonal survey periods (Fall 2017, Spring 2018, Fall 2018, Winter 2019, and Spring 2019). Many of the same species were among the most commonly observed across all surveys (e.g., Magnificent Frigatebird, Masked Booby, Common Tern, etc.) but the data indicate considerable variation in the most frequently observed species (see Figure 7.4-6). The Leach's Storm-Petrel (*Oceanodroma leucorhoa*) was the most abundant species in spring 2018 and the second-most abundant species in spring 2019. Masked Booby was the most abundant species observed during both 2019 survey events (winter and spring).

[12] The high number of Rock Pigeon observed was due to a single observation of a large group of this species recorded when leaving the Port of Georgetown. This species is common in developed portions of the Guyana coast and is not typically associated with nearshore marine or offshore environments.

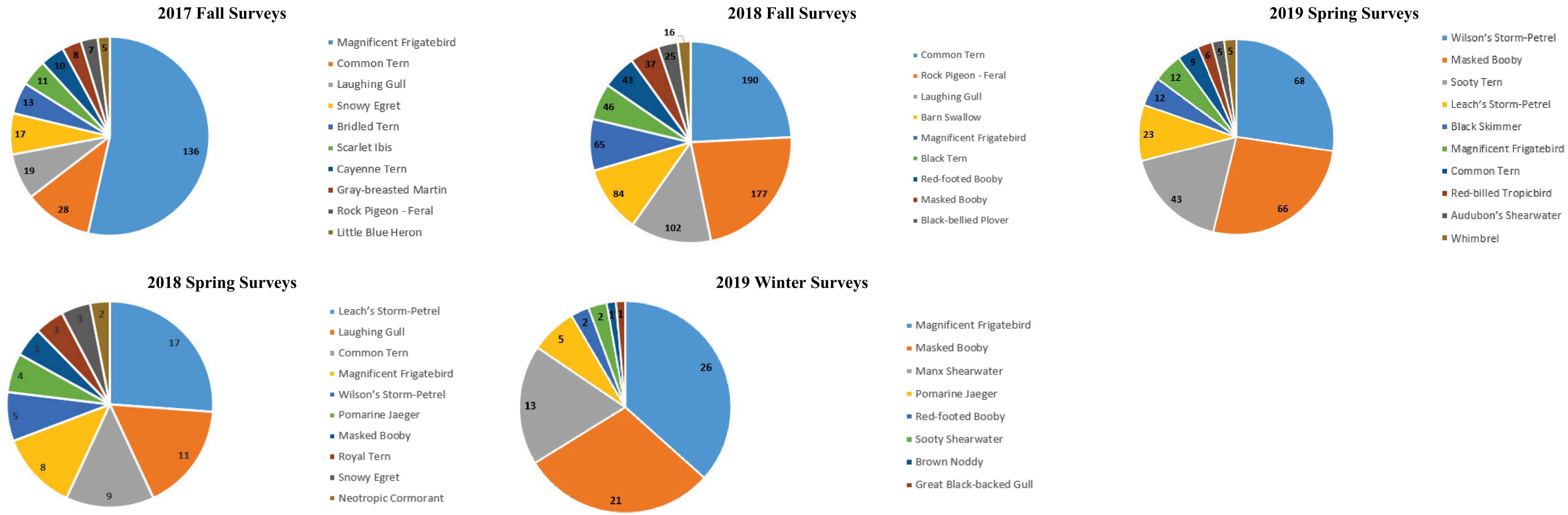


Figure 7.4-6: Most Frequently Observed Bird Species Recorded During Five Seasons of EEPGL-Commissioned Marine Bird Surveys

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Species Richness and Diversity

The number of bird species (described as species richness) and the diversity of bird species encompassing a broad range of bird types (i.e., landbirds, coastal birds, shorebirds, and pelagic and nearshore birds that collectively are considered seabirds) (see Figure 7.4-7), recorded during the EEPGL-commissioned marine bird surveys were higher than expected based on historical records for the region and expert knowledge. The surveys showed a clear differentiation in the species assemblage (types of birds) observed by season: nearshore marine birds were the dominant type during the Fall 2017 and Fall 2018 surveys, pelagic birds heavily dominated the Spring 2019 survey, and the Winter 2019 survey was the only survey conducted to date to have only nearshore marine and pelagic birds observed (Figure 7.4-7).

Species richness varied across surveys and seasons. The highest species richness was recorded during the Fall 2017 and Fall 2018 surveys and the lowest species richness was recorded during the Winter 2019 survey (the only survey conducted outside the migratory period) (see Figure 7.4-8).

Species richness documented during the Spring 2018 and Spring 2019 surveys were comparable (19 species in 2018 and 20 species in 2019). The fall surveys in 2017 and 2018 had similar species richness and categories of species across years, with some notable exceptions, including the preponderance of migratory swallow species and migratory shorebird species (e.g., sandpipers, plovers, etc.) recorded during the Fall 2018 surveys. It is notable that incidental observations of birds collected separately from the EEPGL-commissioned marine bird survey events also documented high numbers of migratory swallow species during the same fall 2018 period.

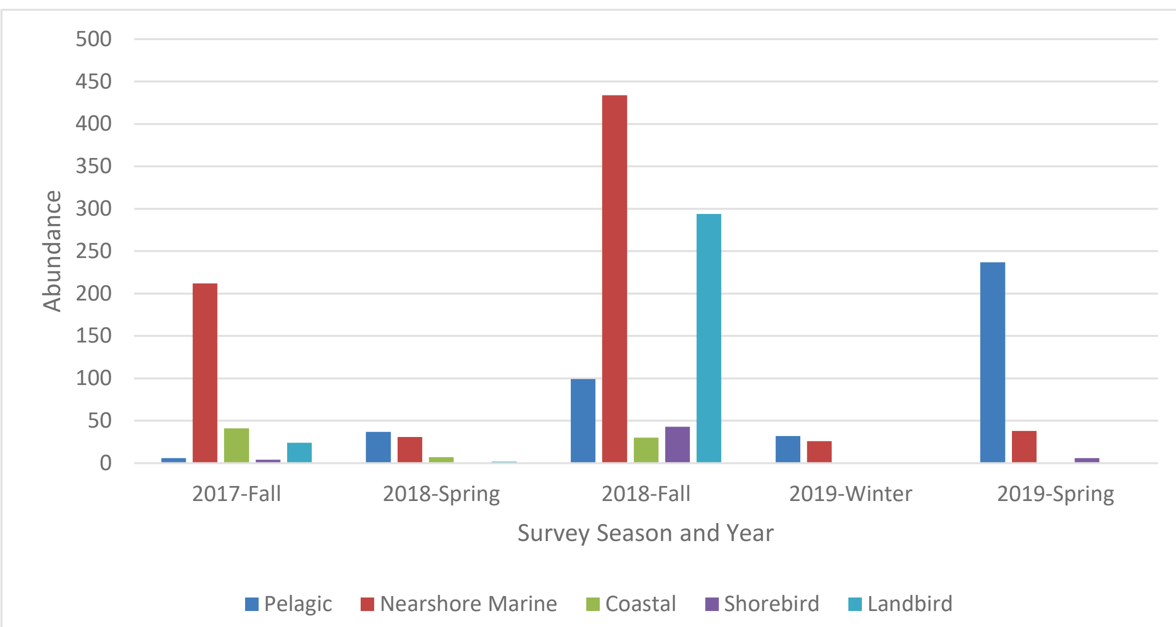


Figure 7.4-7: Bird Species Assemblage (Categories) Recorded during Five Seasons of EEPGL-Commissioned Marine Bird Surveys

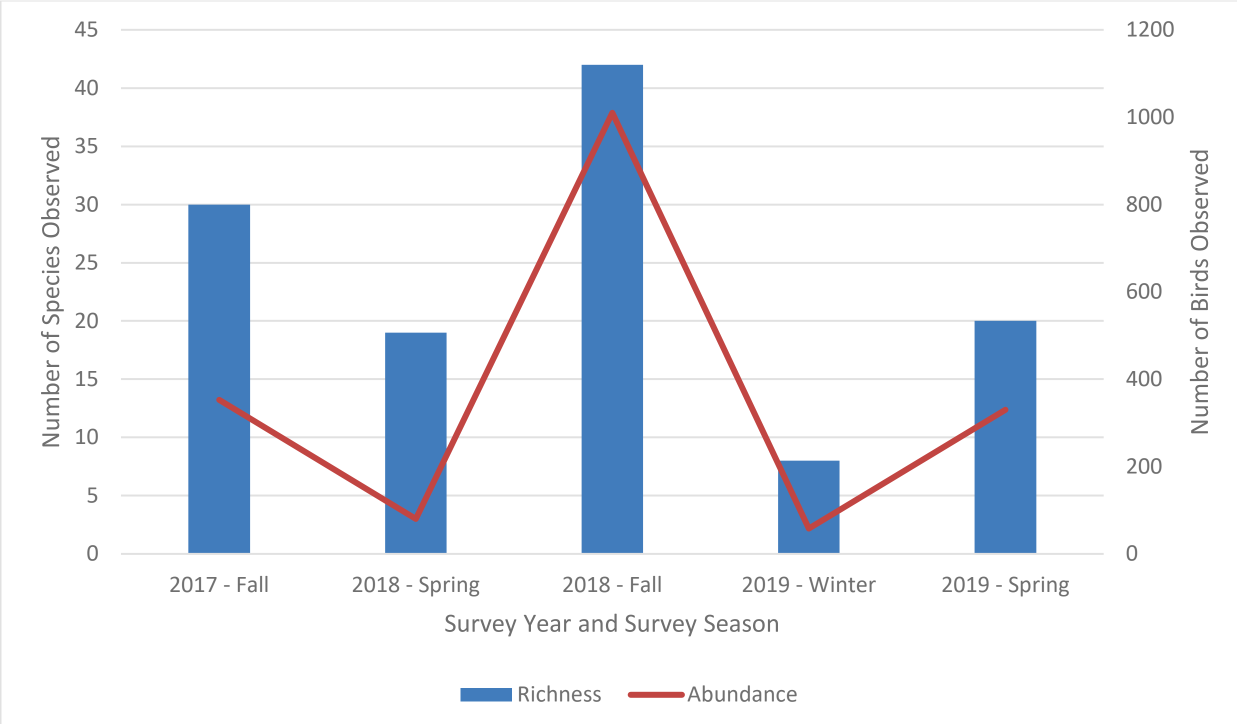


Figure 7.4-8: Seasonal Bird Abundance and Species Richness Documented during EEPGL-Commissioned Marine Bird Surveys

The seasonal variations described above indicate that the Stabroek Block and surrounding offshore area serve as habitat for seabirds undergoing multiple types of trans-continental migrations: classic Nearctic-Neotropic migration (jaegers and Common Tern); transoceanic migration (Bulwer's Petrel, Band-rumped Storm-Petrel, Leach's Storm-Petrel); and austral migration (shearwaters, Wilson's Storm-Petrel [*Oceanites oceanicus*]). Many of the species observed during the Spring 2018 and Spring 2019 surveys were northern breeders that had not yet departed for the breeding grounds or were passing through the region on their way northward, which indicates that Guyana's offshore marine ecosystem may be an important staging area[13] for seabirds breeding in both the northern and southern hemispheres.

In addition to the trans-continental migrations described above, the marine bird survey data indicate that the Stabroek Block and the surrounding offshore area is used by a variety of non-migratory seabirds for regional dispersal (movements between non-breeding and breeding sites). The use of the area for seasonal movements to breeding sites such as the nearby IBAs in Tobago and St. Vincent and the Grenadines (see Section 7.4.2.5, Important Bird Areas for Seabirds near Stabroek Block) is demonstrated by the sightings of Red-billed Tropicbird, Magnificent Frigatebird, and multiple booby species in breeding plumage flying in a northwesterly direction towards Tobago and St. Vincent and the Grenadines. All of these species are known to nest in the Tobago and St. Vincent and the Grenadines IBAs.

[13] Staging areas are areas along bird migration corridors that are consistently used by migrating birds for foraging and resting.

Incidental Seabird Observations Within and Near the Stabroek Block

Incidental observations within and en route to the Stabroek Block have been recorded by Protected Species Observers (PSOs) during various EEPGL-commissioned environmental and geophysical sampling and survey activities offshore Guyana from 2015 through 2019 (RPS 2018; RPS 2019). To date, PSOs have documented 6,955 individual birds representing 69 bird species offshore and nearshore Guyana during 1,816 survey days from May 2015 through April 2019 (RPS 2018; RPS 2019). Of these 69 species, 43 were also observed during the targeted EEPGL-commissioned marine bird surveys described above and 26 species were not documented during the targeted EEPGL-commissioned marine bird surveys. Of the 26 species not observed, four are pelagic seabirds and 22 are landbirds or coastal birds. The four pelagic seabird species recorded by PSOs, but not documented during EEPGL's targeted marine bird surveys, include Black-capped Petrel (*Pterodroma hasitata*), Great Skua, South Polar Skua (*Stercorarius maccormicki*), and Northern Gannet[14]. Of these five species, two (South Polar Skua and Northern Gannet) would be new country records for Guyana if confirmed with photographic evidence.

Similar to that documented in the EEPGL-commissioned marine bird surveys, the most common identified species documented through the incidental observations were Masked Booby (n = 2,521 or 36 percent), Magnificent Frigatebird (n = 1,006 or 15 percent), Barn Swallow (*Hirundo rustica*) (n = 332 or 5 percent), and Brown Booby (*Sula leucogaster*) (n = 254 or 4 percent).

Summary of Available Seabird Data for the Stabroek Block

The following points can be drawn from the EEPGL-commissioned marine bird surveys and incidental bird data collected during other offshore survey missions: (1) a wide complement of seabirds (35 species), including two species of conservation importance (Leach's Storm-Petrel and Black-capped Petrel, see Section 7.4.2.4 Conservation Status of Seabirds Confirmed for Offshore Guyana), occur in the Stabroek Block and surrounding waters; (2) the Guyana offshore avifauna changes substantially and consistently across a broad geographic area over the course of the year; (3) seasonal, latitudinal migration of seabirds, shorebirds, and landbirds occurs in the Stabroek Block and surrounding waters; (4) seabird abundance is generally low but the seasonality and population dynamics of seabirds in the area is not well-understood; (5) bird observations recorded within and near the Stabroek Block during targeted surveys and incidental observations were largely of lone individuals, which is generally characteristic of seabirds when far offshore; (6) seabird abundance increases with proximity to shoreline and many seabirds such as terns and gulls specialize in the nearshore environment instead of far offshore; (7) populations of seabirds and other birds (migrating and vagrant birds) in the Guyanese waters of the southern Caribbean are little studied to date, and the present set of studies constitutes a notable increase in the knowledge of the offshore bird communities, as is confirmed by the documentation of

[14] The Northern Gannet was provisionally identified during the EEPGL-commissioned marine bird surveys but the observations were not confirmed by photographic identification. As such, these are considered provisional records and are not included in the confirmed species list for the EEPGL-commissioned marine bird surveys or the related data analysis.

seasonal migrations in the Stabroek Block by a wide range of bird species and seven new species records for Guyana generated during the EEPGL-commissioned marine bird surveys.

7.4.2.4. Conservation Status of Seabirds Confirmed for Offshore Guyana

Of the 35 species of seabirds known to occur in Guyana based on historical and 2017–2019 survey records, 32 are currently listed on the IUCN Red List as Least Concern, which means that the population status of the species does not meet the IUCN criteria for a Threatened or Near Threatened designation (IUCN 2019) (see Section 7.1.2, Existing Conditions—Protected Areas and Special Status Species). The Barolo Shearwater, a recently described species that was previously considered a population of the Little Shearwater, has not had its conservation status evaluated by IUCN. Of the two remaining species, Leach's Storm-Petrel is classified as Vulnerable; and Black-capped Petrel is classified as Endangered.

Leach's Storm-Petrel was the most common species observed during the Spring 2018 EEPGL-commissioned marine bird surveys within the Stabroek Block and the second-most common species observed during the Spring 2019 marine bird surveys (Figure 7.4-9). Also, this species was previously reported in Guyana in eBird and during prior EEPGL surveys in the Stabroek Block (RPS 2018; RPS 2019). It nests in cold, northern ocean waters, so these individuals were likely undergoing their seasonal migration when observed in the Stabroek Block. Based on the number of sightings during spring over two consecutive years, the Stabroek Block can be considered to contain an appreciable population of this species seasonally.

IUCN-listed as Vulnerable; observed in the Stabroek Block, April 2018

Figure 7.4-9: Leach's Storm-Petrel (*Oceanodroma leucorhoa*)

The Black-capped Petrel, classified by IUCN as Endangered, has been reported in eBird for offshore Guyana and has been recorded during incidental observations collected by PSOs during various sampling activities in and near the Stabroek Block, but has not yet been observed by bird experts or confirmed through photographic documentation during EEPGL-commissioned marine bird surveys, which constitute the only targeted survey of seabirds ever conducted in the region.

The Black-capped Petrel nests in holes on escarpments in the highlands of Haiti and the Dominican Republic, and possibly Cuba, where between 500 and 2,000 nesting pairs occur (Jodice et al. 2015; Simons et al. 2013). Historical nesting areas in Guadeloupe, Martinique, and Dominica are considered to no longer be utilized. Birds nest from January through June, during which adults may make extended foraging trips at sea (Simons et al. 2013). Foraging expeditions of several days and up to thousands of kilometers have been demonstrated by satellite tagging of three nesting adults, which roamed the southern Caribbean in offshore Venezuela, near the Stabroek Block (Jodice et al. 2015). Visual sightings of adults in 2018 have occurred throughout the Caribbean in the waters of Puerto Rico, Dominica, Aruba, and Martinique. Migration occurs after breeding, principally along the Gulfstream along the eastern U.S. shore (eBird 2019b). This species is expected to be a rare transient offshore Guyana.

The Black-capped Petrel tends to feed on vertically migrating nekton[15] (Simons et al. 2013), of which myctophids (lanternfishes, a group of fish species that exhibit bioluminescence) are common to abundant in the waters of the Stabroek Block. The vertical migration of this prey resource at night may make the activity of this bird greater in hours of limited light and night, which could explain why the species was not observed during any of the EEPGL-commissioned marine bird surveys conducted to date - since surveys were not conducted during periods of low light. Other food items include Sargassum (a genus of macroalgae), crustaceans, squid, and fish (Simons et al. 2013).

7.4.2.5. Important Bird Areas for Seabirds near Stabroek Block

Since 2010, BirdLife International has focused its efforts on identifying Marine IBAs with specific significance to seabirds. The types of sites that qualify as Marine IBAs include seabird breeding colonies, foraging areas around breeding colonies, non-breeding (usually coastal) concentrations, migratory bottlenecks, and feeding areas for pelagic species (BirdLife International 2019b). No Marine IBAs have been identified in Guyana, but five Marine IBAs of global or regional importance to seabirds have been designated in neighboring and nearby countries that have reasonable potential, based on documented species life histories and foraging distances, to support seabirds that transit the Stabroek Block during local and regional movements to and from their breeding sites or during offshore foraging trips (Table 7.4-5). Figure 7.4-10 depicts one of the seabird species documented during surveys in the Stabroek Block that breeds in these IBAs. Figure 7.4-11 depicts the location of these IBAs relative to the Stabroek Block.

[15] Actively swimming aquatic organisms in a body of water that can move independently from water currents

Table 7.4-5: Marine IBAs with Importance to Seabirds that Transit the Stabroek Block

Important Bird Area Name	**Country**	**IBA Attributes** [a]
Little Tobago Island	Trinidad and Tobago	This IBA supports globally important breeding populations of Red-billed Tropicbird (*Phaethon aethereus*) and Laughing Gull (*Leucophaeus atricilla*), and regionally important breeding populations of Audubon's Shearwater (*Puffinus lherminieri*), Brown Booby (*Sula leucogaster*), Red-footed Booby (*Sula sula*), and Bridled Tern (*Onychoprion anaethetus*). Seabird population estimated at over 2,000 breeding pairs.
St. Giles Islands	Trinidad and Tobago	This IBA supports globally important breeding populations of Red-billed Tropicbird and regionally important breeding populations of Audubon's Shearwater, Magnificent Frigatebird (*Fregata magnificens*), Masked Booby (*Sula dactylatra*), and Red-footed Booby. Other seabird species including Brown Booby and Brown Noddy (*Anous stolidus*) also breed there. Total seabird population estimated at over 2,000 individuals.
All Awash Island	St. Vincent and the Grenadines	This IBA supports regionally significant breeding populations of several seabird species, most notably a large breeding population of Roseate Tern (*Sterna dougalli*) (~475 pairs). During the non-nesting period, hundreds to thousands of seabirds forage in surrounding waters and use the island for roosting.
Battowia Island	St. Vincent and the Grenadines	This IBA supports regionally significant populations of roosting and breeding seabirds (>5,000 pairs), including Magnificent Frigatebird, Red-footed Booby, Brown Booby, and Laughing Gull.
Petit Canouan Island	St. Vincent and the Grenadines	This IBA supports regionally significant populations of breeding seabirds (>2,200 pairs) including Sooty Tern (*Onychoprion fuscatus*), Brown Booby, Laughing Gull, Magnificent Frigatebird, Roseate Tern, Royal Tern (*Sterna maxima*), and Brown Noddy.

[a] Sources: BirdLife International 2019a, 2019b

One of the species with large breeding colonies in the Tobago and St. Vincent and the Grenadines IBA; observed in the Stabroek Block, January 2019

Figure 7.4-10: Brown Noddy (*Anous stolidus*)

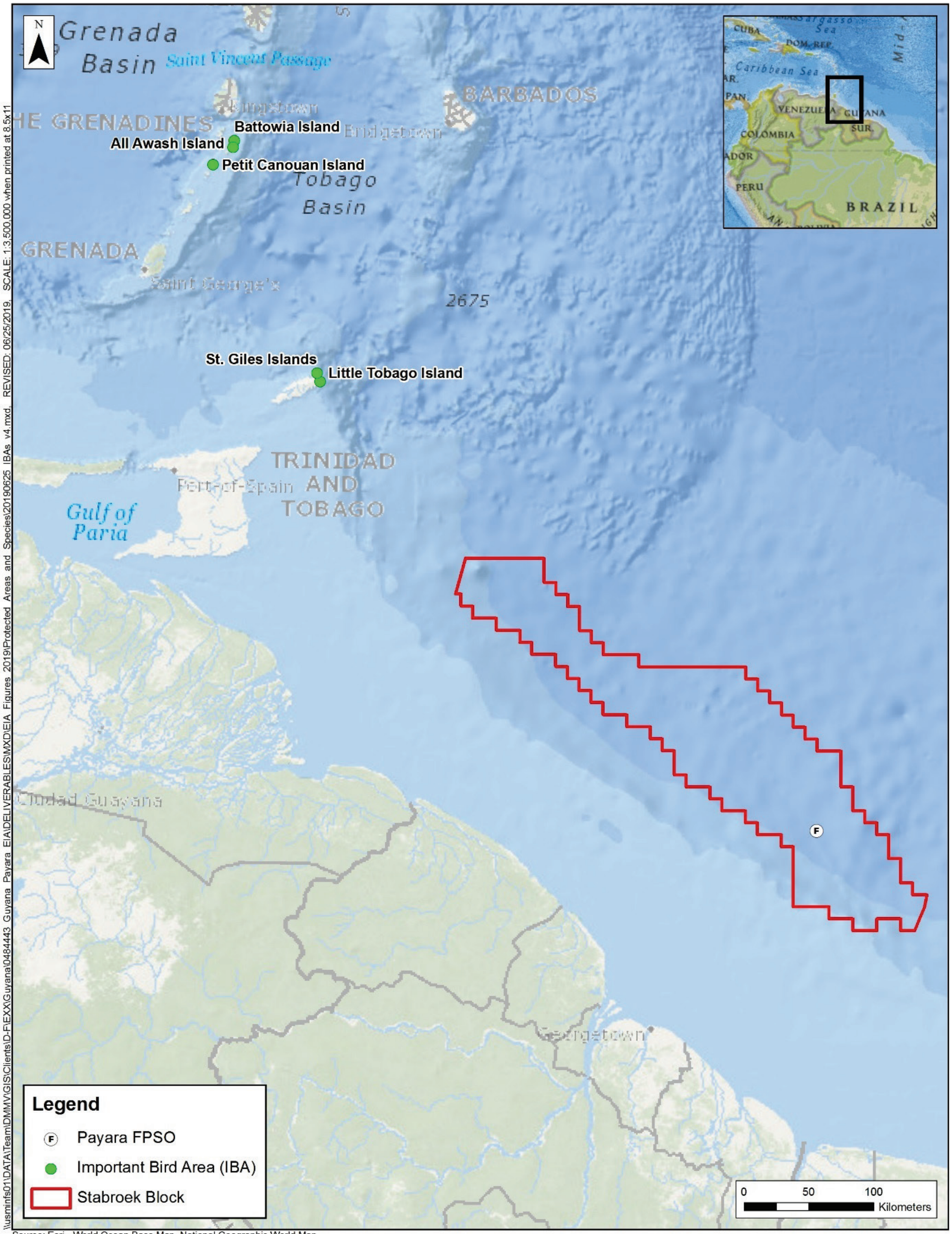


Figure 7.4-11: Location of Marine IBAs with Importance to Seabirds that Transit the Stabroek Block

7.4.3. Impact Assessment—Seabirds

This section discusses potential impacts on seabirds from planned Project activities. Thirty-five seabird species have been documented in Guyana's offshore waters, including the area in the vicinity of the PDA, based on historical and recent survey data. Several resident seabird species occur in the area throughout the year and migratory seabirds typically occur in the area starting in late summer, with many remaining through winter and into early spring. When seabirds are not breeding, they primarily live in offshore environments, moving with prey resources and roosting and loafing on islands or artificial structures in the ocean or simply rafting[16] on the ocean surface. The presence of seabirds in a given area is heavily resource-driven, with individuals and groups of seabirds primarily attracted to prey concentrations. No evidence suggests that large concentrations of seabird prey (primarily fish) consistently occur in the PDA that would promote regular use of the PDA by foraging seabirds. Rather, seabirds in the area are likely transients, moving opportunistically with schools of fish and other prey. The turbid conditions in the PDA further reduce the likelihood that the area has significant importance for foraging seabirds. Further, no islands or artificial structures occur in the PDA, so the area does not contain any known roosting or loafing areas where large numbers of seabirds might congregate. As such and as described above, it is expected that seabirds occur in the PDA throughout the year, but at a relatively low density and for short (transient) periods depending on prey availability. The highest abundance of seabirds offshore Guyana occurs during spring and fall migration.

7.4.3.1. Relevant Project Activities and Potential Impacts

The Project has the potential to impact seabirds through injury (e.g., collision with Project features), disturbance leading to changes in behavior (e.g., via displacement or attraction from sound, lighting, and/or presence of the FPSO), or toxicological effects (e.g., as a result of exposures to Project vessel discharges).

Table 7.4-6 summarizes the Project stages and activities that could result in potential Project impacts on seabirds. Potential impacts on seabirds from unplanned events, including oil spills, contact with the FPSO flare (or heat plume), and vessel and helicopter strikes, are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

[16] Rafting is a common seabird behavior involving a tight aggregation of seabirds floating on the ocean surface to form a "raft."

Table 7.4-6: Summary of Relevant Project Activities and Key Potential Impacts—Seabirds

Stage	Project Activity	Key Potential Impact
Development Well Drilling SURF/FPSO Installation	Presence of drill ships and installation vessels	• Physical presence of drill ships and installation vessels (with lighting), potentially acting as an attractant to seabirds, exposing them to collision risks, additional energy expenditure, and compromised navigation for night-migrating birds • Vessels may be of benefit to some species that use the vessel for rest or shelter during long flights or adverse weather
	Operation of supply and support vessels	• Light and sound disturbance, leading to attraction to or avoidance of the exposed area
	Discharge of drill cuttings	• Exposures to permitted discharges, potentially leading to toxicological impacts
	Discharge of wastewater effluents	
Production Operations	Presence of FPSO	• Physical presence of FPSO (with lighting), potentially acting as an attractant to seabirds, exposing them to collision risks, additional energy expenditure, and compromised navigation for night-migrating birds • Structures may be of benefit to some species that use the structure for rest or shelter during long flights or adverse weather, or as an attractant for seabird prey
	Discharge of cooling water and produced water	• Exposures to permitted discharges, potentially leading to toxicological impacts
	Discharge of wastewater effluents	
	Operation of supply and support vessels	• Avoidance or attraction due to lighting and activity
Decommissioning	Decommissioning activities PDA and related vessel traffic	• Light and sound disturbance from decommissioning activities, potentially leading to attraction to or avoidance of the PDA • Removal of a resting place and reliable food source if the FPSO acts as an attractant for seabird prey

Potential impacts from seabird exposure to discharge of drill cuttings, produced water, and other wastewater effluents are expected to be negligible because the effluents are not highly toxic, the discharges will rapidly mix with ambient water, and the numbers of seabirds potentially exposed to the effluents are expected to be low. Accordingly, these impacts are not discussed further in this section. Sections 6.3.3, Impact Assessment—Marine Geology and Sediments, and 6.4.3, Impact Assessment—Marine Water Quality, provide further analysis of the impacts of these discharges on marine sediment and water quality, respectively.

Potential benefits from the Project to seabirds include the use of the FPSO, drill ships, and installation vessels for rest or shelter during adverse weather conditions or during long migrations. In addition, if such vessels act as consistent attractants for seabird prey, they could induce the creation of a reliable food resource for seabirds in the PDA. While these are not expected to be significant benefits to seabirds at the population level, they are discussed below.

7.4.3.2. Magnitude of Impacts—Seabirds

The assessment of the Project's magnitude of potential impacts on seabirds is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on seabirds is defined according to the definitions provided in Table 7.4-7. The following paragraphs discuss the characteristics of the potential impacts assessed and the resultant magnitude ratings. These are summarized in Table 7.4.8.

Table 7.4-7: Definitions for Intensity Ratings for Potential Impacts on Seabirds

Criterion	Definition
Intensity	Negligible: No discernible change in seabird behavior or presence in the impacted area or very rare instances of injury or mortality.
	Low: Minor behavioral changes in seabirds or occasional injury or mortality of individuals that would not measurably impact habitat use, regional population status, or viability of seabird populations.
	Medium: Regularly observed changes in seabird behavior, injury, and mortality of individuals, but not such that this would affect the long-term viability of regional seabird populations.
	High: Significant changes in seabird behavior or significant mortality that could affect the long-term viability of seabird populations.

Attraction to Project Vessels and the FPSO

Seabirds are known to aggregate around large offshore installations such as drill ships and can be present in above-average numbers due to artificially increased food concentrations, lighting, and attraction to the structure itself for roosting (Wiese et al. 2001). The impacts of attraction and aggregation on seabirds around an offshore facility can be both positive and negative and can vary considerably by species and, more specifically, a species' typical behavior and the type and length of use of the impacted area. The structure may be beneficial to seabirds by providing a resting place or shelter during feeding, migration, or adverse weather in areas where these places would otherwise not be found.

The potential adverse impacts associated with seabird attraction to offshore facilities primarily relate to lighting. The drill ships, installation vessels, and FPSO will operate 24 hours a day, so at night they will constitute a prominent source of artificial light in an otherwise dark environment. The amount of light in the PDA will vary during the different stages of the Project. Lights on offshore oil platforms and other installations are known to act as an attractant to seabirds and typical offshore installation lighting extends roughly 3 to 5 kilometers (2 to 3 miles) around the source (Wiese et al. 2001). Poor weather, such as fog, precipitation, and low cloud cover can exacerbate the impact of nocturnal attraction to lights, especially when coincidental with bird migrations (Ronconi et al. 2015).

Lighting on offshore facilities can be disorienting to night-migrating birds, particularly waterfowl, which migrate using stellar cues that can be obscured by lights (Gaston et al. 2013). Birds lose their stellar cues for nocturnal navigation under low cloud ceiling or other adverse weather conditions, and in these circumstances artificial lights become the strongest cues that birds have for navigation. As a result, they are attracted to the lights and will fly around them for extended periods, a phenomenon referred to in scientific literature as the "trapping effect" or "light circling." The time individual birds spend circling can range from a few minutes to several hours to days, with an average of around 15 minutes (Marquenie 2007). The consequences of this may be: (1) energy wasted circling the installation, which can be problematic for individual birds undergoing long migrations; (2) collision with the structure or other birds, potentially resulting in mortality or injury—which can in turn cause individual birds to remain on the structure for long periods where there is no drinking water; (3) increased exposure to Project facilities and activities from the attraction to the area and potential exposure to radiant heat from flaring events, which can cause injury or death; and (4) increased risk of predation due to weakness, disorientation, or injury following long periods of circling or collision with a Project structure (Baird 1990; Ronconi et al. 2015; Platteeuw and Henkens 1997; Deda et al. 2007).

The potential thus exists for Project lighting to result in behavioral changes in seabirds or occasional injury or mortality of individuals, particularly during the production operations phase of the Project when the FPSO will be a consistent presence for a prolonged period (approximately 20 years). As an embedded control to manage lighting-related impacts from the Project, lighting on the FPSO and major vessels will be directed, where practicable, to required operational areas rather than at the sea surface or skyward. This will reduce the intensity and locations of lighting to which seabirds may be exposed by the Project. Further, the PDA is not located within a major seabird migratory flyway, nor is it known to support large numbers of seabirds; accordingly, the number of individuals that could be impacted by the potential impacts described above is expected to be limited, meaning the Project will not impact any seabird species at the population level. As such, based on the impacts described above and the definitions of the intensity ratings presented in Table 7.4-7, the intensity of the potential impacts on seabirds related to attraction to Project vessels and the FPSO is rated as **Low** during the production operations phase and **Negligible** during the drilling and decommissioning phases. Effects would not extend more than a few kilometers from the light source, so the geographic extent of potential impact is the **Direct AOI**. These impacts are expected to be **Continuous** but infrequent due to the low abundance of seabirds in the PDA throughout much of the year (highest bird abundance occurs during spring and fall migration) and the fact that only some of the exposed individuals would be affected by the attraction-related impacts described above. The potential for the impact will be present throughout the Project life cycle (at least 20 years), yielding a duration of **Long-term** for drilling, installation, and production operations phases, and at least **Medium-term** for the decommissioning stage. This yields a magnitude rating of **Small** for potential impacts on seabirds from attraction to Project features during the production operations phase and **Negligible** during the drilling and decommissioning phases of the Project.

The drill ships, major installation vessels, and FPSO may be of benefit to some species that use the vessels for rest or shelter during long flights or adverse weather. Additionally, major vessels in the PDA could become an attractant for seabird prey (i.e., due to lighting) during the production operations stage. These are considered potential minor **Positive** impacts. These benefits will be most pronounced for the FPSO, as the FPSO will remain in the same location for the Project life cycle (at least 20 years). For this reason, seabirds are likely to become familiar with the location of this potential resting/prey location, and use may increase over time, as compared to mobile vessels operating in the area over a relatively short-time span during the drilling and installation stages. Decommissioning activities for the FPSO and related vessel traffic may impact seabirds in similar ways to that described for the installation and production operations stages but for a much shorter duration. The removal of the FPSO will eliminate the potential benefits from acting as a resting location or prey attractant but, as described above, the benefits are expected to be minor and seabirds are expected to quickly adapt to this change. As such, the intensity, and therefore magnitude, of the impact of a loss of a resting play or prey attract as a result of removal of the FPSO during decommissioning on seabirds is rated as **Negligible**.

Disturbance Related to Project Activities and Features

Seabirds are not known to be particularly sensitive to human activity, so increased human activity in the PDA is expected to have little impact. As such and similar to that described for the attraction effects above, the intensity of this impact on seabirds is rated as **Low** for the production operations phase and **Negligible** for the drilling and decommissioning phases of the Project. Project activities that could result in disturbance or avoidance behavior by seabirds will decrease during the production operations stage, so potential disturbance of seabirds will decrease as well. There will be a small increase in human activity during decommissioning, but that increase will be of relatively short duration and will not rise to the same level of activity associated with drilling and installation. Since any seabird occurring in the **Direct AOI** may experience disturbance from the presence of Project activities and features, disturbance-related impacts are considered to be **Continuous** and **Long-term** for drilling, installation, and production operations phases, and at least **Medium-term** for the decommissioning phase. This yields a magnitude rating of **Negligible** to **Small** for potential impacts on seabirds from disturbance from Project activities and features (Table 7.4-8).

Table 7.4-8: Magnitude of Impact—Seabirds

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Development Well Drilling SURF/FPSO Installation	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Direct AOI	Negligible	Continuous	Long-term	Negligible
	Seabirds—light and sound disturbance from Project activities	Direct AOI	Negligible	Continuous	Long-term	Negligible
Production Operations	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Direct AOI	Low	Continuous	Long-term	Small
	Seabirds—light and sound disturbance from Project activities	Direct AOI	Low	Continuous	Long-term	Small

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Decommissioning	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Direct AOI	Negligible	Continuous	Medium-term	Negligible
	Seabirds—light and sound disturbance from decommissioning activities	Direct AOI	Negligible	Continuous	Medium-term	Negligible
	Removal of the FPSO as a resting place or attractant of prey	Direct AOI	Negligible	Continuous	Medium-term	Negligible

7.4.3.3. Sensitivity of Receptor—Seabirds

Seabirds are expected to occur in the PDA throughout the year, but at low densities and primarily as transients moving with prey resources. All but 2 of the 35 species of seabirds known to occur offshore Guyana and the Stabroek Block are listed on the IUCN Red List as Least Concern or Data Deficient. Since the majority of birds that occur in the Direct AOI do not have elevated conservation status, the determination of sensitivity of seabirds to potential impacts was conducted based on life history and behavior and, hence, their susceptibility to impacts. As stated in Section 7.4.2.1, Background, seabirds in the PDA area are likely to be transients, moving opportunistically with prey or making seasonal dispersal movements or migrations. All survey data conducted to date through EEPGL-commissioned surveys and incidental observations indicate that birds do not congregate in the Stabroek Block, but rather pass through the area as lone individuals or occasionally in pairs. Table 7.4-9 provides definitions for the receptor sensitivity ratings for potential impacts on seabirds. These definitions apply for only those species rated as Least Concern, Data Deficient, or not assessed on the IUCN Red List. Species rated as Near Threatened or higher, specifically the two species of seabirds with elevated conservation status known to occur offshore Guyana—Leach's Storm-Petrel and the Black-capped Petrel—are addressed in Section 7.1, Protected Areas and Special Status Species. Based on the definitions shown in Table 7.4-9, non-special status seabirds are considered to have a **Low** sensitivity.

Table 7.4-9: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Seabirds

Criterion	Definition
Sensitivity	Low: No seabird species known or expected to occur in the PDA possess unique susceptibilities to Project-related impacts. Impacts, should they occur, would be to individual birds and not congregations of birds.
	Medium: One or a limited number of seabird species with elevated susceptibility to Project-related impacts due to prolonged or regular presence in the PDA, and/or one or a limited number of species that exhibit habitat preferences or behaviors that limit their ability to avoid Project-related impacts, but representing a small fraction of the regional or global populations of affected species.
	High: Several seabird species with elevated susceptibility to Project-related impacts due to prolonged or regular presence in the PDA, and/or several species that exhibit habitat preferences or behaviors that greatly limit their ability to avoid Project-related impacts, representing a substantial fraction of the regional or global populations of affected species.

7.4.3.4. Impact Significance—Seabirds

Based on the magnitude of impact of receptor sensitivity ratings described above, the pre-mitigation significance ratings for potential (adverse) impacts on seabirds range are rated as **Negligible** (see Table 7.4-11).

7.4.4. Mitigation Measures—Seabirds

The embedded controls, such as use of directional lighting to the extent practicable, that are integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on seabirds. Table 7.4-10 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.4-10: List of Embedded Controls and Monitoring Measures

Embedded Controls
When non-aqueous drilling fluid (NADF) is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with International Maritime Organization/International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 milligrams per liter (mg/L) on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals
Measure residual chlorine concentration of sewage discharges form the FPSO monthly to ensure it is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to ensure that there are no floating solids or discoloration of the surrounding waters.

Adhere to operational controls regarding material storage, wash-downs, and drainage systems.

Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes:
• Reviewing Safety Data Sheets;
• Evaluating alternate chemicals;
• Considering hazard properties, while balancing operational effectiveness and meeting performance criteria, including:
  – Using the minimum effective dose of required chemicals
  – Considering minimum safety risk relative to flammability and volatility
• Evaluating risk of residual chemical releases into the environment.

Ensure wastewater released from the onboard sewage treatment plant complies with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.
Ensure there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge.
Treat bilge water in accordance with MARPOL 73/78 to ensure compliance with an oil in water content of less than 15 parts per million as applicable.
Where practicable, direct lighting on FPSO and major Project vessels to required operational areas rather than at the sea surface or skyward. Ensure lighting on vessels adheres to maritime safety regulations/standards.
Monitoring Measures
Prior to and post-drilling, a remotely operated vehicle will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to ensure that end of well maximum weighted mass ratio averaged over all well sections drilled using non-aqueous base fluid shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C at 100 meters (approximately 328 feet) from point of discharge.
Use load monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Monitor chlorine concentration of treated sewage discharges.
Perform daily visual inspection of discharge points to ensure absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to ensure compliance with 15 parts per million MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.4-11 summarizes the assessment of potential pre-mitigation and residual Project impacts on seabirds. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the seabird-specific methodology described in Sections 7.4.3.2, Magnitude of Impacts—Seabirds, and 7.4.3.3, Sensitivity of Receptors—Seabirds.

Table 7.4-11: Summary of Potential Pre-Mitigation and Residual Impacts—Seabirds

Stage	Receptor—Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling SURF/FPSO Installation	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Negligible	Low	Negligible	None	Negligible
	Seabirds—light and sound disturbance from Project activities	Negligible	Low	Negligible	None	Negligible
Production Operations	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Small	Low	Minor	None	Minor
	Seabirds—light and sound disturbance from Project activities	Small	Low	Minor	None	Minor
	Seabirds—benefit from use of major vessels as a resting place or attractant of prey	Not rated, (Positive)	Low	Positive	None	Positive
Decommissioning	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Negligible	Low	Negligible	None	Negligible
	Seabirds—light and sound disturbance from Project activities	Negligible	Low	Negligible	None	Negligible
	Seabirds—removal of FPSO as a resting place or attractant of prey	Negligible	Low	Negligible	None	Negligible

7.5. MARINE MAMMALS

7.5.1. Administrative Framework—Marine Mammals

Table 7.5-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on marine mammals.

Table 7.5-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Marine Mammals

Title	Objective	Relevance to the Project
Legislation		
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora.	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a supportive mechanism cognizant of the national goals for wildlife protection, conservation, management, sustainable use, and external trade.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.

7.5.2. Existing Conditions—Marine Mammals

A basic understanding of the existing species composition and distribution of the marine mammal community in the vicinity of the PDA and in the Stabroek Block is provided by various sources, including regional compilations (Ward et al. 2001; Ward and Moscrop 1999), Marine Mammal Observer (MMO) data collected during EEPGL's exploration activities from 2015 to 2019 (Appendix O, Protected Species Observer Summary), published studies on cetaceans in offshore waters of neighboring countries (Suriname and Venezuela; de Boer 2015), and incidental commercial fishery interaction reports (Project GloBAL 2007).

Information from these reports and other studies provides the foundation for the existing conditions on cetaceans offshore Guyana. At one time, two pinniped groups (seals and sea lions) were documented in the region, but they are now considered extinct or extremely rare in the region. Therefore, pinnipeds are not expected to be encountered in coastal waters adjacent to the PDA (Ward et al. 2001).

EEPGL's MMO data were collected by PSOs participating in various programs offshore Guyana during 2015 through 2019. Data were collected during five survey types—three dimensional (3D)/four dimensional (4D) surface seismic; field geotechnical; automated underwater vehicle (AUV); vertical seismic profile (VSP); and environmental baseline/metocean. The MMO data collection effort considered for the purpose of this assessment consisted of the following:

- 3D/4D surface seismic
  - Stabroek 3D: 12 July 2015 to 17 February 2016
  - Canje 3D: 18 March 2016 to 20 August 2016
  - Liza 3D/4D: 23 August 2017 to 19 November 2017
  - Northwest Stabroek and Southeast Stabroek *Ramform Tethys* and *Ramform Atlas*: 05 December 2018 to April 2019
- Field geotechnical survey
  - Canje: 28 July 2018 to 28 September 2018
  - Liza: 28 July 2018 to 28 September 2018
  - Payara Geotechnical, Geophysical/AUV and Environmental Baseline: 05 September 2018 to 27 December 2018
- AUV
  - Liza AUV: 17 December 2015 to 23 March 2016
  - Hammerhead AUV: 16 March 2019 to 17 April 2019
- VSP
  - Liza-1 Stabroek Zero-Offset VSP: 09 May 2015 to 12 May 2015
  - Liza-1 Stabroek Walk Away VSP: 06 June 2015 to 08 June 2015
  - Liza-2 Stabroek Walk Above VSP: 28 March 2016 to 01 April 2016
  - Payara-1 Stabroek Zero-Offset VSP: 04 December 2016 to 05 December 2016
  - Stabroek VSP 1: 29 September 2017 to 02 October 2017
  - Stabroek VSP 2: 15 December 2017 to 17 December 2017
  - Stabroek VSP 3: 03 January 2018 to 08 January 2018
  - LongTail-1 *Stena Carron* Zero Offset VSP: 02 June 2018 to 06 June 2018
  - LongTail-1 *Bourbon Orca* Walk-Away VSP: 15 June 2018 to 20 June 2018
  - Hammerhead *C-Installer* Walk-Away VSP: 28 August 2018 to 30 August 2018
  - Pluma-1 *Noble Tom Madden* VSP: 12 November 2018 to 16 November 2018
  - Pluma-1 *PSV Eland* VSP: 28 November 2018 to 29 November 2018
  - Pluma-1 *PSV Eland* VSP: 11 December 2018 to 13 December 2018
  - Stabroek *Stena Carron* VSP: 23 January 2019 to 03 February 2019
  - Stabroek *Noble Tom Madde*n VSP: 07 April 2019 to 08 April 2019
  - Stabroek *Noble Tom Madden* VSP: 17 April 2019 to 19 April 2019

- Environmental Baseline and Metocean Surveys
  - Liza Environmental Baseline 1: 27 September 2017 to 02 October 2017
  - Liza Environmental Baseline 2: 18 October 2017 to 28 October 2017
  - Liza Environmental Baseline 3: 28 October 2017 to 20 November 2017
  - Liza Environmental Baseline 4: 19 March 2018 to 16 April 2018
  - *Sea Service* Metocean Retrieval Survey: 01 October 2018 to 06 October 2018
  - Southeast Stabroek / Kaieteur *Proteus* Environmental Baseline Survey: 08 April 2019 to 15 April 2019

7.5.2.1. Regional Setting

The equatorial waters of Guyana are located within sub-region VI of the Wider Caribbean Region. This sub-region includes the countries of Guyana, Suriname, and French Guiana (Ward and Moscrop 1999). Many cetacean species are known to occur either seasonally or year-round in the Caribbean region, but there are limited data describing the life history, behavior, and movement patterns of most marine mammals offshore Guyana. The cetacean community is also under-recorded in waters off of French Guiana (de Boer 2015; Mannocci et al. 2013). In contrast, more detailed records exist for Venezuela and the southern Caribbean region. It should be noted that the scarcity of cetacean records for sub-region VI can be attributed to a lack of survey effort rather than an absence of marine mammals (de Boer 2015).

7.5.2.2. Marine Mammal Data from the Project Development Area Vicinity

Historical Marine Mammal Data

The 2007 Global Bycatch Assessment of Long-lived Species Country Profile of Guyana (Project GloBAL 2007) provides a list of marine mammals whose distributions overlap with Guyana's Exclusive Economic Zone. The cetacean species documented in this report are listed in Table 7.5-2 along with their IUCN Red List status (IUCN 2019).

Table 7.5-2: Marine Mammals with Ranges that include Waters Offshore Guyana

Common Name	Scientific Name	IUCN Status	Notes
Sei whale	*Balaenoptera borealis*	EN	The sei whale is a baleen whale and is the third-largest after the blue whale and the fin whale. It inhabits most oceans and adjoining seas, and prefers deep offshore waters.
Bryde's whale	*Balaenoptera brydei*	DD	Bryde's whales are moderately sized and closely resemble their relative, the sei whale.
Blue whale	*Balaenoptera musculus*	EN	Blue whales are the largest mammals on earth. Their diet consists almost entirely of krill. Blue whales were hunted nearly to extinction.
Fin whale	*Balaenoptera physalus*	EN	Fin whales are the second largest mammal after blue whales. They are found worldwide and their food consists of small fish, squid, copepods, and krill.
Minke whale	*Balaenoptera acutorostrata*	LC	Minke whales are the second smallest baleen whale.

Common Name	Scientific Name	IUCN Status	Notes
Short-beaked common dolphin	*Delphinus delphis*	LC	Short-beaked common dolphins occur throughout warm temperate and tropical oceans. Short-beaked common dolphins can occur in aggregations of hundreds or even thousands of dolphins. They sometimes associate with other cetacean species, such as pilot whales.
Long-beaked common dolphin	*Delphinus capensis*	DD	Long-beaked common dolphin is more geographically restricted (i.e., smaller in area) than that of the short-beaked common dolphin. It has a varied diet. One of the main threats to this dolphin is fishery by-catch
North Atlantic right whale	*Eubalaena glacialis*	EN	The North Atlantic right whale is a baleen whale that was once a preferred target for whalers. They feed mostly on copepods and krill.
Pygmy killer whale	*Feresa attenuata*	DD	The pygmy killer whale is a poorly known and rarely seen dolphin that avoids human contact. They are often caught in drift gill nets.
Short-finned pilot whale	*Globicephala macrorhynchus*	DD	Short-finned pilot whales are very sociable and are rarely seen alone. They are found in groups of 10 to 30, although some pods are as large as 50. The species primarily feeds on squid, but will also feed on certain species of fish and octopus. They feed nearly 300 meters (approximately 984 feet) deep or more, and spend great lengths of time at depth. A pod may spread out up to 800 meters (approximately 2,640 feet) to cover more area to find food.
Risso’s dolphin	*Grampus griseus*	LC	Risso’s dolphins are found worldwide in temperate and tropical waters, just off the continental shelf on steep banks. Risso’s dolphins feed almost exclusively on neritic and oceanic squid, mostly nocturnally.
Pygmy sperm whale	*Kogia breviceps*	DD	The pygmy sperm whale is not much larger than many dolphins. Pygmy sperm whales are normally either solitary or found in pairs. They feed mainly on cephalopods.
Dwarf sperm whale	*Kogia simus*	DD	The dwarf sperm whale is the smallest species commonly known as a whale. Dwarf sperm whales feed mainly on squid and crab. Their preferred habitat appears to be just off the continental shelf.
Fraser’s dolphin	*Lagenodelphis hosei*	LC	Fraser’s dolphin is normally sighted in deep tropical waters. Fraser's dolphins swim quickly in large, tightly packed groups of about 100 to 1,000 in number.
Humpback whale	*Megaptera novaeangliae*	LC	The humpback whale is found in oceans and seas around the world. Humpback whales typically migrate up to 25,000 kilometers (approximately 15,534 miles) each year. Humpbacks feed only in summer, in polar waters, and migrate to tropical or subtropical waters to breed and give birth in the winter. Once hunted to the brink of extinction, its population fell by an estimated 90% before a 1966 moratorium. Since this time, stocks have partially recovered.

Common Name	Scientific Name	IUCN Status	Notes
Blainville's beaked whale	*Mesoplodon densirostris*	DD	Blainville's beaked whale is found in tropical and warm waters in all oceans, and has been known to range into very high latitudes. The whales are seen in groups of three to seven individuals. Dives have been measured as long as 22 minutes.
Gervais' beaked whale	*Mesoplodon europaeus*	DD	Gervais' beaked whale forms small groups. They most likely feed on squid. Although this species frequently strands, until 1998, no one had made a confirmed sighting of the species at sea.
True's beaked whale	*Mesoplodon mirus*	DD	True's beaked whales have been seen in small groups, and are believed to be squid eaters. Little else is known.
Melon-headed whale	*Peponocephala electra*	LC	Melon-headed whale is closely related to the pygmy killer whale and pilot whale, collectively this dolphin species is known by the common name blackfish. It is also related to the false killer whale. The melon-headed whale is widespread throughout the world's tropical waters, although not often seen by humans because it prefers deep water.
Sperm whale	*Physeter macrocephalus*	VU	The sperm whale is the largest of the toothed whales that can be found anywhere in the open ocean. Females and young males live together in groups while mature males live solitary lives outside of the mating season. Females give birth every 4 to 20 years and care for the calves for more than a decade. A mature sperm whale has few natural predators. They feed on squid and fish and usually dive between 300 to 800 meters (984 to 2,625 feet) to forage.
False killer whale	*Pseudorca crassidens*	DD	False killer whales live in temperate and tropical waters throughout the world. As its name implies, the false killer whale shares characteristics, such as appearance, with the more widely known killer whale. Like the killer whale, the false killer whale attacks and kills other cetaceans.
Pantropical spotted dolphin	*Stenella attenuata*	LC	Pantropical spotted dolphin is found in the world's temperate and tropical oceans. This species was threatened due to the killing of millions of individuals in tuna purse seines until the rise of "dolphin-friendly" tuna capture methods in the 1980s benefited the species. It is now one of the most abundant dolphin species in the world.
Clymene dolphin	*Stenella clymene*	DD	Clymene dolphins spend most of their lives in waters more than 100 meters (330 feet) in depth, but occasionally move into shallower, coastal regions. They feed on squid and small schooling fish, hunting either at night, or in mesopelagic waters where there is only limited light.
Striped dolphin	*Stenella coeruleoalba*	LC	The striped dolphin inhabits temperate or tropical, offshore waters. It moves in large groups—usually up to thousands of individuals in number. The adult striped dolphin eats fish, squid, octopus, krill, and other crustaceans.

Common Name	Scientific Name	IUCN Status	Notes
Spinner dolphin	*Stenella longirostris*	DD	The spinner dolphin is a small dolphin found in offshore tropical waters around the world. The species primarily inhabits coastal waters, islands, or banks.
Rough-toothed dolphin	*Steno bredanensis*	LC	Rough-toothed dolphins can be found in deep warm and tropical waters around the world and are typically social animals. An average group has between 10 and 20 members. They have also been reported to school together with other species of dolphin, and with pilot whales, false killer whales, and humpback whales.

Source: Project GloBAL 2007; de Boer 2015; IUCN 2012; Minasian et al. 1984

EN = Endangered; LC = Least Concern; VU = Vulnerable; DD (Data Deficient) = Inadequate information to make a direct, or indirect, assessment of a species' risk of extinction based on its distribution and/or population status.

In 2015, the Dutch Institute for Marine Resources and Ecosystem Studies published a peer-reviewed article summarizing marine mammal data collected off Suriname in 2012, and incidental observations off Suriname and adjacent waters during 2008–2012 (de Boer 2015). The data from this study were collected at similar depths and distances offshore as the PDA. De Boer (2015) documented 10 identifiable species (shown in bold in de Boer 2015, Table 5-A). The article also documented incidental sightings of various marine mammals, including common bottlenose dolphins (*Tursiops truncatus*) off Trinidad, dolphins (*Stenella* sp.) off Guyana, and Guiana dolphin (*Sotalia guianensis*) at the entrance of the Suriname River during transit to the survey area (from Trinidad to Suriname). Thus, it is possible these species may be encountered closer to shore where Project-related marine support vessels are expected to transit.

De Boer (2015) reported the cetacean community in the Suriname area is primarily composed of odontocetes (toothed whales, sperm whales, beaked whales, killer whales, and dolphins). In general, these animals are more common offshore of Suriname than the baleen whales (including Bryde's whales [*Balaenoptera brydei*] and sei whales [*Balaenoptera borealis*]). The occurrence of baleen whales is likely seasonal, since Bryde's/sei whales were only recorded in June and July. Additional opportunistic records show that large baleen whales have been observed in early October (de Boer 2015). According to de Boer (2015), shelf and offshore waters are important habitat for the dolphin community.

De Boer (2015) noted that the most abundant species documented offshore Suriname were sperm whale (*Physeter macrocephalus*) and melon-headed whale (*Peponocephala electra*). Spinner dolphin (*Stenella longirostris*) and pantropical spotted dolphin (*Stenella attenuata*) were also frequently encountered in large groups. In general, the relative abundance of cetaceans was relatively low, given the water depth (approximately 1,190 to 3,350 meters [approximately 3,900 to 11,000 feet]). Based on these data, and other systematic surveys in tropical regions in the eastern Atlantic and western Africa, estimated densities were higher in areas that spanned both deep and shallow waters versus surveys only conducted in deep water offshore Suriname (de Boer 2010). For example, tropical shallow-shelf waters off the Maldives in the Indian Ocean generally support a more diverse and abundant cetacean community (Clark et al. 2012).

Other older reports provide additional information for context. For example, the International Whaling Commission Scientific Committee has published data from Venezuela (Bolaños-Jiménez et al. 2006) and French Guiana (Ridoux et al. 2010), which are relevant to Guyana given the close proximity. These reports indicate bottlenose dolphins are incidentally captured in gillnet and trawl fisheries in these countries. Gray river dolphin (*Sotalia fluviatilis*; locally referred to as tucuxi), despite being a primarily freshwater species, is also reported to be incidentally captured in gillnets and seines throughout its range, which includes the Guianas (French Guiana, Suriname, and Guyana). The West Indian manatee (*Trichechus manatus*) is sparsely distributed in coastal and riverine waters of the region and may be encountered in the Demerara River area. This species is discussed in more detail in Section 7.6, Riverine Mammals.

EEPGL-Commissioned Marine Mammal Data

As summarized above, EEPGL has commissioned the collection of marine mammal data offshore Guyana since 2015, during various survey activities related to oil and gas activities. Data on marine mammals have been collected using visual and auditory detection methods. Together, these survey efforts represent more than 18,000 hours of survey time and have generated the most comprehensive dataset available on marine mammal activity off the coast of Guyana (RPS 2018; RPS 2019).

A comprehensive summary of MMO data from 2015 through April 2018 was provided as part of the Liza Phase 2 Development Project EIA. A summary of MMO observations from May 2018 through April 2019 is included as Appendix O, Protected Species Observer Summary Report (RPS 2019). The following discussion is focused on the May 2018 through April 2019 report.

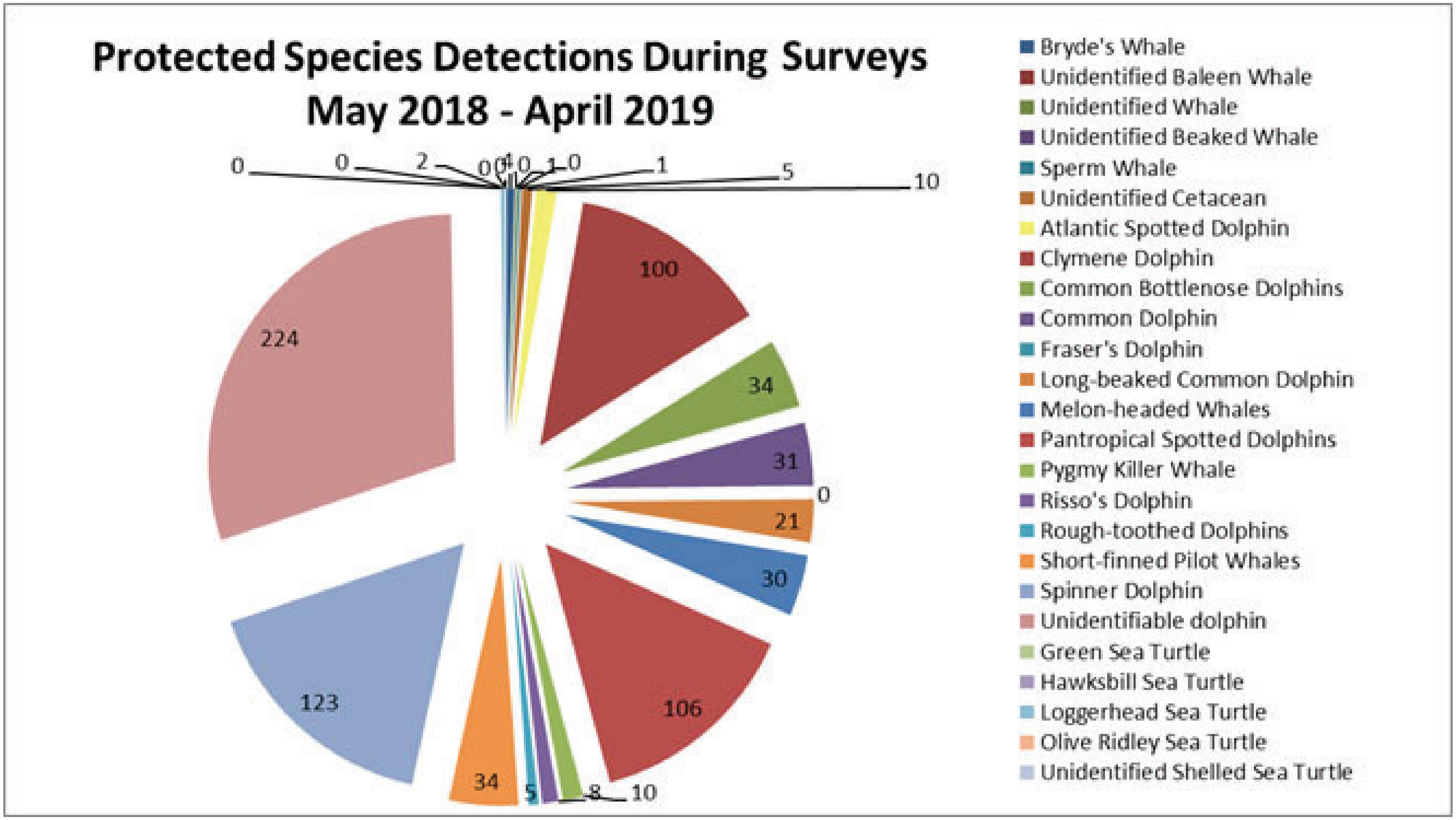
Overview of May 2018 through April 2019 Marine Mammal Survey Data

Between May 2018 and April 2019, PSOs conducted 3,092.3 hours of observations (1,615 hours and 53 minutes [active source], 1,476 hours and 26 minutes [inactive source], and 795 hours and 02 minutes [AUV survey]). In addition, passive acoustic monitoring (PAM) operators conducted 792.5 hours (435 hours and 31 minutes [active source] and 356 hours and 59 minutes [inactive source]) of visual and acoustic observations, respectively. PSOs scanned the sea surface by eye and the aid of binoculars at approximately 20-minute intervals. Shifts lasted no more than 4 hours followed by a break of no less than 2 hours. Monitoring occurred daily beginning at dawn (defined as approximately 15 minutes before sunrise) and continued throughout the day until the survey area could no longer be effectively observed due to darkness (approximately 15 minutes after sunset). Acoustic monitoring was conducted nightly, beginning approximately 15 to 20 minutes prior to dusk, and continuing until daylight, for as long as the PAM hydrophone cable was deployed. Acoustic monitoring overlapped visual monitoring efforts by 15 to 20 minutes at dawn and dusk. During an acoustic monitoring period, the PAM operator aurally monitored audio feed using headphones from up to all four hydrophone elements, which was first mixed using a RME *Fireface800* unit. Visualizations of the audio feed were also monitored via use of *Pamguard* software on two computer monitors: one configured to display low-frequency modules and the other configured to display high-frequency modules. Using this equipment, PAM operators detected and identified marine mammals based on the type of sound (click, burst pulses, moans, and creaks) and frequency. This also facilitated determination of the bearing and estimated distance to the animal using frequency or a detection scoring system developed by Gannier et al. (2002).

In total, 749 protected species detections (visual detections [n = 539 or 72 percent] and acoustic detections [n = 210 or 28 percent]) were made during May 2018 through April 2019 (Figure 7.5-1). Dolphins (number [n] = 526 detections or 72 percent) were the most common protected species detected by PSOs (visual) followed by whales (n = 11 detections or 1.5 percent), and turtles (n = 2 detections or 0.27 percent). Dolphins accounted for 100 percent of acoustic detections made by PAM operators; no whales were detected using the PAM equipment. This resembles the results from the prior EEPGL-commissioned surveys from 2015 through April 2018, during which dolphins accounted for 64 percent of visual detections and 94 percent of acoustic detections (RPS 2018). The total number of detections was 570 during 2015 through 2018. Most of the detections were acoustic (n = 364 detections). The majority of detections were of dolphins (82.5 percent of all detections, 63.8 percent of visual detections, and 94 percent of acoustic detections), with acoustic detections of unidentifiable dolphins accounting for the majority of all detections (58.2 percent). The visual detections included whales, dolphins, and sea turtles while acoustic detections consisted of whales and dolphins.

The most common identified dolphins in the May 2018 through April 2019 surveys (n = 12 delphinid species) were spinner dolphins (n = 123 or 23 percent) followed by pantropical spotted dolphins (n = 106 or 20 percent) and clymene dolphins (*Stenella clymene*) (n = 100 or 19 percent). The most common identified whales (n = 2 species) were Bryde's whales (n = 4 detections or 36 percent) and sperm whales (n = 1 detection or 9 percent); there were a few other whales detected, but their identification was unable to be confirmed.

Detection rates were calculated using the total numbers of visual and acoustic detections, along with the total visual and acoustic monitoring effort. Monitoring effort was then converted into decimal numbers and the total number of detections was divided by the total monitoring effort to estimate the detection rate for visual, acoustic, and total detections. The VSP-related data were excluded from this analysis due to the static nature of the surveys in comparison to the seismic and AUV surveys, with only a small area covered in VSP surveys, leading to potential bias in detection rate. Based on this approach, 103 detections (38 visual and 65 acoustic detections) were observed in the area. Overall, the estimated visual detection rate based on 1,702.03 hours of monitoring was 0.0223 detections per hour of monitoring effort. The estimated acoustic detection rate based on 792.30 hours of monitoring was 0.0820 detections per hour of monitoring effort. The overall detection rate was 0.0413 detections per hour of monitoring effort. These detection rates are similar to, although slightly higher than, those reported for the 2015–April 2018 data summarized in Liza Phase 2 Development Project EIA, which reported a visual detection rate of 0.0226 detections per hour of monitoring effort, an acoustic detection rate of 0.0616 per hour of monitoring effort, and an overall detection rate of 0.0370 per hour of monitoring effort.



Note: shown as a breakdown by species across all EEPGL-commissioned data collection efforts

Figure 7.5-1: Protected Species Detections (Visual and Acoustic)—May 2018–April 2019

Comparison of May 2018 through April 2019 Marine Mammal Data with Prior (2015 through April 2018) EEPGL-Commissioned Marine Mammal Data

Over the approximately 5-year study period (2015-2019), there have been 1,322 marine mammal detections (also includes taxonomically unidentified dolphins and whales). Of these detections, 674 were identifiable to species (see Figure 7.5-2). To date, 15 cetacean species have been confirmed as observed in the Stabroek Block. The May 2018–April 2019 surveys identified three new species not previously recorded during the prior EEPGL-commissioned surveys during 2015 through April 2018: pygmy killer whale (*Feresa attenuata*), long-beaked common dolphin (*Delphinus capensis*), and clymene dolphin. In 2018–2019, the clymene dolphin, long-beaked common dolphin, and pygmy killer whale were confirmed; these species were not detected in the 2015–2018 surveys. Table 7.5-3 summarizes the species visually documented during these surveys. Most of the species identified are relatively common according to the IUCN (Least Concern status); it is noted, however, that several of the whales listed in Table 7.5-2 are globally rare (e.g., blue whale [*Balaenoptera musculus*], sei whale, North Atlantic right whale [*Eubalaena glacialis*]) and would not necessarily be expected to be detected, even though their historically documented range includes the survey area. It should also be noted this does not necessarily mean that rare or uncommon species listed in Table 7.5-2 do not occur in the Guyana Exclusive Economic Zone; rather it means it is more unlikely they will be detected in the area.

Table 7.5-3: Marine Mammal Species Visually Observed during EEPGL Activities (2015-2019)

Common Name	Scientific Name
Bryde's whale	*Balaenoptera brydei*
Sperm whale	*Physeter macrocephalus*
Melon-headed whale	*Peponocephala electra*
Short-finned pilot whale	*Globicephala macrorhynchus*
Pygmy killer whale	*Feresa attenuata*
Atlantic spotted dolphin	*Stenella frontalis*
Common bottlenose dolphin	*Tursiops truncatus*
Short-beaked common dolphin	*Delphinus delphis*
Long-beaked common dolphin	*Delphinus capensis*
Fraser's dolphin	*Lagenodelphis hosei*
Pantropical spotted dolphin	*Stenella attenuate*
Risso's dolphin	*Grampus griseus*
Rough-toothed dolphin	*Steno bredanensis*
Spinner dolphin	*Stenella longirostris*
Clymene dolphin	*Stenella clymene*

Source: RPS 2019

There were some minor differences between the most frequently observed species reported in the first comprehensive MMO report (2015–2018) and the most frequently observed species in the second comprehensive MMO report (2018–2019). In both reports, unidentified dolphins were the most common group identified; however, spinner and pantropical dolphins were detected more often in the surveys covered in the second report, as compared to the surveys covered in the first report. Also, clymene dolphins were detected in the second report's surveys, but this species was not detected in the first report's surveys. Another difference between the two sets of surveys was that sperm whales were detected more often in the first report's set of surveys than in the second report's set of surveys. The higher number of detections of sperm whales in the first report's set of surveys likely reflects the greater number of survey hours in that set of surveys compared with the second report's set of surveys (15,695 hours of visual and auditory monitoring effort in the first report's set of surveys versus 2,494 hours of visual and auditory monitoring effort in the second report's set of surveys. Overall marine mammal detection rates were similar across both sets of surveys: the first set of surveys (2015–2018) had an overall detection rate of 0.037 detections per hour of monitoring effort and the second set of surveys (2018–2019) had an overall detection rate of 0.041 detections per hour of monitoring effort.

Summarizing all data collected to date spanning the roughly 5-year study period (ranging from 2015 through April 2019), sperm whales (n = 41 detections or 3.1 percent) were the most commonly identified species of whale, followed by the Bryde's whale (n = 15 detections or 1.6 percent) during the entire study period (Figure 7.5-3). Overall, the most common confirmed (identified) marine mammals detected were spinner dolphin, pantropical spotted dolphin, clymene dolphin, common bottlenose dolphin, and sperm whale; these species represented 36 percent of all the detections during 2015–2019. The distribution of detections among identified species was relatively similar between the two groups of surveys except for the differences in sperm whale and clymene dolphin detections noted above.

RPS graphed detections per hour of observation effort by month for the survey period from 2015 through April 2018 (RPS 2018). Toothed whale detections showed seasonal variability, with an increase in autumn and winter and a decrease in spring and summer (Figure 7.5-4). Accounting for the amount of survey effort, the seasonal pattern in detections (normalized per hour of observation) was consistent among years. Based on these detections, toothed whale abundance offshore Guyana likely varies with season. Some seasonal variability was observed in baleen whales, but the relatively small number of baleen whale detections compared to toothed whale detections makes comparisons difficult.

Figure 7.5-5 summarizes the locations of marine mammal sighting across the various surveys.

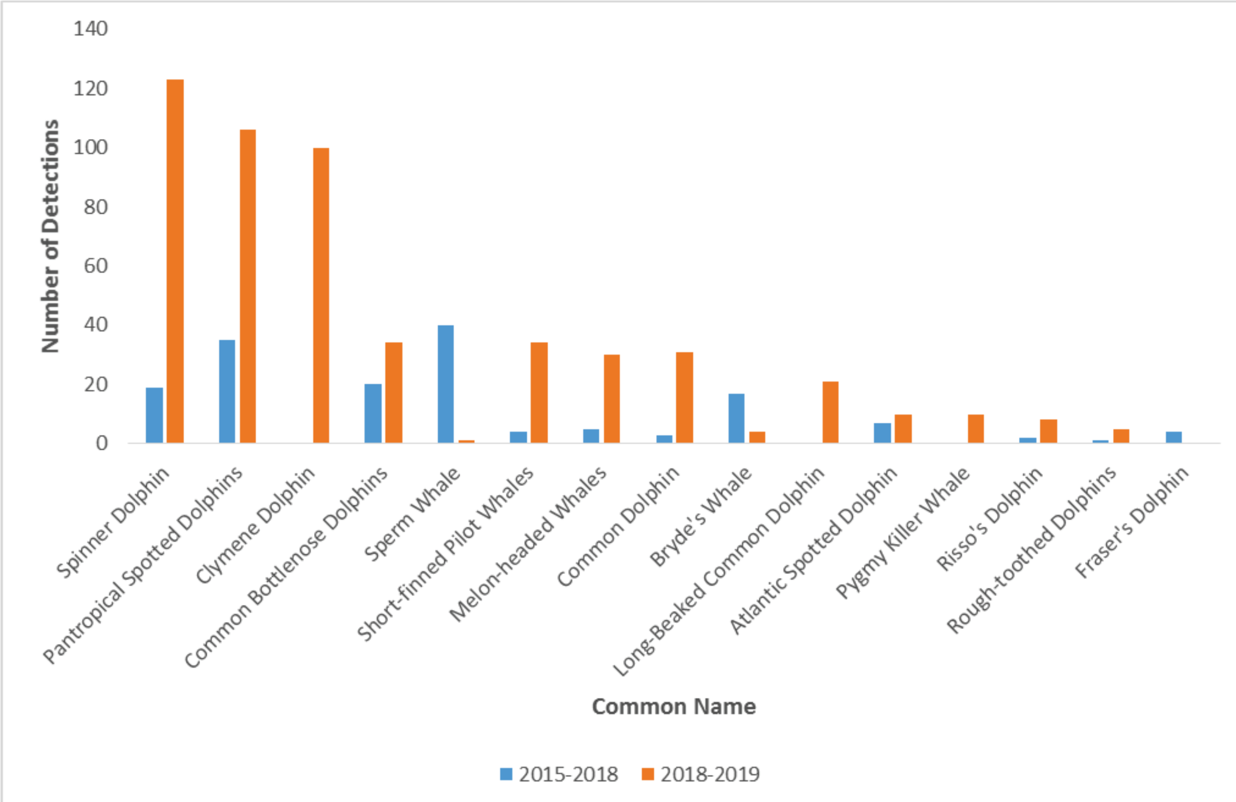


Figure 7.5-2: Confirmed Marine Mammal Sightings in the Stabroek Block, by Species for the 2015–2018 and 2018–2019 Survey Periods

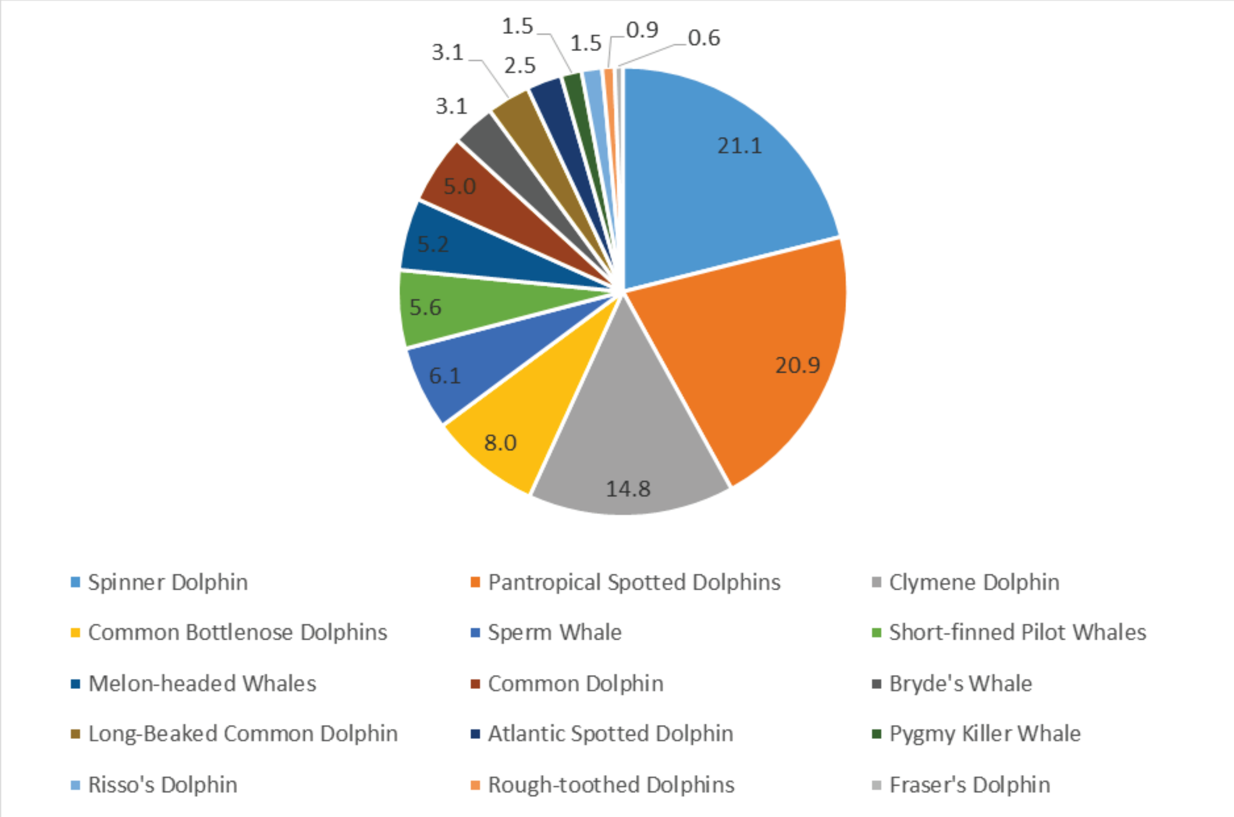
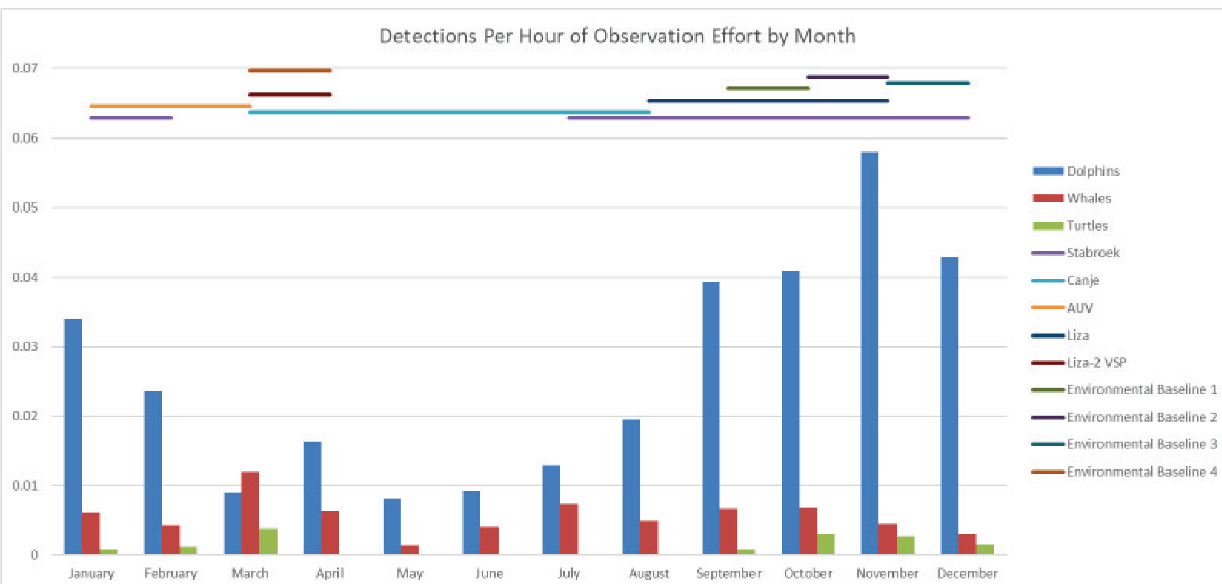


Figure 7.5-3: Distribution of Confirmed Marine Mammal Sightings in the Stabroek Block, by Species (2015–2019)



Source: RPS 2018

Figure 7.5-4: Seasonal Variations in Marine Mammal and Turtle Sightings in the Stabroek Block (2015–2018)

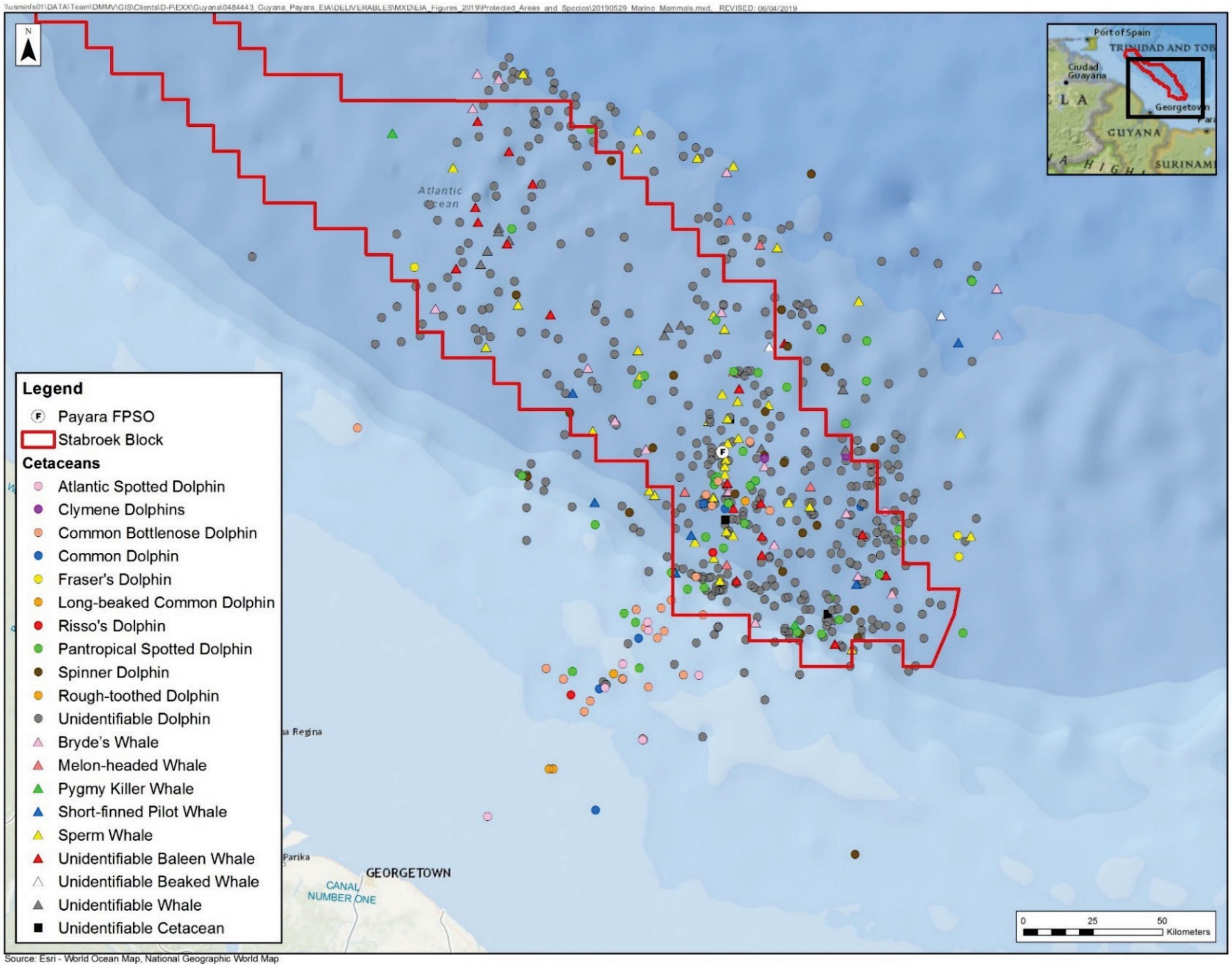


Figure 7.5-5: Locations of Marine Mammal Sightings Relative to the Stabroek Block (2015–2019)

A survey of 125 nearshore Guyanese fisherfolk indicated they encounter various marine mammals, such as Amazon river dolphin (*Inia geoffrensis*; locally referred to as boto), tucuxi, spotted dolphin, common dolphin, spinner dolphin, and bottlenose dolphin (Charles et al. 2004). Although two of the six species mentioned in the captains' survey (botos and tucuxis) were not recorded in the EEPGL-commissioned surveys, the findings were generally consistent with the results from the EEPGL-commissioned surveys as follows:

- Botos and tucuxis are primarily associated with freshwater and—less frequently—estuarine environments, so these species are not expected to occur offshore where EEPGL-commissioned surveys took place.
- The fishing boat captains did not mention frequent encounters with any whale species.
- The Guyana fishing fleet has historically concentrated its efforts in comparatively shallow continental shelf waters, south of the EEPGL-commissioned survey areas, and
- The EEPGL-commissioned surveys did not document any whales farther south (i.e., shallower) than the 2,000-meter (approximately 6,561-foot) isobath.

The combined findings of the EEPGL-commissioned surveys and the Charles et al. (2004) survey, suggest that the Project is likely near or southward of the southern boundary of the primary habitat for whales offshore Guyana; the Project is located in water depths between approximately 1,900 and 2,100 meters (between approximately 6,200 and 6,900 feet). These findings also suggest that dolphins may be present throughout the Project AOI and at all times of the year; however, they are likely to be more abundant in the Project AOI in the autumn and winter months.

Figures 7.5-6 and 7.5-7 include photographs of marine mammals observed in the Stabroek Block during EEPGL-commissioned surveys in 2018 and 2019.

Photo credit: Meshach Pierre

Note: observed in the Stabroek Block during marine bird surveys conducted aboard the Captain Grady*, April 2019*

Figure 7.5-6: Common Bottlenose Dolphin (*Tursiops truncates*)

Photo credit: RPS 2019

Note: observed in the Stabroek Block from the Sea Service*, October 2018*

Figure 7.5-7: Rough-toothed Dolphin (*Steno bredanensis*)

7.5.3. Impact Assessment—Marine Mammals

As described above, toothed whales (sperm, melon-headed, and pilot whales) and dolphins (pantropical and bottlenose) are the marine mammal species most likely to be encountered in the PDA. Bryde's whales and other unidentified baleen whales have also been observed in offshore waters in the PDA. Nearshore, common, spotted, and spinner dolphins may also be encountered in the PDA.

7.5.3.1. Relevant Project Activities and Potential Impacts

As shown in Table 7.5-4, the impact assessment considers the potential for planned Project activities to impact marine mammals either through injury (e.g., as a result of exposure to sound from Project activities), toxicological effects (e.g., as a result of exposure to Project vessel discharges), or disturbance leading to changes in behavior and reduced vigor (e.g., as a result of light, sound, and/or actions from Project activities). Potential impacts on marine mammals from vessel strikes are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Table 7.5-4: Summary of Relevant Project Activities and Key Potential Impacts—Marine Mammals

Stage	Activity	Key Potential Impact
Development Well Drilling FPSO and SURF Installation	Vessel operations	• Sound disturbance leading to deviation from area
	Power generation	• Sound exposure leading to permanent threshold shift injury • Sound disturbance leading to deviation from area
	VSP	
	Remotely operated vehicle operations	
	Pile driving	
	Lighting on drill ship and installation vessels	• Offshore lighting is not considered to have a negative impact on marine mammals; it is considered to be an attractant for fish, and therefore a secondary attractant for some marine mammals.
	Permitted drill cuttings and fluids discharge	• Exposures to permitted discharges, potentially leading to toxicological impacts
	Permitted liquid waste discharge	

Stage	Activity	Key Potential Impact
Production Operations	Well stream production, processing, and storage operations	• Sound disturbance leading to deviation from area
	Power generation	
	Permitted cooling and produced water discharge	• Exposures to permitted discharges, potentially leading to toxicological impacts
	Permitted other liquid waste discharge	
	Lighting on FPSO	• Offshore lighting is not considered to have a negative impact on marine mammals; it is considered to be an attractant for fish, and therefore a secondary attractant for some marine mammals.
	Operation of tankers, tugs, and supply and support vessels	• Sound disturbance leading to deviation from area
Decommissioning	Vessel operations	• Exposures to permitted discharges, potentially leading to toxicological impacts. • Sound disturbance leading to deviation from area

7.5.3.2. Magnitude and Sensitivity Definitions for Potential Impacts on Marine Mammals

Following the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude ratings of potential impacts on marine mammals are determined based on geographic extent, frequency, duration, and intensity.

The intensity of potential impacts on marine mammals from underwater sound is defined according to the definitions provided in Table 7.5-5.

Table 7.5-5: Definitions for Intensity Ratings for Potential Impacts on Marine Mammals

Criterion	Definition
Intensity	Negligible: No discernible change in marine mammal behavior or mortality.
	Low: Limited increases in injury or disturbance to marine mammals are perceptible, causing slight changes in the behavior of marine mammals.
	Medium: Increases in injury or disturbance to marine mammals are evident and may lead to irregular impacts on life functions (e.g., feeding, breeding, migration route changes) or, in very rare instances, mortality.
	High: Increases in injury or disturbance to marine mammals are sufficient to cause mortality or conditions of chronic behavioral changes impacting life functions.

As discussed in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species, because one of the marine mammals observed in the PDA (i.e., sperm whale) is listed as Vulnerable by IUCN, the marine mammals impact assessment was conducted based on the conservative assumption that this species would be the receptor for potential impacts. Accordingly, the receptor sensitivity ratings for special status species were used, as defined in Table 7.5-6. Based on the definitions defined below, the representative species assumed to be the receptor for potential impacts is considered to have a **Medium** sensitivity.

Table 7.5-6: Definitions for Receptor Sensitivity for Potential Impacts on Marine Mammals (Adopted from Potential Impacts on Special Status Species)

Criterion	Definition
Sensitivity	Negligible: Species with no scientifically recognized (e.g., IUCN Red List or regional equivalent) elevated conservation status or other specific value or importance attached to them.
	Low: Species and sub-species of Least Concern on the IUCN Red List (or not meeting criteria for medium or high value), or without specific anatomical, behavioral, or ecological susceptibilities to potential Project-related impacts.
	Medium: Species listed as Vulnerable or Near Threatened on the IUCN Red List; species protected under national legislation; nationally restricted range species; nationally important numbers of migratory or congregatory species; species not meeting criteria for high value; and species vital to the survival of a medium value species.
	High: Species on IUCN Red List as Critically Endangered or Endangered; species having a globally restricted range (i.e., endemic species to a site, or found globally at fewer than 10 sites, fauna having a distribution range less than 50,000 km^2), internationally important numbers of migratory or congregatory species, key evolutionary species, and species vital to the survival of high value species.

7.5.3.3. Characterization of Impacts—Injury or Disturbance from Underwater Sound

The main sources of underwater sound associated with development well drilling activities are from the VSP[17] activities (generating impulsive sound) and marine vessels (generating non-impulsive sound). The primary sources of sound from FPSO and SURF installation activities are from impact pile drivers for the FPSO mooring system and selected SURF equipment, such as manifolds (generating impulsive sound) and marine vessels (generating non-impulsive sound). Sound sources from production operations and decommissioning activities are primarily limited to marine vessels (generating non-impulsive sound).

Underwater sound can potentially cause a variety of impacts on marine mammals, such as behavioral changes in life functions (e.g., feeding, breeding, migration route deviations) or direct physical impacts affecting auditory systems.

Marine Mammal Auditory Functions

The potential for anthropogenic sound to impact marine animals depends on how well the animals can detect the sound and react. Sounds are less likely to be disruptive if they are at frequencies that animals cannot detect. However, when the sound pressure is high enough, it can cause physical injury through non-auditory mechanisms (i.e., barotrauma). For sound levels below such extremes, frequency weighting may be applied to scale the importance of sound components at particular frequencies in a manner reflective of an animal's sensitivity to those frequencies.

[17] The VSP has a small source that produces seismic impulses over a period of time (for the purposes of this assessment, it was assumed that the source will produce 20 to 40 seismic pulses, less than 1 second in length, over a 6- to 12-hour period). The wavefield generated by this source is recorded by instruments in the borehole.

Auditory weighting functions for marine mammals, called M-weighting functions, were initially proposed by Southall et al. (2007) and then later modified by the U.S. National Oceanic and Atmospheric Administration (NOAA 2013) and Finneran (2015). For this assessment, values are presented using Southall et al. (2007) M-weighting functions and the weighting functions suggested by Finneran (2015).

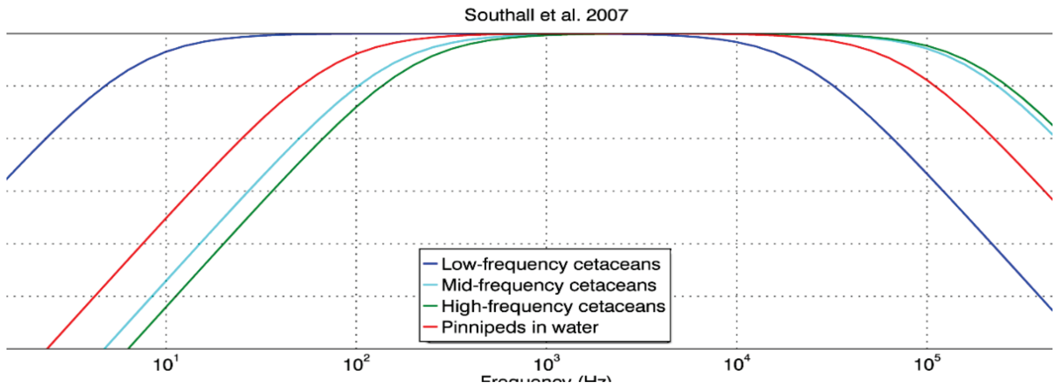
Southall et al. (2007) proposed M-weighting functions for five functional hearing groups of marine mammals:

- Low-frequency cetaceans (LFCs)—mysticetes (baleen whales);
- Mid-frequency cetaceans (MFCs)—some odontocetes (toothed whales);
- High-frequency cetaceans—odontocetes specialized for using high-frequencies;
- Pinnipeds in water[18]—seals, sea lions, and walruses (not addressed here); and
- Pinnipeds in air (not addressed here).

NOAA (2013) suggested further modifications to the LFC function, including two variations (for phocid and otariid pinnipeds) to the Southall et al. (2007) M-weighting function for pinnipeds in water. A U.S. Navy Technical Report (Finneran 2015) recommended new auditory weighting functions that consider the overall shape of the auditory weighting functions to be more like human A-weighting functions, which follow the sensitivity of the human ear at low sound levels. Although the inclusion of some species changed (e.g., the addition of hourglass [*Lagenorhynchus cruciger*] and Peale's [*Lagenorhynchus australis*] dolphins to the high-frequency functional hearing group), the five recommended functional hearing groups remain as presented in NOAA 2013. More information on the marine mammal auditory weighting functions described above, including the analytical formulation of these metrics, is provided in Appendix G, Underwater Sound Modeling Report.[19] The auditory weighting functions recommended by Southall et al. (2007) and Finneran (2015) are shown on Figure 7.5-8 and 7.5-9, respectively.

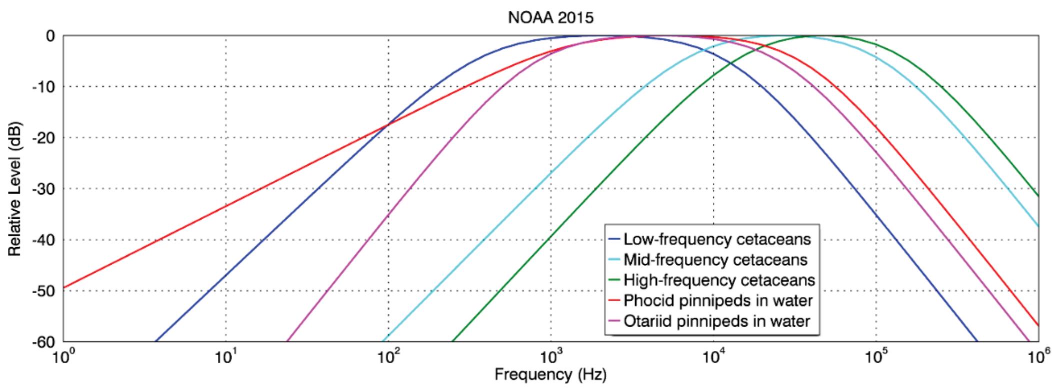
[18] Pinnipeds were included in Southall et al 2007, but are not relevant to this analysis of auditory impacts because pinnipeds are either likely extinct or extirpated offshore Guyana.

[19] The results of the 2016 study provided in Appendix G (originally prepared for the Liza Phase 1 Project) have been determined to be appropriate for use in the underwater sound impact assessment for the Payara Project (see discussion below).



Source: JASCO 2016

Figure 7.5-8: Auditory Weighting Functions for Marine Mammal Hearing Groups as Recommended by Southall el al. (2007)



Source: JASCO 2016

Figure 7.5-9: Auditory Weighting Functions for Marine Mammal Hearing Groups as Recommended by Finneran (2015)

LFCs (including baleen whales) and MFCs (including dolphins and toothed whales) have been observed within or near the PDA, so this section only focuses on these marine mammal hearing groups.

JASCO conducted underwater sound modeling for the Liza Phase 1 Development Project EIA (JASCO 2016). For the purpose of this EIA, JASCO compared the design, location, and layout of the Liza Phase 1 Project and the Payara Project and made the following determination:

> "Therefore, based on the bathymetric relationship between the Liza Phase 1 and Payara sound source locations, the homogeneous environmental properties over a large area that encompasses both the Liza and Payara projects development areas, and the similarity in noise-producing activities for the two projects, we estimate that model results for the Payara scenarios would present little changes in the distances (and if anything, shorter distances) to marine mammal injury thresholds provided for Liza Phase 1." Appendix G, Underwater Sound Modeling Report)

Based on JASCO's determination (i.e., the results of the modeling analysis completed for the Liza Phase 1 Development Project were applicable to the impact assessment for the Payara Project [and possibly conservative because the Payara Project is in deeper water than the Liza Phase 1 Project and so even fewer marine mammals could be exposed to Project-related sound at levels of concern]), the description of the modeling evaluation below (conservatively) references JASCO's original analysis for the Liza Phase 1 Development Project (JASCO 2016).

The modeling was performed for two types of sources: impulsive and non-impulsive. Impulsive sources (VSP and impact pile driver activities) are typically brief and intermittent, with a rapid rise time and decay. Piles can be driven into the seabed using different impact hammer equipment, such as diesel hammer, air or steam hammer, and hydraulic hammer. Diesel hammers produce underwater sound waveforms with each pile strike that are similar to those of air hammers, while hydraulic hammers produce a somewhat different waveform signature with a much more rapid rise time. Driven piles may be used instead of or in combination with suction piles. A suction pile (or suction caisson) can be conceptually described as an upturned bucket that is embedded in the marine sediment by pushing or creating a negative pressure inside the caisson skirt. The suction caisson technology functions very well in a seabed with soft clays or other low-strength sediments, and is in many ways easier and quieter to install than driven piles, which must be hammered into the seabed. For the purpose of this assessment, it was conservatively assumed that only impact pile drivers will be used (i.e., no suction piles) for the Project.

In contrast, non-impulsive sources (marine vessels' main propulsion systems and internal machinery [e.g., generators, cranes]) can be brief or prolonged, and continuous or intermittent. However, one major difference is that non-impulsive sources do not have the high peak pressure and rapid rise time characterizing impulsive sounds.

Three complementary acoustic models (AASM[20], MONM[21], and FWRAM[22]) were used to predict underwater acoustic fields for the Project's potential sound sources. Based on available information, the model results were used to estimate the distances to marine mammal injury (permanent threshold shift [PTS][23]) thresholds. Source levels for the VSP were predicted using JASCO's AASM.

The VSP source considered was a six-element source array with a total volume of 1,200 cubic inches. The AASM produces a set of "notional" signatures for each array element based on the following:

- Source array layout;
- Volume, tow depth, and firing pressure of each element in the source array; and
- Interactions between different elements in the array.

[20] Air Gun Array Source Model

[21] Marine Operations Noise Model

[22] Full Waveform Range-dependent Acoustic Model

[23] PTS is a sound-induced impact that results in a decrease in hearing sensitivity that is not expected to improve over time (OSHA 2013).

For the modeling, source-level spectra from measurements of surrogate vessels, including FPSOs, drill ships, pipelaying vessels, tugs, and support vessels, were adjusted to the specifications of the proposed Project vessels. Surrogate vessels were then chosen based on the similarity to the vessel specifications and types of operation for the Project.

Underwater sound propagation (i.e., transmission loss) was modeled with JASCO's MONM and FWRAM. The 3D acoustic fields were computed by modeling transmission loss within multiple 2D vertical planes extending from the source. The underwater sound fields were modeled for water column sound speed profiles during April, which has the historically lowest surface temperatures (colder water causes upward sound refraction and causes sound to travel further). Predicted sound fields were assessed across three dimensions, and the perceived sound level reported at each point in the horizontal plane was the maximum predicted sound level over all modeled depths for that point on the horizontal plane.

Based on these reported sound levels in the horizontal plane, two distance parameters were reported for each threshold:

- R_{max}, the maximum horizontal distance from the source where the predicted sound level reaches a threshold; and
- $R_{95\%}$, the maximum horizontal distance from the source where the predicted sound level reaches the threshold after the 5 percent of the predicted threshold-exceeding area farthest from the source is excluded. Regardless of the geometric shape of the "maximum-over-depth" footprint, $R_{95\%}$ is the predicted range encompassing at least 95 percent of the area (in the horizontal plane) that will be exposed to sound at or above the threshold.

To evaluate various operations, six scenarios were considered in this modeling study:

1. The operation of an FPSO vessel;
2. The installation of the FPSO vessel, which includes mooring the FPSO and using several installation and service vessels;
3. Installation of a drill center, which includes the operation of a drill ship and a pipelaying vessel for the installation of SURF at a drill center;
4. The completion of a VSP operation;
5. The installation of manifold foundation piles for SURF equipment at a drill center through underwater impact pile driving; and
6. The installation of anchor mooring piles at the FPSO location through underwater impact pile driving.

The sound footprint for each scenario was modeled to estimate the above-referenced distance parameters assuming thresholds are equal to the injury criteria prescribed by Southall et al. (2007) and Finneran (2015). The sound footprints were calculated as frequency-weighted (M-weighted) sound exposure levels (SELs) assuming 24 hours of operation. The sound footprints account for source-specific sound emission characteristics and site-specific environmental parameters.

Additional information on the underwater sound modeling methodology, including a detailed description of all model input parameters and approximate locations of modeled sources for all scenarios is provided in Appendix G, Underwater Sound Modeling Report.

Underwater Sound Criteria

Potential auditory impacts of planned Project activities on marine mammals were evaluated using Southall et al. (2007) and Finneran (2015) acoustic threshold levels for onset of PTS in LFCs and MFCs (Table 7.5-7).

Table 7.5-7: Acoustic Threshold Levels for Onset of PTS in Low-Frequency Cetaceans and Mid-Frequency Cetaceans

Marine Mammal Hearing Group	Estimated Auditory Bandwidth	PTS Onset Acoustic Thresholds (Injury Criteria)			
		Impulsive		Non-impulsive	
		Peak Sound Pressure Level (unweighted) (dB peak)	SEL (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	Peak Sound Pressure Level (unweighted) (dB peak)	SEL (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)
Southall et al. 2007					
LFCs (baleen whales)	7 Hz to 22 kHz	230	198	230	215
MFCs (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz	230	198	230	215
Finneran 2015					
LFCs (baleen whales)	7 Hz to 25 kHz	230	192	Not available	207
MFCs (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz	230	187	Not available	199

µPa = microPascal; dB = decibel; Hz = hertz; kHz = kilohertz; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level

Modeling Results

Tables 7.5-8 to 7.5-13 present the above-referenced distance parameters describing modeled horizontal distances to the point that Project-associated sound would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs, according to Southall et al. (2007) and Finneran (2015) criteria, for the six above-referenced scenarios, respectively. Decommissioning activities were not subjected to underwater sound modeling, as activities during the decommissioning stage will be similar to those of SURF installation activities in terms of types of sound sources (i.e., marine vessels only). Further, decommissioning activities are expected to be shorter in duration and involve a smaller fleet of marine vessels; therefore, the potential underwater sound impacts on marine mammals for decommissioning are expected to be no greater than those of SURF installation activities (Scenario 3).

The results presented in the tables below account for embedded controls for underwater sound management. Specifically, EEPGL will use the following embedded controls for the Project (see Section 2.13, Embedded Controls):

- Gradually increasing intensity of seismic impulses to allow sensitive species to vacate the area before injury occurs (i.e., soft starts), use of MMOs during VSP, and implementation of other measures recommended by the Joint Nature Conservation Committee (JNCC 2017), as applicable; and
- Maintaining equipment, marine vessels, and helicopters in good working order and operating them in accordance with manufacturers' specifications to limit sound levels to the extent reasonably practicable.

Table 7.5-8: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 1—FPSO Operations

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al. (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)
Non-impulsive sources (marine vessels)						
Low-frequency cetaceans	215	6	6	207	<5	<5
Mid-frequency cetaceans	215	<5	<5	199	<5	<5

Source: JASCO 2016

µPa = microPascal; dB = decibel; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level

Table 7.5-9: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 2—Installation of the FPSO Vessel, Including Mooring the FPSO and Using Several Construction and Service Vessels

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	215	<5	<5	207	<5	<5
Mid-frequency cetaceans	215	—	—	199	—	—

Source: JASCO 2016

µPa = microPascal; dB = decibel; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level
"—" = predicted sound levels at all locations are below injury criteria.

Table 7.5-10: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 3—Installation of a Drill Center, Including Operation of a Drill Ship and a Pipelaying Vessel

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)
Non-impulsive sources (marine vessels)						
Low-frequency cetaceans	215	9	9	207	6	6
Mid-frequency cetaceans	215	<5	<5	199	--	--

Source: JASCO 2016

μPa = microPascal; dB = decibel; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level

Table 7.5-11: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 4—Completion of a Vertical Seismic Profile

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	198	73	68	192	39	36
Mid-frequency cetaceans	198	35	32	187	--	--

Source: JASCO 2016

μPa = microPascal; dB = decibel; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level

Table 7.5-12: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 5—Installation of Manifold Foundation Piles

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	198	1,300	NV	192	1,025	NV
Mid-frequency cetaceans	198	762	NV	187	136	NV

Source: JASCO 2016

μPa = microPascal; dB = decibel; m = meter; NV = no value; s = second; SEL_{24h} = 24-hour sound exposure level

Table 7.5-13: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 6—Installation of Mooring Piles for the FPSO

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 µPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 µPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	198	1,375	NV	192	1,075	NV
Mid-frequency cetaceans	198	725	NV	187	100	NV

Source: JASCO 2016

µPa = microPascal; dB = decibel; m = meter; NV = no value; s = second; SEL_{24h} = 24-hour sound exposure level

The results for the six scenarios are discussed below. It is important to note these results assume the sources are stationary for 24 hours, and that marine mammals will remain within the stated distance for the entire accumulation period (24 hours). This adds an element of conservatism to the assessment because it is unlikely any marine mammal would stay within the modeled injury zone for the entire 24-hour duration, and the thresholds are based on a 24-hour exposure period.

Scenario 1—FPSO Operation

Modeling predicted that non-impulsive underwater sound for Scenario 1 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 6 meters (19.7 feet) and less than 5 meters (16.4 feet), respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Scenario 2—Marine Vessels during FPSO Installation

Modeling predicted that non-impulsive underwater sound for Scenario 2 would attenuate to below PTS onset acoustic thresholds for LFCs at a maximum horizontal distance of less than 5 meters (16.4 feet) (based on the more conservative injury criteria for the marine mammal hearing group). Modeling predicted that MFCs would not be impacted at any distance under this scenario because the predicted underwater sound in the mid-frequency range would be below PTS onset acoustic thresholds at all locations.

Scenario 3—Marine Vessels (Drill Ship, SURF installation vessels)

Modeling predicted that non-impulsive underwater sound for Scenario 3 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 9 meters (29.5 feet) and less than 5 meters (16.4 feet), respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Scenario 4—Vertical Seismic Profile

Modeling predicted that impulsive underwater sound from the VSP for Scenario 4 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 73 meters (240 feet) and 35 meters (115 feet), respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Scenario 5—Pile Driving during SURF Installation

Modeling predicted that impulsive underwater sound from pile driving for Scenario 5 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 1,300 meters (4,270 feet) and 762 meters (2,500 feet), respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Scenario 6—Pile Driving during FPSO Installation

Modeling predicted that impulsive underwater sound from pile driving for Scenario 6 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 1,375 meters (4,510 feet) and 725 meters (2,380 feet), respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Summary of Potential for Injury Due to Underwater Sound

With respect to acoustic injury thresholds, modeling results indicate sound levels from vessels and the VSP are insignificant compared to the predicted sound levels from impact pile driving. The maximum distances from Project underwater sound sources to injury thresholds for both LFCs and MFCs are greatest for pile driving, although the area within which injury could potentially occur would be over 40 percent smaller for MFCs as compared to the potential area for LFCs (Figure 7.5-10). Regardless of which type of pile installation methodology is used (impact driven or suction), neither group of marine mammals would be expected to experience a negative impact at the population level. Based on the premise that marine mammals will actively avoid physical discomfort associated with Project-related sound, if impact-driven piles are used, MFCs would be expected to generally avoid the portion of the water column within at least approximately 700 meters from the location where pile driving is taking place. It is also expected that LFCs would generally avoid the portion of the water column within at least 1,400 meters (4,593 feet) of the activity. It is expected both categories of cetaceans would avoid these areas for the duration of the pile-driving activity.

Figure 7.5-10 illustrates the vertical distances to acoustic injury thresholds for Scenario 6 (Installation of Mooring Piles for the FPSO) for the Payara Project (showing the approximate depths for the shallowest and deepest of the FPSO mooring piles). As shown in the figure, LFC species, including many of the larger baleen whales and dolphins, and some MFC species, including toothed whales, will naturally remain outside of the area of potential effect because it will be deeper than their deepest recorded dive. Some MFC species, such as sperm whales dive much deeper than LFC species (approximately 1,200 meters [approximately 3,900 feet] in tropical and subtropical latitudes) (Mate undated; Amano and Yoshioki 2003; Watwood et al. 2006) but not deep enough that they could potentially be exposed to sound levels within the PDA that would cause injury or harm. Even if an individual of an MFC species were to dive to a sufficient depth to encounter the acoustic injury threshold, it would be physiologically unable to remain at these depths for a sufficient duration to cause injury.

PTS (were it to occur) would be irreversible by definition, but given the depth of the water in the PDA and the physiological limitations that would prevent marine mammals from diving deep enough and for a long enough period of time to experience PTS, pile driving is not expected to cause permanent injury to marine mammals passing through the PDA or irreversible effects on their hearing abilities.

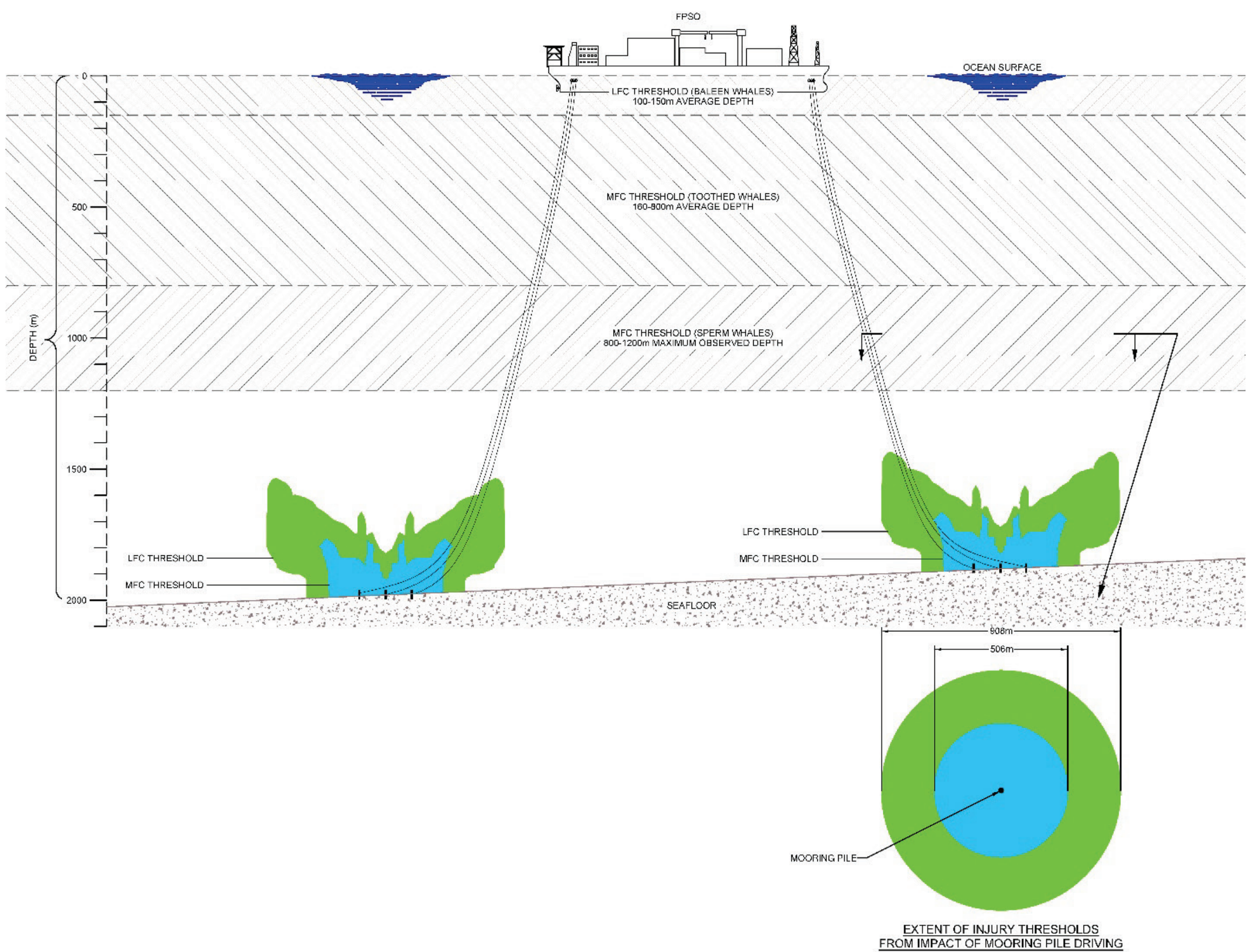


Figure 7.5-10: Vertical and Horizontal Distances to Acoustic Injury Thresholds from FPSO Mooring Pile Driving and Cetacean Dive Characteristics

Magnitude of Impacts—Potential Injury Due to Underwater Sound

Potential injury-related impacts would be limited to the PDA (where pile driving and VSP would occur), so the geographic extent is considered to be the **Direct AOI**. The potential for acoustic injury impacts on marine mammals is limited primarily to pile driving and VSP activities, which will be **Episodic** in nature and **Medium-term** (as they would occur in aggregate more than a week but less than a year). The intensity of potential acoustic injury impacts is considered **Negligible**, based on the following considerations:

- The potential for marine mammals to be exposed to sufficient sound levels and associated duration to cause injury is extremely small due to the depths at which the sound above the injury threshold will occur. Most of the marine mammals expected to be present in the PDA do not dive to the depths that will be required or, if they do (such as occasional deep diving by sperm whales), they do not remain submerged at these depths for sufficient time to experience acoustic injuries.
- EEPGL has committed to using MMOs and soft-start procedures for VSPs in accordance with JNCC (2017) guidelines, and soft starts for pile driving to further reduce the potential for impacts on marine mammals.
- If an individual mammal were to approach an operating VSP or pile driver, they would experience disturbance prior to being exposed to sound levels above injury thresholds, and would likely divert away from the sound source.

This results in a magnitude rating of **Negligible** for potential acoustic injury impacts to marine mammals, as summarized in Table 7.5-14.

Disturbance from Anthropogenic Underwater Sound

Anthropogenic sounds below acoustic injury thresholds have the potential to mask relevant or naturally occurring sounds in the animals' environment. Masking can occur from natural and anthropogenic sounds (Hildebrand 2005) and can cause behavioral changes that can have ecological consequences for marine mammals. These may include changes in biologically important behaviors (e.g., breeding, calving, feeding, or resting), diving behavior (e.g., reduced or prolonged dive times, increased time at the surface, or changes in swimming speed), and historical migration routes (NOAA undated).

Although the above changes could occur in the PDA as a result of Project-generated sound, findings from U.S. territorial waters suggest that the population-level significance of disturbance from impulsive sound over a small area such as the PDA will likely be minor and temporary. U.S. National Marine Fisheries Service reported that;

> "…available data do not indicate that sound and disturbance from oil and gas exploration and development activities since the mid-1970s had lasting population level adverse impacts on bowhead whales. Data indicate that bowhead whales are robust, increasing in abundance, and have been approaching (or have reached) the lower limit of their historic population size at the same time that oil and gas exploration activities have been occurring in the Beaufort Sea and, to a lesser extent, the Chukchi Sea." (MMS and NOAA 2007)

The U.S. Bureau of Ocean Energy Management also reported that despite more than 50 years of oil and gas exploration and development in the Gulf of Mexico, there are no data to suggest these activities are significantly impacting marine mammal populations (BOEM 2014). Furthermore, the PDA is not known to be an important feeding, breeding, or calving area for marine mammals. It is highly likely individual animals would divert around an operating pile driver or VSP to avoid Project-generated sound, but no significant impacts on life functions or potential population-level implications from underwater sound are expected. However, the potential extent for disturbance impacts will be larger than the extent for potential injury effects (although still expected to be limited to the Direct AOI).

Magnitude of Impacts—Potential Disturbance Due to Underwater Sound

Potential disturbance-level impacts could extend outside of the Direct AOI via sound propagation, so the geographic extent for this potential impact is considered to be the **Direct AOI + Central Stabroek Block**. The potential for acoustic disturbance impacts on marine is considered **Episodic** for impulsive sound activities (VSP and pile driving) and **Continuous** for non-impulsive activities (e.g., vessel operations, FPSO operation). Disturbance-level impacts would be present on a **Medium-term** basis for impulsive activities and non-impulsive activities during decommissioning, and on a **Long-term** basis for non-impulsive activities for drilling and installation and production operations. The intensity of potential disturbance-level sound impacts is considered to be **High** for impulsive sound impacts and **Negligible** to **Low** for non-impulsive sound impacts (based on the duration of the effect and the distance to which the effects could extend). This results in magnitude ratings of **Medium** for impulsive sound impacts and **Negligible** to **Small** for non-impulsive sound impacts, as summarized in Table 7.5-14.

Table 7.5-14: Magnitude Ratings for Impacts on Marine Mammals from Underwater Sound

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Development Well Drilling SURF Installation	Injury from sound exposure	Direct AOI + Central Stabroek Block	Negligible	Episodic	Medium-term	Negligible
Development Well Drilling (impulsive sound activities) SURF Installation (impulsive sound activities)	Disturbance from sound exposure	Direct AOI + Central Stabroek Block	High	Episodic	Medium-term	Medium
Development Well Drilling and SURF installation (non-impulsive sound activities from marine vessel operations)	Disturbance from sound exposure	Direct AOI + Central Stabroek Block	Low	Continuous	Long-term	Small
Production operations (non-impulsive sound activities from marine vessel operations and FPSO operations)	Disturbance from sound exposure	Direct AOI + Central Stabroek Block	Low	Continuous	Long-term	Small

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Decommissioning (non-impulsive sound activities from marine vessel operations)	Disturbance from sound exposure	Direct AOI + Central Stabroek Block	Negligible	Continuous	Medium-term	Negligible

Impact Significance— Potential Injury or Disturbance Due to Underwater Sound

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance rating for potential acoustic injury impacts on marine mammals is **Negligible**, and the pre-mitigation significance rating for potential sound-related disturbance impacts ranges from **Negligible** to **Moderate**.

7.5.3.4. Characterization of Impacts—Exposure to Permitted Discharges

Magnitude of Impact—Exposure to Permitted Discharges

The Project will involve routine, permitted discharges of waste streams to the sea. These discharges will begin during the development well drilling and FPSO/SURF installation stages and continue through the production operations stage and into the decommissioning stage. As described in Chapter 2, Description of the Project, and Section 6.4.3, Impact Assessment—Marine Water Quality, these discharges will be treated (as needed) in accordance with industry guidelines. Furthermore, marine mammals will be transient in the PDA and the duration of their exposure to any discharges will be very limited. Any potential impacts would be expected to be acute and recovery would be expected to occur quickly after the affected individual(s) exit the mixing zone. As such, the intensity of potential impacts on marine mammals from exposure to permitted discharges is considered **Negligible.** Impacts would occur within the **Direct AOI** (PDA) and would be **Continuous** and **Long-term**. Accordingly, the magnitude of impact is **Negligible** (Table 7.5-15).

Table 7.5-15: Magnitude Ratings for Potential Impacts from Permitted Discharges on Marine Mammals

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
All Project Stages	Exposures to permitted discharges	Direct AOI	Negligible	Continuous	Long-term	Negligible

Impact Significance—Exposure to Permitted Discharges

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance rating for potential toxicological effects on marine mammals from exposure to permitted discharges is **Negligible**.

7.5.3.5. Characterization of Impacts—Artificial Lighting

Artificial lighting is not known to directly attract or disturb marine mammals, so any potential impacts of artificial light on marine mammals are likely to be indirectly caused by a potential change in prey distribution. Fish and squid are known to be attracted to artificial light, and even plankton are sometimes capable of weak volitional movement through the water column in response to changing ambient light levels. Small fish, squid, and/or plankton make up a substantial part of most marine mammals' diets, so to the extent that Project vessels and the FPSO could facilitate the concentration of plankton and/or small fish and squid at the surface or around the vessels or FPSO, food density would increase and marine mammals may be attracted to the vessels to feed more efficiently. This impact is expected to be limited to only the immediate vicinity of the vessels and therefore only have a small influence on forage availability. This impact is thus rated as **Positive**, due to the potential for attracting food sources and the lack of documented adverse effects on marine mammals from artificial lighting.

7.5.4. Mitigation Measures—Marine Mammals

The embedded controls integrated into the Project design and operational procedures constitute the practicable best management measures that are available to reduce the significance of potential impacts on marine mammals. Table 7.5-16 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.5-16: List of Embedded Controls and Monitoring Measures

Embedded Controls
When non-aqueous drilling fluid (NADF) is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
Employ trained MMOs during the conduct of seismic-related activities.
Conduct a continuous observation of a mitigation zone (500 meters [1,640 feet] around the sound source) to verify whether it is clear of marine mammals and marine turtles before commencing sound producing seismic operations. Do not commence sound-producing seismic operations (including soft starts) if marine mammals or turtles are sighted within the mitigation zone during the 30 minutes prior to commencing sound-producing operations in water depths less than 200 meters (656 feet), or 60 minutes prior to commencing sound-producing operations in water depths greater than 200 meters (656 feet).
Where practicable, ensure that sound-making devices or equipment are equipped with silencers or mufflers and are enclosed, and/or use soft-start procedures (e.g., for pile driving, vertical seismic profiling, etc.) to reduce noise to levels that do not cause material harm or injury to marine species
Adhere to the JNCC Guidelines (2017) during the conduct of seismic-related activities.
During pile-driving activities, gradually increase the intensity of hammer energy to allow sensitive marine organisms to vacate the area before injury occurs (i.e., soft starts).
Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with International Maritime Organization/International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.

Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 milligrams per liter (mg/L) on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals
Measure residual chlorine concentration of sewage discharges form the FPSO monthly to ensure it is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to ensure that there are no floating solids or discoloration of the surrounding waters.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' specifications and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Implement a chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
Ensure wastewater released from the onboard sewage treatment plant complies with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.
Ensure there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge.
Treat bilge water in accordance with MARPOL 73/78 to ensure compliance with an oil in water content of less than 15 parts per million as applicable.
Monitoring Measures
Monitor on an ongoing basis visual detections of Marine Mammals, Riverine Mammals, and Marine Turtles.
Prior to and post-drilling, a remotely operated vehicle will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to ensure that end of well maximum weighted mass ratio averaged over all well sections drilled using non-aqueous base fluid shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C at 100 meters (approximately 328 feet) from point of discharge.
Use load monitoring system in the FPSO control room to support FPSO offloading.

Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Monitor chlorine concentration of treated sewage discharges.
Perform daily visual inspection of discharge points to ensure absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to ensure compliance with 15 parts per million MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.5-17 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine mammals. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, as well as the marine mammals-specific methodology described in Sections 7.5.3.2 and 7.5.3.3.

Table 7.5-17: Marine Mammals—Pre-Mitigation and Residual Impact Significance Ratings

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling FPSO/SURF Installation	Injury from sound exposure	Negligible	Medium	Negligible	None, other than implementation of embedded controls (e.g., soft-start procedures for VSP and pile driving)	Negligible
Development Well Drilling (impulsive sound activities) SURF Installation (impulsive sound activities)	Disturbance from sound exposure	Medium	Medium	Moderate	None, other than implementation of embedded controls (e.g., soft-start procedures for VSP and pile driving)	Moderate
Development Well Drilling (non-impulsive sound activities) from marine vessel operations	Disturbance from sound exposure	Small	Medium	Minor	None	Minor

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Production operations (non-impulsive sound activities) from operating FPSO and marine vessel operations	Disturbance from sound exposure	Small	Medium	Minor	None	Minor
Decommissioning (non-impulsive sound activities) from marine vessel operations	Disturbance from sound exposure	Negligible	Medium	Negligible	None	Negligible
All Project Stages	Exposures to permitted discharges (liquid effluent discharges containing various chemical substances, plus elevated temperature during production operations)	Negligible	Medium	Negligible	None	Negligible
	Offshore lighting as an attractant of food sources for marine mammals	Positive	Medium	Positive	None	Positive

7.6. RIVERINE MAMMALS

7.6.1. Administrative Framework—Riverine Mammals

Table 7.6-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on riverine mammals.

Table 7.6-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Riverine Mammals

Title	Objective	Relevance to the Project
Legislation		
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora.	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a supportive mechanism cognizant of the national goals for wildlife protection, conservation, management, sustainable use, and external trade.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.

7.6.2. Existing Conditions—Riverine Mammals

Riverine mammals are aquatic mammals that live in inland and coastal riverine and wetland environments. Many riverine mammal species also spend time in nearshore marine environments, so they have a wide range of salinity tolerance, frequenting freshwater, estuarine, and marine environments. The distribution and composition of riverine mammals in Guyana is largely unknown and no known systematic survey of riverine mammals has been conducted in the country. According to Hollowell and Reynolds (2005), the riverine mammals of Guyana consist of five species, including the West Indian manatee (*Trichechus manatus*), giant otter (*Pteronura brasiliensis*), neotropical otter (*Lontra longicaudis*), Amazon river dolphin (also locally referred to as boto; *Inia geoffrensis*), and gray river dolphin (also locally referred to as tucuxi; *Sotalia fluviatilis*). Table 7.6-2 lists these species along with their IUCN Red List classification (IUCN 2019) and their habitat preferences. These species also use coastal and nearshore marine habitats, as confirmed by a survey of nearshore Guyana waters conducted by Charles et al. (2004) of 125 Guyanese captains of trawl, drift seine, and red snapper fishing vessels. As discussed in Section 7.5, Marine Mammals, numerous other species of marine mammals, particularly dolphins, occasionally occur in riverine habitats of Guyana, but since these species are primarily associated with marine habitats, they are not discussed further in this section.

Table 7.6-2: Riverine Mammals of Guyana

Common Name	Scientific Name	IUCN Status	Habitat Preferences
West Indian manatee	*Trichechus manatus*	VU	Inhabits rivers, lakes, coastal and inland lagoons, and coastal marine environments, including seagrass, mangrove, and coral reef ecosystems (Deutsch et al. 2008).
Giant otter	*Pteronura brasiliensis*	EN	Inhabits large, slow-moving inland freshwater rivers, streams, lakes, and swamps that possess high fish densities. May occur in agricultural canals, reservoirs, and drainage channels along roads (Groenendijk et al. 2015).
Neotropical otter	*Lontra longicaudis*	NT	Occurs in a large variety of habitats, from rocky shorelines to deciduous and evergreen forests, warm and cool climate rainforests, and coastal savanna swamps. Occurs in both fresh and saline environments, including areas with high levels of human influences such as agricultural areas and pastures (Rheingantz and Trinca 2015).
Gray River dolphin (locally referred to as tucuxi)	*Sotalia fluviatilis*	DD	Inhabits the inland freshwaters of the white, clear, and black waters of the Amazonian rivers. Display a preference for the junctions of rivers and channels. The most preferred habitat is where a sediment-rich white-water channel meets low pH black water (Secchi 2012).
Amazon River dolphin (locally referred to as boto)	*Inia geoffrensis*	EN	Inhabits the inland freshwaters of the Amazon and Orinoco rivers. Sexual segregation is common: females with dependent calves spend more time inside the flooded forest and in lakes and small tributaries during the rainy season, while most adult males spend most of their time in the main rivers. During the dry season, this species is often concentrated below channel confluences (da Silva et al. 2018).

Source: IUCN 2019

DD = Data Deficient; EN = Endangered; NT = Near Threatened; VU = Vulnerable

7.6.2.1. Regional Setting and Species Descriptions

The riverine mammals of Guyana occupy a wide variety of inland and coastal habitats, including inland rivers and wetlands and coastal and nearshore marine waters. These habitats are by extension interconnected with similar habitats of the Amazon River in Brazil and the Orinoco River delta in Venezuela via the Amazonian-Orinoco Influence Zone. The Amazonian-Orinoco Influence Zone is an Ecologically or Biologically Significant Area (EBSA) that encompasses the offshore waters of eastern Trinidad, Guyana, Suriname, French Guiana, and northern Brazil, and borders the shoreline from the Orinoco River in the north to the Amazon River in the south (Secretariat of the Convention on Biological Diversity 2014). This EBSA's uniqueness and biological productivity are driven largely by the influence of freshwater inputs from the Amazon River and the nutrients it carries, which extend north and west across the coast of northern South America to the Orinoco River delta in Venezuela.

West Indian Manatee

The West Indian manatee is known to occur throughout the Gulf of Mexico and the Caribbean Sea. Two subspecies of the West Indian manatee are currently recognized based on skull characteristics (Domning and Hayek 1986): the Antillean manatee (*T. manatus manatus*), and the Florida manatee (*T. manatus latirostris*). There is also a smaller species of manatee, *Trichechus inunguis*, landlocked in the Amazon basin, which may occasionally penetrate into southern Guyana close to the boundary with Brazil, but since this species is a rare transient species in southern Guyana, it is not discussed further herein. The two subspecies of West Indian manatee are not easily distinguishable externally, but they occupy distinctively different geographic ranges. The range of the Florida manatee is limited to the southeastern United States. The Antillean manatee occurs throughout the Caribbean and the Northwestern Atlantic Ocean from Mexico, east to the Greater Antilles, and south to Brazil. The subspecies is extant or transient in 41 countries in the Caribbean region (Deutsch et al 2008).

Throughout most of its range, the West Indian manatee prefers the shallow waters of rivers and estuaries that contain aquatic vegetation. Early records from a study by Bertram and Bertram (1960) on the status of the West Indian manatee in the Guianas revealed that in Guyana the manatees live mainly in the rivers of the coastal plain, particularly in the regions of wet savannah where suitable vegetation is available for food. Northwestern Guyana and the eastern region near the Suriname border support the greatest numbers of manatees in the country, but nowhere are they abundant. The study also documented that very little is known about the life history of manatees in the Guianas.

No systematic, range-wide survey or population estimate of West Indian manatees, particularly the Antillean subpopulation, exists. However, IUCN estimates that approximately 2,600 Antillean manatees currently exist, scattered widely through the Caribbean region (IUCN 2019). Geographic distribution is not continuous and local populations are patchy and fragmented. IUCN lists the West Indian manatee (total population including both subspecies) as Vulnerable because the number of mature individuals is currently estimated at less than 10,000 individuals - based on combined population estimates for the Florida and Antillean subspecies, and the combined population is expected to decline at a rate of at least 10 percent over the course of three generations as a result of habitat loss and anthropogenic factors (IUCN 2019). Historically, manatees were hunted for food, but today they are threatened by habitat loss, poaching, entanglement with fishing gear, and increased boating activity.

Giant Otter

The giant otter is endemic to South America and is distributed east of the Andes in the Orinoco, Amazon, and Parana basins, as well as several other river basins in the Guianas. The northern limit of its distribution range is located in northern Venezuela, and the southern limit is in Misiones, Argentina. According to Duplaix (1980), giant otters select their habitat according to prey abundance/availability/vulnerability criteria that fluctuate seasonally. The species prefers slow-flowing, clear, freshwater creeks and rivers in pristine interior forests, particularly in areas with low levels of human activity. Low, sloping banks with good cover and close access to prime fishing areas are preferred by otters for their “campsites” (where they rear their cubs). In Guyana, these habitat conditions are met in the interior rivers, particularly the Rupununi River, where several family groups of giant otters reside (Duplaix 2004; Roopsind 2019).

Studies on the giant otter in Guyana’s rivers by Laidler (1984) reported their presence near the coastal village of Morawhanna in the Barima River northwest Guyana, in the Mahaica River, and in the East Demerara Water Conservancy (one of Guyana’s major water storage and flood control facilities) and its tidal creeks, including Lama Creek, Maduni Creek, and Carabice Creek. Other studies confirmed the presence of the species in the Mahaica River and also reported sightings of the species in the Abary River and in inland freshwater habitats of the Rupununi Savannah, the Potaro Plateau in western Guyana, and the Sipuruni River (Duplaix 2004 and Melquist 1984).

No range-wide estimates of abundance or trends in abundance exist for the giant otter and no country-specific survey data exist for giant otter in Guyana; however, available data elsewhere in the species’ range indicate that the global population size is low and decreasing due to habitat loss, habitat degradation, and other human activities. Moreover, most populations are isolated from each other, increasing local extinction risk. The giant otter is listed as Endangered by the IUCN based on low and decreasing population size combined with limited resilience to reductions in habitat quality, late maturity and breeding age, and suspected low adult and cub survival, all of which limit giant otter recovery and re-colonization (IUCN 2019). Historically, giant otters were hunted for their pelts. Today, they are primarily threatened by increased human settlement and activity throughout the species’ range, which results in habitat loss and degradation, overfishing, introduction of diseases from domestic animals, and poaching. In the Guiana Shield region (Suriname, Guyana, French Guiana, Venezuela, and northern Brazil) and in southeastern Peru, gold mining is a significant threat to the species due to the resulting habitat loss and degraded water quality.

Neotropical Otter

The neotropical otter occurs from northwestern Mexico to Uruguay (Gallo 1991), Paraguay, and the northern part of Argentina to Buenos Aires province (Chehebar 1990; Cockrum 1964; Redford and Eisenberg 1992). The species occurs from sea level up to 4,000 meters (13,123 feet) above sea level (Muanis and Oliveira 2011). The species is found in both fresh and saline environments and occurs in a large variety of habitats, including rocky shorelines, deciduous and evergreen forests, warm and cool climate rainforests, and coastal savanna swamps (Emmons and

Feer 1990, in Rheingantz and Trinca 2015). Preferred habitat conditions for this species include high-quality riparian cover (i.e., with dense, native vegetation) (Bertonatti and Parera 1994; Redford and Eisenberg 1992) and abundant potential den sites (Soldateli and Blacher 1996). In Guyana, they are known to occur in drainage ditches related to rice and sugar cane plantations (Larivière 1999.

No range-wide estimates of abundance or trends in abundance or survey data for neotropical otter in Guyana exist; however, limited data throughout the species' range indicate a decreasing population trend. The species is listed as Near Threatened by the IUCN (Rheingantz and Trinca 2015). Historically, neotropical otters were hunted for their pelts to the point of localized extinction. Today, they are still threatened by hunting, but also by habitat loss and degradation from deforestation, mining, and water pollution.

Gray River Dolphin

The gray river dolphin is a freshwater species that occurs throughout the Amazon and Orinoco river basins (Secchi 2012). Gray river dolphins occur in the main tributaries of the Amazon/ Solimões river basins and they cross international boundaries in areas such as Leticia, located between Brazil and Colombia. During the rainy season, gray river dolphins may move into smaller tributaries, but apparently they do not move into the inundated forest to feed as Amazon river dolphins often do, staying primarily in main river channels and their tributaries and lakes (da Silva and Best 1996). The geographic range of gray river dolphins largely overlaps with that of Amazon river dolphins in the Amazon and Orinoco systems, but the two species generally do not interact. No recent data exist on the population size and distribution of gray river dolphins in Guyana. Historical surveys of gray river dolphins in Guyana's rivers reported their presence in the Demerara, Cuyuni, Mazaruni, and Essequibo rivers (IUCN 2019).

The gray river dolphin is listed as Data Deficient by the IUCN (IUCN 2019). There are no records of past or recent commercial fisheries for the species (IWC 2001). Currently, gray river dolphins in the Amazon region, including Guyana, are threatened primarily by incidental mortality in fishing gear (IWC 2001), as well as chemical and noise pollution, overfishing of prey, and boating activity (IUCN 2019).

Amazon River Dolphin

Amazon river dolphins are a strictly freshwater species inhabiting inland rivers and lakes throughout the Amazon and Orinoco river basins in Brazil, Bolivia, Colombia, Ecuador, Peru, Venezuela, and Guyana (Best and da Silva 1989a,b; WWF 2019).

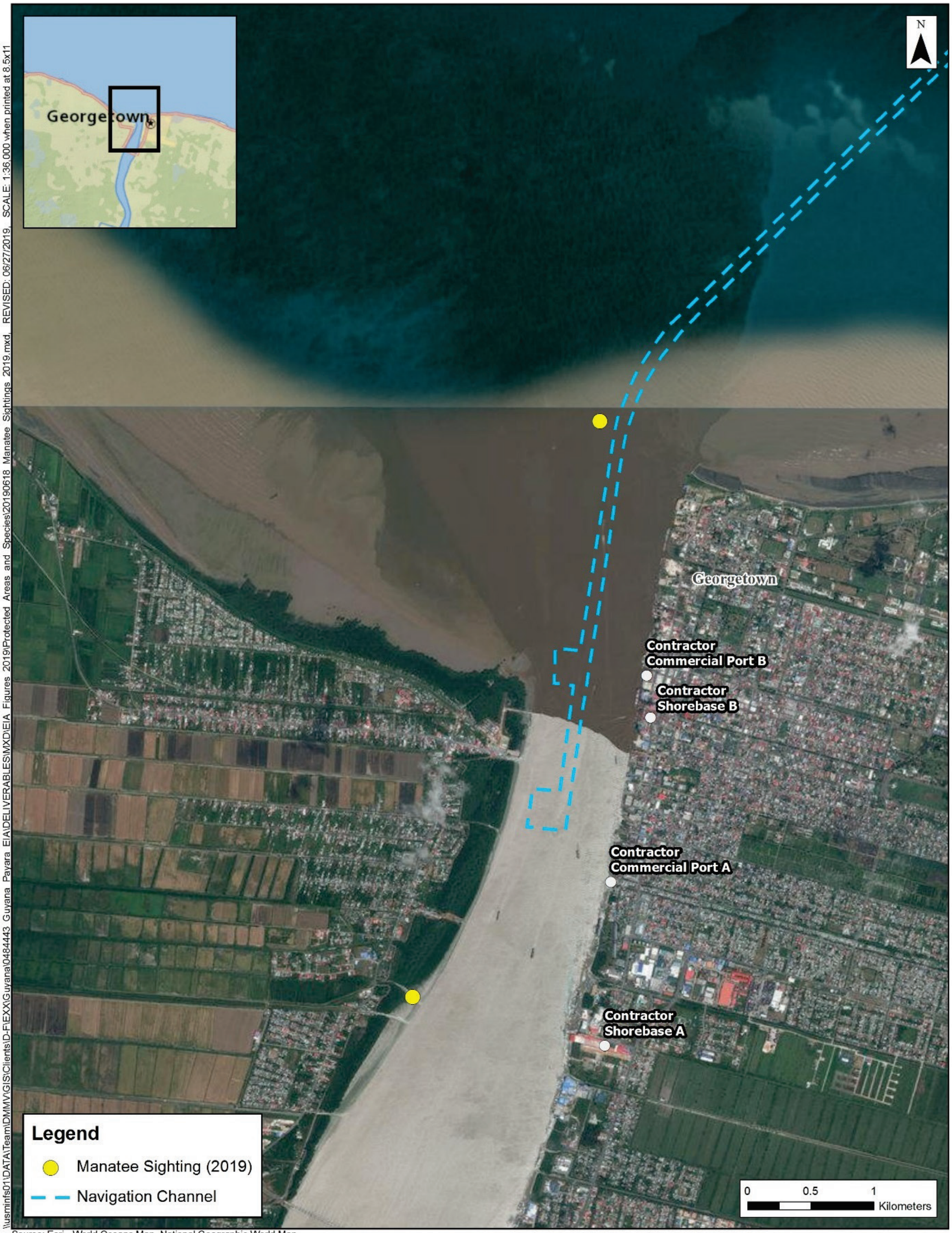
There is limited information on the population structure of Amazon river dolphins throughout their range and there are no range-wide estimates of abundance or trends in abundance (da Silva et al. 2018). No survey data for the species in Guyana exist. Water level affects the use of habitat by Amazon river dolphins for all age classes; however, females with dependent calves spend more time inside interior flooded forests and in lakes and small tributaries during the rainy season, while most adult males spent most of their time in the main rivers. During the dry season, this species is often concentrated below channel confluences (da Silva et al. 2018).

The Amazon river dolphin is listed as Endangered by the IUCN (da Silva et al. 2018). This status is based on a suspected reduction of 50 percent or more in total population size over a period of three generations (75 years, encompassing past and future) as well as the following: (1) evidence of range-wide population fragmentation; (2) deterioration of habitat quality as a result of water basin management (e.g., dam construction), human demographic changes, and economic development; and (3) exploitation (hunting for bait and for predator control and incidental mortality in fishing gear). Ongoing threats to the species throughout its range include incidental mortality in fishing gear, deliberate killing for fish bait or predator control, habitat alteration, and environmental pollution.

7.6.2.2. Riverine Mammal Data for the Direct Area of Influence

EEPGL commissioned a targeted survey of riverine mammals in early 2019 in the area between the Demerara Harbour Bridge and the mouth of the Demerara River. The objective of the survey is to document the species assemblage and abundance of riverine mammals within the lower Demerara River between the Demerara Harbour Bridge and the mouth of the Demerara River, including the portion of the river around the shorebase facilities where Project-related vessel traffic and onshore infrastructure operations will occur. The survey was conducted 2 days per month during daylight hours from dawn to dusk (roughly 24 hours of survey time per month) using visual scans of the river's surface with the naked eye and with binoculars from a vessel.

To date, two riverine mammal survey events have been conducted—one in April 2019 and one in May 2019—each yielding a single observation of West Indian manatee. The first manatee sighting occurred during high tide at the mouth of the Demarara River on 14 April 2019 and the second sighting occurred during high tide within the confluence of the Demerara River and a drainage canal on the left bank of the river on 31 May 2019 (see Figure 7.6-1). No other riverine mammals were observed during the April and May 2019 survey events.



Source: Esri - World Oceans Map, National Geographic World Map

Figure 7.6-1: Location of Riverine Mammal Sightings Recorded During EEPGL-Commissioned Riverine Mammal Surveys in April and May 2019

7.6.3. Impact Assessment—Riverine Mammals

Of the five species of riverine mammals in Guyana, two species could have the reasonable possibility to interact with planned Project activities—the West Indian manatee and the neotropical otter—as these species occur in in the brackish/intertidal waters of the Demerara Harbour where Project-related vessel traffic will occur. The other three species, the giant otter, gray river dolphin, and Amazon river dolphin are freshwater species that are not likely to be encountered within areas affected by planned Project activities.

7.6.3.1. Relevant Project Activities and Potential Impacts

As shown in Table 7.6-3, the impact assessment considers the potential for planned Project activities to impact riverine mammals through temporary displacement (e.g., as a result of increased vessel traffic within the Demerara Harbour from Project activities). Impacts on riverine mammals related to unplanned events (e.g., vessel strike and oil spill) are discussed in Section 9.10, Riverine Mammals.

As described in Section 8.4, Marine Use and Transportation, the Project's marine activities will increase the existing marine traffic in Georgetown Harbour by 1 to 4 percent over existing conditions. Specifically, it is estimated that during development drilling and FPSO/SURF installation, installation and support vessels may make an average of approximately 12 to 15 round-trips per week between the Stabroek Block and shorebases. During the production operations stage, it is estimated that this number will be reduced to approximately five to ten round-trips per week. These vessel round-trips will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad and Tobago.

Table 7.6-3: Summary of Relevant Project Activities and Key Potential Impacts—Riverine Mammals

Stage	Project Activity	Key Potential Impact
All Project stages	Onshore infrastructure operations; Project-related vessel operations	Behavioral changes or displacement of riverine mammals as a result of increased vessel traffic within Georgetown Harbour

7.6.3.2. Magnitude of Impacts—Riverine Mammals

The assessment of the Project's magnitude of potential impacts on riverine mammals is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on riverine mammals from Project-related vessel traffic is defined according to the definitions provided in Table 7.6-4. The following paragraphs discuss the characteristics of the potential impacts assessed and the resultant magnitude ratings. These are summarized in Table 7.6-5.

Table 7.6-4: Definitions for Intensity Ratings for Potential Impacts on Riverine Mammals

Criterion	Definition
Intensity	Negligible: No discernible change in riverine mammal behavior or presence in the impacted area.
	Low: Minor behavioral changes (temporary avoidance of impacted area) by riverine mammals that would not measurably impact habitat use, local population status, or viability of riverine mammal population.
	Medium: Observable changes in riverine mammal behavior (long-term avoidance or abandonment of previously occupied habitats) or low levels of injury or mortality that would not affect the long-term viability of the riverine mammal population.
	High: Significant changes in riverine mammal behavior (species eliminated from the impacted area) or significant mortality that could affect the long-term viability of the riverine mammal population.

Historical and ongoing human activities within Georgetown Harbour have substantially modified the primary ecological functions and species composition of habitats within the harbor, resulting in habitat loss and species displacement. Resident riverine mammals of the harbor are, therefore, habituated to the constantly changing and human-influenced environments of the harbor. Onshore infrastructure operations of the Project within the harbor will use existing shorebase support facilities and as such, onshore Project activities are predicted to have little to no impact on resident riverine mammals because they are already habituated to human activities and vessel traffic. The slight increase in overall marine vessel traffic in Georgetown Harbour that will occur as a result of the Project may result in a slight incremental increase in temporary avoidance behavior and displacement from the vessel transport route, which itself represents a small portion of the available riverine habitat within the harbor. It is expected that resident riverine mammals will move away (or have already moved away based on the pre-existing history of marine vessel activity) to areas of the harbor with lower vessel traffic. As such, the intensity of the potential impacts on riverine mammals is rated as **Low**.

Project-related marine traffic will occur on a routine basis and continue throughout the Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages, **Long-term** for drilling, installation, and production operations phases, and at least **Medium-term** for the decommissioning stage. This yields a magnitude rating of **Small** for potential impacts on riverine mammals from Project-related marine traffic.

Table 7.6-5: Magnitude of Impact—Riverine Mammals

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Development Well Drilling SURF/FPSO Installation Production Operations	Behavioral changes or displacement of riverine mammals as a result of increased vessel traffic within Georgetown Harbour	Direct AOI (Georgetown Harbour)	Low	Continuous	Long-term	Small
Decommissioning	Behavioral changes or displacement of riverine mammals as a result of increased vessel traffic within Georgetown Harbour	Direct AOI (Georgetown Harbour)	Low	Continuous	Medium-term	Small

7.6.3.3. Sensitivity of Receptors—Riverine Mammals

Of the two riverine mammals likely to be encountered within Georgetown Harbour, the West Indian manatee has the highest threat level, listed as Vulnerable by the IUCN, and as such the assessment of impacts on riverine mammals was conducted based on the conservative assumption that this species would be the receptor for potential impacts. Consistent with the receptor sensitivity ratings used for the assessment of potential impacts on special status species, as defined in Table 7.6-6, riverine mammals are considered to have a **Medium** sensitivity.

Table 7.6-6: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Special Status Species (Adopted for Potential Impacts on Riverine Mammals)

Criterion	Definition
Sensitivity	Negligible: Species with no specific value or importance attached to them.
	Low: Species and sub-species of Least Concern on the IUCN Red List (or not meeting criteria for medium or high value), or without specific anatomical, behavioral, or ecological susceptibilities to potential Project-related impacts.
	Medium: Species listed as Vulnerable, Near Threatened, or Data Deficient on the IUCN Red List; species protected under national legislation; nationally restricted range species; nationally important numbers of migratory or congregatory species; species not meeting criteria for high value; and species vital to the survival of a medium value species.
	High: Species on IUCN Red List as Critically Endangered or Endangered. Species having a globally restricted range (i.e., endemic species to a site, or found globally at fewer than 10 sites, fauna having a distribution range less than 50,000 km^2), internationally important numbers of migratory or congregatory species, key evolutionary species, and species vital to the survival of high value species.

7.6.3.4. Impact Significance—Riverine Mammals

Based on the magnitude of impact and receptor sensitivity ratings described above, the significance ratings for potential impacts on riverine mammals is **Minor**.

7.6.4. Mitigation Measures—Riverine Mammals

The embedded controls integrated into the Project design and operational procedures constitute the practicable best management measures that are available to reduce the significance of potential impacts on riverine mammals. Table 7.6-7 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.6-7: List of Embedded Controls and Monitoring Measures

Embedded Controls
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' specifications and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Monitoring Measures
Monitor on an ongoing basis visual detections of marine mammals, riverine mammals, and marine turtles.

Table 7.6-8 summarizes the assessment of potential pre-mitigation and residual Project impacts on riverine mammals.

Table 7.6-8: Summary of Potential Pre-Mitigation and Residual Impacts—Riverine Mammals

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Behavioral changes or displacement of riverine mammals as a result of increased vessel traffic within Georgetown Harbour	Small	Medium	Minor	None	Minor

7.7. MARINE TURTLES

7.7.1. Administrative Framework—Marine Turtles

Table 7.7-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on marine turtles.

Table 7.7-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Marine Turtles

Title	Objective	Relevance to the Project
Legislation		
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Regulations, 2013 (recently supplemented by passing of Wildlife Conservation and Management Act, 2016)	Provides for the establishment of a Management Authority and the management of the country's flora and fauna. Provides for classification of some species as vulnerable, endangered, or critically endangered; 2016 act specifies that the act applies to all species in CITES Appendices I, II and III unless otherwise reserved by Guyana.	Provides a supportive mechanism to achieve the national goals for wildlife protection, conservation, management, and sustainable use.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region; Specially Protected Areas and Wildlife Protocol	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	CITES is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.	CITES works by subjecting international trade in specimens of selected species to certain controls. All import, export, re-export, and introduction from the sea of species covered by the convention have to be authorized through a licensing system.

Title	Objective	Relevance to the Project
United Nations Environment Agreements	The Cartagena Convention works in support of other global environmental conventions, agreements, and commitments such as: Convention on Biological Diversity; Convention on Migratory Species; Ramsar Convention on Wetlands; CITES; Stockholm Convention on chemicals management; Basel Convention on hazardous waste.	Contracting parties to the convention are also required to protect and preserve rare or fragile ecosystems and habitats of depleted, threatened, or endangered species, and develop technical and other guidelines for the planning and environmental impact assessments of important development projects.
International Maritime Organization Agreements	The Cartagena Convention works in support of other global environmental conventions, agreements, and commitments such as: International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978, on ship-generated wastes; Ballast Water Convention; London Convention.	Contracting parties to the convention are also required to protect and preserve rare or fragile ecosystems and habitats of depleted, threatened, or endangered species; and develop technical and other guidelines for the planning and environmental impact assessments of important development projects.

7.7.2. Existing Conditions—Marine Turtles

According to the *Regional Sea Turtle Conservation Program and Action Plan for the Guianas* (Reichart et al. 2003) and Dow et al. (2007), marine turtles are an important natural resource shared by various countries throughout the Caribbean region and the Guiana Shield region, which includes Venezuela, Guyana, Suriname, French Guiana, and Brazil. The existing conditions for marine turtles in the Project AOI were described using observational data collected during various offshore exploration activities from 2015 to 2019, marine turtle telemetry studies conducted at Shell Beach (as described in Section 7.7.2.2, data from Reichart (2003), and data compilations from Project GloBAL (2007).

7.7.2.1. Regional Setting and Species Descriptions

Five marine turtle species are found in Guyana and the surrounding region. Four marine turtles (green turtle [*Chelonia mydas*], leatherback turtle [*Dermochelys coriacea*], hawksbill turtle [*Eretmochelys imbricata*], and olive ridley turtle [*Lepidochelys olivacea*]) nest on Guyana's beaches. A fifth species, loggerhead turtle (*Caretta caretta*) also occurs offshore Guyana, but rarely come ashore to nest in Guyana. In addition to relying on sandy beaches for egg-laying, marine turtles rely on healthy coral reef, seagrass, and hard-bottom habitats for food and refuge. Based on available information, post-hatchlings and juvenile green turtles are reported to feed on prey found within sargassum mats (USFWS 2018), while the other marine turtle lifestages are associated with clearer offshore waters or coral reef environments where they prey on a variety of items (Piniak and Eckert 2011).

Green Turtle

Green turtles are generally found in tropical and subtropical waters along coastlines and continental islands between the latitudes of 30° North and 30° South (NOAA 2019). They are distributed worldwide, nesting in more than 80 countries and inhabiting the coastal waters of more than 140 countries (NMFS and USFWS 2007). In the Atlantic Ocean, green turtles are found from Texas to Massachusetts, throughout the Caribbean, and off of the coast of South America. In the Pacific, they are primarily found south of San Diego, California, Hawaii, Guam, and the Mariana Islands. Adult green turtles are benthic herbivores (Bjorndal 1997) and they play an important role in seagrass and macro-algal ecosystems by pruning them, increasing the nutrient cycle, and preventing the creation of sediment (Bjorndal and Jackson 2003; Jackson 2001). After hatching, hatched green turtles swim offshore to find sargassum mats. As they grow larger and older, green turtles move to foraging areas with seagrass beds (Troëng et al. 2005). Green turtles are listed by the IUCN as Endangered (EN) (IUCN 2019).

Leatherback Turtle

Leatherback turtles are the largest of all marine turtle species, but unlike other turtles, they do not have a hard shell. Instead, their carapace is made of small bony plates (osteoderms) covered by leathery skin. Leatherbacks are found in pelagic and coastal tropical and temperate marine waters, where they spend most of the time feeding on jellyfish, salps, and siphonophores (Dass 2011). Leatherbacks are highly migratory, making distinct and extensive seasonal migrations to foraging and nesting beaches and they show fidelity to both foraging and nesting regions (Fossette et al. 2010). Individuals generally nest from March to mid-July in the northwestern Atlantic (Troëng et al. 2004). Young leatherback turtles remain in tropical latitudes until the length of their shell reaches approximately 100 centimeters (39.4 inches) (Eckert 1999; Eckert 2001). The largest nesting colony in the Caribbean region is in Trinidad (NWA Leatherback Working Group 2018). Leatherback nesting was previously abundant in Suriname and French Guiana, but dramatic population declines have been noted in these areas. The species also nests in Guyana, Venezuela, Colombia, Costa Rica, Puerto Rico, and several islands in the Caribbean. Leatherback turtles are listed by the IUCN as Vulnerable (VU). The species' status is currently under review by IUCN based on recent analysis of nesting trends in the Northwest Atlantic (IUCN 2019; NWA Leatherback Working Group 2019).

Hawksbill Turtle

The hawksbill turtle is a small- to medium-sized marine turtle that has an elongated head that tapers to a point with a beaklike mouth (NOAA 2014). These turtles are circumtropical and can be found in waters from latitudes of 30° North to 30° South in the Atlantic, Pacific, and Indian Oceans. They are found in various wide-ranging locations depending on their lifestage and diet (Mortimer and Donnelly 2008). In the Atlantic Ocean, hawksbill turtles are found within lagoons, ledges, and caves associated with coral reef environments; their diet consists of sponges (NOAA 2014). These types of habitats are generally found northwest of the PDA in the Caribbean Sea. The hawksbill turtle is listed as Critically Endangered (CR) by the IUCN (IUCN 2019).

Loggerhead Turtle

The loggerhead turtle is broadly distributed throughout the world. It is found in the Atlantic, Pacific, and Indian Oceans, as well as the Mediterranean Sea. Loggerhead turtles have oceanic and nearshore life-history phases and sometimes their preferred habitat alternates between offshore and nearshore environments. As juveniles, loggerhead turtles feed on bottom-dwelling marine organisms, but in the open ocean, loggerhead turtles primarily feed near the ocean surface and are particularly associated with sargassum habitat in the North Atlantic Ocean. The loggerhead turtle is classified as Endangered (EN) by the IUCN (IUCN 2019).

Olive Ridley Turtle

The olive ridley turtle is a small turtle compared to the other marine turtles. This species has a circumtropical distribution. Olive ridley turtles are best known for their behavior of synchronized nesting in mass numbers, termed *arribadas*. Similar to other marine turtles, females always return to the same beach to nest where they initially hatched. The olive ridley diet is wide-ranging, consisting of protochordates, jellyfish, tunicates, sea urchins, bryozoans, bivalves, snails, shrimp, crabs, rock lobsters, and sipunculid worms. The Guianas region is known for supporting important leatherback, olive ridley, and green turtle colonies (Alvarez-Varas 2016). The olive ridley turtle primarily nests along the French Guiana coast with small nesting areas along the northeastern coast of Venezuela to Suriname and in eastern Brazil (Piniak and Eckert 2011). The olive ridley turtle is classified as VU by the IUCN (Abreu-Grobois and Plotkin 2008).

Marine Turtle Nesting in Guyana

Four species of marine turtles nest in Guyana (green, hawksbill, leatherback, and olive ridley). According to available information, the primary marine turtle nesting site in Guyana is Shell Beach, which is located in Region 1 on the northwestern coast of Guyana (e.g., Alvarez-Varas 2016). The exact locations of secondary nesting sites in Guyana change each year with coastal erosion, which either creates or destroys nesting areas, but they are generally distributed along the northwest coast between the Pomeroon River and the Waini River estuaries. Historically, leatherback turtles were the most common species that nested on Guyana's beaches (e.g., Almond Beach); however, many leatherback turtles and eggs were intentionally taken by residents in the late-1980s, so it is difficult to determine whether they are the most common nesting species (Pritchard 1986). Nonetheless, leatherback and green turtles commonly nest on Guyana's beaches followed by olive ridley and hawksbill turtles, which nest infrequently. One of the largest leatherback nesting populations in the Atlantic Ocean is found within the region (the large estuary of the Maroni River at the border between French Guiana and Suriname; Fossette et al. 2008). According to the Center for Rural Empowerment and the Environment, the primary nesting season for the leatherback, green, hawksbill, and olive ridley turtles in Guyana (Shell Beach) is February to August; nesting occurs at night (PAC 2014).

Habitat Use by Marine Turtles

Because female marine turtles come ashore to nest, the adult (and specifically the female) lifestage is most easily studied and well-known; however, much less information is available about habitat use and movements of sub-adults and juveniles. Studies conducted to date have documented the early life history (activities and movements) of marine turtles. Young marine turtles live in the open ocean for the first few years of life, a period that has been termed the surface-pelagic or open-ocean stage. Reich et al. (2007) used stable isotope analysis to confirm that following the initial post-hatching "scramble" to the water, young green turtles lead a carnivorous existence in offshore habitats for 3 to 5 years before making a rapid shift to coastal habitats, where they switch to an herbivorous feeding strategy. At one time, researchers assumed post-hatchling and young juvenile turtles drifted with oceanic currents during their surface-pelagic stage. However, Putman and Mansfield (2015) reported that hatchling green and Kemp's ridley turtles are capable of directional swimming and do exhibit some degree of volitional movement while in the open ocean (McClellan and Read 2007; McClellan et al. 2009; McClellan and Read 2009; McClellan et al 2010).

Threats to Marine Turtle Populations

Similar to other regions, the primary threats to marine turtles in Guyana are poaching, intentional and incidental take during fishing activities, habitat disturbance and degradation, coastal zone development, coastal erosion, lighting, and debris. Population monitoring and conservation activities are limited in Guyana because of logistical challenges associated with the remoteness of primary nesting sites and limited research funding.

Marine turtles are incidentally (e.g., Guimaraes et al. 2017) and sometimes intentionally (e.g., Lagueux et al. 2014) taken in commercial fisheries around the world, which has negatively impacted their populations. Commercial fisheries are one of the biggest threats to the conservation and recovery of marine turtles globally (Wallace et al. 2010). One of the problems is the overlap between commercial fishing grounds and marine turtle foraging areas (Fossette et al. 2014). In some regions around the world (e.g., United States and Costa Rica), turtle excluder devices[24] (TEDs) are required to be installed in trawls, which has been beneficial for marine turtles in many regions. Despite their effectiveness at reducing the bycatch of marine turtles in commercial fisheries, not every country requires TEDs for a variety of reasons (Duarte et al. 2019). Tambiah (1994) estimated that 1,300 marine turtles per year are incidentally taken in trawl nets off Guyana. The mortality rate of taken individuals is around 60 percent. Tambiah (1994) also reported that gillnet fisheries in Guyana and Suriname are an even bigger threat than trawl fisheries, incidentally capturing 21,600 marine turtles per year. The report highlights that the highest bycatch of olive ridley coincides with the peak shrimp fishery (February–March), which is also when the nesting olive ridley turtle arribadas in Suriname take place (January–March).

[24] A TED is a specialized device installed in trawl gear that allows a marine turtle to escape.

7.7.2.2. Marine Turtle Data Offshore Guyana

Protected Species Observer Data for Marine Turtles

EEPGL has commissioned the collection of protected species observer data for marine mammals and turtles (also referred to herein as "MMO data") offshore Guyana since 2015. Data on marine turtles have been collected using visual detection methods during more than 18,000 hours of survey time, generating the most comprehensive dataset available on marine turtle activity offshore Guyana. A comprehensive summary of MMO data from 2015 through April 2018 was provided as part of the Liza Phase 2 Development Project EIA (RPS 2018). A summary of MMO observations from May 2018 through April 2019 is included as Appendix O, Protected Species Observer Summary Report, to this EIA.

During the over 18,000 hours of survey time in and around the Stabroek Block and between the Stabroek Block and the Guyana coast from May 2015 through April 2019, a total of 15 marine turtles were detected (Figure 7.7-1). The species detected include green, hawksbill, loggerhead, and olive ridley turtles. No leatherback turtles were detected during the surveys. Unidentified shelled marine turtles represented 5 of the 15 observations, followed by four detections of loggerhead turtles and two detections each of green, hawksbill, and olive ridley turtles.

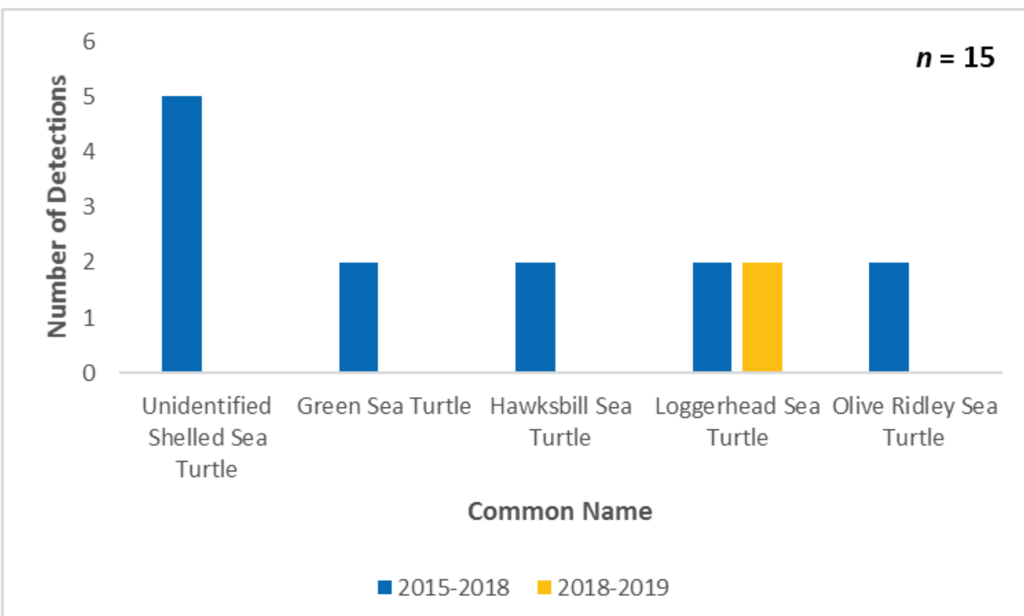


Figure 7.7-1: Number of Visually Detected Marine Turtles during EEPGL-Commissioned Protected Species Surveys 2015–2019

Participatory Fishing Study (January-April 2019)

During the EEPGL-commissioned voluntary fish study that occurred from January to April 2019, additional anecdotal information on marine turtles was collected from interviewing fisherfolk. Fisherfolk reported encountering all four species of marine turtles known to nest in Guyana. They indicated that turtles attempted to nest on the sand banks in Riverview (Region 4) and Lima

(Region 2) several years ago, but turtles are no longer attempting to nest in those areas given the recently established mangrove planting programs in those regions. Many fisherfolk in Region 2 indicated they have been seeing marine turtles in the seaweed just off the Pomeroon River; it is possible the seaweed could be suitable habitat for green turtles. Almost all of the fisherfolk interviewed in Region 1 reported observing marine turtles during fishing activities and several fisherfolk admitted accidentally catching marine turtles in their fishing gear; all marine turtles captured in fishing gear were reported to be released alive. A few fisherfolk in Waramuri (Region 1) indicated they frequently encounter marine turtles in the vicinity of Shell Beach. Similarly, fisherfolk from Smith's Creek (Region 1) report encountering many juvenile marine turtles (Appendix T, Participatory Fishing Survey Quarterly Report).

Conservation Group Marine Turtle Satellite Tracking Studies

The Sea Turtle Conservancy actively maps marine turtle movements by placing satellite transmitter tags on individual turtles after nesting. In May 2012, the Sea Turtle Conservancy tracked three leatherback turtles from their nesting site at Shell Beach and discovered that each turtle remained offshore of Shell Beach and in Guyana's territorial waters for several weeks. By the second to third week of June, two had moved farther offshore in transit to the waters off Nova Scotia, while one remained off the coast of Guyana until the third week of July and eventually transited to Honduran waters. One individual swam through the Stabroek Block before moving northward (Sea Turtle Conservancy 2012). These movements are consistent with other researchers (Pritchard 1973; Fossette et al. 2010) that have reported most marine turtles migrate away (approximately a few hundred kilometers) from nesting beaches during post-nesting periods. Most turtles remain relatively close to nesting beaches during the nesting season (Shillinger et al. 2010; Bond and James 2017) because they often return to nesting beaches multiple times to lay additional eggs (multiple clutches). After nesting, marine turtles are highly migratory, making extensive trips to and from foraging areas. Fossette et al. (2010) reported the tracking duration for 16 turtles from 103 to 715 days for recorded distances ranging from 2,834 to 17,614 kilometers (1,7601 to 10,945 miles).

EEPGL-Commissioned Tracking Studies

To study turtle movements in Guyana, the Consultants enlisted the assistance of the Chelonian Research Institute in 2018 and 2019 to develop and conduct a research program on marine turtle movements. The program included three deployments to the SBPA, two in 2018 and one in 2019:

- Deployment 1 was undertaken from 21 to 27 March 2018. All field work was permitted through the Guyana Protected Areas Commission and all conditions detailed in the Protected Areas Commission's "Letter of No Objection to ERM Conducting Turtle Telemetry Study in the Shell Beach Protected Area" dated 19 March 2018 were strictly followed. This deployment was the first component of a satellite tagging study conducted to satisfy the conditions of the Environmental Permit for the Liza Phase 1 Development Project. Scientists tagged four green turtles (designated as Sibille, Becky, Violet, and Karin for the purpose of tracking) with satellite tags at Shell Beach during this deployment.

- Deployment 2 was undertaken from 8 to 14 June 2018, for which all field work was conducted in accordance with the permit conditions detailed in the Protected Areas Commission's "No Objection to ERM Conducting 2nd Turtle Telemetry Study in 2018 in the Shell Beach Protected Area" letter dated 31 May 2018. During this deployment, scientists placed satellite tags on three leatherback turtles (designated as Julie, Denise, and Arleen for the purposes of tracking).
- Deployment 3 was undertaken from 7 to 17 May 2019 by the same field team as in 2018 and led by the Chelonian Research Institute. The field work was conducted in accordance with the permit conditions detailed in the Protected Areas Commission's "No Objection to Dr. Kelly Stewart and Team Conducting Turtle Telemetry Research in the Shell Beach Protected Area" letter dated 3 May 2019 and the EPA's "Permission to Conduct Biodiversity Research" letter dated May 2, 2019. At the time of writing, data generated from this research had yet to be published in agreement with the Government of Guyana and was not available for use in this EIA or any other similar analysis.

During all deployments, the field teams worked in close collaboration with Protected Areas Commission rangers and local community members during field activities in the SBPA. Representatives from the EPA and University of Guyana were present during the third deployment.

Inter-nesting Movements

Based on tracking data (early October 2018, when the last transmitter of the four green and three leatherback turtles that had been tagged ceased operating), all individuals showed strong nesting-site fidelity[25] and three different inter-nesting movement behaviors were identified:

- Remaining in the immediate vicinity of Almond Beach, making small near-shore loops;
- Moving moderate distances up and down the Guyana-Venezuela coastline, making small near-shore loops; and
- Moving great distances, making small near-shore loops in the vicinity of Almond Beach and offshore loops between Venezuela, Trinidad, and Guyana.

The data showed turtles returned to nest between two and six times, exclusively on Almond Beach at about 12-day intervals, except for one green turtle (Violet) who also nested across the Barima-Waini river mouth and at a longer time interval than the other turtles. All turtles demonstrated remarkable nest-site fidelity despite displacement distances among nests. With respect to the area used by the turtles during the inter-nesting period, there were no significant differences among species or individuals; however, leatherback turtles were generally found farther from shore than green turtles (Figure 7.7-2).

[25] The tendency of an individual to habitually return to the same area used for a specific lifestage or activity such as nesting or foraging

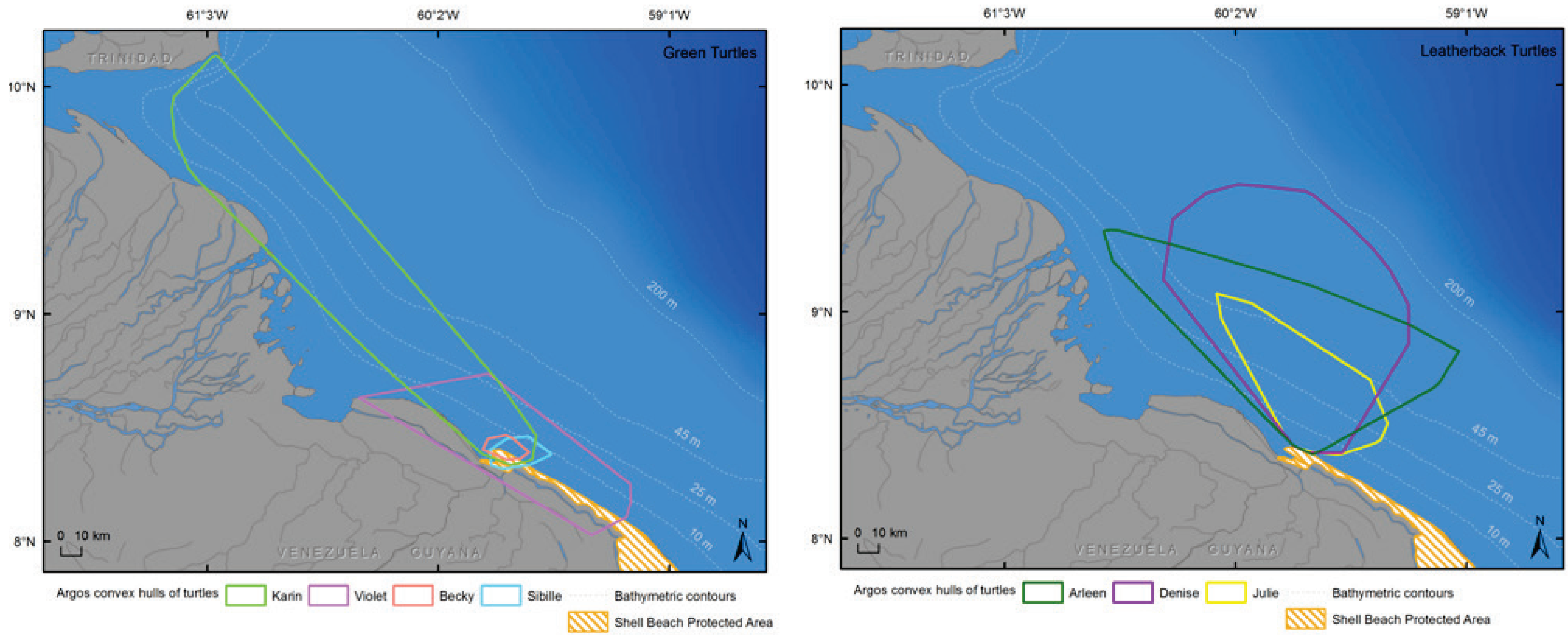


Figure 7.7-2: Spatial Footprints of Green and Leatherback Turtle Inter-nesting Movements from Almond Beach

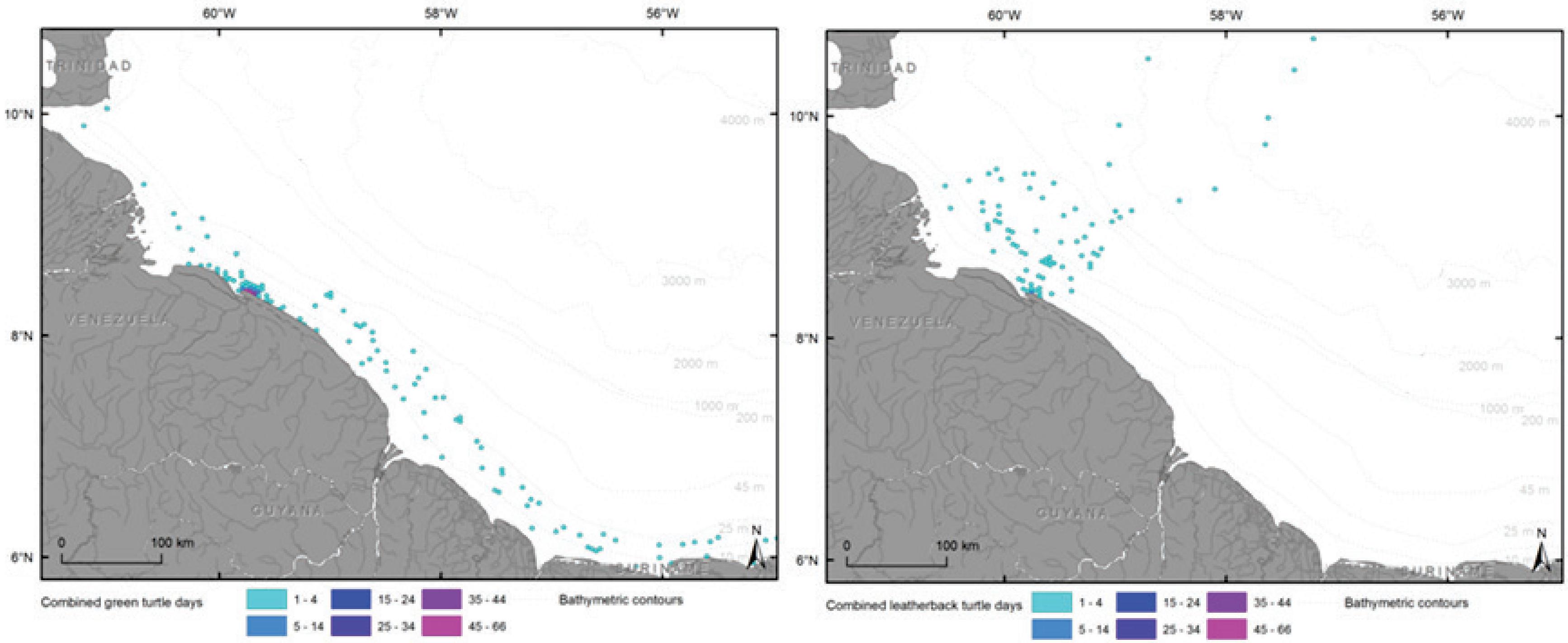
Generally, the turtles' inter-nesting habitat use was concentrated within the territorial seas of Guyana in the direct vicinity of Almond Beach, but it also included the territorial seas of Venezuela and Trinidad. The three leatherback turtles and one of the green turtles, demonstrated more itinerant[26] movement behaviors. Karin, a green turtle, moved the farthest during the inter-nesting period, extending 261.7 kilometers (162.6 miles) along the coast, and 50 kilometers (31.1 miles) offshore of the Orinoco River Delta in Venezuela on one loop and reaching the Port of Galeota on the Trinidad coastline on another loop. Julie displayed the most moderate offshore movements (54 kilometers [33.6 miles]) among the leatherback turtles during the nesting season, traveling 104.9 kilometers (65.2 miles) along the coasts of Guyana and Venezuela, and staying around the 50-meter (164-foot) depth contour. Denise, a leatherback turtle, moved the farthest distance from shore (111 kilometers [69.0 miles]), crossing the 100-meter (328.1-foot) depth contour during three inter-nesting loops that spanned 120.4 kilometers (74.1 miles) of shoreline, which included Guyana and Venezuela (see Appendix R, Turtle Telemetry Tracking Report). Sibille and Becky remained near their capture locations, spanning 16.7 kilometers (10.4 miles) and 17.8 kilometers (11 miles) of coastline, respectively. These turtles circled the 10-meter (32.8-foot) depth contour, and never traveled more than 11 kilometers (6.8 miles) from shore.

Despite the differences in inter-nesting movements documented above, the center of inter-nesting activity for all tracked turtles was immediately adjacent to the nesting beach.

The two green turtles that exhibited the widest inter-nesting travels (Karin and Violet), dove 16.7 meters (54.8 feet), but spent most of their time within the upper 5 meters (16.4 feet) of the water column. The two comparatively far-ranging turtles traveled into Venezuelan waters, venturing 30 to 40 kilometers (18.6 to 24.9 miles) off the coast near the Orinoco Delta, and traveling approximately 60 kilometers (37.3 miles) southeast of Almond Beach. These two turtles very likely remained near the surface more than the others because the metabolic demands were greater given their extended movement behavior, which forced them to use more energy breathing than the other turtles. These finding suggest that green turtles making long, cross-continental shelf movements before and after the nesting season remain near the surface, which makes spotting them easier for shipboard observers (see Appendix R, Turtle Telemetry Tracking Report).

Figure 7.7-3 depicts the movements undertaken by tagged green and leatherback turtles during their inter-nesting and early migration periods nearshore and offshore Guyana. The tagged green turtles occurred primarily in the nearshore environments along the Venezuela and Guyana coastlines and the tagged leatherbacks concentrated around the Venezuela coastline, with some individuals venturing further offshore (Figure 7.7-3).

[26] Moving from place to place



A synopsis of habitat use of turtles nearshore and offshore Guyana presented as the number of days that turtles occupied individual hexagons of approximately 16.25 square kilometers (4,015.5 acres). This encompassed the turtles' inter-nesting periods and part of their migration period.

Figure 7.7-3: Synopsis of Habitat Use of Turtles Nearshore and Offshore Guyana

Leatherback turtles occupied deeper water than green turtles during the inter-nesting period. Green turtles spent most of their time in less than 5 meters (16.4 feet), while leatherback turtles spent most of their time in less than 10 meters (32.8 feet) of water. Leatherback turtles are known to dive deep. The one leatherback turtle with a depth sensor tag, Denise, dove to 134.5 meters (441.3 feet) during the inter-nesting period. Most of the time, Denise made dives within the upper 10 meters (32.8 feet). A week after she migrated away from the nesting site, she started making deep dives every two or three days, the deepest of which (560.5 meters [1,839 feet]) was the day before her last transmission, where she was in water depths exceeding 5,000 meters (3.1 miles). Details on the vertical habitat use of turtles during their entire respective tracking periods are summarized in Table 7.7-2 (see Appendix R, Turtle Telemetry Tracking Report).

Table 7.7-2: Turtle Daily Vertical Habitat Use

Turtle ID	Water Depth (m)		Turtle Depth (m) [a]		Maximum Dive Depth (m) [b]	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Green Turtles						
173290 Sibille	10.5 (9.1)	1.0–42.0	-	-	-	-
173293 Violet	9.9 (6.9)	1.0–42.0	6.9 (5.4)	0.0–34.0	12.5 (6.1)	1.8–33.8
173291 Becky	12.2 (11.1)	1.0–69.0	-	-	-	-
173294 Karin	9.1 (9.1)	1.0–48.0	6.0 (5.1)	0.5–37.0	10.3 (6.8)	2.8–37.0
Leatherback Turtles						
173284 Julie	58.9 (198.4)	1.0–1065.0	-	-	-	-
173288 Denise	1400.9 (1961.8)	1.0–5437.0	22.7 (33.5)	0.5–560.5	108.3 (100.0)	7.3–560.5
173285 Arleen	3909.9 (1932.3)	1.0–5963.0	-	-	-	-

m = meters; SD = standard deviation
[a] Turtle daily vertical habitat use (i.e., depth) was inferred from sampling bathymetric maps and from dive data collected by the turtle tags. Sibille, Becky, Julie, and Arleen were not equipped with dive recorders.
[b] This table shows the mean and standard deviation as well as the range. For example, the maximum depth of a given dive was on average 10 to 13 meters (32.8 to 42.7 feet) for green turtles. Maximum dives of 30 to 40 meters (98.4 to 131.2 feet) were rare but are captured in the range column of the table. The same logic applies to leatherbacks.

Post-Nesting Dispersal Movements

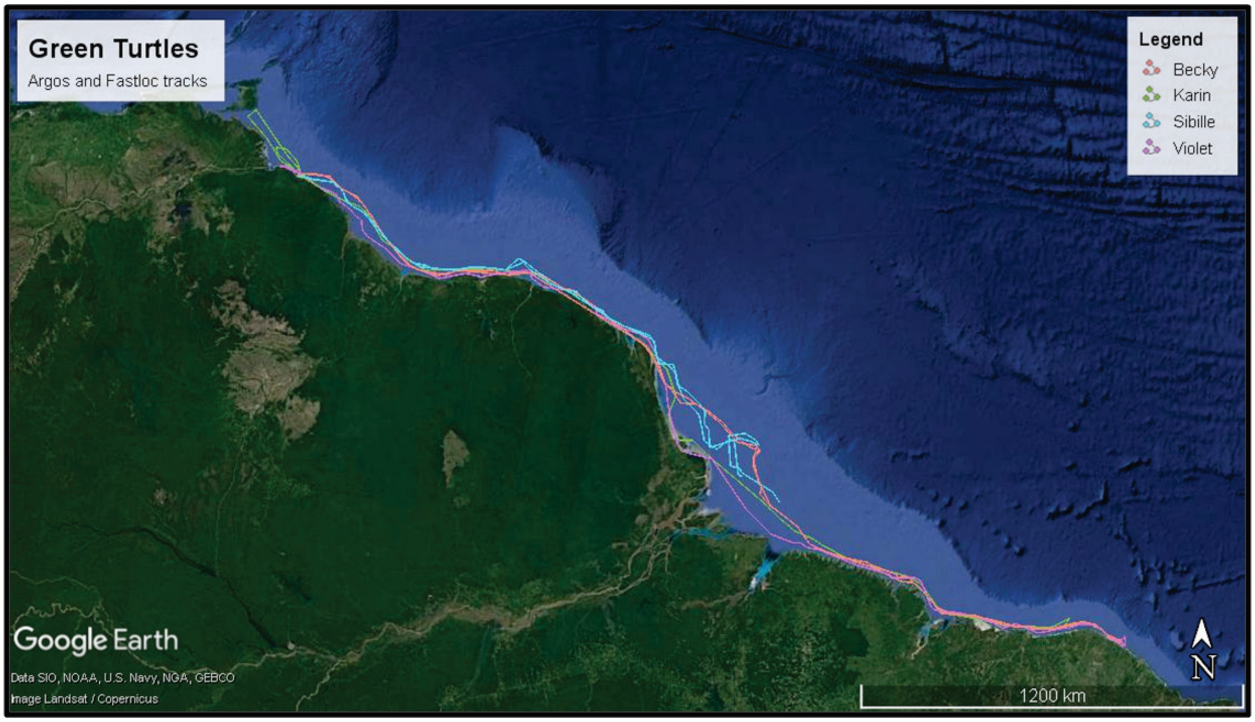
Researchers were able to track the movement pattern and behavior after departing the Shell Beach nesting site to their foraging grounds for all of the tagged turtles. All four green turtles migrated southeast to Brazil, following a near-shore corridor across an average distance of 2,485 kilometers (1,544.1 miles); all three leatherback turtles initially headed directly out to sea in a northeasterly direction. Both green and leatherback turtles used much deeper waters during their migration periods than during other periods. Both green turtles made various deep dives (60 meters [196.9 feet]) before or after moving near major river mouths (i.e., the Essequibo

River, Guyana; the Corentyne River, Suriname; the Amazon and Pará rivers, the Mearima River/Arraial Bay, and the Parnaíba River, Brazil). Three green turtles displayed movements to the foraging grounds near Ceará, Brazil. Two of three turtles overlapped geographically in the area, adjacent to the Mundaú River Estuary Environmental Protection Area. The three green turtles displayed similar foraging habitat use (area) and movements (dispersal from foraging centroid) among individuals, and their locations were at similar distances from shore as during the inter-nesting period, although water depths in the foraging area were slightly deeper.

The fourth green turtle and the leatherbacks were not tracked to their foraging grounds prior to the satellite tags ceasing to transmit. The first leatherback migrated 4,634 kilometers (2879.4 miles) over 96 days. Based on her route, it appeared she was heading for the Laurentian Channel, which corresponds to previous research. Canadian waters off Nova Scotia, Cape Breton, and Newfoundland have been previously described as critical foraging habitat for leatherback turtles.

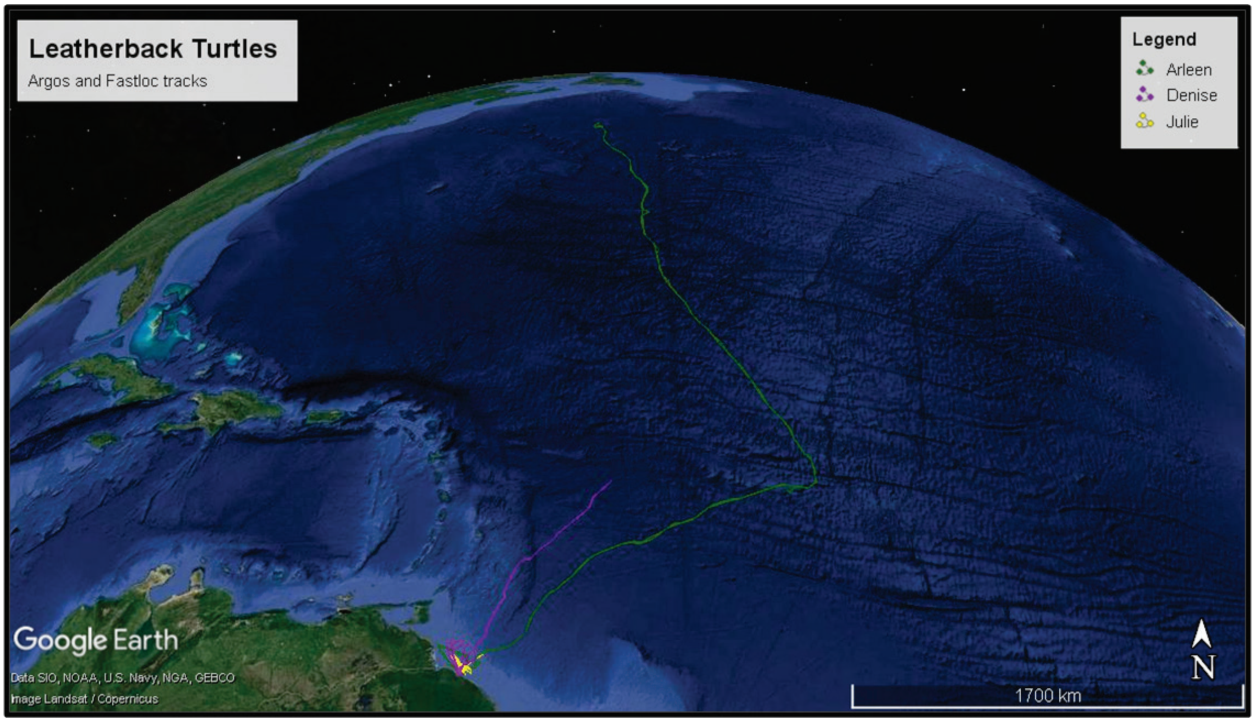
To examine the influence of ocean currents on the turtle movement, movement tracks were overlaid on monthly-averaged geostrophic current (altimetry) imagery, which included sea surface height (SSH) and velocity. Examining green turtle migrations showed the turtles occupying a narrow band close to the shore, where the current velocity and SSHs were the lowest; SSHs were, however, elevated near the major river mouths in Brazil. Leatherback turtles began to migrate in early to mid-July, which coincided with the onshore movement of the Guiana Current near Shell Beach; this formed a large divergent zone approximately 200 kilometers (124.3 miles) offshore.

In summary, green turtles followed a narrow migration corridor along the coastline after nesting, avoiding the opposing Guiana and North Brazil western boundary currents. In contrast, leatherback turtles dispersed into the high seas after nesting, taking an initial northeasterly course. Figures 7.7-4 and 7.7-5 show the recorded track paths for green and leatherback turtles.



Where double lines appear for a given turtle, this indicates deviations between the tracks derived from Argos and Fastloc® location data. In most cases the difference is unapparent.

Figure 7.7-4: Migration Routes of Green Turtles Tracked from Shell Beach



Where double lines appear for a given turtle, this indicates deviations between the tracks derived from Argos and Fastloc® location data. In most cases the difference is unapparent.

Figure 7.7-5: Migration Routes of Leatherback Turtles Tracked from Shell Beach

7.7.3. Impact Assessment—Marine Turtles

As described above, leatherback, green, hawksbill, loggerhead, and olive ridley turtles are found in Guyanese waters and could be encountered in the PDA. Four of these species—green turtle, leatherback, hawksbill, and olive ridley turtle—nest on Guyana's beaches, particularly in the SBPA, located near Guyana's border with Venezuela. Loggerhead turtles occur in offshore Guyanese waters, but rarely come ashore to nest.

7.7.3.1. Relevant Project Activities and Potential Impacts

As shown in Table 7.7-3, planned Project activities could potentially impact marine turtles through auditory injury (i.e., as a result of exposure to sound from Project activities), disturbance leading to changes in behavior (e.g., from underwater sound, lighting, and/or actions from Project activities), or toxicological effects (e.g., as a result of exposures to Project vessel discharges).

Potential impacts on marine turtles from vessel strikes are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Table 7.7-3: Summary of Relevant Project Activities and Key Potential Impacts—Marine Turtles

Stage	Project Activity	Key Potential Impact
Drilling and Installation	Vessel operations	• Displacement from habitat to avoid disturbance from vessel activity • Sound exposure leading to PTS injury
	Power generation	• Displacement from habitat to avoid disturbance from vessel activity or sound • Sound exposure leading to PTS injury
	VSP and pile driving	
	Remotely operated vehicle operations	
	Lighting on drill ship and installation vessels	• Disturbance to at-sea hatchlings and adults
	Permitted drill cuttings and fluids discharge	• Exposures to permitted discharges, potentially leading to toxicological impacts on sensitive lifestages (at-sea hatchlings)
	Permitted liquid waste discharge	
Production Operations	Vessel operations (e.g., FPSO supply barges, support vessels, drill ship, platform supply vessels, fast supply vessels, large crane vessel, fast supply vessel, field intervention vessel, light installation vessel, and multi-purpose support vessels)	• Displacement from habitat to avoid disturbance from vessel activity or sound
	Power generation	
	Operation of tankers, tugs, and supply and support vessels	
	Well stream production, processing, and storage operations	
	Permitted cooling water and produced water discharge	• Exposures to permitted discharges, potentially leading to toxicological impacts on sensitive lifestages (at-sea hatchlings)
	Other permitted liquid waste discharge	
	Lighting on FPSO	• Disturbance to at-sea hatchlings and adults

Stage	Project Activity	Key Potential Impact
Decommissioning	Vessel operations	• Displacement from habitat to avoid disturbance from vessel activity • Exposures to permitted discharges, potentially leading to toxicological impacts on sensitive lifestages (at-sea hatchlings)

7.7.3.2. Magnitude and Sensitivity Definitions for Potential Impacts on Marine Turtles

Following the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude ratings of potential impacts on marine turtles are determined based on geographic extent, frequency, duration, and intensity.

The intensity of potential impacts on marine turtles is defined according to the definitions provided in Table 7.7-4.

Table 7.7-4: Definitions for Intensity Ratings for Potential Impacts on Marine Turtles

Criterion	Definition
Intensity	Negligible: No Project-related change in marine turtle behavior or injury, or disturbance across only a very limited area.
	Low: Limited Project-related disturbance or injury of marine turtles is perceptible, potentially causing slight changes in the behavior of marine turtles.
	Medium: Project-related disturbance or injury of marine turtles is evident, potentially leading to limited mortality or impacts on life functions (e.g., feeding, breeding, migration route changes).
	High: Project-related disturbance or injury of marine turtles is sufficient to cause extensive mortality or chronic behavioral changes at a population level.

As discussed in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species, because the marine turtles occurring in the Project AOI are listed as CR (one species), EN (two species), or VU (two species) by IUCN, the marine turtles impact assessment applied the sensitivity ratings for special status species, as defined in Table 7.7-5. Applying a conservative approach and using the highest applicable sensitivity rating, this yields a **High** sensitivity. As discussed below, this sensitivity rating applies to all impacts other than anthropogenic disturbance at sea.

Contrary to other potential impacts, anthropogenic disturbance of turtles at sea is not known to be a major contributor to declines in listed turtle species. Accordingly, the sensitivity rating for this particular impact was not defined based on marine turtles' listing status, but rather on the basis of their expected propensity to adapt to occasional disturbance. Also, turtles are expected to be less sensitive to impacts when at sea compared to when nesting or immediately leading up to or following nesting. This is due to the vast areas in which turtles disperse during the non-nesting period and the very low abundance of turtles in the offshore environment in and near the PDA (based on over 18,000 hours of survey data collected in the Stabroek Block and between the Stabroek Block and the Guyana coast from 2015 through 2019). On this basis, receptor sensitivity for marine turtles is considered **Low** for impacts related to anthropogenic disturbance (including disturbance from artificial lighting).

Table 7.7-5: Definitions for Receptor Sensitivity for Potential Impacts on Marine Turtles (Adopted from Potential Impacts on Special Status Species)

Criterion	Definition
Sensitivity	Negligible: Species with no scientifically recognized (e.g., IUCN Red List or regional equivalent) elevated conservation status or other specific value or importance attached to them.
	Low: Species and sub-species of Least Concern on the IUCN Red List (or not meeting criteria for medium or high value), or without specific anatomical, behavioral, or ecological susceptibilities to potential Project-related impacts.
	Medium: Species listed as VU or Near Threatened on the IUCN Red List; species protected under national legislation; nationally restricted range species; nationally important numbers of migratory or congregatory species; and species not meeting criteria for high value.
	High: Species on IUCN Red List as CR or EN; species having a restricted range (i.e., endemic species to a site, or found globally at fewer than 10 sites, fauna having a distribution range less than 50,000 square kilometers/19,305.1 square miles), internationally important numbers of migratory or congregatory species, key evolutionary species, and species vital to the survival of high value species.

7.7.3.3. Characterization of Impacts—Auditory Injury from Anthropogenic Underwater Sound

The main sources of underwater sound associated with development well drilling activities are from VSP[27] activities (generating impulsive sound) and marine vessels (generating non-impulsive sound). The primary sources of sound from FPSO and SURF installation activities are from impact pile drivers for the FPSO mooring system and selected SURF equipment, such as manifolds (generating impulsive sound), and marine vessels (generating non-impulsive sound). Sound sources from production operations and decommissioning activities are primarily limited to marine vessels (generating non-impulsive sound).

Underwater sound can potentially cause a variety of impacts on marine turtles, such as behavioral changes in life functions (e.g., feeding, breeding, migration route deviations) or direct physical impacts affecting auditory systems.

Marine Turtle Auditory Functions

Marine turtles are capable of hearing sound despite lacking a visible external ear, but the biological significance of hearing in turtles is unknown. Marine turtles are not known to use sound to communicate like cetaceans, but they do use it for navigation, locating prey, avoiding predators, and general environmental awareness (Piniak et al. 2012). Hearing capabilities have been studied in only a few individual marine turtles, but the available data suggest that turtles have limited hearing capacity compared to other marine taxa (e.g., cetaceans).

All species of marine turtles can detect low-frequency sound, with indications that they have the highest hearing sensitivity in the frequency range of 100 to 700 hertz (Hz) (Bartol and Musick 2003; Piniak et al. 2012; Nelms et al. 2016). The auditory capabilities of marine turtles appear to vary among species. According to Piniak et al. (2012), green turtles detected tonal

[27] The VSP has a small source that produces seismic impulses over a period of time (for the purposes of this assessment, it was assumed that the source will produce 20 to 40 seismic pulses, less than 1 second in length, over a 6- to 12-hour period). The wavefield generated by this source is recorded by instruments in the borehole.

stimuli between 50 and 1,600 Hz underwater (maximum sensitivity: 200–400 Hz) and 50 and 800 Hz in air (maximum sensitivity: 300–400 Hz), leatherbacks detected tonal stimuli between 50 and 1,200 Hz underwater (maximum sensitivity: 100–400 Hz) and 50 and 1,600 Hz in air (maximum sensitivity: 50–400 Hz), and hawksbills detected tonal stimuli between 50 and 1,600 Hz in both media (maximum sensitivity: 200–400 Hz). The same study reported that marine turtles were more sensitive to airborne stimuli than underwater stimuli in terms of sound pressure, but they were more sensitive to underwater stimuli in terms of sound intensity. These hearing ranges overlap the sound produced by seismic airguns (Nelms et al. 2016).

Since marine turtles have been shown to hear and respond to low-frequency sounds, modeling results pertinent to LFCs (see Section 7.5.3, Impact Assessment—Marine Mammals) were used as a proxy for potential acoustic injury predictions for marine turtles. As described in Section 7.5.3, modeling predicted that impulsive underwater sound from VSP will attenuate to PTS onset acoustic thresholds for LFCs at maximum horizontal distances of 73 meters (approximately 240 feet), based on the more conservative injury criteria for the LFC marine mammal hearing group.

Observational records and dive profile data for tagged turtles (tagged by a CRI-led effort in 2018) suggest that most marine turtles occupy the upper 50 meters (164.0 feet) of the ocean during the inter-nesting period (see Appendix R, Turtle Telemetry Tracking Report), although leatherback turtles are known to dive deeper during their migration journeys. The VSP source for the Project will be located within 5 meters (approximately 16 feet) of the ocean surface, so marine turtles may be present at the same general depth as this source. Modeling indicates that marine turtles will be susceptible to PTS if they approach closer than 73 meters (239.5 feet) from an active seismic source and could encounter sufficient sound levels to disturb them, which could cause them to either avoid the sound source or could attract them to the sound source. Preliminary studies indicate that individual turtles are equally likely to move toward a sound source than from it. While the horizontal extent of the modeled potential auditory injury impact zone is significantly larger for pile driving than for VSP, the shallowest extent of this impact zone is more than 1,500 meters (4,920 feet) below the sea surface, and most turtles are not known to dive to this depth. Leatherback turtles have been reported to dive 1,186 meters (3,891.1 feet; López-Mendilaharsu et al. 2008) but they would not remain at this depth long enough to be injured by this type of noise source.

The only other low-frequency sound that marine turtles could potentially be exposed to as a result of the Project, other than VSP, would derive from vessels operating in the PDA, and modeling indicates vessel sounds will decrease below the threshold for acoustic injury to LFCs at 5 to 6 meters (approximately 16 to 20 feet) from the source (see Appendix G, Underwater Sound Modeling Report).

Magnitude of Impacts—Potential Auditory Injury from Anthropogenic Underwater Sound

Potential auditory injury-related impacts on marine turtles from Project-related underwater sound will be limited to the PDA (where pile driving and VSP will occur), so the geographic extent is considered to be the **Direct AOI**. The potential for acoustic injury impacts on marine turtles is limited primarily to impulsive sound during the drilling and installation stages (pile driving and VSP activities), which will be **Episodic** in nature and **Medium-term** (as they will occur in aggregate more than a week but less than a year). Potential impacts from non-impulsive sound will occur during all Project stage, so the impact would be **Continuous** and either **Long-term** (in the case of drilling and installation) or **Medium-term** (in the case of decommissioning).

The following considerations formed the basis for the assignment of an intensity rating:

- The activity that presents the greatest risk of acoustic injury (from a sound level perspective) to marine turtles (pile driving) will only occur during the initial installation stage, and therefore represents a relatively short-term source of potential impact (greater than 1 week but less than 1 year). The potential for marine turtles to be exposed to sufficient sound levels at a sufficient duration to cause auditory injury is extremely small, or possibly non-existent, due to the depths at which sound above the injury threshold will occur. Most of the marine turtles expected to be present in the PDA do not dive to the depths that would be required to reach these threshold levels or, if they do (such as occasional deep diving by leatherback turtles), they do not remain submerged at these depths for sufficient time to experience acoustic injuries.
- EEPGL has committed to using MMOs and soft-start procedures for VSPs in accordance with JNCC (2017) guidelines and soft starts for pile driving to further reduce the potential for impacts on marine mammals, which would be expected to reduce the potential for impacts on marine turtles.

The intensity of potential acoustic injury impacts is considered **Negligible** for the drilling and installation stage of the Project when a marine turtle could be exposed to sound from pile driving and VSP. Based on the very small distance to which auditory injury threshold levels are expected to propagate from the FPSO and marine vessels, the intensity of potential acoustic injury impacts is also considered **Negligible** for the production operations and decommissioning stages, when the underwater sound present in the Direct AOI will be limited to power generation and vessel traffic.

These ratings yield a magnitude rating of **Negligible** for potential auditory impacts on marine turtles (Table 7.7-6).

Table 7.7-6: Magnitude Ratings for Auditory Injury from Anthropogenic Underwater Sound

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Drilling and Installation (impulsive sound activities)	Marine turtles – auditory injury from sound exposure	Direct AOI	Negligible	Episodic	Medium-term	Negligible
Drilling and Installation Production Operations (non-impulsive sound activities)	Marine turtles – auditory injury from sound exposure)	Direct AOI	Negligible	Continuous	Long-term	Negligible
Decommissioning (non-impulsive sound activities)	Marine turtles – auditory injury from sound exposure	Direct AOI	Negligible	Continuous	Medium-term	Negligible

Impact Significance— Potential Acoustic Injury from Anthropogenic Underwater Sound

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance rating for potential acoustic injury impacts on marine turtles is **Negligible**.

7.7.3.4. Characterization of Impacts—Disturbance from Underwater Sound

Anthropogenic sounds below injury thresholds have the potential to mask relevant sounds in the animals' environment (Hildebrand 2005); however, there are no quantitative data demonstrating masking impacts for marine turtles, and it is currently understood that turtles do not use sound to communicate (Piniak et al. 2012). As such, the potential risk of impacts from masking is considered negligible.

Aside from fishing and entanglement, which are the greatest and most well documented sources of marine turtle disturbance, injury, and mortality, limited information exists describing the potential impacts associated with anthropogenic disturbance of turtles at sea and whether and to what extent these disturbances contribute to population declines in marine turtle populations. Behavioral responses to sound by marine turtles can vary from swimming to the surface and remaining at the surface to increasing their swimming speed and displaying erratic behavior (Nelms et al. 2016). Startle responses to sudden sounds have been observed in marine turtles. For example, McCauley et al. (2000) found that turtles showed behavioral responses to approaching seismic survey sound at approximately 166 decibels (dB) re 1 microPascal (µPa)[28], and more significant disturbance at 175 dB re 1 µPa. Startle responses and other behavioral changes are more likely from high-level impulsive sound sources, such as VSP activities, rather than from

[28] Sound levels expressed in dB in water are not the same as sound levels expressed in dB in air due to differences in the reference level and impedance of the two media. For sounds in water, the reference level is expressed as "dB re 1 µPa," referring to the relative amplitude of a sound wave to a reference pressure of 1 µPa (the reference level for sounds in water) (IAGC 2014).

non-impulsive sound sources such as vessels. Avoidance of the noise source is another common behavior.

One study found that post-nesting loggerhead turtles use the same post-nesting habitat areas year after year even though they contain vessel traffic and other disturbing activities, despite having closer choices of protected habitats with little or no vessel traffic or disturbing activities. This suggests that the drive for post-nesting dispersal habitat site fidelity is stronger than the turtle's desire or ability to avoid areas with high levels of human or vessel activity, or that they simply do not consider or respond to human activity as a threat (Zbinden et al. 2008). Nevertheless, increased activity in the PDA and between the PDA and shorebases could cause turtles approaching nesting beaches from the northeast to deviate from their normal migration route.

Magnitude of Impacts—Potential Disturbance Due to Underwater Sound

Potential disturbance-level impacts could extend outside of the Direct AOI via sound propagation, so the geographic extent for this potential impact is considered to be the Direct AOI + Central Stabroek Block. The potential for acoustic disturbance impacts on marine turtles is considered **Episodic** for impulsive sound activities (VSP and pile driving) during the drilling and installation stage and **Continuous** for non-impulsive activities (e.g., vessel operations, FPSO operation) during all Project stages. Disturbance-level impacts would be present on a **Medium-term** basis for impulsive activities and on a **Long-term** basis for non-impulsive activities (primarily related to the production operations phase, when sound sources will be present for at least 20 years). The intensity of potential disturbance-level sound impacts is considered to be **Low** for impulsive sound activities (based on the distance to which they could potentially exert a disturbance effect) and **Negligible** for non-impulsive activities (based on the expectation that the associated sound levels would not be expected to result in a measurable change in behavior and—if so—only within a localized area. This results in magnitude ratings of **Small** for impulsive sound activities and **Negligible** for non-impulsive sound activities, as summarized in Table 7.7-7.

Table 7.7-7: Magnitude Ratings for Disturbance from Anthropogenic Underwater Sound

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Drilling and Installation (impulsive sound activities)	Marine turtles—disturbance from sound exposure	Direct AOI + Central Stabroek Block	Low	Episodic	Medium-term	Small
Drilling and Installation Production Operations (non-impulsive sound activities)	Marine turtles—disturbance from sound exposure	Direct AOI + Central Stabroek Block	Negligible	Continuous	Long-term	Negligible
Decommissioning (non-impulsive sound activities)	Marine turtles—disturbance from sound exposure	Direct AOI + Central Stabroek Block	Negligible	Continuous	Medium-term	Negligible

Impact Significance— Potential Disturbance from Anthropogenic Underwater Sound

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance rating for potential disturbance impacts on marine turtles is **Negligible**.

7.7.3.5. Characterization of Impacts—Exposure to Permitted Discharges

Magnitude of Impact—Exposure to Permitted Discharges

The Project will involve routine, permitted discharges of waste streams to the sea. These discharges will begin during the development well drilling and FPSO/SURF installation stages and continue through the production operations stage and into the decommissioning stage. As described in Chapter 2, Description of the Project, and Section 6.4.3, Impact Assessment—Marine Water Quality, these discharges will be treated (as needed) in accordance with industry guidelines. Furthermore, marine turtles will likely be transient in the PDA and the duration of their exposure to any discharges is expected to be very limited. Any potential impacts would be expected to be acute and recovery would be expected to occur quickly after the affected individual(s) exit the mixing zone. As such, the intensity of potential impacts on marine turtles from exposure to permitted discharges is considered **Negligible**. Impacts would occur within the **Direct AOI** (PDA) and would be **Continuous** and **Long-term**. Accordingly, the magnitude of impact is **Negligible** (Table 7.7-8).

Table 7.7-8: Magnitude Ratings for Potential Impacts from Permitted Discharges

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
All Project Stages	Exposures to permitted discharges	Direct AOI	Negligible	Continuous	Long-term	Negligible

Impact Significance—Exposure to Permitted Discharges

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance rating for potential toxicological effects on marine turtles from exposure to permitted discharges is **Negligible**.

7.7.3.6. Characterization of Impacts—Artificial Lighting

Magnitude of Impacts—Artificial Lighting

There will be artificial lights in the PDA from various vessel types and Project features, most significantly the FPSO, and the amount of light in the PDA will vary between stages of the Project. Marine turtles are known to be sensitive to artificial light primarily when in close proximity to nesting beaches, because artificial light in the nearshore environment or along the shoreline can cause a variety of potential impacts on the behavior of nesting turtles and hatchlings including reduced nesting rates, premature abandonment of nests/interruption of the egg laying process, and disorientation of hatchlings and adults (Witherington and Martin 2003;

NOAA 2014). At no point will the offshore light from the FPSO affect nesting marine turtles (or hatchling turtles making their way from their nest to the sea) since the PDA is located 207 kilometers (128 miles) offshore and the light from the PDA will not be visible from the shore where turtle-nesting activities occur. Based on the definitions for impact intensity presented in Table 7.7-4 above, the intensity of impacts on marine turtle nesting and immediate post-hatching dispersal from Project-related lighting is therefore considered **Negligible**. Impacts would occur within the **Direct AOI** (PDA) and would be **Continuous** and **Long-term**. This yields a magnitude rating of **Negligible** for the coastal environment (Table 7.7-9).

Many studies have demonstrated the impact of onshore lighting on the behavior of nesting marine turtles and hatchlings (attraction, disorientation, nesting abandonment or disruption, etc.) but the effects of artificial light in the offshore environment on marine turtles are not well understood. A recent acoustic-tagging study demonstrated that light is an important navigational cue once hatchlings enter the water and the presence of artificial light in the nearshore environment can affect the swimming and orientation behavior of hatchlings by attracting them towards the artificial light source and sometimes triggering circling behavior around the light source (Thums et al. 2016). These alterations in behavior can cause disorientation, increased energy expenditure, and increased vulnerability to predation (Thums et al. 2016). If nesting turtles and hatchlings are disoriented on land and in the nearshore environment, they may also experience similar effects in the offshore environment; however, it is likely that these effects would only occur at the surface in the immediate vicinity of the light source. Based on the definitions for impact intensity presented in Table 7.7-4 above, the intensity of impacts on marine turtles from Project-related lighting in the offshore environment is considered **Low**. Impacts would occur within the **Direct AOI** (PDA) and would be **Continuous** and **Long-term**. This yields a magnitude rating of **Small** for impacts of artificial lighting on marine turtles in the offshore environment (Table 7.7-9).

Table 7.7-9: Magnitude Ratings for Potential Impacts from Artificial Lighting

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
All Project Stages	Impact on nesting turtles and immediate post-dispersal hatchlings from nearshore and coastal artificial lighting	Direct AOI	Negligible	Continuous	Long-term	Negligible
All Project Stages	Impact on turtles in the offshore environment from artificial lighting from vessels and the FPSO	Direct AOI	Low	Continuous	Long-term	Small

Impact Significance— Exposure to Artificial Lighting

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance ratings for potential impacts on marine turtles from exposure to artificial lighting are **Negligible**.

7.7.3.7. Characterization of Impacts—Displacement from Habitat as a Result of Disturbance

Magnitude of Impact—Displacement from Habitat as a Result of Disturbance

During the Project life cycle (at least 20 years), levels of human activity (e.g., vessel traffic, equipment, and materials in the water) will be higher than the low levels that currently exist in the offshore portion of the AOI. Marine turtles are sensitive to anthropogenic activities on and off (i.e., at sea) land, and disturbance in the offshore environment would likely cause some level of avoidance of, and thus displacement from, impacted areas by individual turtles (e.g., McClellan and Read 2009). For example, vessel traffic has been shown to alter marine turtle behavior and displace individuals from areas where vessels are active (McCelland and Read 2009). Typically, affected turtles are displaced short distances and if an affected turtle's home range overlaps with the displacement area, the displaced turtle will usually return a short while later. Little is known about marine turtle avoidance behavior during migrations, but they would be expected to be at similar risk for alteration of course during migration compared with other lifestages. The primary impact from avoidance behavior, particularly when the displacement is confined to a relatively small area such as the PDA, is increased energy expenditure.

Based on available information on marine turtles in the PDA and the surrounding region, low numbers of marine turtles are expected to occur in the PDA and, when they do occur there, they are expected to be transiting through the PDA while en route to preferred habitats. The PDA is not known to contain any habitats that are regularly used by marine turtles during any lifestage. As such, the level of displacement potentially caused by Project activities is expected to be low.

Project activities that could disturb marine turtles transiting the PDA will decrease during the production operations phase, so potential disturbance-related impacts on marine turtles are expected to decrease with time. There will be a small increase in human and vessel activity during decommissioning compared to the production operations phase, but that increase will be of relatively short duration and it will not rise to the same level of activity associated with drilling and installation. Project-related vessel traffic between the shorebases and PDA could cause a limited amount of additional avoidance by turtles passing through the PDA or the marine transit corridor compared with current conditions. However, the transit corridor is a very small fraction of the geographic range of the five marine turtle species occurring in Guyana so temporary displacement of individuals from this area due to vessel or other Project-related disturbance is expected to be inconsequential for the marine turtle populations in the region.

Based on the definitions for impact intensity presented in Table 7.7-4 above, the intensity of impacts on marine turtles from displacement is considered **Negligible**. Impacts would occur within the **Direct AOI** and would be **Continuous** and **Long-term**. This yields a magnitude rating of **Negligible** for impacts of displacement on marine turtles in the offshore environment (Table 7.7-10).

Table 7.7-10: Magnitude Ratings for Potential Impacts from Habitat Displacement

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
All Project Stages	Habitat displacement	Direct AOI	Negligible	Continuous	Long-term	Negligible

Impact Significance—Habitat Displacement

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance rating for potential impact on marine turtles from habitat displacement is **Negligible**.

7.7.4. Mitigation Measures—Marine Turtles

The embedded controls integrated into the Project design and operational procedures constitute the practicable best measures that are available to reduce the significance of potential impacts on marine turtles. Table 7.7-11 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.7-11: List of Embedded Controls and Monitoring Measures

Embedded Controls
When non-aqueous drilling fluid (NADF) is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
Employ trained MMOs during the conduct of seismic-related activities.
Conduct a continuous observation of a mitigation zone (500 meters [1,640 feet] around the sound source) to verify whether it is clear of marine mammals and marine turtles before commencing sound producing seismic operations. Do not commence sound-producing seismic operations (including soft starts) if marine mammals or turtles are sighted within the mitigation zone during the 30 minutes prior to commencing sound-producing operations in water depths less than 200 meters (656 feet), or 60 minutes prior to commencing sound-producing operations in water depths greater than 200 meters (656 feet).
Where practicable, ensure that sound-making devices or equipment are equipped with silencers or mufflers and are enclosed, and/or use soft-start procedures (e.g., for pile driving, vertical seismic profiling, etc.) to reduce noise to levels that do not cause material harm or injury to marine species
Adhere to the JNCC Guidelines (2017) during the conduct of seismic-related activities.
During pile-driving activities, gradually increase the intensity of hammer energy to allow sensitive marine organisms to vacate the area before injury occurs (i.e., soft starts).
Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with International Maritime Organization/International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 milligrams per liter (mg/L) on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C at 100 meters (approximately 328 feet) from discharge point.

Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals
Measure residual chlorine concentration of sewage discharges form the FPSO monthly to ensure it is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to ensure that there are no floating solids or discoloration of the surrounding waters.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' specifications and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Implement a chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
Ensure wastewater released from the onboard sewage treatment plant complies with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.
Ensure there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge.
Treat bilge water in accordance with MARPOL 73/78 to ensure compliance with an oil in water content of less than 15 parts per million as applicable.
Where practicable, direct lighting on FPSO and major Project vessels to required operational areas rather than at the sea surface or skyward. Ensure lighting on vessels adheres to maritime safety regulations/standards.
Monitoring Measures
Monitor on an ongoing basis visual detections of marine turtles.
Prior to and post-drilling, a remotely operated vehicle will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to ensure that end of well maximum weighted mass ratio averaged over all well sections drilled using non-aqueous base fluid shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C at 100 meters (approximately 328 feet) from point of discharge.
Use load monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.

Monitor chlorine concentration of treated sewage discharges.
Perform daily visual inspection of discharge points to ensure absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to ensure compliance with 15 parts per million MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.7-12 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine turtles. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine turtle-specific methodology described in Sections 7.7.3.2 through 7.7.3.7.

Table 7.7-12: Marine Turtles—Pre-Mitigation and Residual Impact Significance Ratings

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling (impulsive sound activities) FPSO/SURF Installation (impulsive sound activities)	Auditory injury from sound exposure	Negligible	High	Negligible	None, other than implementation of embedded controls (e.g., soft-start procedures for VSP and pile driving)	Negligible
All Project stages (non-impulsive sound activities)	Auditory injury from sound exposure	Negligible	High	Negligible	None	Negligible
Development Well Drilling (impulsive sound activities) SURF Installation (impulsive sound activities)	Disturbance from sound exposure	Small	Low	Negligible	None, other than implementation of embedded controls (e.g., soft-start procedures for VSP and pile driving)	Negligible
All Project stages (non-impulsive sound activities) from operating FPSO and marine vessel operations	Disturbance from sound exposure	Negligible	Low	Negligible	None	Negligible

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Exposures to permitted discharges (liquid effluent discharges containing various chemical substances, plus elevated temperature during production operations)	Negligible	High	Negligible	None	Negligible
	Impact on nesting turtles and immediate post-dispersal hatchlings from nearshore and coastal artificial lighting	Negligible	High	Negligible	None	Negligible
	Disturbance to turtles in the offshore environment from artificial lighting from vessels and the FPSO	Small	Low	Negligible	None	Negligible
	Habitat displacement as a result of avoidance behavior	Negligible	High	Negligible	None	Negligible

7.8. MARINE FISH

7.8.1. Administrative Framework—Marine Fish

Table 7.8-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on marine fish.

Table 7.8-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Marine Fish

Title	Objective	Relevance to the Project
Legislation		
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Regulations, 2013 (recently supplemented by passing of Wildlife Conservation and Management Act, 2016)	Provides for the establishment of a Management Authority and the management of the country's flora and fauna. Provides for classification of some species as vulnerable, endangered, or critically endangered; 2016 act specifies that the act applies to all species in CITES Appendices I, II and III unless otherwise reserved by Guyana.	Provides a supportive mechanism to achieve the national goals for wildlife protection, conservation, management, and sustainable use.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.

7.8.2. Existing Conditions—Marine Fish

Guyana's marine fish community inhabits a large and ecologically diverse marine area, from shallow, turbid, coastal waters to the deep, clear, open ocean. The life cycles of many of the fish species present in the community exemplify the ecological connectivity among the mangroves, estuaries, and offshore zones, because many fish species are dependent on different habitats at specific life stages or occur in more than one habitat type. Several species that occur in the inshore and offshore zones as adults are dependent on coastal mangroves and estuaries as juveniles, particularly drums, croakers, marine catfishes, and snappers. Catfishes occur in the mangroves, estuaries, and oceanic waters as adults. Some other species, including snooks and tarpon, may occur occasionally in the ocean, but are specifically adapted to completing their entire life cycles in mangrove-lined estuaries (MOA 2013). Further offshore, near the interface of the turbid North Brazil Current with oceanic water, the fish community is more complex, consisting of pelagic, highly migratory species such as tunas, jacks, and mackerels in the upper water column and a diverse groundfish community, including snappers and groupers, in the demersal zone (lowest section of the water column, near the seafloor) (MOA 2013). Sharks are found across the continental shelf.

Prior to 2015, much of the available information about marine fishes offshore Guyana was known from studies of commercial landings, or inferred studies of similar locales. Beginning in 2015, EEPGL commissioned a program of collecting incidental observations of marine fish from PSOs engaged in marine mammal-focused surveys offshore Guyana. EEPGL subsequently commissioned a series of surveys targeted at fish in the Stabroek Block and in the area between the Stabroek Block and the Guyana coast from 2017 to 2019. These surveys were conducted in separate zones within this area by teams of international and Guyanese fish experts, as follows:

- Stabroek Block: October 2017 and April 2018;
- Continental Shelf: September–October 2017, April 2018, and December 2018;
- Nearshore Zone: September–October 2017, April 2018, January 2019;
- Estuarine Zone: April 2018 and January 2019.

The targeted fish surveys covered the following zones using the techniques listed below:

- Southern Stabroek Block, using deepwater traps and pelagic longlines;
- Continental shelf, using trawls and longlines;
- Nearshore habitats, using seine nets and cast nets; and
- Estuaries, using electrofishing equipment.

An ichthyoplankton component was added in December 2018 to assess diversity and distribution of early life stages of marine fish. This component was carried out concurrently with the other sampling efforts in the four zones identified above. The results of these targeted fish surveys are presented in ERM 2018 for surveys conducted from September 2017 to April 2018 and in Appendix N, Nearshore and Offshore Fisheries Study Summary Report—Dry Season 2018-2019, for surveys conducted in December 2018 and January 2019.

7.8.2.1. Target Surveys of Deepwater and Offshore Pelagic Fish Community

The discussion of deepwater and offshore pelagic fish community data is derived from sampling conducted in the Stabroek Block (i.e., October 2017 and April 2018). Compared to the shallower environments, Guyana's deepwater environment appears to be lacking in numbers or variety of species. The deepwater and offshore pelagic fish surveys sampled pelagic fish and demersal fish at several locations on the continental slope (Figure 7.8-1). Demersal fish were sampled between depths of 800 and 1,500 meters (approximately 2,600 and 4,900 feet). These samples documented three deepwater species: Robinson's hagfish (*Myxine c.f. robinsorum*), sharp-tailed eel (*Coloconger meadi*), and lanternfish (Myctophidae) (ERM 2018). According to Guyana's Centre for the Study of Biodiversity, Robinson's hagfish and sharp-tailed eel were both new species records for Guyana at the time. Robinson's hagfish was the most abundant of the deepwater fishes caught in the study, accounting for over 90 percent of the total catch.

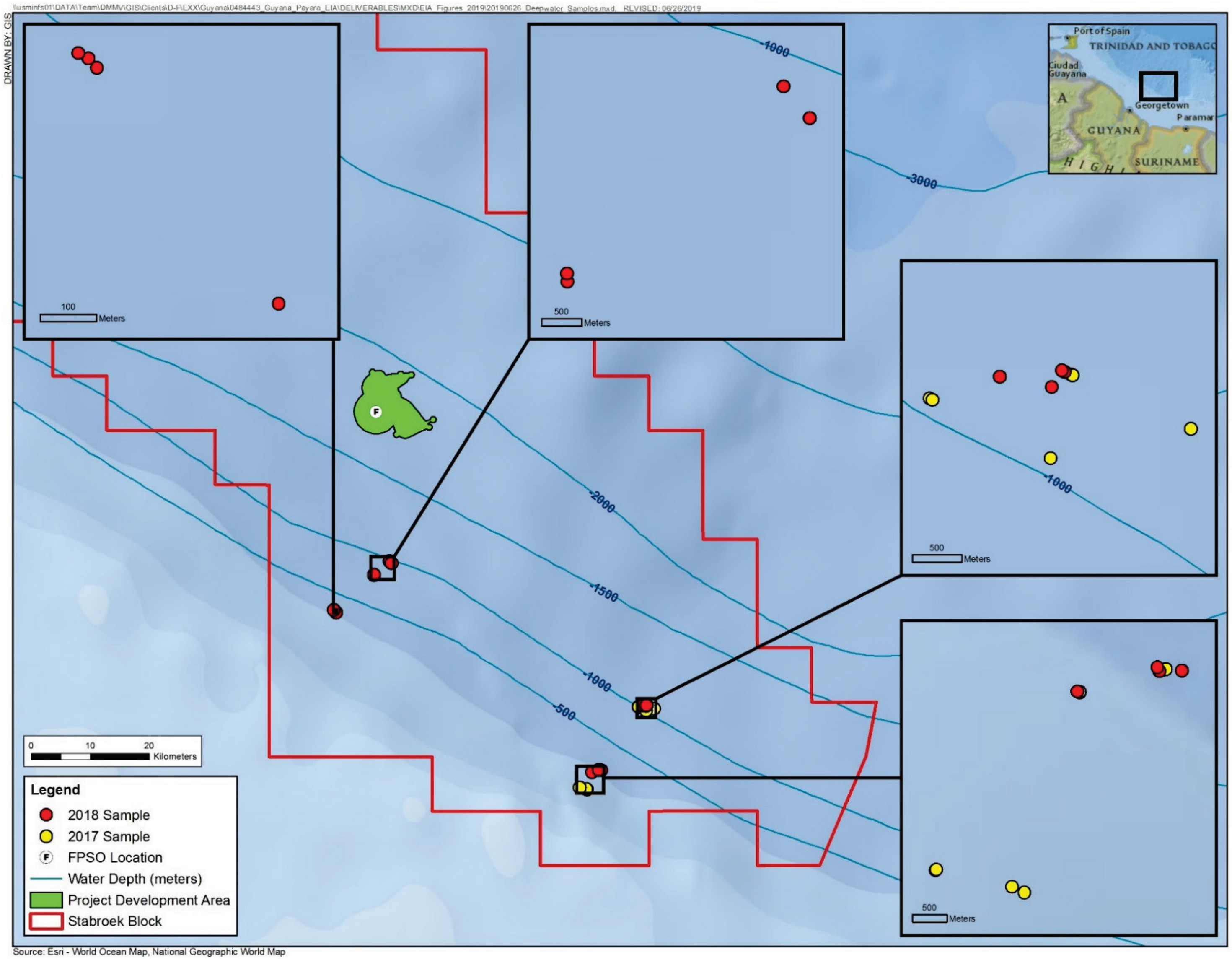


Figure 7.8-1: Locations of Deepwater and Offshore Pelagic Fish Sampling Stations in Stabroek Block (2017–2018)

Robinson's hagfish was most common near the 1,000-meter (approximately 3,300-foot) isobath. No fish were captured deeper than 1,000 meters (approximately 3,300 feet). These are the only species of demersal fishes to have been captured and positively identified from the Stabroek Block to date, although other taxa have been incidentally documented from deepwater images taken during various non-fish targeted surveys, which include:

- A study of deepwater habitats using remotely operated vehicles (ROVs) and drop cameras produced images of putative grenadiers (Macrouridae), skates/rays, and tripodfish (*Bathypterois* sp.) within the Stabroek Block, although none were identifiable to species (ERM 2018); and
- In 2019, Fugro published an investigation of anomalous so-called *hard seafloor features* (HSFs) within and near the vicinity of the Payara Subsea PDA (Appendix H, Hard Seafloor Feature Report). This study captured a photo of an eelpout that was provisionally identified as possibly a member of the genus *Lycodonus*.

Population studies for fish in deep sea environments (demersal) are scarce. The low productivity of deep sea environments compared to more shallow water environments is thought to limit reproductive potential of deepwater organisms in general, so the low numbers of fish in the demersal samples are expected.

Pelagic sampling of the top 50 meters (approximately 164 feet) of the water column within the Stabroek Block has documented only one species of fish, dolphinfish (*Coryphaena hippurus*) to date, although other oceanic/pelagic species that are known from Guyana's continental shelf, including bigeye scad (*Selar crumenophthalmus*), king mackerel (*Scomberomorus cavalla*), and various species of sharks (*Carcharinus* spp.), could also occur in the pelagic zone of the block. Smalleye smoothhound (*Mustelus higmani*) is known to occur as deep as the southern edge of the Stabroek Block, and southern red snapper (*Lutjanus purpureus*) support a small, targeted, deepwater trap fishery that reportedly extends to the edge of the continental shelf. All of these species were captured at the outer-continental shelf stations during the fish study and should be considered as possibly occurring in the PDA.

In the summer of 2011, several islands in the eastern Caribbean (e.g., Anguilla, Antigua and Barbuda, Barbados, British Virgin Islands, Guadeloupe, Martinique, St. Lucia, St. Maarten/ St. Martin) experienced large amounts of sargassum washing ashore. In 2012 and 2014, Barbados, Guadeloupe, Dominica, Antigua and Barbuda, St. Croix, and Puerto Rico reported "moderate" amounts of sargassum coming ashore. The sargassum consisted of two species: common gulfweed (*Sargassum natans*) and broad-toothed gulfweed (*Sargassum fluitans*) (CRFM undated). Similar episodes were reported across the Caribbean region again in 2018. A large amount of sargassum was also documented in the Stabroek Block in 2015. Subsequent analysis of satellite imagery revealed that although sargassum densities were unusually high offshore Guyana in 2015, sargassum concentrations fluctuate annually and have a seasonal peak between April and September (Palandro 2016).

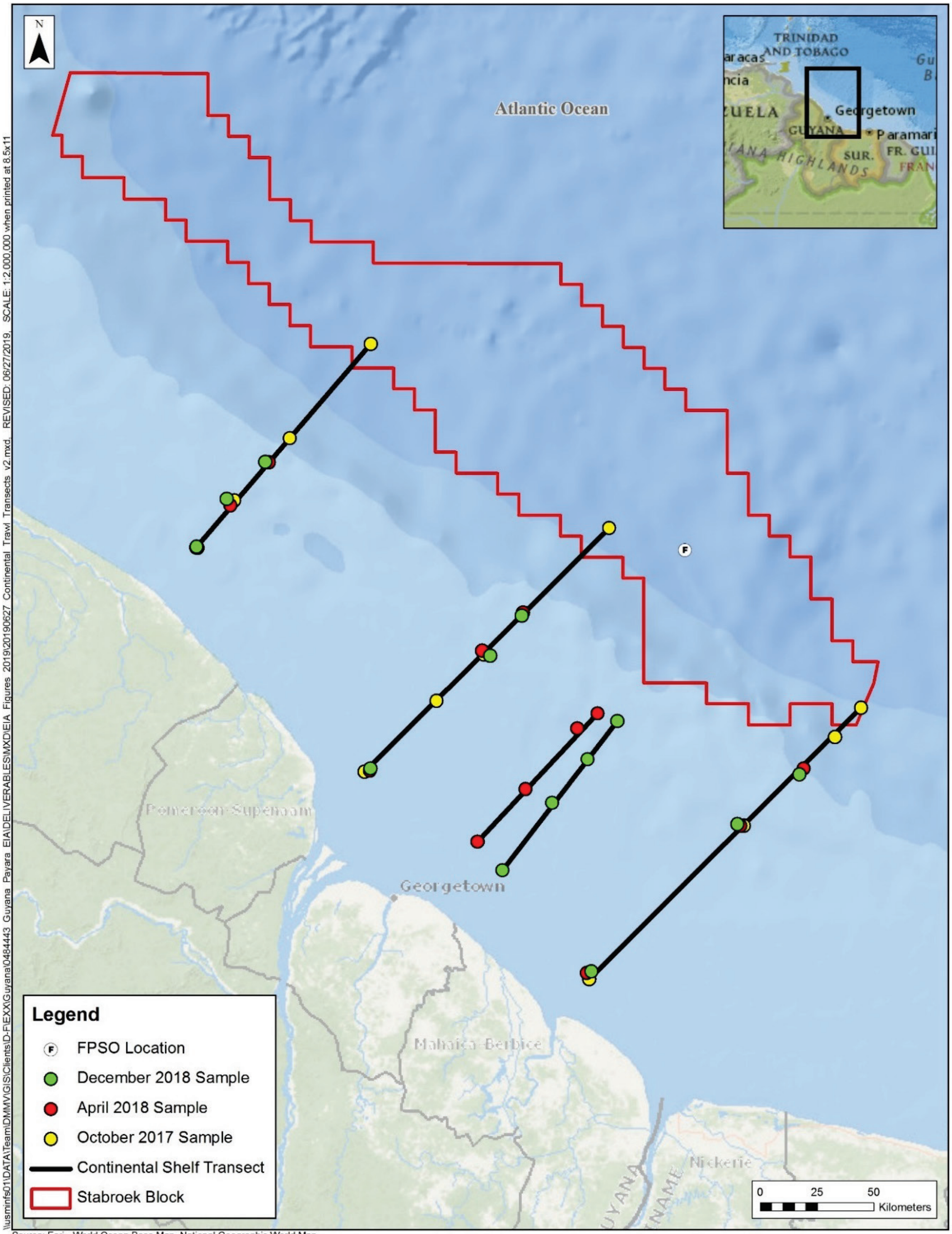
The presence of such large amounts of sargassum is significant from a fish biodiversity perspective, because sargassum has several important ecological roles related to marine fishes, including:

- Concentrating forage fish that are preyed upon by large pelagic fishes, including juvenile swordfish (*Xiphiaa gladius*), dolphinfish, filefishes, jacks, flying fishes (Exocoetidae), triggerfishes, and various tunas;
- Spawning habitat for flying fish; and
- Habitat for unique fishes and other organisms that spend most or all of their lives in floating mats of sargassum, including the sargassum fish (*Histrio histrio*).

7.8.2.2. Targeted Surveys of Continental Shelf Fish Community

The discussion of continental shelf fish community data is derived from sampling conducted across the continental shelf (i.e., September–October 2017, April 2018, and December 2018) as well as historical data (see discussion of the Lowe-McConnell (1962) study below) and incidental observations (see Section 7.8.2.3). The stations sampled as part of the 2017–2018 continental shelf survey events (Figure 7.8-2) were located in water from 11 to 2,340 meters (approximately 36 to 7,700 feet), although most sites were less than 100 meters (approximately 328 feet) deep. The continental shelf sampling also included demersal sampling in depths from 10 to 85 meters (approximately 33 to 280 feet). The continental shelf was the most diverse environment sampled during this assessment (compared to nearshore and deepwater environments), accounting for 109 fish species (Appendix N, Nearshore and Offshore Fisheries Study Summary Report—Dry Season 2018-2019). In the first two sampling seasons, the largest catch in biomass (39.9 percent) was obtained along the northwesternmost continental shelf transect, which is located offshore of the SBPA in Region 1. In December 2018, the two southeasternmost transects accounted for the highest biomass (31 percent for each transect).

The most complete historical data on marine fish in Guyana's territorial waters come from a 2-year trawl survey in 1958 and 1959. The survey consisted of 35 cruises lasting 4 to 11 days each, and included data from 1,070 stations comprising 2,246 fishing hours (Lowe-McConnell 1962). The study documented the presence of 213 species of fish, comprised primarily of drums, croakers, catfishes, jacks, grunts, and snappers. In general, this study described catfishes, jacks, and grunts as dominating the nearshore zone, and snappers and various other demersal species, including some that are typical of clearwater tropical reef systems, as more abundant at deeper sites further offshore. The results of the continental shelf survey are largely consistent with these findings. In 2017 and 2018, the sea catfishes, including gillbacker catfish (*Sciades parkeri*), curass (*Sciades proops*), highwaterman catfish (*Hypophthalmus edentatus*), and several croakers/seatrouts, including bangamary (*Macrodon ancylodon*), white bashaw (*Cynoscion acoupa*), and sea trout (*Cynoscion virescens*), were all prevalent at depths of 10 to 15 meters (approximately 33 to 49 feet) (Figure 7.8-3). The snappers and grunts, represented chiefly by banded grunt (*Conodon nobilis*), Caesar grunt (*Haemulon carbonarium*), mutton snapper (*Lutjanus analis*), lane snapper (*Lutjanus synagris*), and southern red snapper (Figure 7.8-3) occurred deeper, primarily between 45 and 60 meters (approximately 148 to 197 feet), although they likely extend deeper based on their known depth ranges elsewhere.



\\usmnfs01\DATA\Team\DMMV\GIS\Clients\D-F\EXX\Guyana\0484443 Guyana Payara EIA\DELIVERABLES\MXD\EIA Figures 2019\20190627 Continental Trawl Transects v2.mxd. REVISED: 06/27/2019. SCALE: 1:2,000,000 when printed at 8.5x11

Source: Esri - World Ocean Base Map, National Geographic World Map

Figure 7.8-2: Location of Continental Shelf Fish Sampling Stations (2017–2018)

		
highwaterman catfish (*Hypophthalmus edentatus*)	**gillbacker catfish (*Sciades parkeri*)**	**lane snapper (*Lutjanus synagris*)**
		
curass (*Sciades proops*)	**bangamary (*Macrodon ancylodon*)**	**mutton snapper (*Lutjanus analis*)**
		
sea trout (*Cynoscion virescens*)	**southern red snapper (*Lutjanus purpureus*)**	**luna lionfish (*Pterois lunulata*)**

Figure 7.8-3: Characteristic Fishes from Guyana's Continental Shelf

Based on comparisons with species lists from nearby countries, Lowe-McConnell determined that about 50 percent of Guyana's marine fish species were widely distributed coastal species, about 10 percent were clear-water associated species more typical of the Caribbean Islands, about 5 percent were more southerly species typical of the Brazilian coast, and the balance were habitat generalists with no defined regional habitat associations. Lowe-McConnell also noted that the North Atlantic Continental Shelf is continuous from the Gulf of Mexico to Brazil and that there were no major barriers to migration through this area, so Guyana's marine fish community would be expected to have many species in common with other countries in the region. This finding is consistent with the findings of the targeted continental shelf fish surveys in 2017 and 2018, and likely explains the presence of so many widespread species in the dataset.

Lowe-McConnell's study and the demersal component of the 2017–2018 continental shelf fish surveys both documented several species of typically reef-associated fish, although some notable differences between the two studies suggest the clear-water fish community on the outer continental shelf has undergone significant changes in the last half century. Lowe-McConnell's paper on Guyana's fishery resources noted the presence of coral fragments in trawl samples, but described those coral fragments as dead; no living corals were mentioned. As described in Section 7.9.2, Existing Conditions—Marine Benthos, the 2017–2018 continental shelf fish surveys documented the presence of living hard corals (*Madrepora oculata* and *Solenosmilia variabilis*) at depths of 40 to 90 meters (approximately 131 to 295 feet) on three of the four continental shelf transects (Figure 7.8-2). Lowe-McConnell noted the presence of some typically reef-associated fishes in her samples, including butterflyfishes, angelfishes, wrasses, and parrotfishes (Lowe-McConnell 1962). The study also documented a few reef-associated species, including ocellated moray (*Gymnothorax ocellatus*), French angelfish (*Pomacanthus paru*), and spotfin butterflyfish (*Chaetodon ocellatus*), in the same depth ranges as the living corals, but no parrotfishes or wrasses. Although it is unlikely that significant recovery of Guyana's hard corals has occurred since the time of Lowe-McConnell's study, given the intensity of the trawling activity on the continental shelf, the 2017–2018 study clearly shows that living hard corals do persist on Guyana's continental shelf and that coral-associated fishes occur in these habitats.

The study also documented the exotic luna lionfish (*Pterois lunulata*) and red lionfish (*Pterois volitans*) in the same depth range as the corals and reef-associate native species. The presence of invasive lionfish in the tropical Western Atlantic Ocean and Caribbean Sea has been a topic of conservation concern for more than three decades since they first appeared in southern Florida (FWC 2018) and began threatening native fishes and commercial ground-fisheries (NOAA 2017). The presence of luna lionfish and red lionfish offshore Guyana and the apparently coincident decline of coral-associated fishes offshore may indicate that the invasion is having an effect on Guyana's native fishes. A time series of the expansion of lionfish throughout the Western Atlantic region provided by the U.S. Geological Survey suggested that as of 2017, lionfish had not been found in Guyana, despite having been found in neighboring Tobago and Venezuela (USGS 2018); however, these data are subject to revision, so it is unclear whether the presence of lionfish in the fish study samples represents a novel invasion. Regardless of when the lionfish first arrived in Guyana, luna lionfish were captured again in the December 2018 continental shelf survey, so their presence appears to be persistent.

Pelagic sampling of the continental shelf during the 2017–2018 fish study also documented the importance of the continental shelf as a nursery area for sharks (Figure 7.8-4). Spinner shark (*Carcharinus brevipinna*) comprised a significant component of the longline samples during the wet and dry seasons. Spinner sharks accounted for nearly 20 percent of the total abundance in the 2017 longline samples from the continental shelf, second only to the spearfish remora (*Remora brachyptera)*, which are often associated with sharks and other large pelagic marine animals. No spinner sharks were positively identified in the 2018 samples, but juvenile *Carcharinus* that were too small to identify comprised 50 percent of the total longline catch on the continental shelf in 2018, possibly indicating a seasonal component to the value of the area as nursery habitat for the species. Although the sharks in the study were identified in the field as spinner sharks, field identification of *Carcharinus* species (especially of immature specimens) can be very difficult. A recent genetic study of sharks in Guyanese fish markets did not document spinner sharks, but did identify the very similar smalltail shark (*C. porous)* and blacktip shark (*C. limbatus)*, which together comprised over 25 percent all samples in the study (Kolman et al. 2017); accordingly, the identification of the sharks in the 2017–2018 fish study should be viewed as provisional. Regardless of the species, the presence of large numbers of immature *Carcharinus* sharks is significant both in terms of the ecology of the area—as sharks are apex predators on the continental shelf—and in terms of fishery management. Sharks are a target species for the demersal longline (locally referred to as caddell lines) fishery, and shark stocks are well-known to be highly sensitive to fishing pressure due to their low reproductive success rates and long generation times. There are no official management plans or quotas in place for the Guyanese shark fishery, so the fishery may be susceptible to over-exploitation, particularly if large numbers of juveniles are being removed from the population before having the opportunity to reproduce.

Figure 7.8-4: Juvenile *Carcharinus* Sharks from Guyana's Continental Shelf, March 2018

7.8.2.3. Additional Surveys of Deepwater and Offshore Pelagic Fish and Continental Shelf Fish Communities

Additional information on pelagic species within the PDA is available from visual observations made during EEPGL-commissioned PSO activities in the southeastern half of the Stabroek Block and surrounding offshore and continental shelf region since 2015 (Figure 7.8-5). From these opportunistic observations made since 2015, a total of 31 fish taxa were assessed to be present in the Stabroek Block at least on an occasional basis (Table 7.8-2).

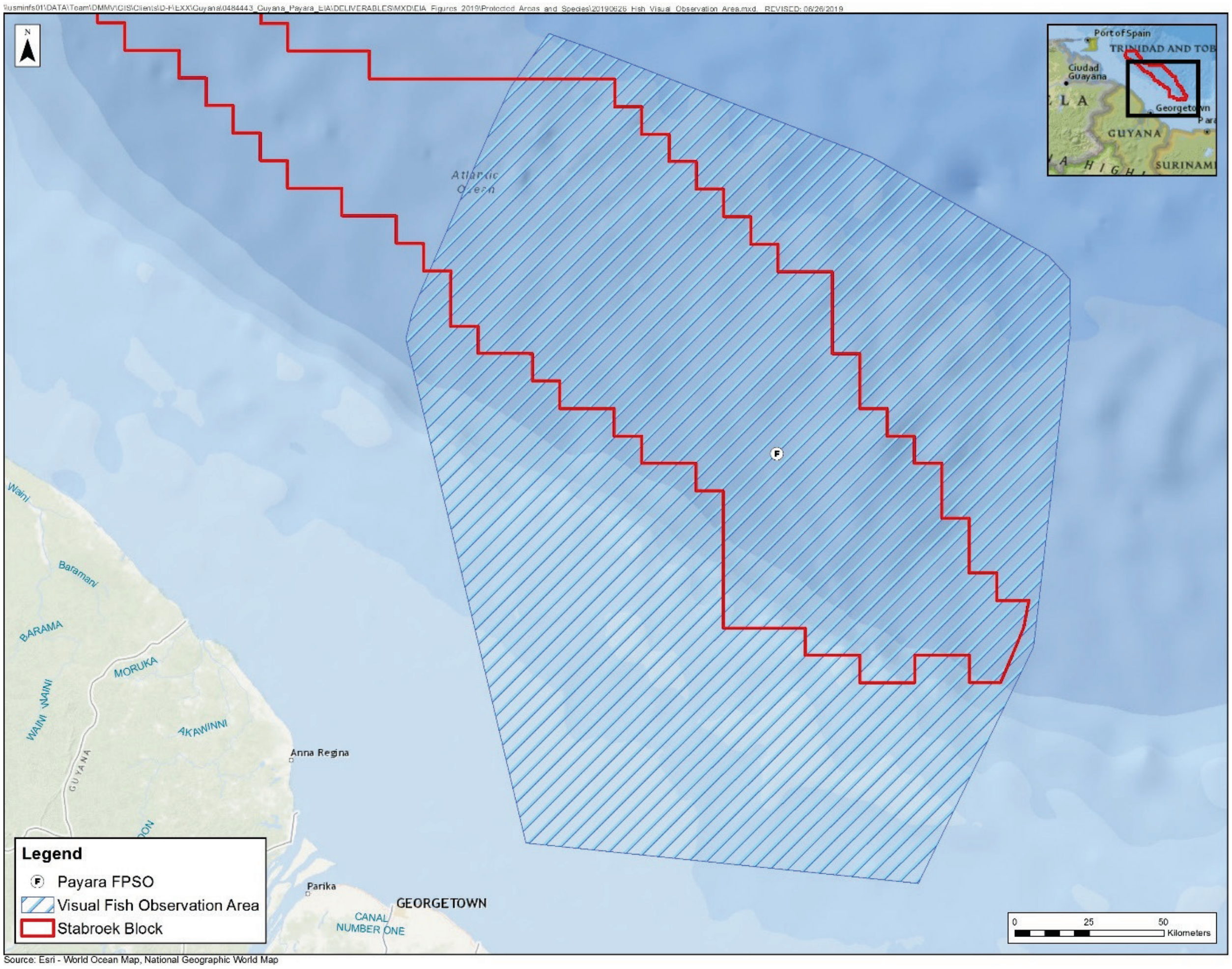


Figure 7.8-5: Approximate Area of Visual Fish Observations from EEPGL-Commissioned PSO Surveys since 2015

Table 7.8-2: Fish Species Observed in the Stabroek Block and between the Stabroek Block and the Guyana Shore during EEPGL-Commissioned PSO Activities Since 2015

Common Name	**Scientific Name**	**IUCN Status [a]**
Atlantic bonito	*Sarda sarda*	LC
Atlantic flying fish	*Chellopogon melanurus*	LC
Atlantic tripletail	*Lobotes surinamensis*	LC
bar jack	*Caranx ruber*	LC
blackfin tuna	*Thunnus atlanticus*	LC
blackwing flying fish	*Hirundichthys rondeletii*	LC
blue marlin	*Makaira nigricans*	VU
clearwing flying fish	*Cypselurus comatus*	LC
eelpout	*Lycodonus* sp.	—
four-wing flying fish	*Hirundichthys affinis*	LC
jack crevalle	*Caranx hippos*	LC
king mackerel	*Scomberomorus cavalla*	LC

Common Name	Scientific Name	IUCN Status [a]
largehead hairtail	*Trichiurus lepturus*	LC
little tunny	*Euthynnus alletteratus*	LC
dolphinfish/mahi-mahi	*Coryphaena hippurus*	LC
manta ray	*Mobula* sp.	—
margined flying fish	*Cheilopogon cyanopterus*	LC
ocean sunfish	*Mola mola*	VU
planehead filefish	*Stephanolepis hispidus*	LC
porcupinefish	*Diodon hystrix*	LC
rainbow runner	*Elagatis bipinnulata*	LC
sailfish	*Istiophrous albicans*	LC
skipjack tuna	*Katsuwonus pelamis*	LC
smalleye smoothhound	*Mustelus higmani*	LC
southern red snapper	*Lutjanus purpureus*	—
swordfish	*Xiphiaa gladius*	LC
unidentified grenadiers	Macrouridae	—
unidentified skates and rays	Rajiformes	—
tiger shark	*Galeocerdo cuvier*	NT
tripodfish	*Bathypterois* sp.	DD-LC
yellowfin tuna	*Thunnus albacares*	NT

DD-LC = Data Deficient-Least Concern; LC = Lease Concern; NT = Near Threatened; VU = Vulnerable
[a] IUCN status is given as "—" for multi-species groups or taxa for which a species-specific identification could not be made.

7.8.2.4. Nearshore and Estuarine Fish Community

The discussion of nearshore and estuarine fish community data is derived from sampling conducted across all of the nearshore and estuarine sampling dates identified above (i.e., September–October 2017, April 2018, and January 2019). These nearshore and estuarine surveys (Figures 7.8-6 and 7.8-7, respectively) sampled coastal fish communities in Regions 1 through 5. The nearshore fish community was the second-most diverse environment sampled during this assessment (compared to deepwater and continental shelf environments), accounting for 79 fish species. The estuarine fish community accounted for 20 species sampled at five estuarine stations.

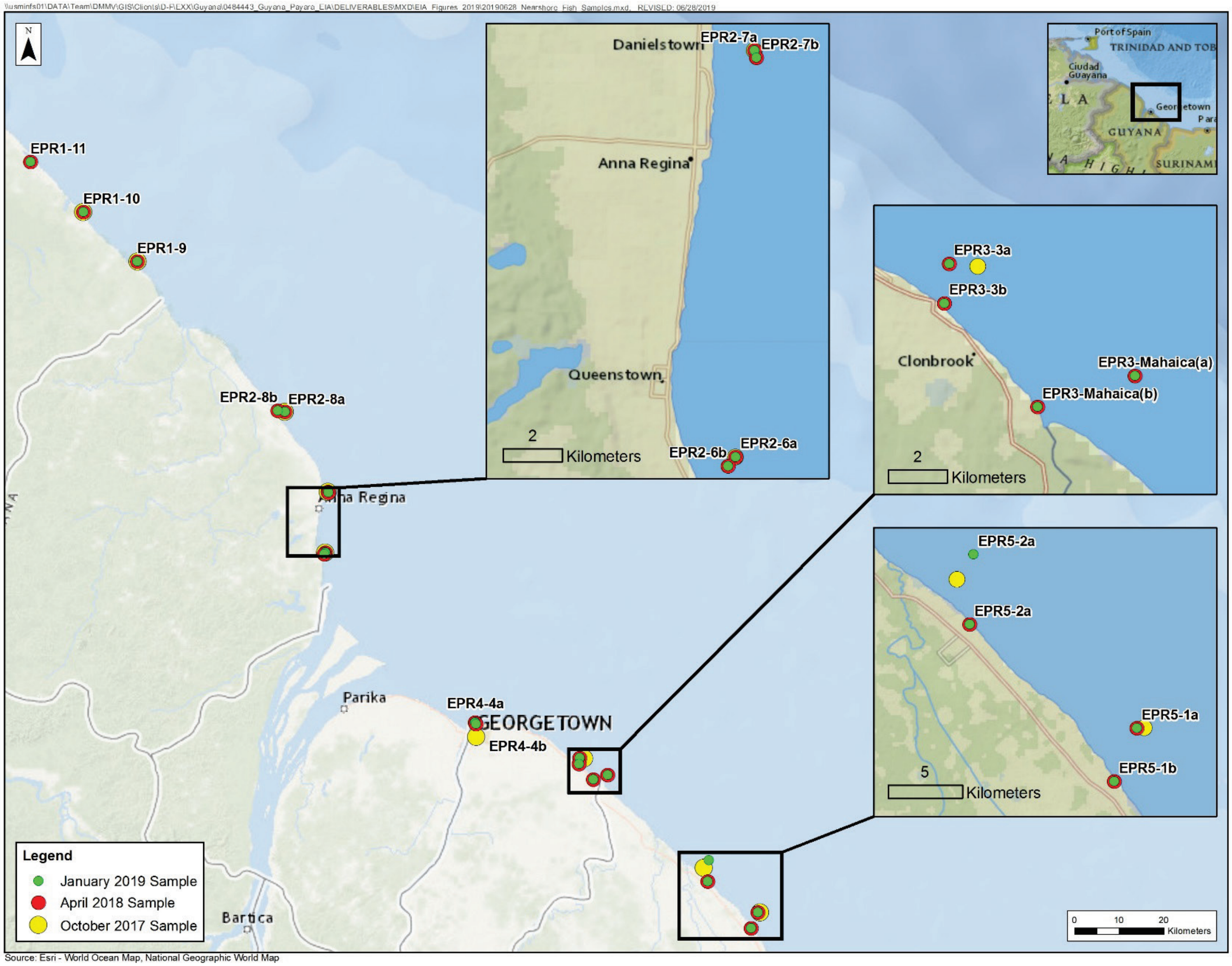


Figure 7.8-6: Nearshore Fish Sampling Stations (2017–2019)

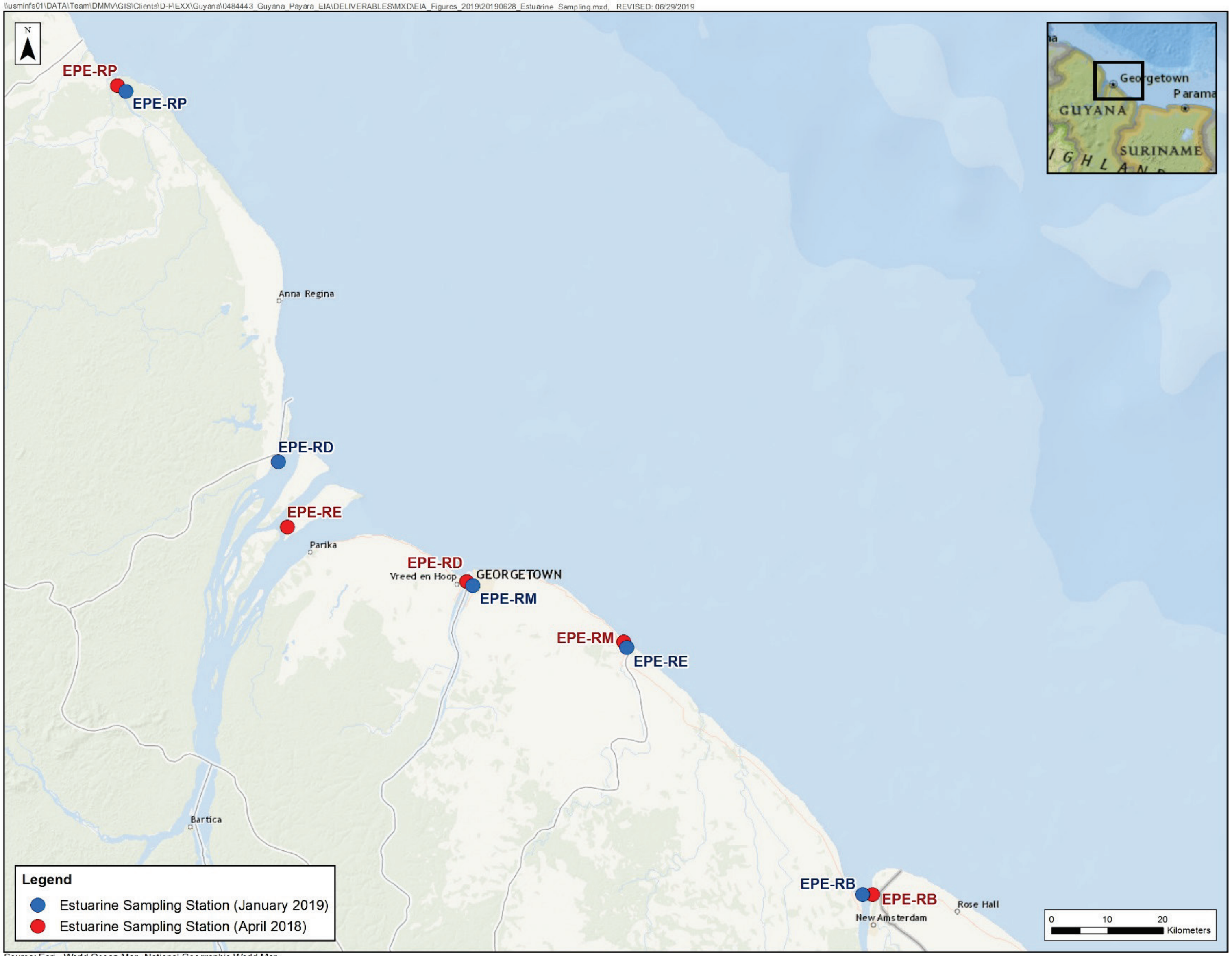


Figure 7.8-7: Estuarine Fish Sampling Stations (2017–2019)

Based on the nearshore and estuarine data from the 2017 and 2018 sampling events (the only year for which wet and dry season data are available), the composition of the nearshore fish community is strongly influenced by seasonal fluctuations in freshwater input. Twenty-five species were captured during the dry season in 2017, and the two most common species (bangamary and highwaterman catfish) were also common on the inner continental shelf during this period, underscoring the importance of marine influence during periods of low riverine discharge. The nearshore community shifts to a more freshwater/brackish community in the wet season; in fact, eight of the nine species captured in the 2018 wet season estuarine surveys also appeared in the wet season nearshore dataset. Most of the species captured in the nearshore zone during the wet season (April 2018) were anadromous or euryhaline species. The 2019 nearshore fish survey data are discussed below.

The nearshore and estuarine surveys in early 2019 were conducted during a transition period between wet and dry periods, and yielded 46 species and 13 species, respectively—the most species of any of the nearshore or estuarine surveys to date. The January 2019 nearshore data included 29 species (54 percent of all species collected in that survey) that had not been collected at the nearshore stations in 2017 or 2018. Seven of these species were anchovies in the genera *Anchovia*, *Anchoviella*, *Lycengraulis*, and *Pseudenbatos*. Despite belonging to the same family (Engraulidae), sharing many superficial anatomical similarities, and occupying similar trophic positions in the foodweb, this group exhibits a wide range of habitat requirements and life histories. Some (e.g., Bates' sabretooth anchovy [*Lycengraulis batesii*]) have a predominantly freshwater distribution. Others (e.g., Zabaleta anchovy [*Anchovia Clupeoides*]) have a predominantly coastal marine distribution, but are found in estuaries as well. Their simultaneous presence suggests that conditions in the nearshore zone in January 2019 were temporarily supportive of species from both the wet-season and dry-season communities at the limits of their respective ranges.

There is another subset of species that has occurred in the nearshore zone in all three survey seasons (2017, 2018, and 2019), and on that basis can be considered more or less permanent residents of the nearshore marine environment. Nine species appeared in the nearshore samples in all three seasons, and the most prominent members of this group (accounting for five of the nine species) are the catfishes and drums/croakers (Ictaluridae and Scianidae, respectively). All of these species are demersal or at least generally bottom-oriented, but unlike many of the offshore demersal species, none are known to have a particular affinity for hard bottom or reef-like habitat. Six of these nine species have been found previously in either the continental shelf or the estuary samples as well, so most of these species likely move freely along the coast and into the estuaries as conditions and life histories require.

Another noteworthy aspect of the estuarine surveys was the prevalence of leptocephalus[29] larvae in the samples. The larvae were not identified to species, but they comprised more than 30 percent of the entire catch across the five estuarine stations and were the most common species in the wet season (April) estuarine dataset in 2018. Tarpon and ladyfish are both

[29] A leptocephalus is a slim, transparent larval form of eels and other more distantly related species including tarpon (*Megalops atlanticus*), known as "cuffum" in Guyana, and ladyfish (*Elops saurus*), known as "silverfish" in Guyana.

nearshore marine/estuarine species, but the leptocephali could also have been the larvae of a marine eel, such as a moray. Regardless of the species, their ubiquity and abundance in the estuarine stations underscores the importance of the estuaries as fish nursery habitats.

7.8.2.1. Ichthyoplankton Community

The ichthyoplankton community was sampled across 17 stations distributed across all four zones (deepwater, continental shelf, nearshore, and estuarine) in December 2018–January 2019 (Figure 7.8-8). A total of 8,107 marine organisms representing 152 taxa (including unidentified eggs) were identified in the samples. Overall, 13 taxa (including unidentified eggs as a "taxon") accounted for 90 percent of the catch. Sixty-one percent (n = 4,967) of the catch consisted of anchovies and drums/croakers. Some marine organisms representing these families were unable to be identified to lower taxa, and the other taxa in the samples were identified to genus or species but not specifically grouped by family. As such, these two families likely represented a larger portion of the catch.

In terms of the species able to be identified to a specific species, broadband anchovy (*Anchoviella lepidentostole*), red-eye round herring (*Etrumeus teres*), and white bashaw were the most abundant taxa, representing around 9 percent of the catch. Taxa with a strictly marine distribution represented 15 percent of the overall taxa in the samples, and represented a slightly higher percentage of the species in the nearshore samples than in the continental shelf and deepwater samples. Most of the marine organisms were collected at one nearshore station (ECP-R3-A). Despite the greater number of marine organisms collected at nearshore stations, the mean number of taxa collected at offshore stations (26.8 taxa) was higher than the mean number of taxa collected at nearshore stations (10 taxa).

The distribution of marine organisms varied by the total number collected per sampling station, and also differed by the particular life-stage collected and the particular life-stage that was most abundant at a particular sampling station. The most abundant life-stage identified was yolk-sac larvae (n = 3,943 or 43 percent) followed by post-yolk-sac larvae (n = 2,479 or 30.5 percent) and eggs (n = 1,515 or 18.7 percent). The least abundant lifestages were juvenile (n = 132 or 1.6 percent), leptocephalus (n = 37 or 0.45 percent), and adult (n = 1 or 0.01 percent). Sampling station ECP-R3-A was dominated by the yolk-sac larvae stage, while sampling stations EOP-R4-B and EOP-R4-E were dominated by post-yolk-sac larvae and egg, and egg and post-yolk-sac larvae lifestages, respectively. The most abundant individual life-stage differed among the primary taxa. For instance, the yolk-sac larvae stage was the most common life-stage for Engraulidae and the post-yolk-sac life-stage was the most common life-stage for Sciaenidae. The most common lifestages for broadband anchovy were the post-yolk-sac and juvenile lifestages. For red-eye round herring and acoupa weakfish, the most common lifestages were post-yolk-sac. The most common lifestages in the nearshore stations were the yolk-sac larvae followed by the post-yolk-sac larvae and juveniles.

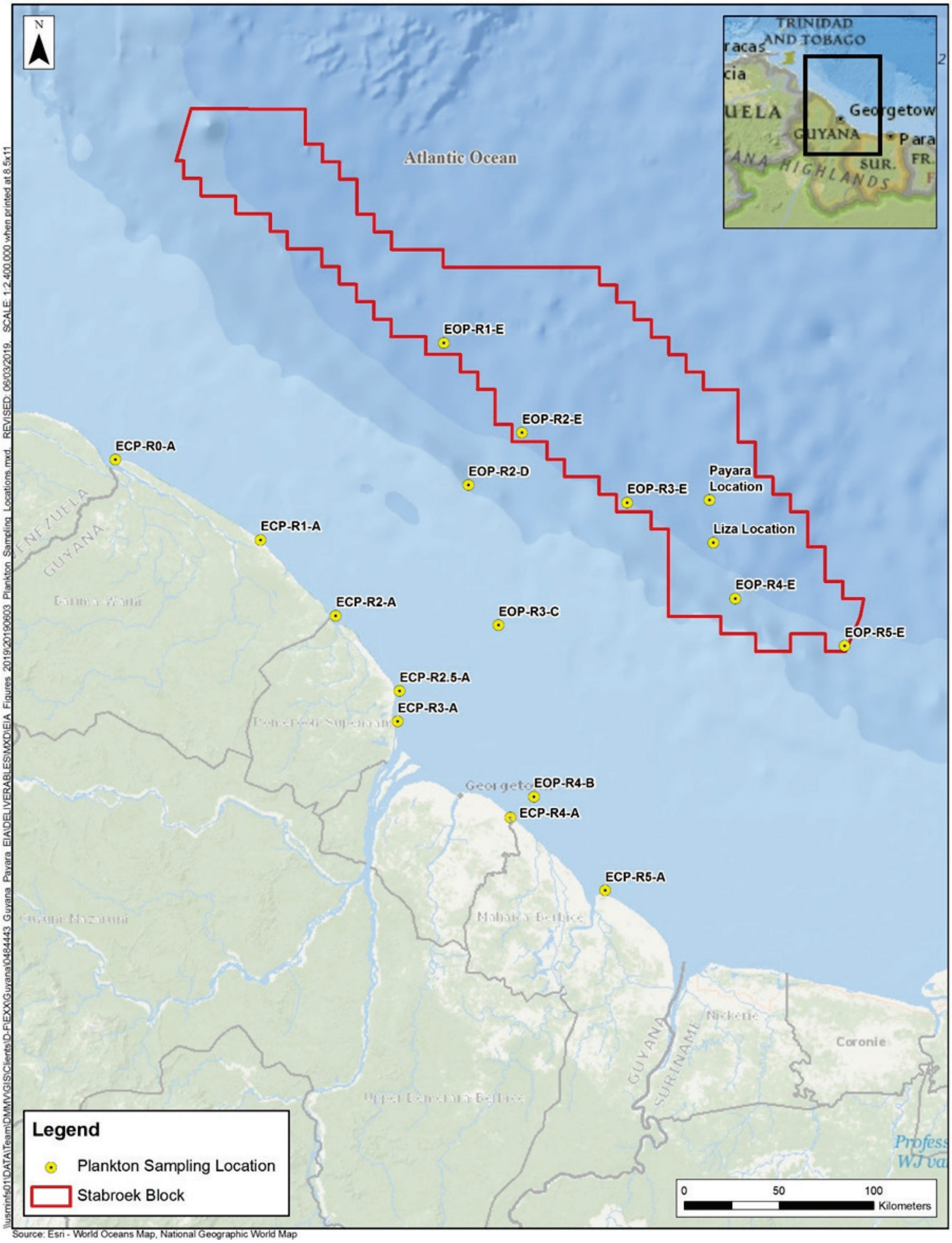


Figure 7.8-8: Ichthyoplankton Sampling Locations (2018–2019)

At the offshore stations, the most common lifestages were post-yolk-sac larvae, egg, and leptocephalus. The relative abundance of leptocephali in the offshore samples in the December 2018–January 2019 events (transitional between wet and dry seasons), coupled with the apparent seasonal increase in leptocephali in the estuaries during the wet season (as observed in April 2018) may suggest that these are marine species that are spawned offshore and move toward the coast as early-stage larvae to complete their development in inshore waters—a life cycle strategy that is employed by eels in the Anguilla genus in the north temperate Atlantic region.

Based on the preliminary findings, the data suggest that the Guyana nearshore and offshore waters are diverse in terms of species richness (n = 151 taxa; excluding eggs, since they can be classified under a number of taxa), but the catch distribution is skewed toward a limited number of stations and taxa, suggesting a patchy spatial distribution and a low number of abundant taxa. Overall, the preliminary findings suggest the waters off Guyana are more diverse (number of taxa) and abundant (nominal counts) than other nearby regions within the American continent. However, the low number of abundant species was similar to that of other nearby regions.

Ichthyoplankton sampling of the nearshore and continental shelf suggest the waters off Guyana provide habitat for the early lifestages of a variety of taxa. As expected, taxa and lifestages are more abundant in particular locations and times. Moreover, the preliminary findings suggest the species composition and relative abundance (nominal counts) of ichthyoplankton off Guyana is similar to that of nearby regions, such as Brazil, indicating this region is as important as others for providing habitat for both nearshore and offshore species.

7.8.3. Impact Assessment—Marine Fish

This section addresses the potential impacts of planned Project activities on marine fish. Key potential impacts on marine fish assessed include changes in the distribution of fish due to altered water quality; auditory impacts on fish from vessel activity, VSP activities, and pile driving; localized changes in distribution and habitat usage due to altered bottom habitats and the presence of Project infrastructure; attraction to artificial light; and entrainment in water intakes.

Although marine fish are grouped as a single receptor in this EIA, the term “marine fish” encompasses several groups including pelagic species, demersal species, resident species, and migratory species. Each of these groups will have a unique set of sensitivities and exposures to different Project-related impacts depending on their differing habitat requirements and life histories. For example, surface-dwelling pelagic fish will have a greater potential to experience water quality changes related to planned discharges as compared to bottom-dwelling species, and bottom-dwelling species will have a greater potential to experience changes in physical habitat structures as compared to pelagic species.

7.8.3.1. Relevant Project Activities and Potential Impacts

Table 7.8-3 summarizes the planned Project activities that could potentially impact marine fish.

Table 7.8-3: Summary of Relevant Project Activities and Key Potential Impacts—Marine Fish

Stage	Project Activities	Key Potential Impact
Development Well Drilling SURF/FPSO Installation	Drilling operations and VSP Artificial lighting on drill ships and major installation vessels Installation of FPSO moorings and SURF equipment, including pile driving Permitted liquid waste discharge Permitted drill cuttings and fluids discharge	• Changes in the distribution of fish due to altered water quality • Auditory impacts from vessel sound • Auditory impacts from sound from VSP and pile driving • Attraction to artificial light
Production Operations	Permitted liquid-waste discharge (primarily cooling water and chlorinated effluent) Tanker and tug operations Presence of subsea infrastructure Intake of seawater for cooling water, injection water, and ballast water Artificial lighting on the FPSO	• Changes in the distribution of fish due to altered water quality • Auditory impacts from vessel sound • Changes in distribution and habitat usage due to altered bottom habitats and the presence of Project infrastructure • Loss of fish eggs and larvae due to entrainment of immature life stages • Attraction to artificial light
Decommissioning	Abandonment and removal activities Permitted liquid waste discharge	• Auditory impacts from vessel sound • Changes in the distribution of fish due to altered water quality • Attraction to artificial light

The Project includes several embedded controls that will reduce the magnitude of impacts on marine fish:

- FPSO onboard treatment of produced water, bilge water, and sanitary wastewater prior to discharge;
- Use of oil/water separators to ensure compliance with an oil-in-water content of less than 15 parts per million (ppm) (per the International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978) for bilge water;
- Use of water-based drilling fluids (WBDF) and low-toxicity International Association of Oil and Gas Producers Group III non-aqueous drilling fluid (NADF) during drilling;
- Use of solids control and drill cuttings dryer systems to treat non-aqueous base fluid (NABF) cuttings prior to discharge;
- Gradual increase in intensity of seismic pulses during VSP and hammer energy (during pile driving) to allow sensitive species to vacate the area before auditory injury can occur; and

- Screening of cooling water and ballast water intakes for FPSO and drill ships to reduce the impingement and entrainment of fish.

On the basis of the definitions and embedded controls described above, the characteristics of the various potential impacts on marine fish identified in Table 7.8-3 are discussed below.

7.8.3.2. Magnitude and Sensitivity Definitions for Potential Impacts on Marine Fish

Following the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude ratings of potential impacts on marine fish are determined based on geographic extent, frequency, duration, and intensity (see Table 7.8-4).

Table 7.8-4: Definitions for Intensity Ratings for Potential Impacts on Marine Fish

Criterion	Definition
Intensity	Negligible: No Project-related disturbance or injury of marine fish, or disturbance across only a very limited area.
	Low: Limited Project-related disturbance or injury of marine fish is perceptible, potentially causing slight changes in the behavior of marine fish.
	Medium: Project-related disturbance or injury of marine fish is evident, potentially leading to minor impacts on life functions (e.g., feeding, breeding, migration route changes).
	High: Project-related disturbance or injury of large numbers of marine fish, sufficient to cause extensive mortality or chronic behavioral changes at a population level.

Several marine fish species with an elevated IUCN conservation status are known to occur in the PDA based on direct capture or visual observation, but the bulk of the marine fish observed or captured do not have an elevated IUCN status. Table 7.8-5 provides definitions for receptor sensitivity ratings for potential impacts on marine fish. These definitions apply for only those species rated as Least Concern, Data Deficient, or not assessed on the IUCN Red List. Species rated as Near Threatened or higher are addressed in Section 7.1, Protected Areas and Special Status Species. Based on the sensitivity rating definitions below, the receptor sensitivity for marine fish is generally considered **Low** for pelagic species and **Medium** for demersal species. This is principally due to the fact that demersal species are less mobile than pelagic species and would therefore be more susceptible to localized Project impacts; however, this difference in relative sensitivity does not apply for demersal species that are highly mobile or have demonstrated habituation to a particular impact.

Table 7.8-5: Definitions for Receptor Sensitivity Ratings for Impacts on Marine Fish

Criterion	Definition
Sensitivity	Low: Species and sub-species without specific anatomical, behavioral, or ecological susceptibilities to Project-related impacts, or having previously demonstrated habituation to a specific category of anticipated impact.
	Medium: Species with one of the following characteristics: specific anatomical, behavioral, or ecological susceptibilities to Project-related impacts; importance to local or regional fisheries; or vital importance to the survival of another medium-sensitivity species, but not meeting criteria for high value sensitivity.
	High: Species with two of more of the following characteristics: specific anatomical, behavioral, or ecological susceptibilities to Project-related impacts; importance to local or regional fisheries; or vital importance to the survival of another medium-sensitivity species.

7.8.3.3. Characterization of Impacts—Changes in the Distribution of Fish Due to Altered Water Quality

The Project will routinely discharge several waste streams to the sea. These discharges will begin during the drilling and installation stages and continue into the decommissioning stage. Drilling fluids and cuttings discharges will be unique to the drilling stage. The initial well sections will use WBDF, and the cuttings and fluids will be discharged either at the seafloor—causing turbidity near the seafloor around the immediate vicinity of each well, or from the drill ships—causing turbidity higher in the upper water column. For subsequent well sections, cuttings and residual drilling fluids will be discharged from the drill ships. For discharges from the drill ships, turbidity plumes will impact a larger area as the cuttings fall through the water column; however, the turbidity plume in this case will be diluted across a larger area, thereby reducing potential related impacts at any single location. Fish are expected to generally avoid these turbidity plumes while drilling is occurring, reducing potential respiratory impacts associated with gill fouling, but are expected to return after drilling is complete. WBDF and the residual quantities of low-toxicity NABF adhered to discharged cuttings are expected to have no measureable toxicological impacts on fish.

As described in Section 6.4.3, Impact Assessment—Marine Water Quality, and Appendix J, Water Quality Modeling Report, most of the planned discharges that will occur during production operations are not known to have adverse impacts on marine life or will comprise negligible volumes; however, the increased temperature and chlorine concentrations in the cooling water discharges have the potential to adversely impact marine life. Elevated temperature is known to have several potential physiological lethal and sub-lethal impacts on fish, including reduced reproductive success, reduced early life-stage survivorship, and increased metabolic stress. Thermal thresholds for such impacts vary widely by species, but thresholds from the scientific literature range from about +1.5 degrees Celsius (˚C) to +6˚C (Donelson et al. 2014; Pankhurst and Munday 2011). Under the conservative assumptions described in Section 6.4.3, Impact Assessment—Marine Water Quality, localized sea surface temperatures around the point of discharge from the FPSO are expected to increase as a result of the Project, but these increases are predicted to be no more than 3˚C above ambient temperatures within 100 meters (approximately 330 feet) horizontal distance from the discharge outlet. This finding indicates that within 100 meters (approximately 330 feet) of the FPSO, the intensity of thermal discharges will diminish to near the lower end of the range within which adverse thermal impacts on fish are expected to occur. It is also noted that most of the research on thermal thresholds for these types of impacts has focused on reef- or structure-oriented species that spend their entire adult lives in a small area rather than the open-ocean pelagic species that will occur near the surface in the PDA. Pelagic species will be much more likely to move away from a thermal mixing zone that exceeds their optimum range than will structure-oriented species, so not only will thermal impacts affect a very small area of the ocean surface, but the species that occur within the PDA will also tend to be exposed less to these thermal impacts based on their propensity to actively avoid suboptimal water temperatures.

Similar to temperature increases, hypochlorite can also induce a range of negative impacts on fish, including disruption of cardiac function, respiration, and growth. There are no regulatory limits for residual hypochlorite in marine discharges in Guyana, and toxicity depends not only on dosage (concentration and exposure time) but also on individual species' sensitivity to hypochlorite. This makes defining a single impact threshold for hypochlorite exposure difficult. Most studies indicate harmful effects on fish have been observed at mean concentrations above 0.2 ppm (Kegley et al. 2016). Although the available studies cite a variety of exposure times and toxicity endpoints, they generally indicate residual chlorine from hypochlorite poses the greatest risk to aquatic species if they are exposed to elevated concentrations for extended periods of time (72 to 96 hours) (see Appendix J, Water Quality Modeling Report). While hypochlorite concentrations immediately adjacent to the discharge point could transiently exceed levels that pose fish toxicity concerns (assuming the fish remained in the area long enough to experience the impact), concentrations are expected to decrease to less than 0.11 ppm within 100 meters (approximately 330 feet) of the discharge point.

The combined impact of increased temperature and chlorine concentrations will make the localized mixing zone inhospitable to some species. However, unless fish are physically confined or otherwise prevented from escaping unfavorable water quality conditions (e.g., in the case of fish eggs), fish are usually capable of detecting and avoiding harmful water quality conditions, thereby minimizing potential toxicological impacts. This is especially true of water quality conditions that cause discomfort or are otherwise physically apparent at sub-lethal levels like hypochlorite.

Installation of moorings for the FPSO, installation of SURF equipment, and drilling of development wells will disturb the seafloor temporarily within the PDA. These disturbances will create turbidity plumes and alter localized bottom contours within the area. The main potential impacts of turbidity plumes on fish are gill fouling and reduced visibility. Visibility is a minor factor at the depths that occur in the PDA because the species that live at these depths are naturally adapted to what is essentially total darkness, but fouled gills can lead to respiratory distress over long exposures. The turbidity plumes are expected to dissipate rapidly downcurrent, and fish are expected to temporarily vacate the immediate vicinity of activities at the seafloor until turbidity reaches acceptable levels. This behavioral response will limit fishes' exposure to turbidity, and fish are expected to return to the vicinity of the Project subsea infrastructure once seafloor disturbance activities are complete. Decommissioning will cause similar small turbidity plumes near the seafloor if selected components of the SURF are removed and as mooring lines from the FPSO are placed on the seafloor. Impacts from these turbidity plumes will be similar to those associated with drilling and installation, although they will be smaller and have a shorter duration.

For these reasons, declines in water quality are expected to negatively impact fish abundance in the immediate vicinity of the well heads, SURF, and drill ships during drilling and installation, the FPSO and tanker(s) during production operations, and the SURF during decommissioning, but are not expected to cause significant fish mortality. Limited, localized impairments in water quality will be largely confined to the PDA, but they will likely cause minor changes in the distribution and composition of the fish community within parts of the PDA. As discussed below, the physical attraction that offshore facilities can exert on fish could actually result in net increases in the local abundance of certain fish species, thereby offsetting potential negative impacts associated with localized water quality impairment. The net impact in this case is predicted to be a localized shift away from sensitive species (including some pelagic and sedentary species) toward sedentary or structure-oriented species that are more tolerant of minor water quality impairments. Any impacts on transient fish swimming through the mixing zone are expected to be acute, and affected individuals are expected to recover quickly after exiting the mixing zone.

In summary, offshore pelagic fish will be exposed to:

- Permitted liquid effluent discharges and elevated total suspended solids (TSS) concentrations resulting from discharge of drill cuttings from drilling of bottom-hole sections during the drilling and installation stage;
- Permitted liquid effluent discharges as a result of FPSO discharges during the production operations stage; and
- Permitted liquid effluent discharges from decommissioning vessels during the decommissioning stage.

Offshore demersal species will be exposed to:

- Elevated TSS concentrations at the seafloor resulting from drilling the initial (riserless) well sections during the drilling and installation stage; and
- Elevated TSS concentrations during decommissioning stage seabed disturbance.

The intensity of impacts on pelagic and demersal offshore species is considered **Low** for drilling and installation stages because while drill cuttings discharges will result in TSS concentrations above biological thresholds, the portion of the Stabroek Block that will be exposed to concentrations that exceed biologically relevant water quality standards is relatively small; accordingly while fish may change their movement patterns slightly to avoid impaired water quality, these behavioral changes will be slight.

The intensity of impact on pelagic species will remain **Low** during production operations due to FPSO discharges, but the intensity of impact on demersal species will decrease to **Negligible** during production operations, because water quality impacts at the seafloor will cease during normal operations. During the decommissioning stage, the intensity of impact on pelagic species will be **Negligible** due to the elimination of FPSO discharges; while demersal species will experience an impact from seabed disturbance during decommissioning, the area in which this impact will occur will be very localized in nature, yielding a **Negligible** intensity. Coastal species will not be exposed to discharges from planned Project activities. Discharges from drilling and installation vessels, the FPSO, and decommissioning vessels will occur on an essentially continuous basis in the PDA during their respective stages of activity, so the frequency of this impact is considered **Continuous** for all Project stages. Elevated TSS concentrations from drill cuttings discharges will and from seabed disturbance during decommissioning will persist for less than a year in aggregate, so the duration of water quality impacts for these stages is considered **Medium-term**. Discharges from the FPSO will occur over the entire life of the Project (i.e., on the order of at least 20 years), so the duration of the impact for this stage is considered **Long-term**. This yields magnitude rating ranging between **Negligible** and **Small** for potential impacts on marine fish (Table 7.8-6).

Table 7.8-6: Magnitude Ratings for Potential Impacts on Marine Fish from Altered Water Quality

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Drilling and Installation	Exposure to Altered Water Quality (Offshore Pelagic and Offshore Demersal Species)	Direct AOI	Low	Continuous	Medium-term	Small
Production Operations	Exposure to Altered Water Quality (Offshore Pelagic Species)	Direct AOI	Low	Continuous	Long-term	Small
	Exposure to Altered Water Quality (Offshore Demersal Species)	Direct AOI	Negligible	Continuous	Long-term	Negligible
Decommissioning	Exposure to Altered Water Quality (Offshore Pelagic and Offshore Demersal Species)	Direct AOI	Negligible	Continuous	Medium-term	Negligible

Impact Significance—Exposure to Altered Water Quality

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance rating for potential water quality-related effects on marine fish ranges from **Negligible** to **Minor**.

7.8.3.4. Characterization of Impacts—Auditory Impacts on Marine Fish from Vessel Activity, Vertical Seismic Profile Activities, and Pile Driving

The same sound sources associated with the Project that could impact marine mammals (Section 7.5.3, Impact Assessment—Marine Mammals) could also impact marine fish. These can be broadly separated into non-impulsive sources (e.g., vessel sound) and impulsive sources (pile driving and VSP). Hearing abilities and sensitivities differ significantly among fish species. Certain species can be classified as hearing generalists or specialists[30] based on differences in hearing ability conveyed by specific anatomical traits. Although hearing specialists are thought to be more susceptible to auditory impacts within certain audio frequencies than other species, there are no generally accepted thresholds for auditory impacts in either specialist or generalist species, and many species' hearing abilities have yet to be quantified.

Non-Impulsive Sound

A 2014 Environmental Impact Statement conducted by the U.S. Department of the Interior as part of a Programmatic Environmental Impact Statement for proposed geological and geophysical investigations in the Atlantic Outer Continental Shelf off the southeastern United States (BOEM 2014) contained a comprehensive review of auditory impacts on fish from non-impulsive and impulsive sources (including seismic surveys). This study found that fish may experience a range of impacts from non-impulsive sound, including increased stress and threshold shift, and fish may employ behavioral strategies to avoid the sound source (BOEM 2014).

Pelagic marine species and nearshore demersal species will receive the highest exposure to non-impulsive sound because they will be closest to the sound source (i.e., the FPSO and marine vessels associated with the Project). The extent to which auditory impacts will actually occur is highly dependent on the hearing abilities and sensitivities of the species of these fish species and these abilities and sensitivities are currently unknown, but pelagic species have an almost limitless ability to avoid approaching vessels. As discussed in Section 7.8.2.4, the nearshore fish community (including those in the approaches to the Demerara River) is dominated by highly mobile species as well (see Section 7.8.2.4); accordingly, the intensity of potential auditory impacts on pelagic marine species and nearshore demersal species from vessel activity (during all Project stages) is considered **Negligible**. Due to the depths present offshore and the resulting distance between the seafloor and vessels at the surface, the intensity of impacts on offshore (continental shelf and deepwater) demersal species from non-impulsive sound (during all Project stages) is also considered **Negligible**. These sounds will be present whenever the FPSO or support vessels are operating in the PDA or when support vessels are passing through the transit corridor between the PDA and shorebases. The FPSO will be a continuous source of sound, so the frequency of impact for pelagic and offshore demersal species during production operations is considered **Continuous**. Based on the limited number of support vessel movements associated with the Project (on the order of an average of four one-way movements per day during drilling,

[30] Hearing specialists are species that have developed heightened sensitivities to sounds in a specific frequency range. This adaptation occurs in some species to facilitate feeding or social behavior. Hearing generalists hear equally well across a wider range of frequencies but do not possess the acuity of the specialists within their specific frequency range.

installation, and decommissioning; and three one-way movements per day during production operations), the frequency of impacts from non-impulsive sound during the drilling and installation stage is considered **Episodic** for all species, and the frequency of impacts from non-impulsive sound during the production operations stage is considered **Episodic** for nearshore demersal species. Although the proportion of total vessel sound contributed by each type of vessel will vary over time, sound emanating from drill ships, installation vessels, the FPSO, support vessels, offloading tankers, and tugs decommissioning vessels will occur over the entire span of the Project, so the duration of impact from non-impulsive sound is considered **Long-term**.

Impulsive Sound

The impact of impulsive sounds on hearing specialists is the most important factor to consider when assessing potential Project-related auditory impacts on fish for the following reasons:

- Impulsive sound is usually considered more important than non-impulsive sound in terms of impacts on fish because impulsive sound is the category most often associated with hearing loss, auditory injury, or auditory mortality of fish.
- Impulsive sources tend to have more severe impacts on hearing specialist species and those species with well-developed swim bladders[31] because they tend to be more sensitive to auditory impacts, especially within the range of frequencies that they are specially adapted to detect.
- High peak pressures and rapid onset and decay tend to be associated with the most severe auditory impacts on fish, and are characteristic of impulsive sources.
- As described in Appendix G, Underwater Sound Modeling Report, impulsive sound from driven piles and VSP will impact a larger area of the ocean than the non-impulsive sources modeled by JASCO and therefore could impact a larger number of species and individual fish than could the non-impulsive sources.

There have been no published reports to date documenting a lasting impact on fishing or fish stocks as a result of seismic surveys. The U.S. Bureau of Ocean Energy Management (2014) concluded that although hearing specialists are more susceptible than hearing generalists to hearing loss from impulsive sound, such impacts do not always occur and are generally not permanent. Wardle et al. (2001) observed initial “startle” reactions when reef-dwelling fish were exposed to impulses from a seismic array ranging from 210 dB to 195 dB re 1 µPa, but documented no long term effects on fish behaviors or movements at or around the reef. Slotte et al. (2004) used echosounders to assess large-scale movements of uncaged fish in response to seismic impulses and found that fish may vacate an area in response to seismic survey activity, but that such avoidance behaviors are short-term and that fish begin to return to more normal distributions within a few days after exposure.

[31] Caged exposure tests have determined that species with large swim bladders or other highly vascularized, low-density organs or structures tend to be more susceptible to acute acoustic injury than species that lack these features when exposed to such sources within a few meters (Amoser and Ladish 2005; Wysocki and Ladich 2005).

Impacts are expected to be most severe in resident fish that are oriented to structural bottom habitats and are therefore exposed to repeated impulses at a given location over time, but experiments have shown that impacts on these species are often undetectable or transitory. Grebe et al. (2009) exposed a variety of demersal and reef-associated species to seismic impulses and failed to document auditory injury in any species at cumulative SEL levels up to 190 dB re 1 μPa^2-s. Another study of the reef-oriented pollack (*Pollachius pollachius*) documented only minor changes in behavior when exposed to seismic impulses with peak sound pressures of 195 to 218 dB re 1 µPa at ranges of 5.3 to 109 meters (17.4 to 357.6 feet) (Wardle et al. 2001). Documented recovery times vary, but generally range from a few hours to a few days.

The available literature described above suggests that behavioral impacts from impulsive sound sources may begin to occur at peak sound pressures between 180 and 195 dB re 1 µPa, and that injury could occur at peak sound pressures around 220 dB re 1 µPa. The acoustic modeling conducted to assess impacts on marine mammals provides insights into the approximate area of ocean within which behavioral impacts on fish could occur (Appendix G, Underwater Sound Modeling Report). JASCO simulated propagation of impulsive sound from pile driving at a range of dB levels that correspond to the lower to middle range in which behavioral impacts begin to be observed in fish. At low frequencies, where most hearing specialist species tend to be most sensitive, sound levels of 198 dB re 1 µPa were predicted at 1,375 meters (4,511.2 feet) from the sound source. This threshold is near the middle of the range in which behavioral impacts begin to be observed in fish and represents the "worst" case (i.e., largest area of impact) that JASCO modeled. Higher frequency sound attenuated below the 198 dB re 1 µPa threshold at a much shorter distance from the source (i.e., 725 meters [2,378.6 feet]). Although fish-specific noise acoustic modeling was not conducted for this impact assessment, extrapolation from JASCO's analysis strongly suggests that behavioral impacts on fish from impulsive sound will be confined to less than 1.5 kilometers (0.9 mile) from the source.

The intensity of potential auditory impacts on pelagic species from pile driving (during FPSO and SURF installation) is considered **Negligible** due to the depth of acoustic source relative to the surface waters where pelagic species are usually found. The intensity of impacts on demersal species from pile driving (during FPSO and SURF installation) and VSP (during development well drilling) is considered **Medium** based on consideration of the predicted sound levels from these activities, the distance to which they would be expected to propagate, and the proximity of these species to the source. Coastal species will not be exposed to impulsive sound from the Project. Impulsive sounds will occur on an intermittent basis over a relatively short period of time, so the frequency and duration are considered **Episodic** and **Short-term**, respectively.

This yields a magnitude rating of **Negligible** for potential auditory impacts from non-impulsive and impulsive sounds (Table 7.8-7).

Table 7.8-7: Magnitude Ratings for Potential Auditory Impacts on Marine Fish

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Drilling and Installation	Non-impulsive sound (Offshore pelagic species and nearshore demersal species)	Direct AOI	Negligible	Episodic	Long-term	Negligible
Decommissioning	Non-impulsive sound (Offshore demersal species)	Direct AOI	Negligible	Episodic	Long-term	Negligible
Production Operations	Non-impulsive sound (Offshore pelagic species)	Direct AOI	Negligible	Continuous	Long-term	Negligible
	Non-impulsive sound (Nearshore demersal species)	Direct AOI	Negligible	Episodic	Long-term	Negligible
	Non-impulsive sound (Offshore demersal species)	Direct AOI	Negligible	Continuous	Long-term	Negligible
Drilling and Installation	Impulsive sound (Offshore pelagic species)	Direct AOI	Negligible	Episodic	Short-term	Negligible
	Impulsive sound (Offshore demersal species)	Direct AOI	Medium	Episodic	Short-term	Negligible

Impact Significance—Auditory Impacts on Marine Fish

As discussed above, pelagic species are considered to have a **Low** sensitivity due to their ability to avoid Project-related impacts. In the case of non-impulsive sound, the demersal fish species that occur within the shallow approaches to the Demerara River are also considered to have a **Low** sensitivity to vessel sound, because they are acclimated to sound from vessels transiting the Georgetown Harbour and would be capable of moving away from Project vessels, if needed. Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance rating for potential auditory impacts on marine fish is **Negligible**.

7.8.3.5. Characterization of Impacts—Changes in Distribution and Habitat Usage Due to Altered Bottom Habitats and the Presence of Project Infrastructure

None of the fish species that have been documented to date in the deepwater fish surveys, either with fish traps or with ROVs or drop cameras (chimeras/rattails, hagfish, lanternfish, short-tailed eel), are known to be habitat specialists. Nevertheless, some of the deepwater species from the "red fish" zone and all of the reef-associated species identified in the Lowe-McConnell study (1962; see Section 7.8.2, Marine Fish—Existing Conditions) are structure-oriented species. Physical structures provide many benefits to these species, including refuge from currents and predators as well as foraging opportunities. These species are expected to congregate around the well heads and manifolds once the disturbance associated with installation has abated and the Project enters the production operations stage. These communities could be disturbed temporarily during decommissioning if the flowlines are disconnected from the manifolds and retrieved. However, the manifolds and well heads are expected to remain in place in perpetuity (subject to the decommissioning plan), so these facilities will continue to provide habitats for the fish community over the long term.

On the basis of the above factors, the intensity of potential impacts associated with distribution and habitat changes from altered bottom habitats and presence of Project infrastructure (relevant for demersal species only) is considered **Negligible**, especially considering the potential for localized positive effects for reef- or structure-oriented species to mitigate the initial negative effects of habitat disturbance on the demersal fish community as a whole. Some aspects of bottom habitat may change from initial post-installation conditions over time, but for the purposes of this impact assessment the changes are considered **Continuous** and **Long-term**. This yields a magnitude rating of **Negligible** for potential impacts due to altered bottom habitats and the presence of Project infrastructure (Table 7.8-8).

Table 7.8-8: Magnitude Ratings for Potential Impacts on Marine Fish from Altered Bottom Habitats and the Presence of Project Infrastructure

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Production Operations	Altered bottom habitats and presence of Project infrastructure (Offshore Demersal species)	Direct AOI	Negligible	Continuous	Long-term	Negligible

Impact Significance—Altered Bottom Habitats and Presence of Project Infrastructure

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance rating for potential impacts on marine fish due to altered bottom habitats and the presence of Project infrastructure is **Negligible**.

7.8.3.6. Characterization of Impacts—Attraction to Artificial Light

Artificial light has been known for many years to attract fish in a variety of settings, and this phenomenon has been documented around lights on offshore petroleum infrastructure (Hastings et al. 1976; Stanley and Wilson 1997; Lindquist et al. 2005). Results from studies of platforms in the northern Gulf of Mexico suggest that platforms benefit all lifestages of predatory species by attracting and concentrating prey and providing sufficient light to locate and capture them (Keenan et al. 2007). While this may benefit predatory species in the short term, artificially lit structures have the potential to alter predator–prey interactions by creating conditions that favor predatory species at night and disadvantage the prey while simultaneously attracting the prey species. This could ultimately have long-term negative impacts on predatory species if localized depletion of prey resources occurs (Becker et al. 2012). The artificial light produced from the Project vessels may cause small changes in the distribution and/or behavior of fish in the immediate vicinity of the FPSO and possibly the drill ships, installation, and decommissioning vessels, but it will not be substantial enough to alter fish behavior, except in the immediate vicinity of these vessels. On this basis, the intensity of potential impacts associated with attraction to artificial light (relevant for pelagic species only) is considered **Negligible**. Light sources will be present whenever vessels are operating in the PDA or in the transit corridor between the PDA and shorebases, so the frequency of this impact is considered **Continuous** for the production operations stage in the PDA (based on the constant presence of the lighted FPSO) and **Episodic** for other stages and locations within the Direct AOI (based on the infrequent passages of Project-related vessels). Although the proportion of total light contributed by each type of vessel will vary over time, light emanating from drill ships, installation vessels, the FPSO, support vessels, offloading tankers, and tugs decommissioning vessels will occur over the entire span of the Project, so the duration of impact from artificial light is considered **Long-term**. This yields a magnitude rating of **Negligible** for potential impacts due to attraction to artificial lighting (Table 7.8-9).

Table 7.8-9: Magnitude Ratings for Potential Impacts from Attraction to Artificial Light on Marine Fish

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Development Drilling Installation Decommissioning	Attraction to artificial light (Pelagic Species)	Direct AOI	Negligible	Episodic	Long-term	Negligible
Production Operations	Attraction to artificial light (Pelagic Species)	Direct AOI	Negligible	Continuous	Long-term	Negligible

Impact Significance—Attraction to Artificial Light

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance rating for potential impacts on marine fish from attraction to artificial light is **Negligible**.

7.8.3.7. Characterization of Impacts—Entrainment in Water Intakes

Seawater will be withdrawn from the ocean to provide water to inject into the reservoir and cool the FPSO's processing equipment during the production operations stage. Larval and juvenile fish have the potential to be entrained in the intake or impinged on the screens that will be installed to remove particulates from the water before it is pumped into the treatment unit on the FPSO. Most research on entrainment and impingement involves site-specific studies at onshore power plants conducted in North American and European estuaries or nearshore coastal areas where immature fish are concentrated (Barnthouse 2013). Nearshore intakes generally pose a higher risk of entrainment and impingement than offshore intakes (WaterReUse 2011). Information on the entrainment and/or impingement rates at offshore intakes is sparse, but there is some recent evidence that losses from entrainment and impingement are insignificant at the population level, even at power plants in coastal and estuarine settings (Barnthouse 2013). The U.S. Minerals Management Service noted that coastal power plants require much higher volumes of water than individual offshore oil and gas facilities (approximately 10 million gallons per minute for a nuclear power plant; Martinez-Andrade and Baltz 2003), meaning that the entrainment losses at oil and gas facilities would likely be much lower than at power plants. In most cases, extrapolation of the losses of larval fish and eggs at power plant intakes to an equivalent number of adults indicates that entrainment losses are insignificant compared to natural and fishing-related mortality (Barnthouse 2013; WaterReUse 2011). As an embedded control, cooling and ballast water intakes on the FPSO and drill ships will be equipped with screens to reduce entrainment. On this basis, the intensity of potential impacts associated with entrainment of marine fish in water intakes is considered **Negligible**. Demand for cooling water on the FPSO will be constant and will extend through the production operations stage, so the frequency of this impact is considered **Continuous** and the duration is considered **Long-term**. This yields a magnitude rating of **Negligible** for potential impacts associated with entrainment of marine fish in water intakes (Table 7.8-10).

Table 7.8-10: Magnitude Ratings for Potential Impacts from Entrainment in Water Intakes on Marine Fish

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
All Project stages	Entrainment of early life stages (all species)	Direct AOI	Negligible	Continuous	Long-term	Negligible

Impact Significance—Marine Fish –Entrainment in Water Intakes

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance ratings for potential impacts on marine fish from entrainment in water intakes is **Negligible**.

7.8.4. Mitigation Measures—Marine Fish

The embedded controls integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on marine fish. Table 7.8-11 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.8-11: List of Embedded Controls and Monitoring Measures

Embedded Controls
When NADF is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
Where practicable, ensure that sound-making devices or equipment are equipped with silencers or mufflers and are enclosed, and/or use soft-start procedures (e.g., for pile driving, VSP, etc.) to reduce noise to levels that do not cause material harm or injury to marine species.
During pile-driving activities, gradually increase the intensity of hammer energy to allow sensitive marine organisms to vacate the area before injury occurs (i.e., soft starts).
Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with International Maritime Organization/International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 milligrams per liter (mg/L) on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.

Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals
Measure residual chlorine concentration of sewage discharges form the FPSO monthly to ensure it is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to ensure that there are no floating solids or discoloration of the surrounding waters.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' specifications and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Implement a chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
Ensure wastewater released from the onboard sewage treatment plant complies with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.
Ensure there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge.
Treat bilge water in accordance with MARPOL 73/78 to ensure compliance with an oil in water content of less than 15 ppm as applicable.
Provide screening for seawater intakes, if safe and practical, to avoid entrainment and impingement of marine flora and fauna.
Monitoring Measures
Prior to and post-drilling, an ROV will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to ensure that end of well maximum weighted mass ratio averaged over all well sections drilled using NABF shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C at 100 meters (approximately 328 feet) from point of discharge.
Use load monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.

Monitor chlorine concentration of treated sewage discharges.
Perform daily visual inspection of discharge points to ensure absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to ensure compliance with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.8-12 summarizes the assessment of potential pre-mitigation and residual impacts on marine fish from planned Project activities. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine fish-specific methodology described in Sections 7.8.3.2 and 7.8.3.3.

Table 7.8-12: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Fish

Stage	Receptor—Impact	Magnitude of Impact Rating	Sensitivity of Receptor Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Attraction to artificial light (all vessels)	Negligible	Low (Offshore Pelagic Species) Medium (Offshore Demersal Species, Nearshore Demersal Species)	Negligible	None	Negligible
	Auditory impacts from vessel sound	Negligible	Low	Negligible	None	Negligible
Drilling and Installation	Changes in the distribution of fish due to altered water quality	Small	Low (Coastal Species, Offshore Pelagic Species) Medium (Offshore Demersal Species)	Negligible (Coastal, Offshore Pelagic Species) Minor (Offshore Demersal Species)	None	Negligible (Coastal Species, Offshore Pelagic Species) Minor (Offshore Demersal Species)
	Auditory impacts from sound from VSP and pile driving	Negligible	Low (Coastal Species, Offshore Pelagic Species) Medium (Offshore Demersal Species)	Negligible	None	Negligible

Stage	Receptor—Impact	Magnitude of Impact Rating	Sensitivity of Receptor Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Production Operations	Changes in the distribution of fish due to altered water quality	Small (Offshore Pelagic Species) Negligible (Offshore Demersal Species)	Low (Coastal Species, Offshore Pelagic Species) Medium (Offshore Demersal Species)	Negligible	None	Negligible
	Changes in distribution and habitat usage due to altered bottom habitats and the presence of Project infrastructure	Negligible	Medium (Offshore Demersal Species)	Negligible	None	Negligible
	Loss of fish eggs and larvae due to entrainment of immature life stages	Negligible	Low (Coastal Species, Offshore Pelagic Species) Medium (Offshore Demersal Species)	Negligible	None	Negligible
Decommissioning	Changes in the distribution of fish due to altered water quality	Negligible	Low (Offshore Pelagic Species) Medium (Offshore Demersal Species)	Negligible	None	Negligible

7.9. MARINE BENTHOS

7.9.1. Administrative Framework—Marine Benthos

Table 7.9-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on marine benthos.

Table 7.9-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Marine Benthos

Title	Objective	Relevance to the Project
Legislation		
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora.	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a supportive mechanism cognizant of the national goals for wildlife protection, conservation, management, sustainable use, and external trade.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.

7.9.2. Existing Conditions—Marine Benthos

The benthic communities inhabiting the Guyana Basin are influenced by the dominant environmental conditions that characterize the area, including sediment composition, water turbidity, and nutrient loads. This section describes the marine benthos and benthic habitat within the Project AOI.

7.9.2.1. Methodology

This section draws on information provided in the scientific literature; maps; AUV photographs; and field data collected by box coring and sediment profile imaging during environmental baseline surveys (EBSs) completed in 2014, 2016, 2017, and 2018.

Sediment samples were collected from the Stabroek Block offshore Guyana as part of EBSs conducted in 2014 (Maxon and TDI-Brooks 2014), 2016 (FUGRO 2016), 2017 (ESL 2018a), and 2018 (FUGRO 2019). The 2018 EBS was focused on the Payara PDA. The full 2014, 2016, and 2017 EBS reports were provided as Appendices G, H, and I of the Liza Phase 2 Development Project EIA. The full 2018 EBS report is provided as Appendix I, 2018 Environmental Baseline Survey Report, to this EIA. The objectives of the EBSs were generally to characterize the physical, chemical, and biological properties of sediment and the water column, but the specific study objectives varied by study. The number of samples taken in each EBS was determined based on the specific objective of each study, as described in the above-referenced reports.

Sediment samples for benthic macrofauna community analysis were collected using a 0.25 square meter (m^2) box core from 10 sampling stations during the 2014 survey, 25 sampling stations during the 2016 survey, 10 sampling stations during the 2017 survey, and 8 sampling stations during the 2018 survey. The locations of the EBS samples are depicted relative to the PDA in Figure 7.9-1. During the 2016 EBS, water and sediment samples for environmental DNA (eDNA) analysis were sub-sampled from the same 25 sampling stations described above. However, during the 2017 EBS, only water samples were collected for eDNA analysis from the nine sampling stations from three depths (surface, middle, and bottom of the water column) (ESL 2018b). Sediment sub-samples for eDNA were extracted using a sterile plastic scoop, filtered, and frozen in individual plastic bags for subsequent laboratory analysis.

Additionally, this section draws on information provided from benthic incidental catch from 2017 and 2018 fish surveys and images collected from ROV/drop cameras on select transects along the continental shelf and in the Stabroek Block in 2017.

7.9.2.2. Regional Setting

Marine benthic biological resources offshore of Guyana are poorly studied, but do not include the matrix of shallow coral reefs and seagrass meadows that are often considered emblematic of coastal tropical Atlantic environments elsewhere. This is due to the area's highly turbid offshore conditions, which do not permit the growth of warm water corals that rely on symbiotic photosynthetic algae for nourishment.

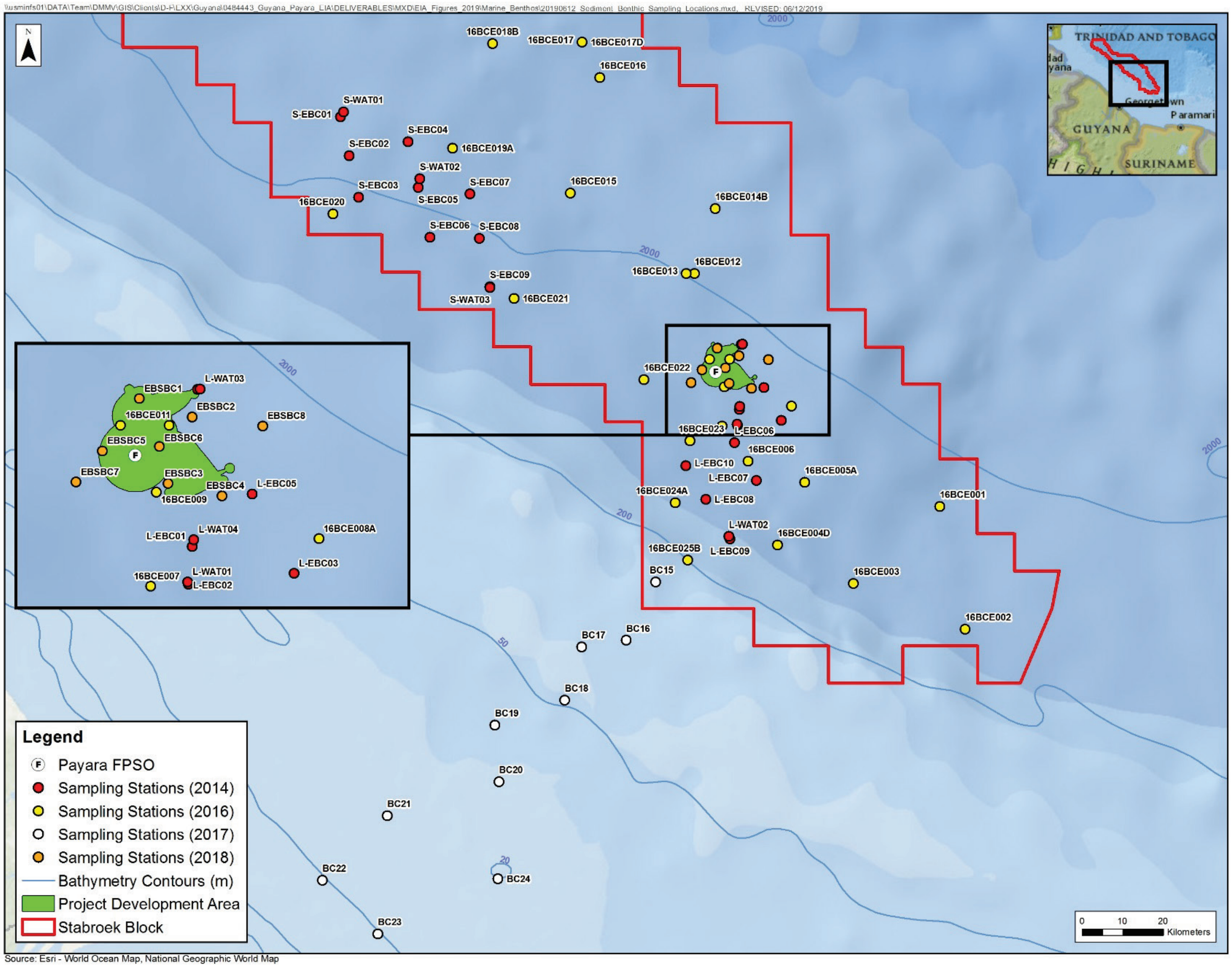


Figure 7.9-1: Locations of Benthic Sampling Stations in the Stabroek Block and along the Continental Shelf

Two cold-water coral species (*Madrepora oculata* and *Solenosmilia variabilis*) were previously known to occur offshore of Guyana. Both species occur in a wide range of depths, *M. oculata* from 55 to 1,950 meters (approximately 180 to 6,400 feet) and *S. variabilis* from approximately 219 to 2,165 meters (approximately 719 to 7,103 feet). The locations and extent of deepwater corals offshore of Guyana have not been published (Freiwald et al. 2004), but both species were documented on the shallow continental shelf based on fragments of live coral found at several locations during the 2017-2018 EEPGL-commissioned fish survey (Figure 7.9-2). Many cold--water corals construct reefs that support highly diverse invertebrate and fish fauna (NOAA 2014). Both *M. oculata* and *S. variabilis* are technically considered reef-building corals, but *M. oculata* is particularly fragile and does not often form deepwater reefs. It more frequently occurs as a commensal[32] species living within or on reefs that were originally constructed by more robust species such as *S. variabilis*. Neither species has been documented to date as inhabiting the Stabroek Block; however, in 2019 Fugro published an investigation of HSFs within and near the vicinity of the Payara Subsea PDA. The associated Fugro report documented the presence of a single occurrence of the black coral *Bathypathes* sp. at one HSF location.

Several species of bentho-pelagic shrimp occur in Guyanese waters, including shallow water species such as seabob (*Xiphopenaeus kroyeri*), southern brown shrimp (*Penaeus subtilis*), and white shrimp (*Penaeus schmitti*). The red-spotted shrimp (*Penaeus brasiliensis*) and the southern pink shrimp (*P. notialis*) are found in deeper waters (EPA 2010). While these species are free swimming, they are often found at or near the bottom. To date, three macrobenthic species, giant isopod (*Bathynomus giganteus*), red deepsea crab (*Chaceon quinquedens*), and flatback lobster (*Stereomastis sculpta*), have been documented to occur in the Stabroek Block and are discussed further below.

Other species that are common to deepsea Caribbean environments, and may be present but have yet to be documented in the Stabroek Block, include several species of isopods (such as *Leptanthura guianae* and *Malacanthura truncata*) (Poore and Schotte 2009, 2015) and amphipods (including *Ampelisca mississippiana*, and *Thaumastasoma* sp.). There are also numerous species of annelids, including the polychaetes *Tharyx marioni*, *Aricidea suecia*, *Levinsenia uncinata*, and *Paraonella monilaris*, as well as bivalves such as *Vesicomya vesical* and *Heterodonta* sp. (Wei et al. 2010).

[32] Living in close association, such that one species benefits without harming the other

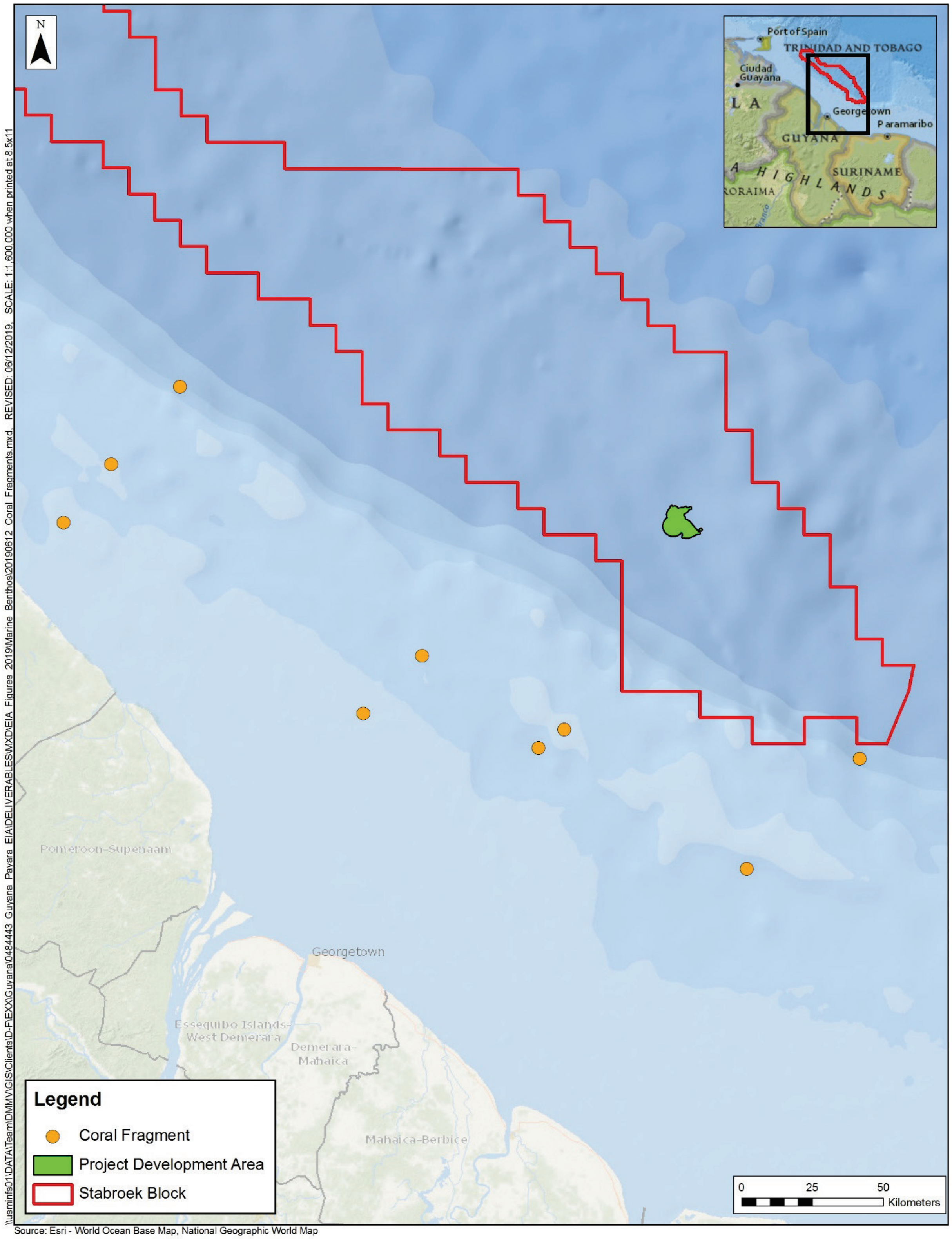


Figure 7.9-2: Locations where Live Coral Fragments Were Found on the Continental Shelf during 2017–2018 Fish Surveys

7.9.2.3. Existing Conditions in the Project Development Area

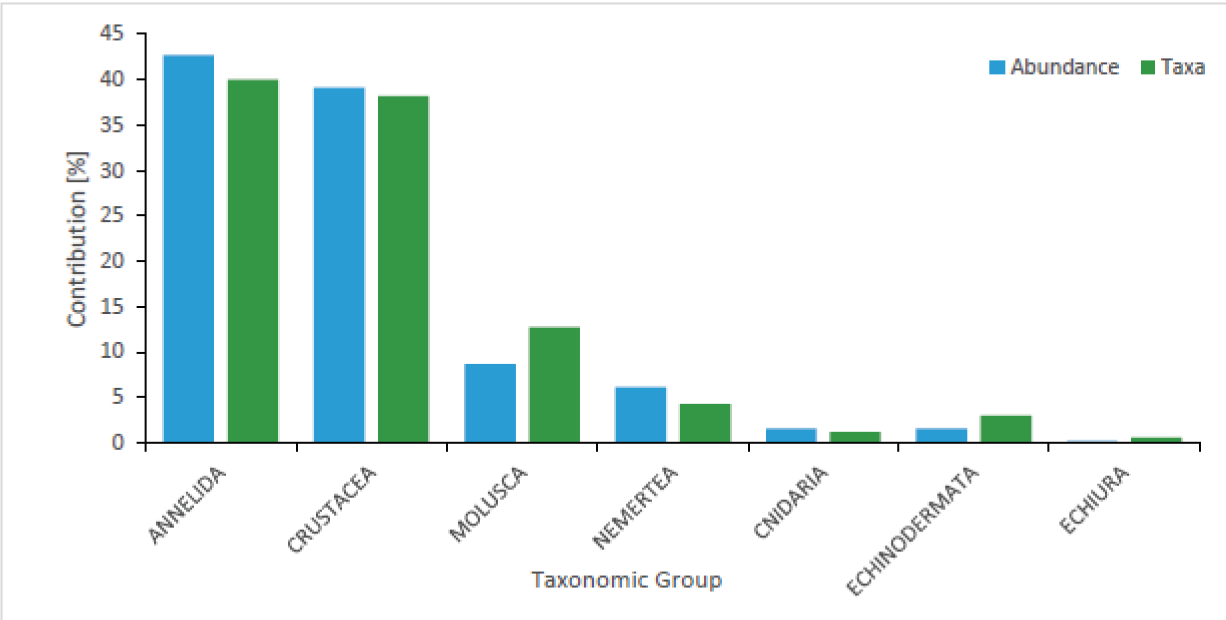
Environmental Baseline Survey Data

EBS samples are an effective means of sampling small, common, infaunal organisms because they cover a small area and penetrate into the sub-seafloor strata. The EBSs conducted to date in the Stabroek Block emphasized water and sediment sampling, but also included benthic biological components because benthic infauna (macrofauna) communities are a useful indicator of environmental health due to their relative sensitivity to changes in sediment physical and chemical conditions.

Results of the 2014 EBS revealed that the total abundance of benthic infauna in the Stabroek Block was low, averaging 116 ± 32.4 organisms per m^2 (Maxon Consulting and TDI Brooks 2014). This organism density is below the range of typical abundances reported from other continental slopes (Rowe et al. 1982; Flach et al. 1999). The observed low density of macrofauna is likely related to limited organic food sources, as indicated by the low organic carbon content in the sediment (see Section 6.3.2.3, Marine Sedimentology).

The most abundant major taxonomic groups from the 2014 EBS were polychaete worms, crustaceans, and mollusks. The overall prevalence of these three groups is typical for marine sediments. Polychaetes were the numerically dominant group identified (average density 47 per m^2, representing 41 percent of the total groups). Polychaetes typically comprise about half of all species and a third of macrofaunal species from deepwater marine habitats worldwide. Aside from polychaetes, no other individual major taxa were abundant, with each of the other taxa groups individually representing less than 14 percent of total abundance. A total of 50 distinct families were identified during the 2014 EBS, with approximately half represented by either one or two individuals. This is a relatively high level of diversity considering the low abundance of macrofauna. Dominant families were typical cosmopolitan inhabitants of shelf and slope sediments worldwide. These included spionid, cirratulid, paraonid polychaetes, phoxocephalid amphipods, and thyasirid and nuculanid (bivalve) mollusks (Maxon Consulting and TDI Brooks-2014).

Similar to the 2014 data, the 2016 EBS data showed an overall prevalence of annelids (including polychaetes), crustaceans, and mollusks typical for marine sediments as well as low macrofaunal densities. The 2016 samples were divided into two 0.1 m^2 sub-samples, and density averaged 20 organisms per 0.1 m^2. Extrapolation to a density per m^2 for comparison to the 2014 data equates to 200 organisms per m^2, but such comparisons are of limited analytical value given the small number of sub-samples analyzed in 2016. While the 2014 survey did not categorize the macrofauna organisms beyond the family level, the 2016 EBS further classified the macrofauna to the order and species level and covered a larger sampling area. Results from the 2016 sampling showed macrofaunal communities within the survey area to be diverse. In 2016, a total of 165 taxa were identified across 7 phyla and 27 families, with 36 identified to species level (including 15 species of polychaetes, 10 crustaceans, 8 mollusks, and 3 sipunculid worms). Annelida were the numerically dominant group (phylum), in terms of species composition (40 percent) and abundance (42.7 percent). Crustaceans accounted for the second highest species composition (38.2 percent) and abundance (39.1 percent), followed by mollusks (12.7 percent and 8.7 percent, respectively) and other taxa (collectively 9.1 percent and 9.5 percent, respectively) (Figure 7.9-3) (FUGRO 2016).

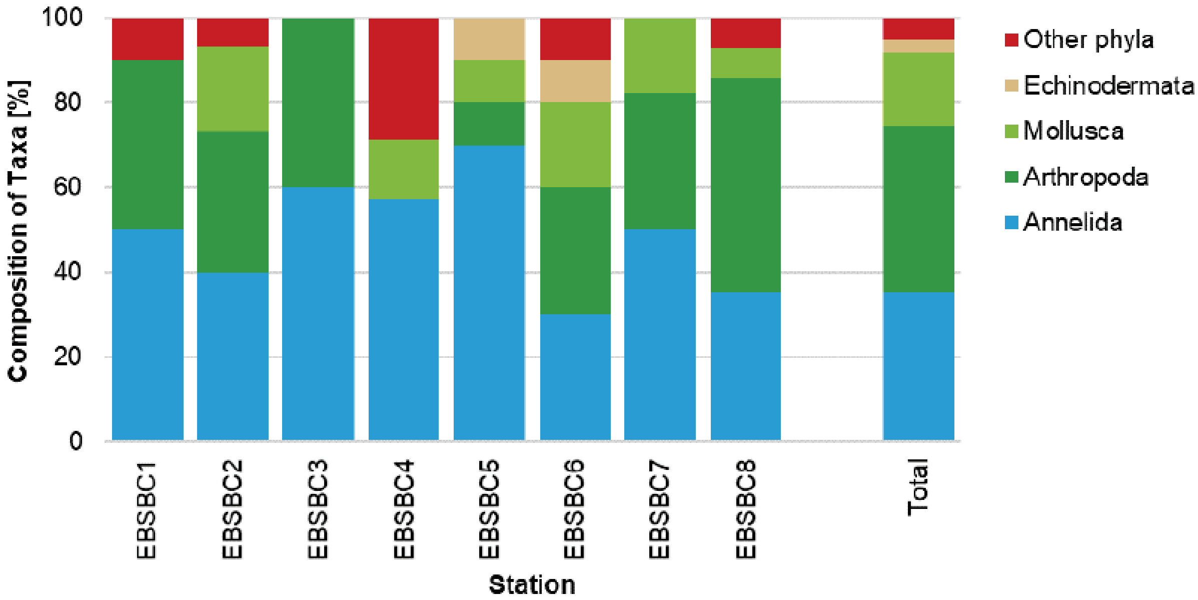


Source: FUGRO 2016

Figure 7.9-3: Abundance and Taxa of Major Taxonomic Groups Identified in 2016 Environmental Baseline Survey

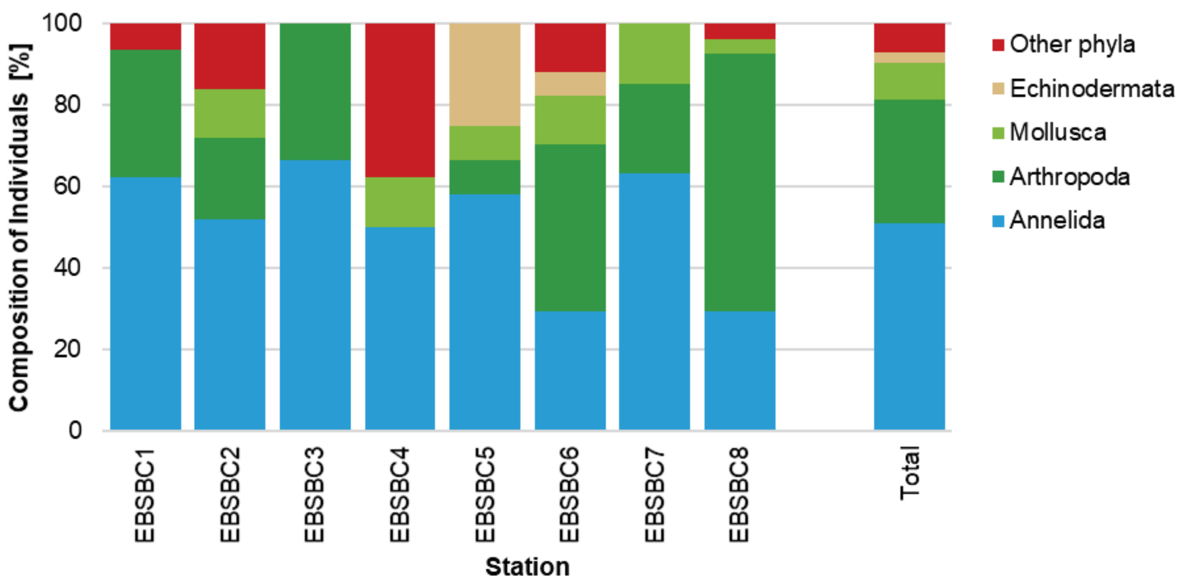
The 2017 EBS data showed a sample density ranging from 8 to 932 organisms per 0.1 m^2, with an average of 136.7 organisms per 0.1 m^2. For the purpose of comparison to 2014 and 2016 data, this equates to approximately 1,367 organisms per m^2. This reflects a higher abundance of organisms on the continental shelf (sampled in 2017) compared to the area sampled in the Stabroek Block (sampled in 2014 and 2016). A total of 11 phyla were identified, with arthropods being the most prevalent, followed by annelids (polychaetes). Within these 11 phyla, a total of 133 taxa and 4,101 specimens were identified (ESL 2018a).

The 2018 EBS was focused on the Payara PDA and the immediately surrounding area. Data from this survey showed a deepsea macrofaunal community similar to what was recorded in the Liza field in the 2016 EBS (FUGRO 2016). A total of 59 taxa were identified (the data were rationalized to account for juveniles, pelagic, colonial, or damaged individuals), with annelids (51 percent) being the most prevalent, followed by arthropods (30.3 percent), mollusks (9 percent), echinoderms (2.6 percent), and other taxa (7.1 percent) (FUGRO 2019). Figure 7.9-4 and Figure 7.9-5 illustrate the composition of taxa and individuals for each sampling station in the 2018 EBS.



Source: FUGRO 2019

Figure 7.9-4: Phyletic Composition of Taxa Identified in 2018 Environmental Baseline Survey



Source: FUGRO 2019

Figure 7.9-5: Phyletic Composition of Individuals Identified in 2018 Environmental Baseline Survey

The macrofaunal abundances surveyed in 2018 within the Payara PDA vicinity are considered low. Typically, continental slope sediments exhibit a decline in macrofaunal abundance with depth in response to declining food availability (Maxon and TDI Brooks 2019). Additionally, the macrofaunal communities within these areas are commonly found within the wider South Atlantic Ocean region. In the Payara PDA vicinity, the faunal community within the survey area was found to be relatively diverse and non-dominated, with a large number of taxa occurring in relatively low abundances. Moderate to high variability was demonstrated across the survey area, with polychaete worms and arthropods the most numerous taxa recorded (FUGRO 2019). One arthropod individually recorded and classified as *Aspidoniscus* sp. A, as well as three arthropod individuals recorded and classified as *Heteromesus*, are considered likely to be new records of these species (FUGRO 2019).

Table 7.9-2 summarizes macrofauna families identified in the 2014, 2016, 2017, and 2018 surveys. As the 2014 survey did not categorize the macrofauna organisms beyond the family level, the commonalities between the 2014, 2016, 2017, and 2018 surveys were identified based on equivalent families. The 2014, 2016, and 2018 surveys characterized the surveyed area to have a diverse macrofauna community, with polychaete worms as the most abundant major taxonomic group in 2014 and 2016 and arthropods the most abundant taxonomic group in 2018. The 2014 survey additionally recognized that overall macrofaunal abundance within the surveyed area was at the lower end of the macrofaunal densities reported for continental slope sediments worldwide (Rowe et al. 1982; Flach et al. 1999). The 2016 and 2018 surveys similarly reported that numbers identified in all taxonomic groups were low. The 2017 survey reported a higher density of organisms, although densities observed varied widely between individual samples. The 2017 survey also recorded a greater diversity of organisms, with malacostracan arthropods being the most abundant type, followed by polychaete worms.

Table 7.9-2: Macrofauna Families Observed in 2014, 2016, 2017, and 2018 Environmental Baseline Surveys

Phylum	Class	Order	Family
Annelida	Polychaeta	Unidentified	Unidentified
		Amphinomida	Amphinomidae
		Eunicida	Dorvilleidae
			Eunicidae
			Lumbrineridae
			Oenonidae
			Onuphidae
		Phyllodocida	Acoetidae
			Eulepethidae
			Glyceridae
			Goniadidae
			Hesionidae
			Nephtyidae
			Nereididae
			Pholoidae
			Phyllodocidae
			Pilargidae

Phylum	Class	Order	Family
			Polynoidae
			Sigalionidae
			Syllidae
		Sabellida	Oweniidae
		Spionida	Longosomatidae
			Spionidae
			Magelonidae
			Serpulidae
			Poecilochaetidae
			Trochochaetideae
		Terebellida	Cirratulidae
			Ampharetidae
			Flabelligeridae
			Terebellidae
			Trichobranchidae
		Not assigned	Orbiniidae
			Paraonidae
			Capitellidae
			Maldanidae
			Opheliidae
			Orbiniidae
			Chaetopteridae
			Scalibregmatidae
		Eunicida	Lumbrineridae
			Onuphidae
	Clitellata	Enchytraeida	Enchytraeidae
Arthropoda	Arachnida	Prostigmata	Microtrombidiidae
	Hexanauplia	Calanoida	Aetideidae
			Bathypontiidae
			Calanidae
			Centropagidae
			Clausocalanidae
			Heterorhabdidae
			Lucicutiidae
			Metridinidae
			Paracalanidae
			Scolecitrichidae
			Temoridae
		Cyclopoida	Cyclopidae
			Oithonidae
		Harpacticoida	Tachidiidae
		Poecilostomatoid	Corycaeidae

Phylum	**Class**	**Order**	**Family**
			Oncaeidae
			Sapphirinidae
		Scalpelliformes	Scalpellidae
		Sessilia	Balanidae
	Insect	Coleoptera	Dermestidae
		Diptera	Empididae
		Lepidoptera	Nymphalidae
	Malacostraca	Amphipoda	Ampeliscidae
			Aoridae
			Caprellidae
			Chevaliidae
			Corophiidae
			Isaeidae
			Ischyroceridae
			Lysianassidae
			Oedicerotidae
			Photidae
			Phoxocephalidae
			Platyischnopidae
			Scopelocheiridae
			Synopiidae
			Unknown Amphipod
		Cumacea	Bodotriidae
			Diastylidae
			Nannastacidae
			Unidentified
		Decapoda	Axiidea*
			Brachyura*
			Paguroidea*
			Alpheidae
			Anomura*
			Callianassidae
			Caridea*
			Crangonidae
			Decapoda*
			Diogenidae
			Micheleidae
			Palaemonidae
			Panopeidae
			Pasiphaeidae
			Pilumnidae
			Pinnotheridae

Phylum	Class	Order	Family
			Porcellanidae
			Processidae
			Pseudorhombilidae
			Sergestidae
		Euphausiacea	Euphausiidae
		Isopoda	Anthuridae
			Anthuroidea*
			Cirolanidae
			Desmosomatidae
			Haploniscidae
			Hyssuridae
			Ischnomesidae
			Leptanthuridae
			Macrostylidae
			Nannoniscidae
			Serolidae
		Leptostraca	Nebaliidae
		Mysida	Mysida
		Tanaidacea	Unidentified
			Agathotanaidae
			Apseudidae
			Apseudomorpha*
			Colletteidae
			Kalliapseudidae
			Leptocheliidae
			Metapseudidae
			Neotanaidae
			Parapseudidae
			Paratanaidae
			Tanaellidae
			Tanaidomorpha*
			Typhlotanaidae
	Ostracoda	Halocyprida	Halocyprididae
		Myodocopida	Myodocopid
	Pycnogonida	Pantopoda	Phoxichilidiidae
Brachiopoda	Lingulada	Lingulida	Lingulidae
Bryzoa	Gymnolaemata	Cheilostomatida	Celleporidae
			Scrupariidae
Chordata	Actinopterygii	Ophidiiformes	Bythitidae
	Anthrozoa	**	Branchiostomatidae
	Ascidiacea	Unidentified	Unidentified
Cnidaria	Anthozoa	Actiniaria	Diadumenidae

Phylum	**Class**	**Order**	**Family**
			Edwardsiidae
		Spirularia	Cerianthidae
		Zoantharia	Zoantheria
	Hydroz	Leptothecata	Campanulariidae
			Lafoeidae
			Sertulariidae
		Siphonophorae	Agalmatidae
		Siphonophorae	Clausophyidae
		Siphonophorae	Diphyidae
		Trachymedusae	Geryoniidae
Echinodermata	Holothuroidea	**	Holothuroidae
		Apodida	Synaptidae
	Ophiuroidea	Ophiurida	Amphiuridae
			Ophiocomidae
			Ophiuridae
			Ophiuroidae*
Hemichordata	**	**	Hemichordata
Mollusca	Not assigned	**	Mactribae
		**	Ungulinidae
		Not assigned	Cardiidae
			Semelidae
			Tellinidae
		Limida	Limidae
		Lucinida	Lucinidae
			Thyasiridae
		Myida	Corbulidae
		Nuculida	Nuculidae
			Sareptidae
		Nuculanida	Nuculanidae
			Yoldiidae
		Ostreida	Pteriidae
		Pectinida	Pectinidae
		Venerida	Arcticidae
	Caudofoveata	Chaetodermatida	Limifossoridae
	Gastropoda	Littorinimorpha	Naticidea
			Eulimidae
		Neogastropoda	Muricidae
			Olividae
	Scaphopoda	Dentaliida	Dentaliidae
Nematoda	Unidentified	Unidentified	Unidentified
	Adenophorea	Desmodorida	Haliplectidae
		Desmoscolecida	Desmoscolecidae

Phylum	Class	Order	Family
		Enoplida	Campgdoridae
		Enoplida	Rhabdodemaniidae
		Monhysterida	Diplopeltidae
			Linhomoeidae
			Monhysteridae
			Siphonolaimidae
			Sphaerolaimidae
		Trichocephalida	Trichinellidae
	Chromadorea	Araeolaimida	Aulolaimidae
	Secernentea	Tylenchida	Paratylenchidae
Porifera	**	**	Porifera
Sipuncula	Phascolosomatidea	Aspidosiphonida	Aspidosiphonidae
	Sipunculidea	Golfingiiformes	Unidentified
			Golfingiidae
			Phascolionidae
	**	**	Sipuncula

Source: Maxon Consulting and TDI Brooks 2014; FUGRO 2016; ESL 2018a; FUGRO 2019

Notes: "Not assigned" indicates that the scientific community has not specifically classified the organism to a given category. The symbols "*" and "**" and the term "unidentified" refer to the surveyors' inability to further identity the categorization of an organism.

All four surveys reported that there was not a strong correlation between macrofaunal communities or number of species and any single physical parameter such as sediment characteristics or water depth (Maxon Consulting and TDI Brooks 2014; FUGRO 2016; ESL 2018a; FUGRO 2019).

Environmental DNA Samples

In addition to direct sampling of whole benthic organisms and subsequent analysis of those specimens by traditional morphological means, the 2016 and 2017 surveys also included collection of complimentary eDNA samples. These samples were used to estimate the presence and absence of organisms from DNA found in the environment. Initial studies of eDNA analysis in seawater show that the approach captures the fish diversity better than or equal to contemporary survey methods (Thomsen et al. 2012; Kelly et al. 2014); however, further studies are needed to validate the eDNA approach in marine environments (Thomsen and Willerslev 2015; Kelly et al. 2014). Morphological analysis of the 2016 survey samples identified 197 distinct taxa[33] (FUGRO 2016). In 2017, survey samples identified specimen from 133 taxa in 11 phyla (ESL 2018a). The eDNA analysis was partially consistent with the morphological analysis, as all of the phyla and 117 of the distinct taxa were confirmed through DNA analysis (CEGA 2019). The DNA data were also consistent with the 2016 and 2017 morphological data in terms of taxonomic dominance. The three data sets identified annelids and arthropods as dominant taxa, although the DNA samples also contained large numbers of taxa in the bacteria,

[33] These taxa were mostly identified to the species rank, but some were only identifiable to family level.

fungi, and hydrozoa (jellyfish and corals) phyla. Other groups where several species were identified included bony fish, snails and slugs, shrimp, stingray, sea anemone, sea cucumber and starfish, bivalves, squids, and sponges.

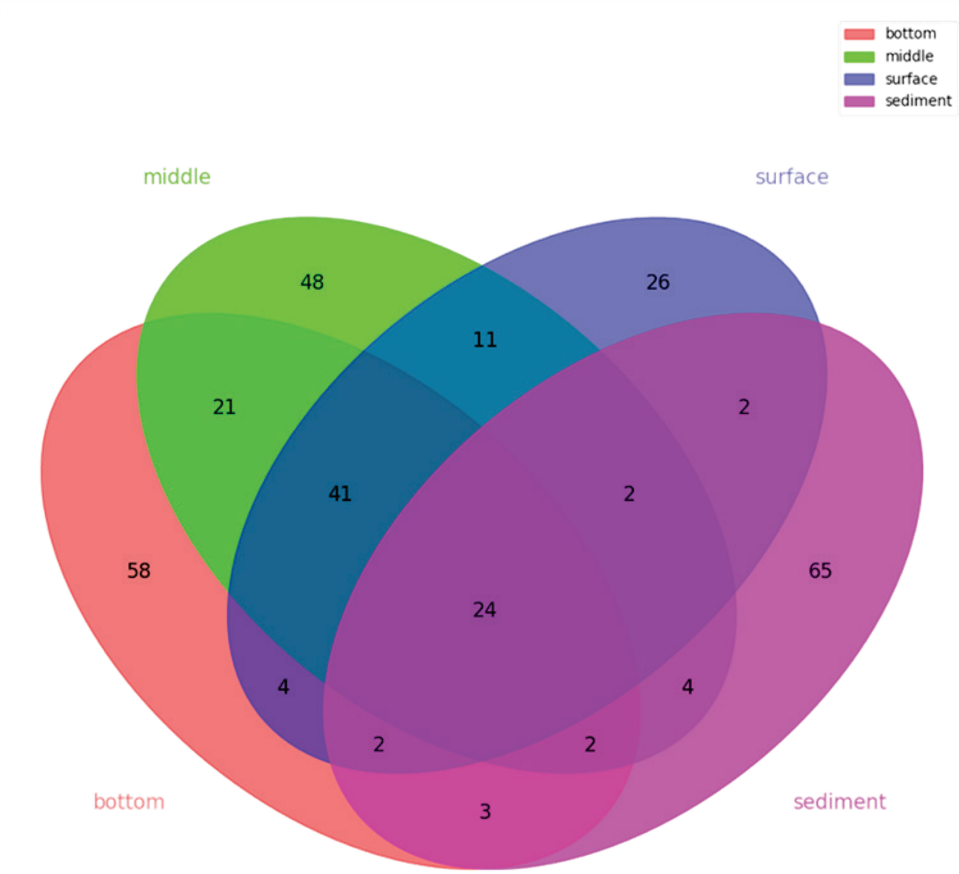
Most of the remaining taxa that were identified from the morphological analysis but not identified in the eDNA analysis have not had their DNA sequence information entered into a reference database (CEGA 2019). In addition to these taxa, 48 taxa detected and identified to at least the genus rank in the eDNA analysis were not documented at the class level or higher in the morphological analysis (see Table 7.9-3).

The results from the 2016-2017 eDNA analysis revealed a total of 503,075 amplicon sequence variants[34] in water and sediment samples. Matching the eDNA to a reference library resulted in the identification of 552 genera (248 from Metazoa[35]) and 618 families (298 from Metazoa). Of these, a total of 408 species were identified (CEGA 2019). These results were then compared to the 2016 and 2017 EBS data, where benthic species were identified by taxonomists (morphological approach). In most cases, the eDNA analysis was able to identify specimens down to the species level, whereas only family level or higher identifications were achieved using the morphological approach. These findings are summarized in Table 7.9-3.

The eDNA study examined sediment samples and water samples taken from three depths: surface of the water column, middle of the water column, and bottom of the water column. The most unique sample type was sediment, which not only had a high number of species not found elsewhere (65), but also showed little overlap with the other sample types. While the water samples also had unique species, there was a high degree of overlap with the other sample types (Figure 7.9-6). The analysis found that collecting water from the middle and bottom of the water column captures more than 70 percent of the total identifiable diversity. However, eliminating one or more sample type would result in not capturing taxa that may be important from a bio-indicator perspective (CEGA 2019).

[34] Amplicon sequence variant is a term used to refer to individual DNA sequences recovered from a marker gene analysis following the removal of spurious sequences generated during amplification and sequencing of a DNA segment. They are inferred sequences of true biological origin.

[35] Metazoa is a grouping of organisms that comprises all animals other than protozoans and sponges. Metazoa are multicellular animals with differentiated tissues.



Source CEGA 2019

Blue = water from the surface of the water column; Green = water from the middle of the water column; Orange = water from the bottom of the water column; Pink = sediment samples, which have the largest number of unique species as well as the least overlap with the other sample types.

Figure 7.9-6: Venn Diagram of the Different Sample Types

Table 7.9-3: Taxonomic Groups Identified at the Species Level in Sediment and Seawater Samples using eDNA Analysis

Phylum	**Class**	**Species**	**2016-2017 Environmental Baseline Survey Morphological ID**
Annelida	Polychaeta	*Alciopina* sp.	
		Aricidea sp.	*Aricidea* sp.
		Cossura candida	
		Eunice impexa	*Eunicida, Onuphis* sp.
		Eunice sp.	*Eunicida, Onuphis* sp.
		Hyalinoecia sp.	
		Laetmonice producta	
		Laonice sp.	Laonice (?)
		Lumbrineris latreilli	Lumbrineridae sp. A
		Onuphis iridescens	Onuphis, Onuphidae
		Owenia fusiformis	
		Phyllodoce groenlandica	Phyllodocidae
		Phyllodoce longipes	Phyllodocidae
		Poecilochaetus serpens	*Poecilochaetus fulgoris* (?)
		Sipunculus nudus	
		Sternaspis scutata	
		Terebella lapidaria	
		Terebellides stroemii	
		Travisia pupa	Travisia
		Typhloscolex sp.	
Arthropoda	Arachnida	*Demodex folliculorum*	
	Branchiopoda	*Macrothrix* sp.	
	Collembola	*Paronellides praefectus*	
	Hexanauplia	*Acartia longiremis*	Copepoda, Hexanauplia, Calanoida
		Acartia tonsa	
		Acrocalanus andersoni	
		Acrocalanus longicornis	

Phylum	**Class**	**Species**	**2016-2017 Environmental Baseline Survey Morphological ID**
		Aegisthidae sp.	
		Ameira scotti	
		Anthessius sp.	
		Bradya sp.	
		Calocalanus curtus	
		Calocalanus minutus	
		Calocalanus styliremis	
		Candacia pachydactyla	
		Centropages furcatus	
		Centropages violaceus	
		Clausocalanus arcuicornis	
		Clausocalanus furcatus	
		Clausocalanus parapergens	
		Clausocalanus paululus	
		Corycaeidae sp.	
		Ctenocalanus vanus	
		Cyclopina gracilis	
		Euchaeta marina	
		Hemicyclops thalassius	
		Heterorhabdus papilliger	
		Lucicutia flavicornis	
		Mecynocera clausi	
		Miracia efferata	
		Mormonilla sp.	
		Nannocalanus minor	
		Oithona nana	
		Oithona plumifera	
		Oithona similis	
		Oithona sp.	

Phylum	**Class**	**Species**	**2016-2017 Environmental Baseline Survey Morphological ID**
		Oithonidae sp.	
		Oncaea prendeli	
		Oncaea sp.	
		Oncaea waldemari	
		Paracalanus aculeatus	
		Paracalanus indicus	
		Paracalanus quasimodo	
		Paracalanus tropicus	
		Pleuromamma abdominalis	
		Pseudocalanus moultoni	
		Sapphirina scarlata	
		Sapphirinidae sp.	
		Scaphocalanus magnus	
		Subeucalanus pileatus	
		Temora stylifera	
		Temora turbinata	
		Triconia elongata	
		Triconia minuta	
		Triconia umerus	
		Undinula vulgaris	
	Insecta	*Attagenus smirnovi*	
		Cryptolestes ferrugineus	
		Diptera sp.	
		Rhagoletis zephyria	
	Malacostraca	*Belzebub faxoni*	
		Euphausia americana	Euphausiidae
		Penaeus brasiliensis	
		Porcellio scaber	Porcellionidae
	Ostracoda	*Halocypris inflata*	Myodocopida

Phylum	Class	Species	2016-2017 Environmental Baseline Survey Morphological ID
		Howeina sp.	
		Porroecia spinirostris	
		Proceroecia microprocera	
Chaetognatha	Sagittoidea	*Sagitta enflata*	
		Sagitta helenae	
Chordata	Actinopteri	*Antigonia capros*	Actinopterygii
		Argyropelecus affinis	
		Bregmaceros sp.	
		Cheilopogon cyanopterus	
		Cheilopogon exsiliens	
		Diaphus dumerilii	
		Diaphus garmani	
		Exocoetidae sp.	
		Maurolicus weitzmani	
	Chondrichthyes	*Dasyatis americana*	
		Hypanus guttatus	
	Thaliacea	*Brooksia lacromae*	
		Doliolum nationalis	
		Iasis cylindrica	
Cnidaria	Anthozoa	*Diadumene leucolena*	Actinaria (burrowing), Actinaria (epibenthic)
		Nanozoanthus harenaceus	
		Stylophora pistillata	
	Hydrozoa	*Agalma okeni*	Cnidaria
		Aglaura hemistoma	
		Amphogona apicata	
		Athorybia rosacea	
		Branchiocerianthus imperator	
		Cordagalma cordiforme	
		Diphyes bojani	

Phylum	Class	Species	2016-2017 Environmental Baseline Survey Morphological ID
		Diphyes dispar	
		Geryonia proboscidalis	
		Lensia campanella	
		Lilyopsis fluoracantha	
		Nanomia bijuga	
		Nectopyramis sp.	
		Obelia bidentate	
		Rosacea cymbiformis	
		Rosacea sp.	
		Solmundella bitentaculata	
		Sulculeolaria quadrivalvis	
		Varitentacula yantaiensis	
	Scyphozoa	*Atolla vanhoeffeni*	
Ctenophora	Tentaculata	*Pleurobrachia bachei*	
Echinodermata	Holothuroidea	*Enypniastes eximia*	Echinodermata
	Ophiuroidea	*Ophiolepis elegans*	Ophiuroidea sp. A, Ophiuroidea sp. B
		Ophiura cf. ljungmani	
Gastrotricha	N/A	*Chaetonotus neptuni*	
		Heterolepidoderma loricatum	
		Platydasys sp.	
		Tetranchyroderma sp.	
		Urodasys sp.	
Hemichordata	Enteropneusta	*Meioglossus psammophilus*	Hemichordata
Kinorhyncha	N/A	*Echinoderes horni*	
		Sphenoderes poseidon	
Mollusca	Bivalvia	*Idas argenteus*	Bivalvia
	Caudofoveata	*Chaetoderma feld*	Caudofoveata
	Cephalopoda	*Abralia* sp.	
		Heteroteuthis dagamensis	

Phylum	Class	Species	2016-2017 Environmental Baseline Survey Morphological ID
		Ornithoteuthis antillarum	
	Gastropoda	*Cavolinia uncinata*	Gastropoda sp. A, Gastropoda sp. B, Gastropoda sp. C, Gastropoda sp. D, Neogastropoda
		Cliopsis krohni	
		Diacavolinia longirostris	
		Limacina inflata	
		Parvanachis obesa	
Nematoda	Chromadorea	*Cynura klunderi*	Nematoda
		Daptonema procerus	
		Halicephalobus sp.	
	Enoplea	*Phanoderma* sp.	
Nemertea	Enopla	*Eumonostilifera* sp.	
		Tetrastemma sp.	
	Palaeonemertea	*Tubulanidae* sp.	
	Pilidiophora	*Hubrechtidae* sp.	
		Micrura ignea	
Platyhelminthes	Catenulida	*Paracatenula* sp.	
	Rhabditophora	*Odontorhynchus aculeatus*	
		Paromalostomum fusculum	
		Prosthiostomum acroporae	
		Psammorhynchus tubulipenis	
Porifera	Demospongiae	*Halisarca dujardini*	Porifera

Source: CEGA 2019

Notes:

1. The data are presented at the taxonomic level provided in CEGA 2019.
2. A positive taxonomic assignment was determined when there was an unambiguous match at 98% identity (or better) across 99% (or more) of the query sequence.
3. Organisms listed are not the dominant taxa but instead those to which the environmental genomics analysis could assign a species name.
4. This table lists identified Metazoan species. However, other taxa were assigned names at higher taxonomic levels (e.g., class, order, or family).
5. Listed in the "2016-2017 Environmental Baseline Survey Morphological ID" column are groups that were also found in the morphology-based analyses and the corresponding ID is provided.

Benthic Bycatch from the 2017 and 2018 Fish Surveys

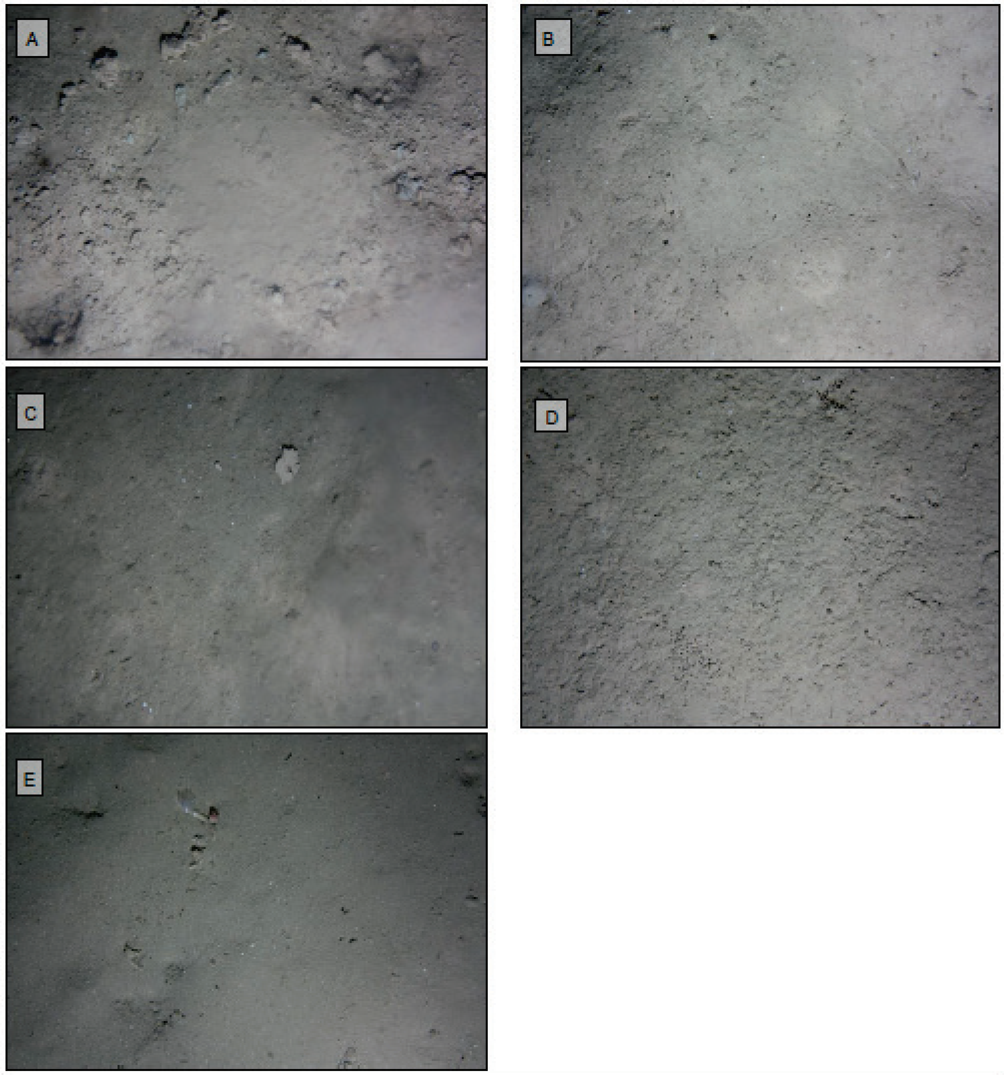
The deepwater samples from the 2017 and 2018 fish surveys produced three benthic species, giant isopod, red deepsea crab, and flatback lobster, none of which were captured in the 2014, 2016, or 2017 EBSs. Giant isopods were overwhelmingly the most prevalent benthic organism caught in the deepsea traps. Over 100 individuals were caught in a single trap in some locations, and baits were entirely consumed by the time some traps were retrieved, indicating that higher catches may have been attained if more bait had been used. Neither giant isopods nor red deep sea crabs were documented to be present in Guyanese waters prior to this survey (Liverpool et al. 2017), although both species are widespread in the temperate and tropical western Atlantic Ocean (Lowry and Dempsy 2006; Liverpool et al. 2018). There were no apparent spatial or seasonal patterns in the distribution of these species other than their apparently uneven distribution across the study area.

ROV Footage and Seabed Photography

Benthic imagery from the Stabroek Bock is available from four surveys. A 2014 survey produced a limited number of still images of macrobenthos from drop cameras; a 2016 survey produced a mosaic of still images of the seafloor; a 2017 ROV survey produced approximately 9 hours of video of the seafloor; and a 2018 AUV survey produced approximately 8,500 kilometers of survey line of side scan sonar (SSS) survey data and 14,000 seafloor photographs of HSFs.

The seabed photography from the 2016 survey indicated that the survey area primarily consists of one broad benthic habitat type: sublittoral sediment (EUNIS[36] code A5). This marine benthic habitat can encompass a wide range of sediments from boulders, cobbles, pebbles and shingles, coarse sands, sands, fine sands, muds, and mixed sediments (Davies et al. 2004). The footage from the 2017 ROV survey is broadly consistent with the findings of the 2016 survey. Each sediment type hosts characteristic biological communities, which together define biotopes. Within the sublittoral sediment habitat, one biotope was identified: circa-littoral sandy mud (A5.35) with aspects of deep sea mud. Benthic epifauna were scarcely observed in the photographs taken in 2016; however, the 2017 ROV footage showed some areas with abundant evidence of active infauna, including holes and sediments that had been disturbed, likely by invertebrates burrowing into the substrate or sifting the surficial sediments for edible material. Figure 7.9-7 provides representative photographs of the circa-littoral sandy mud biotope taken from five of the 2016 sample stations. Epifauna were sparse in the photographs and videos, but evidence of habitation (bioturbation) by tube-building polychaetes (possibly Sabellidae and Terebellidae), burrowing shrimp, and foraminifera can be observed in all of the images of the seafloor. Mud shrimp burrows were evident in most photographs, and some photographs showed other taxa including tusk shells, gastropods, and hydroids.

[36] The European Nature Information System (EUNIS) is a habitat classification system developed by the European Environment Agency in collaboration with international experts. The EUNIS includes all types of natural and artificial habitats, both aquatic and terrestrial.



Source: FUGRO 2016
Photo A: Station NC21_BCE002—mud, tube-building polychaetes and amphipods, mud shrimp burrows, Scaphopoda (tusk shells), gastropods, foraminiferans
Photo B: Station NC21_BCE004—sandy mud, tube-building polychaetes and amphipods, mud shrimp burrows, foraminiferans, unidentified hydroid
Photo C: Station NC21_BCE005—sandy mud, tube-building polychaetes and amphipods, foraminiferans, Scaphopoda
Photo D: Station NC21_BCE024—sandy mud, tube-building polychaetes and amphipods, foraminiferans
Photo E: Station NC21_BCE025—muddy sand, Sabellids and other tube-building polychaetes, mud shrimp burrows, foraminiferans

Figure 7.9-7: Representative ROV Photographs of Benthic Habitat from the Stabroek Block

Photographs from the 2018 AUV survey showed a mottled pattern of low to moderately light-reflective soils with visible shell fragments (FUGRO 2018). Based on the AUV multibeam echosounder bathymetry and backscatter and SSS data, the areal density of the HSFs correlate well with the thickness of stratified sediments and shallow regional mass transport complex sediments (FUGRO 2019). The epifauna present on 80 HSFs present across eight AUV camera sites were identified and quantified in terms of both percentage cover and abundance counts of individual taxa. Table 7.9-4 summarizes the biological cover of the HSFs analyzed. The most frequently occurring and abundant taxa was an elephant ear sponge that has been tentatively identified as the hexactinellid (glass sponge) *Poliopogon amadou*. Following sponges, the most frequently recorded taxon was a brisingid seastar tentatively identified as *Freyella elegans*. The only fish observed during the survey was an eelpout of the family Zoarcidae, which was recorded in association with a single HSF feature (FUGRO 2019).

Table 7.9-4: Epifaunal Taxa Associated with HSFs in the Payara Area

Phyla	Taxa	Mean Coverage [%] [a]	Mean Abundance [N] [a]	Frequency (No.) [b]	Frequency [%] [b]
Porifera (Sponges)	Porifera (indeterminate)	2.7	1.2	41	51.3
	Porifera (massive)	0.6	0.1	3	3.8
	Hexactinellida [c] (spherical)	0.7	0.2	12	15.0
	Porifera (osculate)	0.1	< 0.1	1	1.3
	Hexactinellida (*Poliopogon amadou* [c])	5.0	2.2	57	71.3
Cnidaria (Corals)	*Bathypathes* sp.	0.1	< 0.1	1	1.3
Echinodermata (Seastars and Urchins)	Crinoidea	0.1	0.1	4	5.0
	Ophiuroidea (Ophionereidae [c])	0.1	0.1	7	8.8
	Asteroidea	0.2	0.1	6	7.5
	Brisingida (*Freyella elegans* [c])	1.4	0.3	15	18.8
Chordata (Fish)	Zoarcidae	NA	< 0.1	1	1.3
Indeterminate	Indeterminate	0.8	0.2	13	16.3

Source: FUGRO 2019

NA = not applicable

[a] Mean coverage and abundance per hard seafloor feature (HSF)

[b] Frequency of occurrence within the analyzed AUV imagery subset of 80 images

[c] Tentative identification

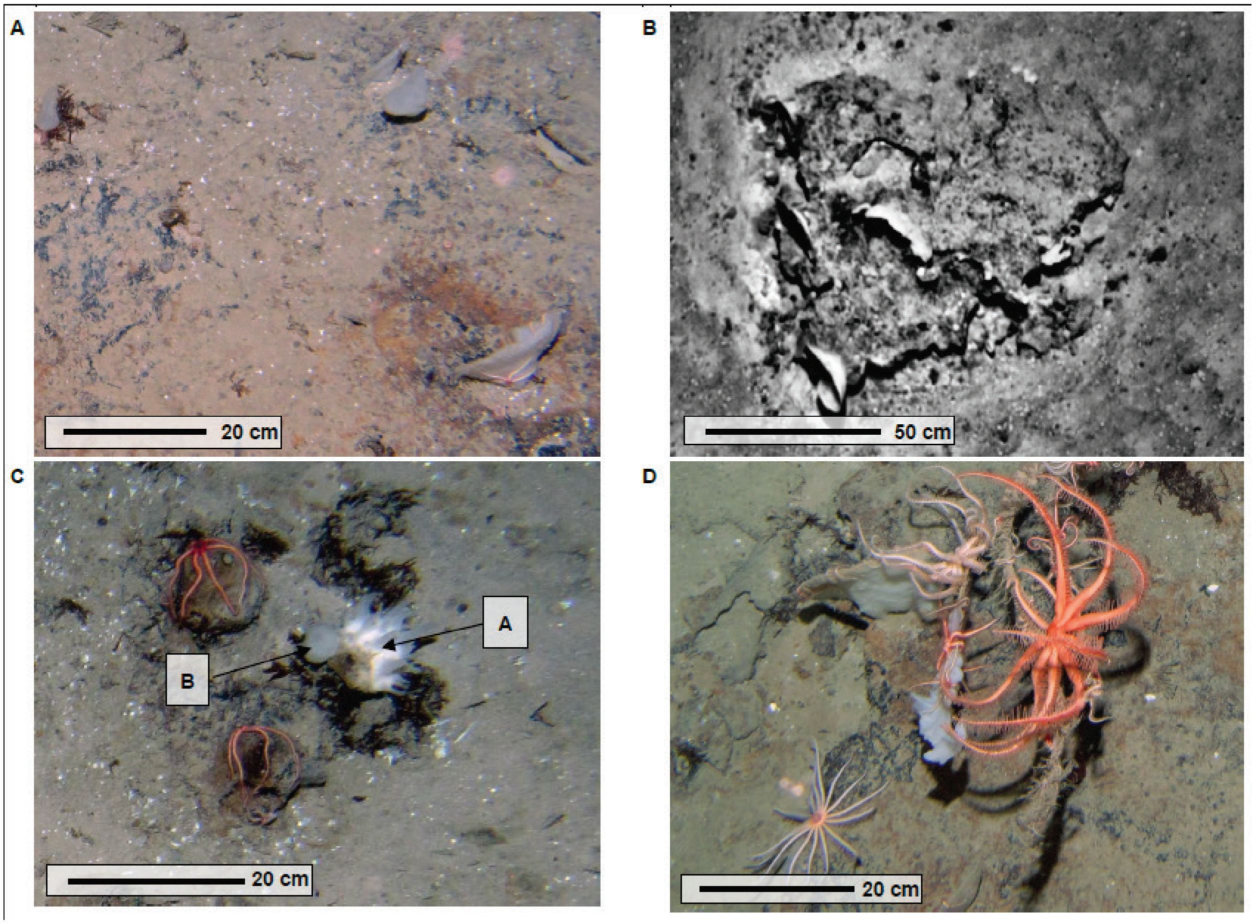
No deepwater coral growth was detected in the 2014, 2016, or 2017 EBS or in the ROV surveys within the PDA (Maxon Consulting and TDI Brooks 2014; FUGRO 2016; ESL 2018b); however, black coral (*Bathypathes* sp.) was identified at one HSF during the 2018 AUV survey. The indeterminate grouping of taxa listed in Table 7.9-4 may also include a small, dark-colored, and irregularly branched coral or hydroid (FUGRO 2019). As stated in Section 7.9.2.2, Regional Setting, two cold-water coral species (*Madrepora oculata* and *Solenosmilia variabilis*) were documented on the shallow continental shelf based on fragments of live coral found at several locations during the 2017-2018 fish survey (Figure 7.9-2 and Figure 7.9-8). In addition, one species of octocoral (*Anthomastus* sp.) has been documented in the deepwater portion of the Stabroek Block. This is based on a single ROV observation that occurred near the Liza-3 exploration well, approximately 15 kilometers (9 miles) southeast of the planned location of the Payara FPSO. *M. oculata* and *S. variabilis* have been documented from the outer continental shelf south of the Stabroek Block.

ERM 2018

Figure 7.9-8: Live Black Coral Fragments from Guyana's Continental Shelf

Photographs of live benthic macrofauna on the seafloor include a few opportunistic photos taken during the 2014 survey, a small number of still images extracted from the deepwater ROV footage in 2017 (see Figure 7.9-9), and a number of AUV photos taken during the 2018 survey (see Figure 7.9-10). Neither giant isopods nor flatback lobsters have been captured in live footage in the Stabroek Block to date; however, they are known to occur in the block on the basis of their capture in the deepwater fish survey, and the isopods are believed to be locally common in at least some parts of the block based on the high numbers that were captured in the deepwater fish traps. Representative photos of giant isopods are included in Figure 7.9-11.

Figure 7.9-9: Representative ROV Photographs of Macrobenthos from the Stabroek Block



Source: FUGRO 2019
Photo A: EBS Transect EBSDDV5—Four elephant ear sponges (Hexactinellida; *Poliopogon amadou* [tentative identification]), with brittlestars (Ophiuroidea; Ophionereidae [tentative identification]).
Photo B: Site 4, Line G18R3021—Six Hexactinellida (*Poliopogon amadou* [tentative identification]), representing 20 percent coverage on an HSF.
Photo C: EBS Transect EBSDDV36—An indeterminate hexactinellid (glass) sponge (A) and spherical hexactinellid sponge (B) with Ophiuroidea (Ophionereidae [tentative identification]).
Photo D: EBS Transect EBSDDV5—Three seastars (Brissingida; *Freyella elegans* [tentative identification]) with sponges and Ophiuroidea (Ophionereidae [tentative identification]).

Figure 7.9-10: Representative AUV Photographs of HSF Epifauna from the Payara Project Development Area

Figure 7.9-11: Representative Photographs of Macrobenthos from Deepsea Traps in the Stabroek Block

7.9.3. Impact Assessment—Marine Benthos

This section addresses the potential impacts on marine benthic biological resources (i.e., benthos) resulting from planned Project activities. The key potential impacts assessed include injury to benthos as a result of deposition of drill cuttings (via smothering, filter fouling, and/or toxicity impacts from residual oil contained on discharged cuttings), injury or disturbance of benthos as a result of disturbance of the seafloor during installation of Project components, and changes to benthic habitat as a result of the initial placement of Project components on the seafloor, as well as the abandonment-in-place of additional components during decommissioning.

7.9.3.1. Relevant Project Activities and Potential Impacts

The PDA is located in the eastern portion of the Stabroek Block in water depths ranging from approximately 1,900 to 2,100 meters (approximately 6,200 to 6,900 feet). As described above, this area's macrofauna community is dominated by polychaete worms and crustaceans as the most abundant major taxonomic groups, followed by mollusks and other taxa. Benthic microepifauna were generally scarce in the EBS samples, with the exception of tube-building polychaetes (possibly Sabellidae and Terebellidae) and burrowing shrimp; however, red crabs and giant isopods were locally abundant as bycatch in deepwater fish samples collected in nearby areas of the Stabroek Block.

The Project has the potential to cause localized impacts on benthos through smothering and/or filter fouling (from deposition of drill cuttings), toxicological impacts (from NADF adhered to deposited cuttings), and crushing or displacement (from placement of subsea infrastructure). These potential impacts will be balanced somewhat by the creation of artificial substrate in the form of manifolds, wellheads, and other infrastructure permanently installed on the seafloor, which will have the potential to benefit benthos by providing additional hard substrate for colonization.

Table 7.9-5 summarizes the Project stages and activities that could result in potential Project impacts on marine benthos.

Table 7.9-5: Summary of Relevant Project Activities and Key Potential Impacts—Marine Benthos

Stage	Project Activity	Key Potential Impacts
Development Well Drilling SURF/FPSO Installation	Discharge of drill cuttings, resulting in increased TSS concentrations in water column and deposition of cuttings on seafloor Installation of FPSO anchor structures and SURF infrastructure on the seafloor	• Smothering of benthos as a result of accumulation of drill cuttings • Increased TSS concentrations in water column, potentially contributing to health impacts on filter-feeding marine benthos • Toxicological impacts on benthos from NADF adhered to deposited drill cuttings • Crushing of benthos where subsea infrastructure is placed

Stage	Project Activity	Key Potential Impacts
Production Operations	Presence of (non-moving) infrastructure on the seafloor	• Creation of artificial substrate for use by benthos during production operations (positive)
Decommissioning	Abandonment of infrastructure on the seafloor	• Creation of artificial substrate for use by benthos indefinitely (positive)

7.9.3.2. Assessment of Impacts

The assessment of the Project's magnitude of potential impacts on marine benthos is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on marine benthos is defined according to the definitions provided in Table 7.9-6.

Table 7.9-6: Definitions for Intensity Ratings for Potential Impacts on Marine Benthos

Criterion	Definition
Intensity	Negligible: No anticipated injury to marine benthos.
	Low: Some measurable injury to marine benthic communities anticipated, but not to the extent that there is an impact on the viability of an entire benthic community or population.
	Medium: Injury to marine benthos anticipated at a moderate scale. Entire communities or populations may be affected, but impacts are not likely to result in a permanent change to the structure or species composition of an entire benthic community or population.
	High: Significant injury to marine benthos anticipated, to the extent that permanent changes to an entire community structure/species composition are likely.

The sensitivity of marine benthos varies among species according to their habitat preferences and behavior. Table 7.9-7 provides definitions for the receptor sensitivity ratings for potential impacts on marine benthos. These definitions apply for only those marine benthos species rated as Least Concern, Data Deficient, or not assessed on the IUCN Red List. Species rated as Near Threatened or higher are addressed in Section 7.1, Protected Areas and Special Status Species.

Table 7.9-7: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Marine Benthos

Criterion	Definition
Sensitivity	Low: No taxa within the benthic community known to possess unique susceptibilities to Project-related impacts. Known taxa are readily able to avoid and/or recover quickly from Project-related impacts.
	Medium: One or a limited number of taxa within the benthic community with elevated susceptibility to Project-related impacts, and/or known taxa exhibit a habitat preference or behavior that limits their ability to avoid Project-related impacts, but representing a small fraction of the overall community.
	High: Several taxa within the benthic community with elevated susceptibilities to Project-related impacts and known taxa exhibit habitat preferences or behaviors that greatly limits to their ability to avoid Project-related impacts, representing a substantial fraction of the overall community.

7.9.3.3. Characterization of Impacts—Injury Due to Drill Cuttings Deposition

Magnitude of Impact—Injury Due to Drill Cuttings Discharge

Planned discharges of drill cuttings and fluids could potentially impact marine benthos as a result of increases in TSS concentrations in the water column, burial and smothering under cuttings accumulated on the seafloor, and exposure to toxins in disturbed sediment or NADF adhered to the accumulated cuttings.

With regard to potential impacts from increases in TSS concentrations, discharged drill cuttings will increase TSS concentrations before settling out of the water columns and accumulating on the seafloor close to the individual wells. According to Fugro's areal density analysis, sponges are the dominant taxon in the HSF community in terms of percent coverage (Fugro 2019). Elevated TSS tends to impact sponges to a greater extent as compared to some other benthic organisms because excessive suspended material can foul the sponges' filter feeding apparatus. Fugro concluded that the sponge community associated with the HSFs was widespread in the vicinity of the Payara Subsea PDA, including areas outside the Subsea PDA, and that the sponge community was generally homogeneous in terms of density and diversity across the study area (Fugro 2019). This indicates that sponges on HSFs within the temporarily elevated TSS zones surrounding the ten drill centers are likely to experience elevated injury/mortality, but that these effects will be localized and will not threaten the integrity or survival of the sponge community outside the immediate vicinities of the drill centers.

Some benthic fauna will also likely be impacted through burial and smothering. Smothering is a biological impact on benthos induced by the physical impact of burial. The severity of burial impacts depends on the sensitivity of the benthic organism, the thickness of deposition, the amount of oxygen depleting material (and the resulting anoxic conditions beneath the depositional layer), and the duration of the burial. Thickness thresholds vary by species and sediment permeability. A threshold deposition rate of 5 centimeters (2 inches) per month for smothering impacts on benthic communities is recommended based on publications by Ellis and Heim (1985) and MarLIN (2019). Smaller threshold values (as low as 1 millimeter [0.04 inch]) have also been reported (e.g., Smit et al. 2006); however, they are associated with instantaneous burials on benthic species, not gradual smothering impacts.

As described in Section 6.3.3, Impact Assessment—Marine Geology and Sediments, modeling of drill cuttings discharges for eight well/current combination scenarios indicated the maximum depositional thickness of cuttings on the seafloor is predicted to be between 116.8 and 255.5 centimeters (46 and 101 inches), depending on currents, drill center locations, and scenario considered. The model-predicted extent of cuttings deposition above the 5 centimeters (2 inches) per month threshold will be confined to within a relatively short distance from the drill center locations, with the area above 5 centimeters (2 inches) accumulation thickness predicted to be approximately 3,571 m^2 (38,400 square feet [ft^2]) for the scenario with the greatest modeled maximum thickness. Figure 7.9-12 depicts the maximum total thickness of deposited cuttings for this scenario.

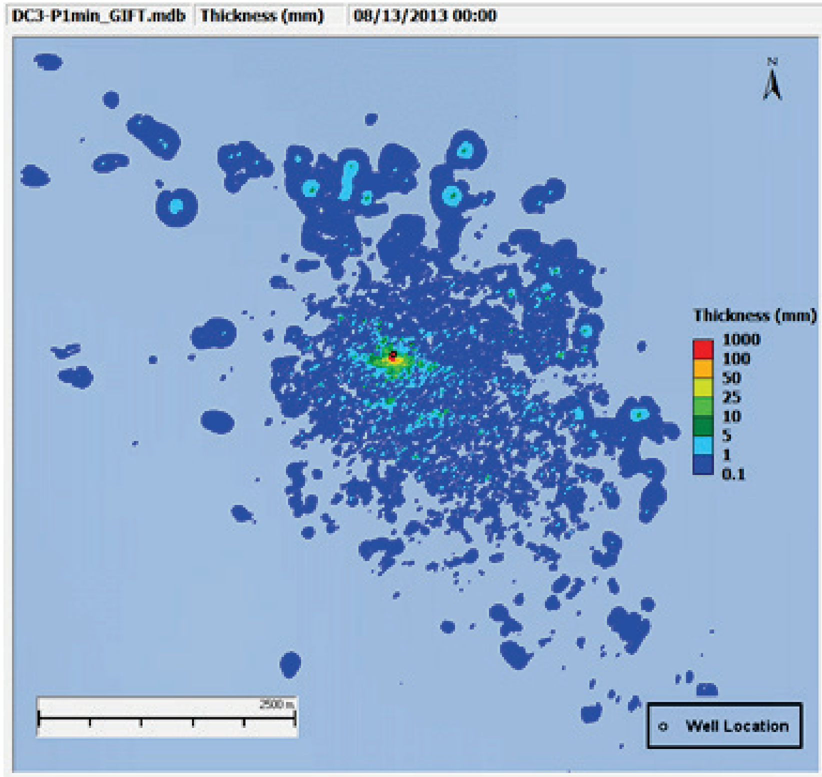


Figure 7.9-12: Accumulated Cuttings based on Model Results

If it is conservatively assumed that up to two drill ships are active simultaneously on Payara drill centers and are both undertaking drilling that matches the above-referenced scenario, the conservative approach is therefore to double the affected area results from Table 6.3-5 to reflect the largest area predicted to be subjected to a cuttings deposition rate greater than 5 centimeters (2 inches) per month at any one time. This results in a predicted area of approximately 7,100 m^2 (approximately 76,400 square feet [ft^2]), which represents approximately 0.01 percent of the area of the Subsea PDA (which itself covers approximately 0.3 percent of the Stabroek Block). Further, the currents are expected to redistribute the cuttings away from their initial deposition sites over time, gradually reducing their thickness on the seafloor at these locations.

With respect to potential impacts from exposure of benthos to toxins in disturbed sediments, the U.S. National Oceanic and Atmospheric Administration (NOAA) has developed numerical sediment quality guidelines (SQGs) as informal (non-regulatory) tools to interpret chemical data from analysis of sediments. As described in Section 6.3.2.3, Marine Sedimentology, sediment samples were collected from eight stations in 2018 as part of the EBS for the Payara PDA (FUGRO 2019b). These data were compared to the NOAA SQGs, where available, to assess the possible toxicological significance of chemical concentrations in the sediments. However, the SQGs were derived in units of dry weight sediments and do not account for geochemical factors in sediments that may influence contaminant bioavailability. The comparison does indicate that a few metals and polycyclic aromatic hydrocarbons (PAHs) are present in the sediments at concentrations that could present a possible threat to organism health.

Specifically, for the 12 metals analyzed and for total PAHs:

- The mean concentration of arsenic (37.8 microgram per gram [µg/g]) exceeds the Effect Range Low[37] (ERL) SQG of 8.2 µg/g, and the maximum concentration (250 µg/g) exceeds the Effects Range Median[38] (ERM) SQG of 70 µg/g.
- The maximum concentration of nickel (26.1 µg/g) exceeds the ERL SQG of 20.9 µg/g, but does not exceed the ERM SQG of 51.6 µg/g.
- Concentrations of cadmium, chromium, copper, mercury, lead, and zinc were all less than the NOAA SQGs.
- Aluminum, barium, iron, and selenium do not have recommended SQGs for comparison.
- Concentrations of total PAHs were nearly three orders-of-magnitude less than the suggested NOAA ERL SQG of 4.022 µg/g and ERM SQG of 44.792 µg/g.

Although chemical information is not available for the specific sub-seafloor strata at the drilling locations, the surficial inorganic sediment chemistry is used for the assessment of the potential for long-term toxicological impacts on the benthos population as a result of seabed disturbance.

Uncontaminated marine sediments contain from 5 to about 40 milligrams per gram dry weight total arsenic, with higher average concentrations generally found in deep-sea sediments. A review of arsenic in the marine environment (Neff 1997) concluded that arsenic concentrations below the ERL are expected to rarely cause adverse effects in benthic organisms, while concentrations of arsenic in sediments between the ERL and ERM may occasionally cause adverse effects. Further, concentrations of arsenic above the ERM value of 70 milligrams per gram are expected to be associated frequently with adverse effects in benthic organisms.

There are limited chronic nickel toxicity data available for marine sediments and tropical marine species. However, the NOAA Screening Quick Reference Tables (SQuiRTs)[39] provides background levels of metals in marine sediments and presents screening concentrations for nickel and other inorganic analytes in marine sediments that may threaten marine animals. The background SQuiRT value for nickel is 9.9 µg/g (NOAA 2008). Using the same rationale that Neff (1997) applied to arsenic, it is considered that concentrations of nickel in sediments between the ERL and ERM may occasionally cause adverse effects.

With respect to potential impacts from exposure of benthos to toxins in the discharged cuttings, embedded controls in the Project design that will reduce the potential impact of drill cuttings discharges on sediment quality include use of International Association of Oil and Gas Producers Group III NADF for bottom-hole sections. Group III NADF includes fluids produced by chemical reactions and highly refined mineral oils which contain levels of total aromatics below 0.5 percent and PAH levels below 0.001 percent (Sanzone et al. 2016). Potential toxicity can be

[37] The ERL value is the concentration of a potential contaminant at which negative effects are rarely observed.

[38] The ERM value is the concentration of a potential contaminant above which negative effects have been observed in more than 50 percent of the cases studied.

[39] SQuiRT benchmark levels are preliminary screening concentrations for chemicals in various environmental media, in this case marine sediments, which are used to evaluate the potential risks to coastal habitats from sediment that may be contaminated with organic and inorganic compounds.

assessed by using the SQGs developed by NOAA (Long et al. 1995) for total PAHs. PAHs are appropriate as a conservative proxy for total hydrocarbons in this case because PAHs are among the most toxic group of petroleum hydrocarbons to marine life (Snyder et al. 2015). Assuming a maximum weight percent of 6.9 NADF on discharged cuttings, as described in Appendix J, Water Quality Modeling Report, the maximum probable concentration of PAHs (assuming a PAH content of 0.001 percent of NADF) in the discharged cuttings would be 0.65 µg/g. This is well below the suggested NOAA ERL SQG of 4.022 µg/g; therefore, there is little potential for changes in sediment quality as a result of discharge of the treated cuttings to lead to toxicological impacts on benthic fauna. Deposited cuttings and additional (non-cutting) sediments will gradually mix with and overlay the cuttings over time, gradually returning the surficial sediment layer to a chemical state similar to existing conditions.

With respect to potential impacts from increased TSS concentrations, this effect will pose little risk to most benthos outside the immediate vicinity of the wells. Deposition above the 5 centimeters (2 inches) smothering threshold and TSS concentrations above the 35 milligrams per liter threshold will occur.

Considering the potential sources of impact from drill cuttings discharge above, all of which will extend over only a localized area in the immediate vicinity of the drill centers (i.e., within a portion of the **Direct AOI**), the intensity of impact on marine benthos from drill cuttings discharges is considered **Low**. While there will be periods curing the drilling and installation stage when sediment disturbance and cuttings deposition will not occur, the impact will be present throughout the drilling and installation stage, yielding a **Continuous** frequency rating. The impacts will persist for less than a year in aggregate, but drilling for the Project is expected to occur over multiple years, so the duration is considered **Long-term**. Applying the methodology described in Chapter 4, Methodology for Conducting the Environmental Impact Assessment, the magnitude of impact on sediment morphology from drill cutting deposition is considered **Small** (see Table 7.9.8)**.**

Table 7.9-8: Magnitude Rating for Potential Impacts on Marine Benthos from Drill Cuttings Discharge

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Drilling and Installation	Marine benthos - injury due to increased TSS concentrations and drill cuttings deposition	Direct AOI	Low	Continuous	Long-term	Small

Sensitivity of Receptor—Injury Due to Drill Cuttings Discharge

A study of benthic megafauna in a similar environment offshore Venezuela found that abundances in the vicinity of offshore development sites were significantly reduced after drilling. Highly mobile organisms returned to the area soon after drilling was completed. However, the species composition of immobile taxa was altered, with analyses suggesting that their density increased further away from areas that had been disturbed. The recovery potential of deepsea marine benthic biological resources, particularly immobile taxa, following cessation of drilling activities is unknown (Jones et al. 2012). Immobile individuals will likely experience injury or mortality in areas where drill cuttings deposition exceeds the above-referenced threshold; however, long-term impacts on the benthos population are not expected as a result of smothering of these individuals. Benthic macrofauna, including shrimp and red crabs, are capable of moving rapidly away from impacted areas, so these species will be expected to mostly avoid injury and mortality due to smothering. Giant marine isopods are comparatively less mobile and will therefore be comparatively more sensitive to potential impacts from smothering than crabs and shrimp.

With respect to toxicity impacts, contaminants deposited on the seafloor can pose risks to those deepsea benthos living within or in close association with bottom substrates that are unable to avoid exposure due to their relatively sedentary existence. These benthos perform functional roles in the deep-sea ecosystem, including sediment bioturbation and stabilization, organic matter decomposition, and nutrient regeneration, and serve as food sources to higher trophic levels; accordingly, toxicity could impact the population size as well as move up the food chain via bioaccumulation.

The most sensitive component of the benthic community to elevated TSS and contaminant concentrations is likely to be the sponges living on the HSFs. Due to their immobile adult life form, sponges located on the HSFs that will be impacted by the elevated TSS and contaminant concentrations will be unable to relocate to avoid impacts. Sponges tend to be slow-growing and long-lived, so impacted populations cannot be expected to recover quickly. Although the sponge-dominated community would be more sensitive to elevated TSS and contaminant concentrations than the rest of the benthic community in the Subsea PDA, the HSF community accounts for less than 2 percent of the seafloor within the Subsea PDA. Therefore, a small fraction of the overall benthic community would have an elevated sensitivity to elevated TSS and contaminants, so the overall sensitivity of marine benthos to physical injury from elevated TSS, toxicity, and drill cuttings deposition impacts was rated as **Medium**.

Impact Significance—Injury Due to Drill Cuttings Discharge

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on marine benthos associated with injury from discharge of drill cuttings is considered **Minor**.

7.9.3.4. Characterization of Impacts—Injury or Disturbance Due to FPSO and SURF Installation

Magnitude of Impact—Injury or Disturbance Due to FPSO and SURF Installation

The shallow sediment layer will be disturbed during installation of subsea infrastructure (SURF and FPSO mooring structures) on the seabed. In addition to disturbance of the habitat, individual benthic organisms are likely to be crushed, dislocated from the substrate (immobile organisms), or dismembered as a result of installation activities. As indicated in Table 7.9-9, which summarizes the area that will be disturbed by installation of various infrastructure components, approximately 80 hectares (approximately 198 acres, incorporating a 50 percent contingency factor) will be subject to essentially one-time disturbance by the installation activities. The use of anchors by vessels other than the FPSO is not expected; other vessels will use dynamic positioning to maintain station offshore, so no anchoring-related impacts will occur as a result of the Project apart from the 7.2 hectares (17.7 acres) of seabed disturbance associated with the FPSO.

Table 7.9-9: Area of Benthic Habitat Disturbed by FPSO and SURF Subsea Infrastructure Installation

Equipment	Quantity	Unit Area / Width	Subtotal (m^2)
Trees	43	21 m^2	903
Flying Leads	10,844 meters	1-meter width	10,844
Production Manifolds	5	135 m^2	675
Production Flowline Structures	17	100 m^2 / 12m	1,700
Water Alternating Gas Injection Manifolds	5	135 m^2	675
Gas Injection Distribution Manifold	1	135 m^2	135
Water Injection Pipeline Structures	7	100 m^2 / 12m	700
Gas Injection Pipeline Structures	12	100 m^2/ 12m	1,200
Gas Injection Line	29,231 meters	3-meter width	87,694
Production Line	56,100 meters	3-meter width	168,300
Umbilical Line	32,804 meters	3-meter width	98,412
Water Injection Line	29,268 meters	3-meter width	87,803
UTA/SDU/EDUs mudmats	10	72 m^2	720
UTA only mudmats	5	40 m^2	400
FPSO Anchor Piles and Chains	22	250 m^2	5,500
FPSO Mooring Leg Prelay [a]	22	3,000 m^2	66,000
		Subtotal	531,661
	Total with approximately 50% contingency		797,500

[a] The mooring legs will be laid on the seafloor prior to arrival of the FPSO, but once the FPSO arrives on station in the PDA it will be connected to the mooring legs, which will suspend the mooring legs in the water column. Therefore, most of the 66,000 m^2 (16.3 acres) of benthic habitat impacts associated with the mooring legs will be temporary.

The mortality of benthos, particularly immobile taxa, which are directly contacted during installation of subsea infrastructure within this area is anticipated to be high. Although some organisms will survive, they may be left with injuries that may impair their survival by making them prone to infection or vulnerable to predators. In addition, the population structure in the specific disturbance areas may temporarily change as more motile benthos taxa enter the disturbed area to scavenge organisms that did not survive. However, this impact will only occur within a small percentage of the Subsea PDA (approximately 1 percent by area) or approximately 0.003 percent of the Stabroek Block. The impact will occur within a portion of the **Direct AOI**. Based on the discussion above, the intensity of impact on marine benthos is considered **Low**. The impact for each portion of the infrastructure will occur on a one-time basis, yielding an **Episodic** frequency rating. The duration for each impact will be **Short-term**. Applying the methodology described in Chapter 4, Methodology for Conducting the

Environmental Impact Assessment, the magnitude of impact on sediment morphology from drill cutting deposition is considered **Negligible** (see Table 7.9-10).

Table 7.9-10: Magnitude Ratings for Potential Impacts on Marine Benthos

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Drilling and Installation	Injury or disturbance due to FPSO and SURF installation	Direct AOI	Low	Episodic	Short-term	Negligible

Sensitivity of Receptor—Injury or Disturbance Due to FPSO and SURF Installation

The sensitivity of the marine benthos population to FPSO and SURF installation impacts is considered **Low**. While the mortality rate of immobile taxa individuals from physical disturbance resulting from installation of the subsea infrastructure will be high, the population is not anticipated to be sensitive to the reduction in individuals within the limited area affected.

Impact Significance—Injury or Disturbance Due to FPSO and SURF Installation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on marine benthos associated with injury or disturbance due to FPSO and SURF installation is considered **Negligible**.

7.9.3.5. Characterization of Impacts—Presence (and Abandonment) of Subsea Infrastructure

Magnitude of Impact—Presence (and Abandonment) of Subsea Infrastructure

As described in Section 2.11, End of Payara Operations (Decommissioning), at the end of operations some subsea infrastructure, including the SURF equipment that is connected to the FPSO (e.g., risers, umbilical), SURF equipment sited on the seafloor, and FPSO mooring system, may be disconnected and abandoned in place on the seafloor in accordance with standard industry practice, consistent with the decommissioning plan. This would constitute an irreversible loss of natural, soft, bottom habitat within the collective footprint of these structures, but some species of benthos may colonize this hard substrate or be attracted to it as an artificial reef, as found in shipwrecks in the Gulf of Mexico (Kilgour and Shirley 2008). This will only occur within the immediate footprint of the abandoned infrastructure and is expected to affect a relatively small number of organisms. This positive impact is also relevant for the production operations stage, as benthic organisms will have the opportunity to colonize elements of subsea infrastructure that remain stationary through the production operations stage. These positive impacts will be temporary for any infrastructure that is removed at the time of decommissioning.

The addition of small amounts of hard substrate will likely increase the diversity of the local benthic community as species that require hard substrate colonize the area where none existed before, but this must be balanced with the loss of soft substrate that will continue to be unavailable within the footprint of the subsea infrastructure. While these effects will occur over a small area of the PDA, the potential net effect on marine benthos is considered **Positive** (see Table 7.9-12).

Sensitivity of Receptor—Presence (and Abandonment) of Subsea Infrastructure

The sensitivity of the marine benthos to this impact is considered **Low**, as only a small number of organisms will be impacted and those are species that are accustomed to colonizing hard substrate, in an area where this type of surface is not common.

Impact Significance—Presence (and Abandonment) of Subsea Infrastructure

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on marine benthos from the presence and abandonment of subsea infrastructure is considered **Positive**.

7.9.4. Mitigation Measures—Marine Benthos

Based on the **Negligible** significance of potential marine benthos impacts, no mitigation measures are proposed. Table 7.9-11 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.9-11: List of Embedded Controls and Monitoring Measures

Embedded Controls
When NADF is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with International Maritime Organization (IMO)/International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 mg/L on a daily basis or 29 milligrams per liter (mg/L) on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals.
Measure residual chlorine concentration of sewage discharges form the FPSO monthly to ensure it is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to ensure that there are no floating solids or discoloration of the surrounding waters.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Implement a chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes: • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including:

– Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
Ensure wastewater released from the onboard sewage treatment plant complies with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.
Ensure there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge.
Treat bilge water in accordance with MARPOL to ensure compliance with an oil in water content of less than 15 ppm as applicable.
Monitoring Measures
Prior to and post-drilling, an ROV will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to ensure that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NABF shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C at 100 meters (~328 feet) from point of discharge.
Utilize load monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Monitor chlorine concentration of treated sewage discharges.
Perform daily visual inspection of discharge points to ensure absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to ensure compliance with 15 ppm MARPOL limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.9-12 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine benthos. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment.

**Table 7.9-12: Summary of Potential Pre-Mitigation and Residual Impacts—
Marine Benthos**

Stage	Potential Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling	Smothering from deposition, filter fouling from elevated TSS concentrations, and/or toxicity impacts	Small	Medium	Minor	None	Minor
SURF/FPSO Installation	Injury or disturbance	Negligible	Low	Negligible	None	Negligible
Production Operations Decommissioning	Creation of artificial substrate	Not Rated (Positive)	Low	Positive	None	Positive

7.10. Ecological Balance and Ecosystems

7.10.1. Administrative Framework—Ecological Balance and Ecosystems

Table 7.10-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on ecological balance and ecosystems.

**Table 7.10-1: Legislation, Policies, Treaty Commitments, and Industry Practices—
Ecological Balance and Ecosystems**

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a supportive mechanism cognizant of the national goals for wildlife protection, conservation, management, sustainable use, and external trade.
International Agreements Signed/Acceded by Guyana		
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection for the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992 and ratified in 1994.

Title	Objective	Relevance to the Project
Protocol on Specially Protected Areas and Wildlife	Protocol supplementing and supporting the Cartagena Convention. Requires signatories to adopt an ecosystem approach to conservation. Provides mechanism for compliance with the Convention on Biological Diversity.	Elaborates on the wildlife goals established in the Cartagena Convention and Convention on Biological Diversity. Guyana acceded and ratified in 2010.
International Convention for the Prevention of Pollution from Ships	Regulates various forms of marine pollution, including oil and fuel, noxious liquid, hazardous substances, sewage, garbage, air emissions, and ballast water.	Impacts the handling and disposition of controlled substances from the drill ships, FPSO, and support vessels. Guyana acceded in 1997.

7.10.2. Existing Conditions—Ecological Balance and Ecosystems

In cooperation with the University of Rhode Island, the U.S. National Oceanic and Atmospheric Administration developed the Large Marine Ecosystem (LME) concept as a model to assess and manage ecological functions at the regional scale. LMEs are defined as relatively large areas of ocean space of approximately 200,000 square kilometers (20,000,000 hectares or approximately 80,000 square miles) or greater. These areas are adjacent to continents in coastal waters where primary productivity is generally higher than in open ocean areas. The PDA is located in the northwestern portion of the North Brazil Shelf LME, which comprises the coastal waters adjacent to northeastern South America from the eastern edge of the Caribbean Sea to the Parnaiba River in Brazil (see Figure 7.10-1). Its width varies, but it extends roughly 500 kilometers (approximately 300 miles) off the coast of Guyana (Marineregions.org 2005).

The Project is also within the Amazonian-Orinoco Influence Zone, an Ecologically or Biologically Significant Area that encompasses the offshore waters of eastern Trinidad, Guyana, Suriname, French Guiana, and northern Brazil, and borders the shoreline from the Orinoco River in the north to the Amazon River in the south (Secretariat of the Convention on Biological Diversity [Secretariat] 2014). Ecologically or Biologically Significant Areas are identified on the basis of the following seven criteria: (1) uniqueness or rarity; (2) special importance for life history stages of species; (3) importance for threatened, endangered, or declining species and/or habitats; (4) vulnerability, fragility, sensitivity, or slow recovery; (5) biological productivity; (6) biological diversity; and (7) naturalness. According to the Secretariat, which designated the Amazonian-Orinoco Influence Zone in 2014, the zone's uniqueness and biological productivity are driven largely by the influence of freshwater inputs from the Amazon River and the nutrients it carries, which extend north and west across the coast of northern South America to the Orinoco River delta in Venezuela. As described in Sections 7.3, Coastal Wildlife; 7.5, Marine Mammals; 7.7, Marine Turtles; and 7.8, Marine Fish; the Amazonian-Orinoco Influence Zone is important for specific life history stages of several species (several of which are special status species) including colonial seabirds, marine mammals, marine turtles, and fish. Plankton plays an important role in the functioning of marine ecosystems serving at the base of the pelagic food web (Roemmich and McGowan 1995). Planktonic organisms have a direct link with fish (even if this link may only exist during the relatively short period when pelagic fish are mainly planktivorous) because they represent a major source of energy (Cushing 1997, in Beaugrand 2005).

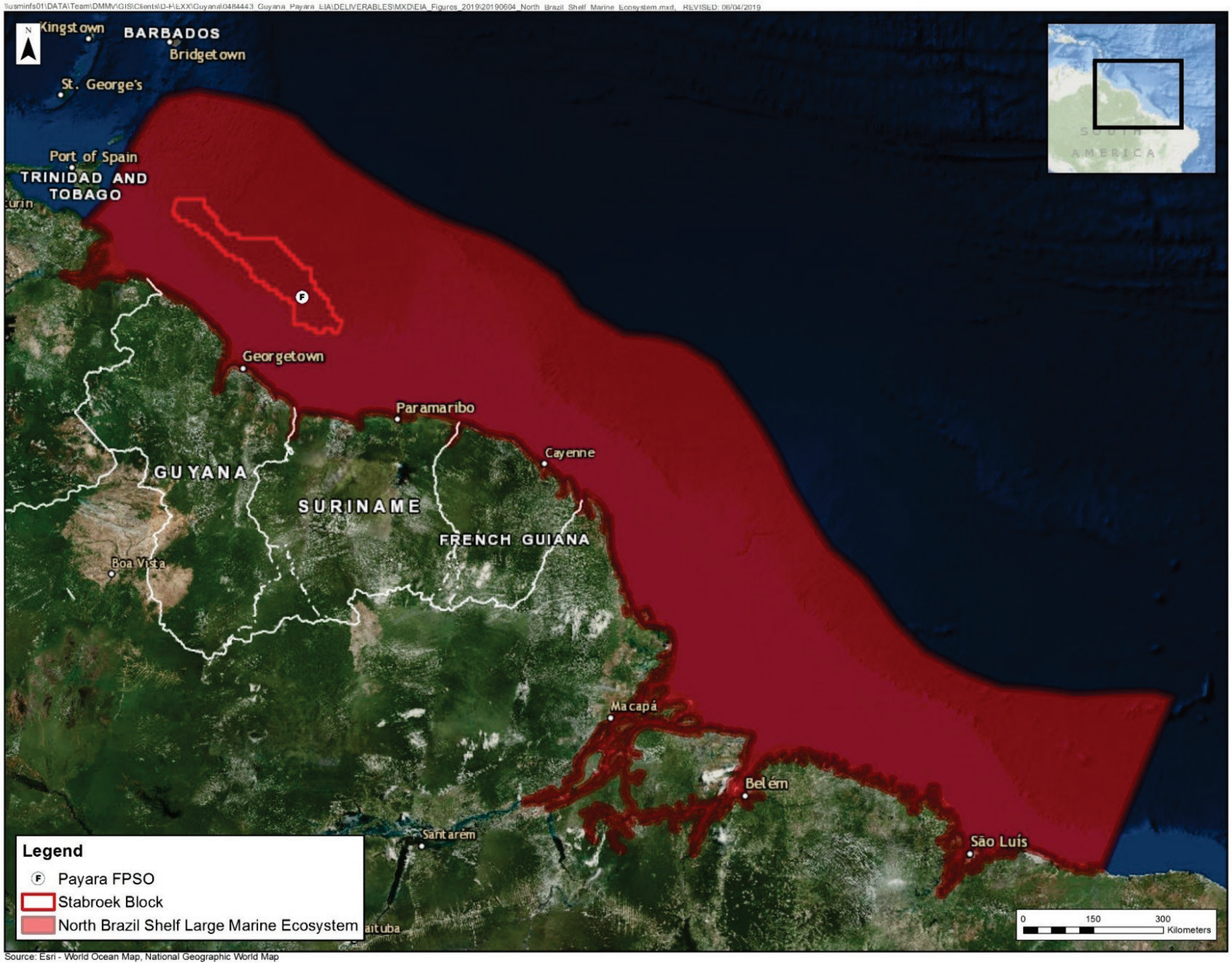


Figure 7.10-1: The North Brazil Shelf Large Marine Ecosystem

The plankton community is also highly influenced by hydro-climatic forces such as currents, temperature, solar radiation, and bioavailability of marine nutrients, so it is the first trophic[40] level at which physical oceanographic and climatic factors are integrated into the pelagic food web.

An EEPGL-commissioned survey of ichthyoplankton[41] in nearshore and offshore waters of the Indirect AOI in 2018 and 2019 (Appendix N, Marine Fish Study Interim Report—Dry Season 2018–2019) revealed that the region provides valuable habitat for various early life stages of fish. A preliminary taxonomic analysis of 17 samples collected during this study identified over 8,000 marine organisms encompassing at least 151 taxa[42]. Over sixty percent of the catch was from the Engraulidae (anchovy) and Sciaenidae (drum or croaker) fish families. Broadband anchovy (*Anchoviella lepidentostole*), red-eye round herring (*Etrumeus teres*), and acoupa weakfish (*Cynoscion acoupa*) were the most abundant fish species identified. Some representative larval fishes from the survey are depicted in Figure 7.10-2. There were slightly more marine organisms collected at the nearshore sample stations than at the offshore stations, although taxa richness was higher at the offshore stations. The offshore stations were also more homogeneous in terms of the number of taxa at each station, as compared to the nearshore stations. It is not known whether these apparent differences between the offshore and nearshore stations represent a seasonal or permanent phenomenon, but as described in Section 6.4, Marine Water Quality, the Guiana Current is known to move seasonally, oscillating between offshore and inshore alignments, and intermittently producing eddies and loop currents that separate from the main current. Off Brazil, researchers have reported that the greatest concentration of larvae varied from nearshore to offshore depending on the season, and temperature can also play a major role in plankton distribution. In light of the dynamic nature of the Guiana Current and the influence that macro-oceanographic factors have on plankton distribution, it is likely that the abundance and distribution of plankton across the North Brazil LME (including both the Direct and Indirect AOIs) varies over time. This expected variability notwithstanding, the limited data available indicate that Guyana's marine ichthyoplankton community is similar to that of other nearby regions (e.g., Brazil; de Macedo-Soares et al. [2014]) in terms of relative abundance, but possibly more diverse in terms of the number of taxa than other regions within the western Atlantic basin such as the Gulf of Mexico (Ditty 1986; Espinosa-Fuentes et al. 2013).

7.10.2.1. Marine Nutrient Cycle

The three most important nutrients in the marine nutrient cycle are nitrogen, phosphorous, and silicon (Nihoul and Chen 2008). The primary source of all of these nutrients in the marine food web is phytoplankton, which assimilate the nutrients from the surrounding seawater. Nitrogen and phosphorous are essential nutrients to all plant life, and silicates enter the marine nutrient cycle largely through diatoms, a specific class of phytoplankton that construct hard silicate exoskeletons.

[40] Relating to a specific rank or position in the food chain

[41] Ichthyoplankton are the eggs and larvae of fish.

[42] The term "taxa" refers to a group of one or more populations of an organism or organisms seen by taxonomists to form a unit, such as a family or genus. The current taxonomic hierarchy has eight ranks from general to specific: domain, kingdom, phylum, class, order, family, genus, and species.

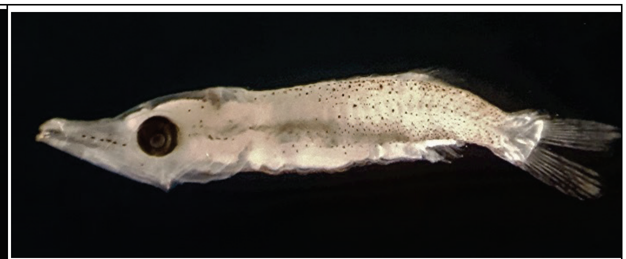
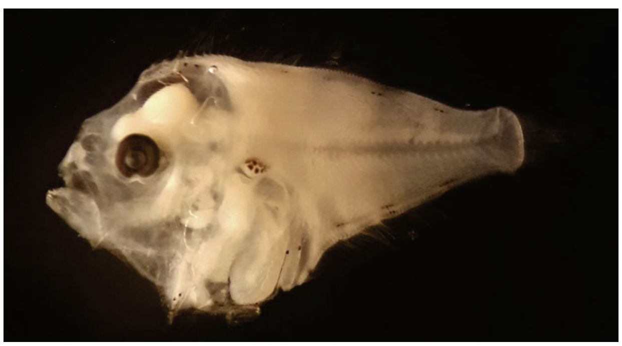
	
Larval king mackerel (*Scomberomorus cavalla*)	**Larval guachanche barracuda (*Sphyraena guachancho*)**
	
Larval snapper (*Lutjanus* sp.)	**Larval horse-eye jack (*Caranx latus*)**
	
Larval flounder (*Syacium* sp.)	**Juvenile whitemouth croaker (*Micropogonias furnieri*)**
	
Larval little tunny (*Euthynnus alletteratus*)	**Larval skipjack tuna (*Katsuwonus pelamis*)**

Figure 7.10-2: Representative Species of Ichthyoplankton from the Indirect AOI

The LME concept was initially based on differences in primary productivity between coastal and open ocean waters (URI 2018). The 66 LMEs that have been delineated are placed in one of five productivity categories, from Very Low to Very High. The North Brazil Shelf LME is in the Highly Productive category (indicating more than 300 grams of carbon produced per square meter of ocean surface per year) and daily primary productivity rates can occasionally exceed 8 grams of carbon per square meter of ocean surface per year in the LME, owing to large nutrient inputs from the Amazon Basin via the Guiana Current as well as complimentary inputs from smaller rivers that drain the Guiana Shield (Heileman 2009). High turbidity, particularly near the coast in waters directly influenced by these rivers, is both a function of the high nutrient load and a control on the primary production that these nutrients promote. As such, primary productivity has been found to be highest in the transition zone between nutrient-rich coastal waters with low sunlight transmission and clearer offshore waters where light is transmitted more readily but nutrients are comparatively scarcer (Heileman 2009).

7.10.2.2. Gene Flow

Marine environments (particularly open-ocean environments such as the Stabroek Block) are often considered homogenous across large geographical distances. Consistent with this view, several studies have shown significantly lower genetic differentiation among populations of marine fish species as compared to freshwater fishes. Based on observed rates of genetic differentiation between generations, genetic exchange between marine fish populations has been estimated to occur at 10 to 100 times the rate of exchange in freshwater populations (Ward et al. 1994). Nevertheless, since the late 1990s, studies have increasingly documented genetic differentiation among populations of marine organisms. Genetic boundaries between populations tend to occur along geomorphic and current boundaries (Ruzzante et al. 1998; Nielsen et al. 2003; Johannesson et al. 2006). Genetic exchange across large expanses of open ocean is aided by the prevalence of planktonic early life stages in numerous taxa.

Several studies of marine biota have been conducted within or in the vicinity of the PDA in recent years, including studies of marine mammals, turtles, fish, and benthos, and none have detected the presence of endemic species. In 2016, environmental DNA was collected from sediment and seawater samples during a baseline survey of the Liza-1 Field. No regionally endemic species were reported. These results are consistent with the concept that genetic isolation is much rarer in the open ocean than on land (CEGA 2016).

7.10.2.3. Biodiversity

Although the marine LME concept was initially based on primary productivity, one of the most readily apparent characteristics of a marine LME is the biodiversity it contains. Detailed information on the biodiversity aspects of the Stabroek Block are provided in Section 7.4.2, Existing Conditions—Seabirds; Section 7.5.2, Existing Conditions—Marine Mammals; Section 7.7.2, Existing Conditions—Marine Turtles; Section 7.8.2, Existing Conditions—Marine Fish; and Section 7.9.2, Existing Conditions—Marine Benthos.

7.10.3. Impact Assessment—Ecological Balance and Ecosystems

This section addresses the potential impacts of planned Project activities on ecological balance and ecosystems. Although there is no universally accepted definition of key ecological functions (in generic terms or with respect to the North Brazil Shelf LME), they generally include such basic processes as nutrient cycling, gene flow, and maintenance of biodiversity. Therefore, these ecological processes were identified as potential ecological/ecosystem receptors.

7.10.3.1 Relevant Project Activities and Potential Impacts

The Project's potential ecosystem-level impacts are indirect impacts that will potentially occur as a result of direct impacts on specific abiotic and biotic components of the larger ecosystem. All planned Project activities that could affect the physical or biological attributes of the Project AOI are broadly relevant to an assessment of impacts on ecological balance and ecosystems because their associated potential impacts will occur within the North Brazil LME. Therefore, rather than focusing on individual Project activities and their separate impacts on specific ecosystem components, this section identifies key ecosystem components and functions, and assesses the ecosystem-level implications of the potential impacts identified in the resource-specific impact assessments discussed in prior sections of Chapter 6 and Chapter 7 that could potentially impact those key components and functions.

Many of the embedded controls identified in Section 2.13, Embedded Controls, will serve to reduce the magnitude of potential impacts on one or more physical, biological, or chemical attributes of the ecosystem, and will therefore play a role in reducing the initial magnitude of potential impacts on ecological balance and ecosystems. On the basis of the definitions described above and the embedded controls described in other relevant sections of the EIA, the magnitudes of the various potential impacts on ecological balance and ecosystems are discussed below.

7.10.3.2 Magnitude of Impact—Ecological Balance and Ecosystems

The assessment of the Project's magnitude of potential impacts on ecological balance and ecosystems from planned Project activities is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on ecological balance and ecosystems is defined according to the definitions provided in Table 7.10-2. The following paragraphs discuss the characteristics of each of the potential impacts assessed and the resultant magnitude ratings. These are summarized in Table 7.10-3.

Table 7.10-2: Definitions for Intensity Ratings for Potential Impacts on Ecological Balance and Ecosystems

Criterion	Definition
Intensity	Negligible: No measureable ecosystem-level changes.
	Low: Changes are perceptible but affect only a small number of species within the ecosystem, and only at one trophic level.
	Medium: Changes are perceptible and affect many species within the ecosystem, at more than one trophic level.
	High: Changes affect numerous species throughout the food web, such that the basic trophic and biodiversity characteristics of the ecosystem are irrevocably altered.

Changes in the Marine Nutrient Cycle

The Project could potentially indirectly impact the marine nutrient cycle through its impacts on marine water quality, which could impact phytoplankton growth and in turn induce further impacts through the marine food web. As discussed in Section 6.4.3, Impact Assessment—Marine Water Quality, planned activities of the Project are predicted to have negligible impacts on water quality, and these potential impacts are predicted to be limited to a relatively small, localized mixing zone around the FPSO and other Project vessels with routine discharges (these will have even smaller zones of influence compared to that of the FPSO). These potential localized impacts are likely to change the species composition of the phytoplankton community to species that are (in the case of FPSO-related impacts) tolerant of elevated water temperatures, and this may increase rates of photosynthesis within the mixing zone; however, based on the negligible significance of potential marine water quality impacts, and the very small portion of the North Brazil Shelf LME that will be exposed to these potential impacts, the Project is predicted to have little if any measureable ecosystem-level impacts on nutrient cycling. On this basis, the intensity of impacts on the marine nutrient cycle is considered **Negligible** during all Project stages. These impacts will occur on an essentially continuous basis in the PDA during their respective stages of activity, so the frequency of this impact is considered **Continuous** for all Project stages. The impacts associated with the FPSO will occur over the entire operational life of the Project (at least 20 years) and impacts associated with other vessels will all be greater than a year, so the duration of the impact for all stages is considered **Long-term**. Following the methodology in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of this impact is rated as **Negligible.**

Impacts on Gene Flow

Maintaining gene flow is critical to supporting the genetic diversity in marine biological populations, which in turn is an important factor in the general resilience and vigor of marine flora and fauna. Obstacles to efficient gene flow occur whenever physiochemical barriers to migration, breeding, or dispersal/colonization occur. Oceanic currents are a key driver of biological dispersal because many marine species spend all or part of their lives drifting as part of the plankton. A project could potentially have significant impacts on gene flow if it impacts large-scale current patterns, alters the geological boundaries of ocean basins, or prevents site-specific reproductive events (such as spawning aggregations) from occurring. The Project is not predicted to have any appreciable impact on regional current patterns that define the North Brazil Shelf LME, nor is it predicted to impact any site-specific reproductive activities that could be considered significant at a regional or ecosystem scale. On this basis, the intensity of impacts on the marine nutrient cycle is considered **Negligible** for all Project stages. These impacts will occur on an essentially continuous basis in the PDA during their respective stages of activity, so the frequency of this impact is considered **Continuous** for all Project stages. These impacts will occur over the entire life of the Project (at least 20 years), so the duration of the impact for all stages is considered **Long-term**. Following the methodology in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of this impact is rated as **Negligible.**

Impacts on Biodiversity

The Project is predicted to have numerous potential impacts of varying levels of significance on marine species, but is not expected to impact large-scale distribution of species or cause the loss of any species from within the North Brazil Shelf LME. Some benthic species may be locally displaced from the footprint of the FPSO and SURF seabed components and some pelagic species may be locally displaced from the surface mixing zone that will form around the FPSO liquid effluent discharges, but these potential impacts will be insignificant at the ecosystem scale. Additionally, there is no reasonable potential for the Project to cause the extinction or extirpation of any species from the North Brazil Shelf LME, or to measurably exacerbate any of the risk factors that have contributed to the listing of the special status species assessed in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species.

The greatest potential for affecting biodiversity in the LME is associated with the potential introduction of exotic species from ballast exchanges by export tankers visiting the LME during production operations. The global movement of ballast water is considered to be the largest transfer mechanism for marine non-indigenous species (Ruiz et al. 2005). Ballast water is water carried in ships' ballast tanks to improve vessel stability, balance, and trim; it is essential for the safe operations of oceangoing ships. It is taken onboard or discharged when cargo is unloaded or loaded, or when a ship needs extra stability in foul weather. When ships take on ballast water, aquatic plants and animals may also be entrained into the ballast tanks. These organisms are transported in the ballast tanks of the ships, and, upon being discharged, some non-native species may survive and establish themselves in the new environment if the habitat conditions are suitable. If the non-native species become invasive, they may result in ecological, economic, and public health impacts (MCA 2008). If the invasive species become dominant in the new environment, they can displace native species, change local/regional biodiversity, and affect local economies based on fisheries. In addition, these invasive species may also affect industries that withdraw coastal water and affect public health (EMSA 2017).

The Caribbean Invasive Alien Species Working Group, of which Guyana is a member, has identified one species, the green mussel (*Perna virdis*), as having been introduced to the Caribbean and South American coastal waters via ballast water (CIASNET 2010).

The Project has the potential to contribute to the spread of marine invasive species, as discharges of ballast water will be required for initial FPSO installation and for recurring tanker offloading during production operations. As discussed in Section 2.7.8.3, Ballast System, ballast water will be required for FPSO transit from the shipyard to the PDA. Once in the PDA, the unneeded ballast water from the FPSO may be discharged. EEPGL's planned ballast water management program will be consistent with international best practice, including provisions in the International Convention for the Control and Management of Ships' Ballast Water (IMO 2004). The initial FPSO ballast discharge will occur only during a limited time period during the installation stage. It is estimated that no more than 550,000 barrels of ballast water will be discharged from the FPSO into Guyanese waters (Table 6.4-7) during this stage. As an embedded control to reduce the potential impact of invasive species introduction, the ballast water taken on at the FPSO's point of origin will be exchanged (prior to arrival in Guyanese waters) with water from deep international waters. This practice is generally thought to reduce the likelihood of introducing invasive species to new coastal habitats because oceanic organisms are considered unlikely to colonize coastal habitats (Ruiz et al. 2005). This rationale is based on an assumption that coastal waters (where most ports are located) are sufficiently different from the open ocean in terms of salinity and physical habitat conditions such that most organisms from the coast will not be able to survive and colonize the open ocean, and vice versa. The environmental conditions at the offshore point where coastal ballast water is exchanged for oceanic water will likely be somewhat similar to the conditions in the PDA. This means that at least some organisms entrained in deeper oceanic waters and then discharged into the PDA will likely survive the event; however, this also means that these organisms will likely include many of the same open-ocean species that occur naturally in the PDA.

During production operations, offloading tankers will routinely discharge ballast water in Guyanese waters as oil from the FPSO is loaded. It is estimated that a maximum of 1,200,000 barrels of ballast water (Table 6.4-7) will be discharged during each loading event. These ballast water discharges will be conducted in accordance with internationally recognized standards and in compliance with International Maritime Organization (IMO) requirements. The ecological effect will be similar to the effect of the ballast discharge from the FPSO in the sense that organisms from the open ocean could be discharged at the FPSO. However, ballast discharges from tankers will occur routinely during the production phase, as compared to the one-time FPSO ballast discharge during the installation phase. Accordingly, the focus of the impact assessment for this aspect is on the production operations stage.

On the basis of the above discussion, the intensity of impacts on biodiversity is considered **Low** during the production operations stage. The potential for an invasive species introduction occurring will persist over the life of the production operations stage and could affect an area beyond the PDA and into portions of the **Indirect AOI**; however, based on the expectation that such an introduction would be infrequent, the frequency is considered **Episodic** in nature. In the event that an introduction does occur and the introduced species becomes established, the associated impacts will occur over the entire operational stage of the Project and potentially beyond (at least 20 years), so the duration of the impact for this stage is considered **Long-term**.

Following the methodology in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of this impact is rated as **Small.**

Table 7.10-3: Magnitude of Impact-Ecological Balance and Ecosystems

Stage	Receptor- Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
All Project Stages	Changes in marine nutrient cycle, resulting in localized and temporary changes in phytoplankton species distribution	Direct AOI	Negligible	Continuous	Long-term	Negligible
	Impacts on gene flow	Direct AOI	Negligible	Continuous	Long-term	Negligible
Production Operations	Introduction of invasive species via ballast water	Indirect AOI	Low	Episodic	Long-term	Small

7.10.3.3. Sensitivity of Receptor—Ecological Balance and Ecosystems

The assessment of the ecosystem as a broad receptor of indirect impacts from the Project is based on the sensitivity of the receptor to the initial direct impact that will drive the ecosystem-level impacts. Ecosystem level sensitivity is defined according to the definitions provided in Table 7.10-4.

Table 7.10-4: Definitions for Receptor Sensitivity Ratings for Impacts on Ecological Balance and Ecosystems

Criterion	Definition
Sensitivity	Negligible: Biological impacts affect receptors with no specific value or importance attached to them.
	Low: Biological impacts affect species and sub-species of Least Concern on the IUCN Red List (or not meeting criteria for medium or high value), or without specific anatomical, behavioral, or ecological susceptibilities to Project-related impacts.
	Medium: Biological impacts affect species listed as Vulnerable, Near Threatened, or Data Deficient on the IUCN Red List, species protected under national legislation, nationally restricted range species, nationally important numbers of migratory or congregatory species, species not meeting criteria for high value, and species vital to the survival of a medium value species.
	High: Biological impacts affect species on IUCN Red List as Critically Endangered or Endangered. Species having a globally restricted range (e.g., fauna having a distribution range less than 50,000 square kilometers (20,000 square miles), internationally important numbers of migratory, or congregatory species, key evolutionary species, and species vital to the survival of high value species.

Based on the sensitivity rating definitions above, the receptor sensitivity for the ecosystem is considered **Low** for impacts on nutrient cycling and gene flow, and **Medium** for impacts on biodiversity. The ratings for nutrient cycling and gene flow are principally due to the assimilative capacity of the LME afforded by its large size, and the assumption that genetic exchange between the North Brazil LME and adjacent LMEs is robust due to the general lack of obstacles to gene flow in the ocean. The sensitivity rating for impacts on biodiversity is principally due to the numerous species in the LME that are listed as Data Deficient by the IUCN, and the fact that the plankton community (which forms the basis of the marine food web) will likely be the first element of the ecosystem to be impacted by introduction of non-indigenous species.

7.10.3.4. Impact Significance—Ecological Balance and Ecosystems

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance ratings for potential impacts on ecological balance and ecosystems ranges from **Negligible** to **Minor**.

7.10.4. Mitigation Measures—Ecological Balance and Ecosystems

The embedded controls integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on ecological balance and ecosystems. Table 7.10-5 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.10-5: List of Embedded Controls and Monitoring Measures

Embedded Controls
Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with IMO/International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 milligrams per liter (mg/L) on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals
Measure residual chlorine concentration of sewage discharges form the FPSO monthly to ensure it is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to ensure that there are no floating solids or discoloration of the surrounding waters.
Abide with IMO (2004) guidelines including the International Convention for the Control and Management of Ship's Ballast Water and Sediments, with the exception of Regulation D-2 (Ballast Water Performance Standard) while the FPSO is on station, and abide with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78).
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Monitoring Measures
Prior to and post-drilling, an ROV will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to ensure that end of well maximum weighted mass ratio averaged over all well sections drilled using NABF shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C at 100 meters (approximately 328 feet) from point of discharge.

Use load monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Monitor chlorine concentration of treated sewage discharges.
Perform daily visual inspection of discharge points to ensure absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to ensure compliance with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.10-6 summarizes the assessment of potential pre-mitigation and residual Project impacts on ecological balance and ecosystems. The significance of impacts was rated based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, and the resource-specific methodology described above.

Table 7.10-6: Summary of Potential Pre-Mitigation and Residual Impacts—Ecological Balance and Ecosystems

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Changes in marine nutrient cycle, resulting in localized and temporary changes in phytoplankton species distribution	Low	Negligible	Negligible	None	Negligible
	Impacts on gene flow	Low	Negligible	Negligible	None	Negligible
Production Operations	Introduction of invasive species via ballast water	Medium	Small	Minor	None	Minor

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8. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIES—SOCIOECONOMIC RESOURCES

For the purposes of this EIA, "socioeconomic environment" is intended to encompass the human aspects of the affected environment, with specific emphasis on the social and economic characteristics of society that could be affected by the Project. This section identifies and assesses the potential impacts on the existing socioeconomic environment in the Project Area of Influence (AOI), including community health and cultural heritage, as a result of Project-related activities. The methodologies specific to the assessment of socioeconomic impacts build upon the general assessment methodology outlined in Chapter 4, Methodology for Preparing the Environmental Impact Assessment. This general approach and methodology have been adapted for use in evaluating impacts on socioeconomic resources/receptors. The evaluation criteria used to determine impact magnitude and sensitivity for specific socioeconomic resources/receptors are summarized in Chapter 4, Methodology for Preparing the Environmental Impact Assessment.

Stakeholder engagement is critical to a robust impact assessment process. A range of stakeholders were interviewed to deepen understanding of the existing socioeconomic conditions. The information gathered was also used to inform the magnitude and sensitivity designations used in this assessment. The following socioeconomic resources/receptors with the potential to be impacted by the Project within the Project AOI are assessed in this section:

- Economic conditions
- Employment and livelihoods
- Community health and wellbeing
- Marine use and transportation
- Social infrastructure and services
- Waste management infrastructure and capacity
- Land use
- Ecosystem services
- Indigenous peoples
- Cultural heritage

Because the Project's primary planned activities are located approximately 207 kilometers (approximately 128 miles) northeast of the coastline of Georgetown, potential impacts on socioeconomic resources/receptors as a result of planned Project activities are expected to be limited. The following are the main planned Project activities with the potential to result in socioeconomic impacts within Guyana:

- Installation and operation of the Floating Production, Storage, and Offloading (FPSO) vessel and Subsea, Umbilicals, Risers, and Flowlines (SURF);
- Drilling of development wells;
- Government revenue generation from the Project;
- Project-related employment and procurement;

- Foreign Project worker presence in the Georgetown area;
- Project use of emergency and health services in the Georgetown area;
- Project-related road and air transportation activity in the Georgetown area;
- Project use of utilities and accommodations in the Georgetown area;
- Project use of waste management infrastructure in the Georgetown area; and
- Marine vessel transits between the Project Development Area (PDA) and shorebase facilities in Guyana and between the PDA and shorebase facilities in Trinidad (in Guyanese territorial waters).

The categories of receptors considered in the assessment of potential socioeconomic impacts from planned Project activities are outlined in Table 8-1, along with the rationale for their inclusion and the potential impacts that could affect them:

Table 8-1: Socioeconomic Receptors and Associated Potential Impacts from Planned Project Activities

Receptor	Rationale for Inclusion	Potential Impacts
General Guyanese population	The Project could have far-reaching economic impacts throughout the country, which could potentially affect all segments of the population, including in the hinterlands.	• Increased government revenues, potentially leading to increased social spending and investment throughout the country • Increased business activity and related employment
General population of Georgetown	The limited amount of time offshore-based foreign Project workers will be on shore will likely be spent in transit (e.g., to/from airports or hotels). Onshore-based foreign Project workers will principally reside in Georgetown, where they will interact with the local population and make use of the same resources and infrastructure as the local population.	• Changes to community dynamics, identity, and sense of safety/security • Increased risk of communicable disease transmission (see Section 8.3, Community Health and Wellbeing)
	Project procurement and Project worker spending level may result in higher demand for goods and services.	• Increased cost of living
	The Project may result in induced influx of job seekers from other areas of Guyana to the Georgetown area.	• Increased risk of communicable disease transmission • Increased competition for employment
	The Project may rely, in a very limited manner, on some medical and health facilities in the Georgetown area to address worker illness and injury.	• Decreased accessibility of medical and health services
Road users in Georgetown (both motorized and non-motorized [e.g., cyclists, pedestrians])	The Project will use existing roads for transporting workers, materials, equipment, and wastes to/from the shorebases and offices/residences.	• Increased traffic congestion • Increased risk of property damage and injury from vehicle accidents

Receptor	Rationale for Inclusion	Potential Impacts
Marine vessel operators in Georgetown Harbour and along the coast	The Project will involve transit of various marine vessels, such as support vessels and tugs, between the Georgetown-area shorebase facilities and the PDA.	• Increased marine traffic congestion (on the order of 1–3%) in Georgetown Harbour and coastal waters between Georgetown-area shorebase facilities and the PDA • Increased risk of marine accidents
Marine vessel operators in the vicinity of the PDA	The Project will establish marine safety exclusion zones around the FPSO, drill ships, and major installation vessels, precluding use of these areas for other activities such as deep-sea fishing.	• (Negligible) reduced availability of ocean areas for non-Project livelihood activities such as deep-sea fishing
Archaeology and heritage resources	The Project will disturb the seafloor in the process of drilling development wells, installing FPSO mooring components, and installing SURF components.	• Damage to underwater archaeological or heritage sites, if present

8.1. Socioeconomic Conditions

This section describes the existing socioeconomic characteristics of the Project AOI, with a focus on the shore zone, or coastal areas. It was developed based on secondary information contained in Project-related materials, socioeconomic reports and data obtained through government entities and other stakeholders, and other relevant data received from public sources. It is also based on information obtained directly from key informant interviews with members of national, regional, and local governments; civil societies and non-governmental organizations (NGOs); local community members; and other Project stakeholders. Specific stakeholder engagement information can be found in Section 4.5, Stakeholder Engagement.

8.1.1. Administrative Framework—Socioeconomic Conditions

Table 8.1-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on economic conditions.

Table 8.1-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Socioeconomic Conditions

Title	Objective	Relevance to the Project
Legislation		
Natural Resource Fund Act (2019)	Establishes the National Resource Fund to manage the natural resource wealth of Guyana for the present and future benefit of the people and for the sustainable development of the country. The act also outlines governance and oversight mechanisms of the fund.	Provides for revenues from the Project to be deposited into the fund and used to finance national development, including initiatives aimed at achieving the government's vision of an inclusive green economy.

Title	Objective	Relevance to the Project
Policies and Strategies		
Green State Development Strategy: Vision 2040 (2019)	Presents Guyana's national development policy for the next 20 years to achieve a green state. Aims to achieve development that provides an improved quality of life for Guyanese people derived from revenues earned from the country's natural resources (e.g., land, water, forests, minerals, oil, and gas).	Recognizes that revenues from the Project will be deposited into the Natural Resource Fund. Indicates that revenues from all of Guyana's natural resources will be used to modernize traditional sectors, maximize efficiency and investment opportunities in high growth sectors, invest in value-adding sectors, and ensure Guyanese have access to better opportunities.
Draft National Energy Policy of Guyana (2017)	Update of the 1994 National Energy Policy of Guyana. Reflects current national, regional, and international commitments. Addresses concerns related to the dependence on imported fossil fuels, the need to address the efficiency and sustainability of energy supply and demand, and considers the recent discovery of offshore petroleum reserves.	Outlines the government's priorities for the development of the oil and gas sector, including the establishment of a new regulatory agency for the sector; implementation of local content policy when completed; and establishment of a Sovereign Wealth Fund. Includes government plans for upgrading energy infrastructure including oil and gas pipelines; storage facilities; oil refineries; and marine transport for oil and gas.
Local Content Policy (under development)	Would provide for preferential treatment of Guyanese where capability exists; building local capacities for the sector; international partnerships to enable technology and knowledge transfer and access to investment opportunities; extending Guyanese participation to support national development; and leveraging the petroleum sector's strategic assets, and skills for the lateral development of other sectors.	Would provide government guidance on Guyanese participation in the petroleum sector. Expected to directly influence Guyanese service provision and employment in the sector. A draft of the Policy is under consideration by the government.

8.1.2. Existing Conditions—Socioeconomic Conditions

8.1.2.1. Administrative Divisions in Guyana

Guyana is divided into 10 administrative regions, pictured on Figure 8.1-1, which are overseen by Regional Democratic Councils (RDCs). These regions are further subdivided into 70 Neighbourhood Democratic Councils (NDCs) and 9 Town Councils (TCs) that are comprised of villages. Within the regions, there is a mixture of Community Development Councils (CDCs) for some villages, and Village Councils (VCs) in titled Amerindian villages. In titled Amerindian villages, the VCs are empowered by the Amerindian Act (2006) to act as village administrators and are comprised of the village leader (known as Toshao) and elected councilors. Elections are held in villages every 3 years to establish the VCs.

Figure 8.1-1: Guyana's Administrative Regions and Townships

In Guyana there is one city that serves as the capital (Georgetown) and nine other townships. In 2015, three of these townships were gazetted as new townships by the Ministry of Communities as part of an administrative decentralization effort. Decentralization continued in 2018 with Mahdia being gazetted by the Ministry of Communities as a township. Georgetown is administered by a mayor and City Council. The townships have mayors and councils. Georgetown and the nine townships serve as an administrative hub for government services, such as passports and driver's licenses. They also provide utilities and public services, such as water and sanitation and banking.

Of the 10 administrative regions, this EIA is focused on the shore zones or coastal areas in Regions 1, 2, 3, 4, 5, and 6. Together, Regions 2–6 account for 49 NDCs, 4 TCs, and 1 City Council in Georgetown. Within Region 1, the near-coastal area is comprised of 13 VCs/CDCs and 1 TC.

Region 1

- Father's Beach Community
- Manawarin Community
- Haimokabra Community
- Waramuri Community
- Santa Rosa Community
- Assakata Community
- Warapoka Community
- Three Brothers Community
- Mabaruma Town Council
- Aruka Mouth Community
- Morawhanna Community
- Smith's Creek Community
- Imbotero Community
- Almond Beach Community

Region 2

- Charity/Urasara
- Evergreen/Paradise
- Aberdeen/Zorg-en-Vlygt
- Anna Regina Town Council
- Annandale/Riverstown
- Good Hope/Pomona

Region 3

- Wakenaam (island)
- Leguan
- Mora/Parika
- Hydronie/Good Hope
- Greenwich Park/Vergenoegen
- Tuschen/Uitvlugt
- Stewartville/Cornelia Ida
- Hague/Blankenburg
- La Jalousie/Nouvelle Flanders
- Best/Klien/Pouderoyen

Region 4

- Georgetown
- Industry/Plaisance
- Better Hope/La Bonne Intention
- Beterverwagting/Triumph
- Mon Repos/La Reconnaissance
- Buxton/Foulis
- Unity/Vereeniging
- Haslington/Grove
- Enmore/Hope

Region 5

- Woodlands/Farm
- Hamlet/Chance
- Profit/Rising Sun
- Mahaicony/Abary
- Union/Naarstigheid
- Seafield/Tempie
- Bath/Woodley Park
- Woodlands/Bel Air
- Zeelust/Rosignol

Region 6

- Ordinance/Fort Lands No. 38
- Kintyre/No. 37
- Gibraltar/Fyrish
- Kilcoy/Hampshire
- Rose Hall Town Council
- Port Mourant/John
- Bloomfield/Whim
- Lancaster/Hogstye
- Black Bush Polder
- Good Hope/No. 51
- Macedonia/Joppa
- Bushlot/Adventure
- Maida/Tarlogie
- No. 52/No. 74
- Corriverton Town Council

8.1.2.2. Population Distribution

Most of Guyana's population is located in the six coastal regions; according to the 2012 national census (BSG 2002; BSG 2012), nearly half of the country's population lives in Region 4 (Demerara-Mahaica), which includes the capital city of Georgetown. Table 8.1-2 summarizes the distribution of population within the 10 regions in 2012, the last year for which complete national census data are available. According to the Bureau of Statistics, Guyana's next national census will commence in 2022 as to avoid conflicting with Guyana's General and Regional Elections. On an annual basis, the Bureau updates population projections using records of births, deaths, and migration, but these projections are not publicly released (ERM/EMC Personal Communication 10).

Table 8.1-2: Regional Population Distribution in Guyana

Region		Population 2002	Population 2012	Percentage Population Change Since 2002	Percent of Guyana's Total Population
1	Barima-Waini	24,275	27,643	+13.9%	3.7%
2	Pomeroon–Supenaam	49,253	46,810	-5.0%	6.3%
3	Essequibo Islands—West Demerara	103,061	107,785	+4.6%	14.4%
4	Demerara-Mahaica	310,320	311,563	+0.4%	41.7%
5	Mahaica—Berbice	52,428	49,820	-5.0%	6.7%
6	East Berbice—Corentyne	123,695	109,652	-11.4%	14.7%
7	Cuyuni-Mazaruni	17,597	18,375	+4.4%	2.5%
8	Potaro—Siparuni	10,095	11,077	+9.7%	1.5%
9	Upper Takutu—Upper Essequibo	19,387	24,238	+25.0%	3.2%
10	Upper Demerara—Berbice	41,112	39,992	-2.7%	5.3%
	Guyana	748,084	746,955	-0.6%	100.0%

Sources: BSG 2012; BSG 2002

Note: Each region's change in population should be weighted based on that region's percent of the total population; therefore, the sum of percentage population changes in each region do not add up to the total national percentage population change.

Population and other demographic information has not been historically collected or available at the NDC/CDC/VC/TC level; however, informal data collected from engagement with NDCs and CDCs/TCs by the Consultants in late 2017 and early 2018 (ERM/EMC 2018) and during 2019

(Appendix V, Interim Ecosystem Services Validation Data Summary) provide some estimates of the population ranges for coastal communities, as described below:

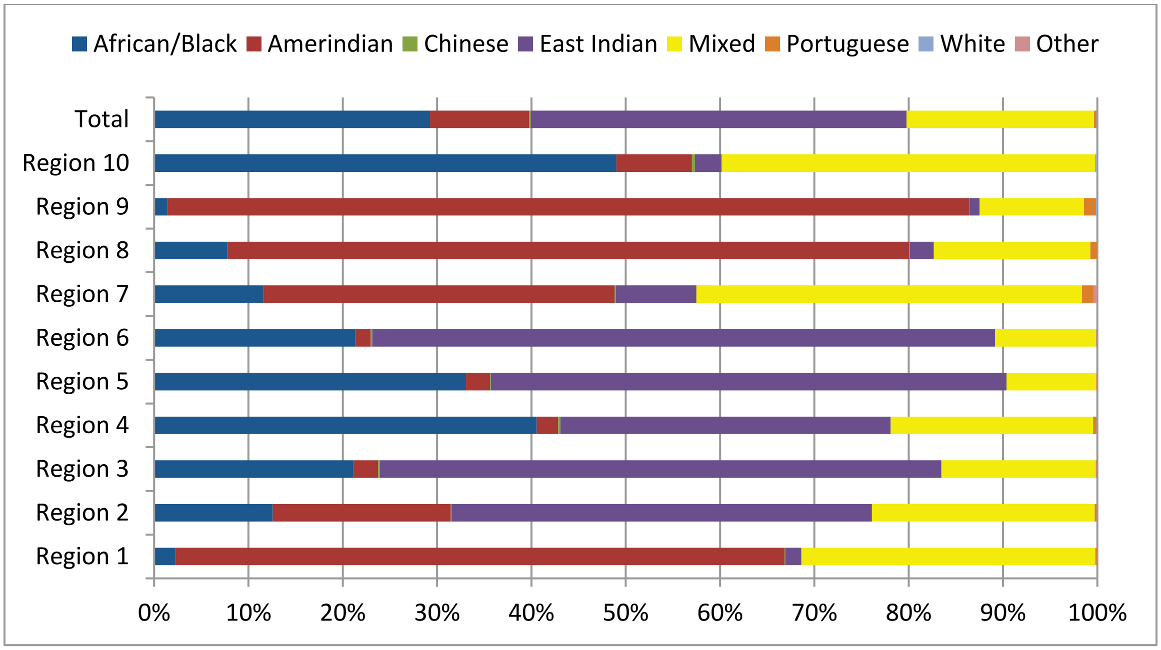
- Region 1: As of mid-2019, each CDC/VC/TC population ranges from approximately 50 to 500 people, with the exception of Father's Beach (23 people), Waramuri and Manawarin (approximately 2,000 and 2,500, respectively) and Mabaruma Town Council and Santa Rosa (approximately 8,000 and 10,500, respectively).
- Region 2: As of mid-2019, each NDC population ranges from approximately 6,000 to 10,900, with the exception of Anna Regina Town Council (approximately 22,000).
- Region 3: As of early-2018, NDCs have several thousand people each. The larger coastal NDCs range in population from Mora/Parika at approximately 10,000, to Best/Klien/Pouderoyen at approximately 20,000, and Tuschen/Uitvlugt and Stewartville/Cornelia Ida at approximately 30,000 each.
- Region 4: As of mid-2019, Georgetown's population is estimated at 132,000. The populations of Better Hope/La Bonne Intention, Industry/Plaisance, Haslington–Golden Grove, and Mon Repos/La Reconnaissance are estimated at 30,000, 25,000, 27,000, and 40,000, respectively. The other NDC populations range from 7,000 to 13,000.
- Region 5: As of mid-2019, Woodlands/Farm, Bath/Woodley Park, and Woodlands/Bel Air are estimated at approximately 20,000, 18,000, and 15,000, respectively. The other NDC populations average a few thousand each, up to an estimated 8,000.
- Region 6: As of early-2018, the Kilcoy/Hampshire NDC population is estimated at 30,000. Several other NDCs average in population between 10,000 and 15,000; most of the smaller NDCs have an average population of a few thousand each.

According to the data collected in 2019, many of the VC and CDCs in Regions 1 and some NDCs and TCs in Region 2 reported an increase in population over the past 2 years, which may be the result of an influx of returning Guyanese and native Venezuelans with Amerindian ties.

Ethnic Composition

Data from the 2012 national census (BSG 2012) indicate that the majority of the population is from two ethnic groups: East Indian descent (39.8 percent) and African descent (29.3 percent). These are followed by populations of mixed ethnicity (19.9 percent) and indigenous peoples who are referred to as Amerindians (10.5 percent). Other ethnicities, including Chinese, white, and Portuguese, collectively make up less than one percent of the population.

Figure 8.1-2 shows the ethnic composition of each region and indicates notable differences between interior and coastal regions and between regions that are highly rural versus more urban. The more populated and urban Regions 3, 4, 5, and 6 are dominated by populations of East Indian and African descent, followed by populations of mixed ethnicity. Amerindian population numbers in these regions are low. The majority residing in the more remote and rural Regions 1, 8, and 9 are of Amerindian ethnicity.



Source: BSG 2012

Figure 8.1-2: Regional Distribution of Ethnicity, 2012

Indigenous Peoples

See Section 8.10.2, Existing Conditions—Indigenous Peoples, for information on existing conditions for Indigenous Peoples.

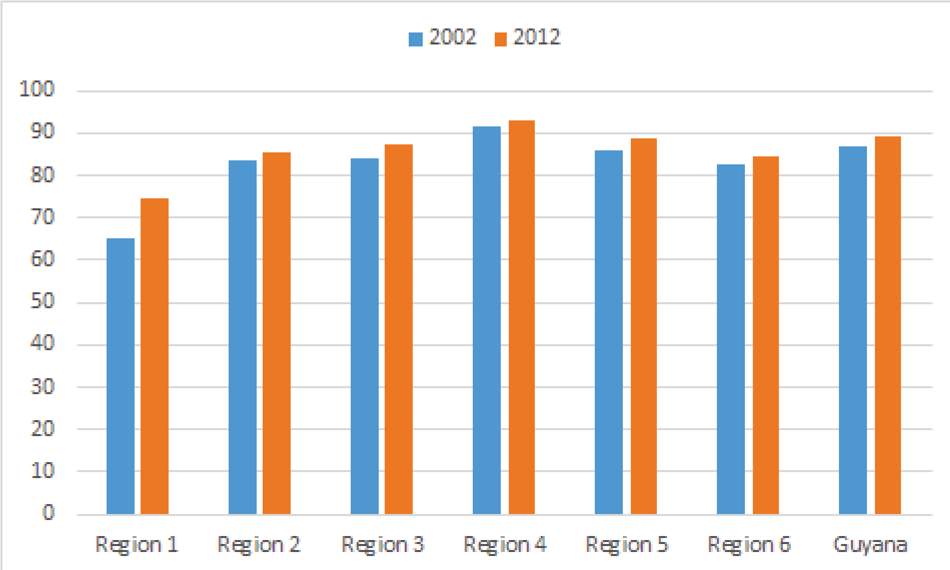
8.1.2.3. Education

Guyana's Constitution states that school attendance is compulsory up to the age of 15. Primary and secondary school are free. The Ministry of Education controls education budgets, policies, and standards, and administers these by district. The country is divided into 11 education districts, 10 of which correspond with the administrative regions; Georgetown makes up the eleventh district.

In the years 2009–2013, an average of 15 percent of the national budget, or approximately 4.7 percent of gross domestic product (GDP), was allocated to education (Ministry of Education 2014). In 2017, $43.1 billion Guyanese dollars (GYD) (approximately $208.2 million U.S. dollars [USD]), which makes up approximately 17 percent of the national budget, was allocated to the education sector (DPI Guyana 2016a; 2016b).

Literacy

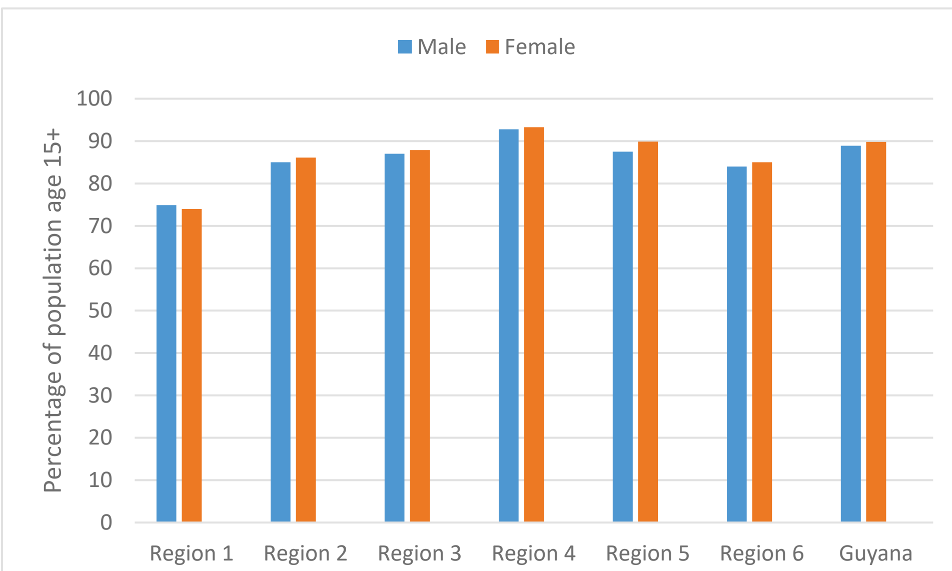
The adult literacy rate (defined as the percent of population age 15 and above that can read and write) increased by 2.5 percent between the 2002 and 2012 censuses. The lowest level of literacy occurs in Region 1, but the 2012 census showed considerable improvement (a 9.4 percent increase) over the rate measured in the 2002 census (BSG 2002; BSG 2012; see Figure 8.1-3).



Source: BSG 2012

Figure 8.1-3: Adult Literacy Rate, 2002 and 2012

Gender differences in literacy are minimal among the regions, with the female population showing a slightly higher rate of literacy than males across most of the coastal regions and the country as a whole (Figure 8.1-4).

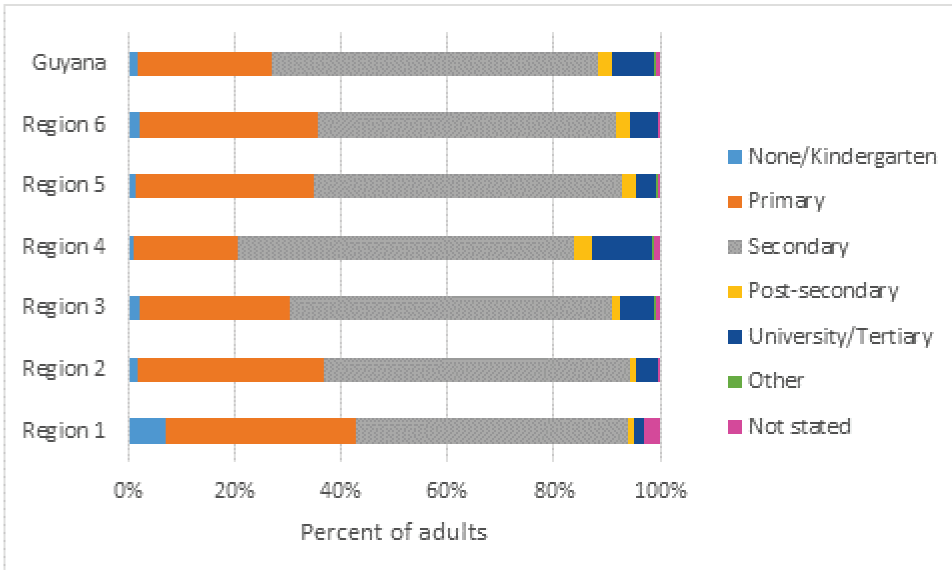


Source: BSG 2012

Figure 8.1-4: Adult Literacy Rate by Gender, 2012

Educational Attainment

Guyana has made progress in achieving universal primary education, but the education system still faces important access issues at the secondary level and quality issues across all levels of schooling. The percentage of children in Guyana attending secondary school was estimated at 84.5 percent in 2014 (World Bank 2016). Data in 2012 on the highest level of education attained by the adult population indicate that the majority of adults in Guyana at the time had attained the secondary level as their highest level (Figure 8.1-5). Of the coastal regions, educational attainment is lowest in Region 1.



Source: BSG 2012

Figure 8.1-5: Highest Educational Attainment Level, 2012

The levels of primary education for the indigenous population are typically lower than for non-indigenous groups of the population. In Amerindian communities, the attendance rate at primary schools has been reported to be 50 percent lower than the average for Guyana (Minority Rights International 2008). Further, only 53 of every 100 students in indigenous communities complete secondary school (UNICEF 2017). This is partly attributable to a shortage of infrastructure, utilities, and qualified teachers (Ministry of Education 2014) and to financial constraints (UNICEF 2017). Standardized teaching methods and curricula that limit appreciation for indigenous culture and values also contribute to lower than average attendance rates. While access to education in Amerindian communities continues to be limited, the stated government policy is to provide indigenous children with the same educational opportunities available to the rest of the population (Minority Rights International 2008).

8.1.2.4. Economic Conditions

Guyana was reclassified by the World Bank from a lower middle-income country to an upper middle-income country in 2016 (World Bank 2016). Guyana's economy grew by 4.1 percent in 2018, up from 2.1 percent growth performance in 2017. This increase was attributed to higher production of bauxite, livestock, forestry, and other crops, in addition to increased construction, manufacturing, and service activities. Furthermore, favorable commodity prices, greater expenditure in investments, and increased domestic demand also significantly influenced growth. However, not all sectors of the economy grew in 2018, as outputs of sugar, rice, gold, and fishing declined (Bank of Guyana 2019). Guyana's main sectors by contribution to GDP in 2018 are summarized in Table 8.1-3.

Table 8.1-3: Economic Sectors and Contribution to GDP at Current Basic Prices in 2018

Sector	Percent of GDP
Agriculture, Fishing, and Forestry	17.4%
Mining and Quarrying	20.39%
Wholesale and Retail Trade	12.8%
Transportation and Storage	7.33%
Construction	11.9%
Manufacturing	3.33%
Public Administration	8.97%
Information and Communication	4.23%
Financial and Insurance Activities	3.99%
Education	3.28%
Other Services	4.05%
Health and Social Services	1.60%
Electricity and Water	2.96%
Real Estate	1.04%

Source: Bank of Guyana 2019

Note: Percentages add to more than 100 (likely in part due to rounding) but have been verified by the Consultants to be as-reported in the referenced source.

Guyana relies heavily on trade, with exports totaling $272.14 billion GYD ($1.373 billion USD) in 2018, down from $297.95 billion GYD ($1.473 billion USD) in 2017 (Bank of Guyana 2019). The main export products for the country are sugar, rice, bauxite, gold, forest products, and fish (FAO 2015). In 2018, exports of sugar, rice, timber, and gold declined 44.1 percent, 7.5 percent, 6.9 percent, and 6.2 percent, respectively. The fisheries sector declined by 6.2 percent in 2018. However, exports of bauxite increased by 22.6 percent (Bank of Guyana 2019).

The investment climate and financial infrastructure in Guyana is underdeveloped, which means the country faces challenges in attracting investments and diversifying the economy. According to the World Bank, the overall business regulatory framework remains complex and cumbersome. A challenging regulatory environment for businesses particularly affects micro-, small-, and medium-sized enterprises, which account for most businesses in Guyana

(World Bank 2016). In 2018, Guyana ranked 134 out of 190 world economies for ease of doing business (World Bank 2019).

Guyana is positioned to become a significant oil producer by the mid-2020s. Accounting for currently known discoveries, future output from the Stabroek Block is estimated at 6 billion oil-equivalent barrels of oil. This estimated output may increase as offshore exploration activities are ongoing. In April 2019, ExxonMobil announced a discovery at the Yellowtail-1 well, its thirteenth discovery in the Stabroek Block (ExxonMobil 2019). The Bureau of Statistics anticipates that as a result of the oil and gas sector, GDP may increase up to 13 times and the Guyanese dollar will appreciate in value against the USD once daily production reaches 1 million BOPD (ERM/EMC Personal Communications 10). In addition to impacts on GDP through fiscal revenue, there will also be opportunities to boost economic growth through increased foreign direct investment in supporting goods and services in the time leading up to oil production, which will present the country with opportunities to diversify production and trade. Nonetheless, the economy's increased dependence on natural resources will also increase its vulnerability to commodity price fluctuations and could reduce the competitiveness of other sectors (IDB 2017).

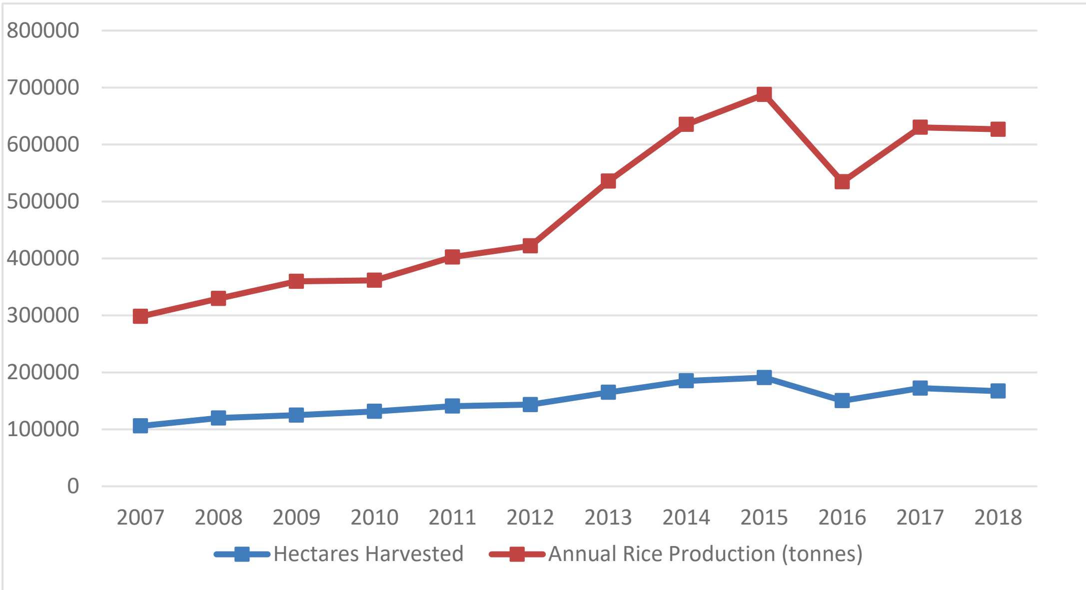
Sectors that are particularly important for the coastal areas (where the potential for socioeconomic effects from the Project is higher, as compared to the rest of the country), as well as the mining and wholesale/retail trade sectors (which are important sectors for the country as a whole), are described in further detail below.

Agriculture

According to the Private Sector Commission (PSC), Guyana has a relatively strong agricultural sector and is the only net exporter of food in the Caribbean. In 2018, the agriculture sector grew by 1.5 percent, compared to 0.4 percent growth in 2017. This increase was attributed to higher outputs of livestock, forestry, and other crops, which offset the significant shortfalls in sugar, rice, and fishing (Bank of Guyana 2019). The agriculture, fisheries, and forestry sectors combined represented 16.1 percent of Guyana's real GDP in 2018, down from 16.6 percent in 2017, 16.9 percent in 2016, and 19.4 percent in 2015. This follows a downward trend of the contribution of the agriculture sector to real GDP from 22.3 percent in 2007 (Bank of Guyana 2019; Ministry of Agriculture 2018). The Ministry of Agriculture is currently drafting a revised National Agriculture Strategy for 2020 to 2025 that will take into consideration the burgeoning oil and gas sector and its interaction with agriculture (ERM/EMC Personal Communication 8).

Rice

In 2018, rice production declined by 0.5 percent to approximately 626,684 tonnes, from 630,104 tonnes in 2017 (see Figure 8.1-6). Furthermore, acreage that was harvested declined by 5,096 hectares to 167,159 hectares, as compared to the 172,255 hectares harvested in 2017 (Bank of Guyana 2019). By the end of the first half of 2018, rice production was 329,504 tonnes, which was 3.8 percent lower than the corresponding period in June 2017 (Bank o Guyana 2018). This decline was due to poor weather conditions, paddy bug infestation, fewer hectares harvested, and lower investments in the sector. Production shortfalls led to lower export volumes, with a consequent 7.5 percent decline in export earnings from rice. The main export markets for Guyana's rice in 2018 were the European Union, Caribbean Community (CARICOM), Mexico, West African countries, and Latin America (Bank of Guyana 2019).



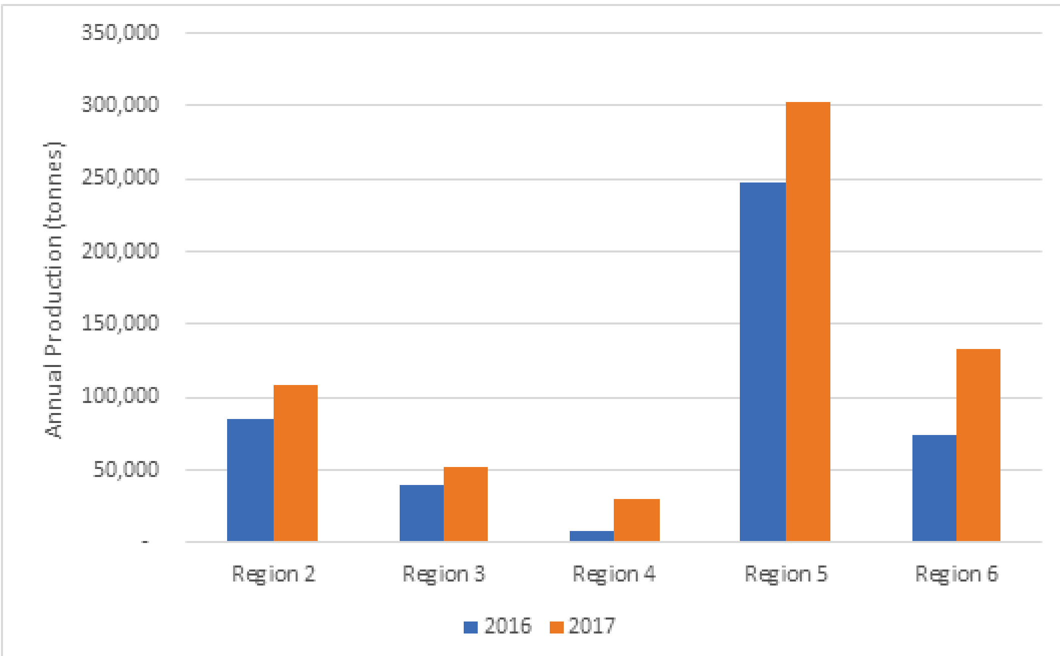
Sources: Ministry of Agriculture 2018; Bank of Guyana 2019

Figure 8.1-6: Annual Rice Production and Hectares Harvested, 2007–2018

Rice is especially important in several coastal NDCs, where it is cultivated for both commercial and subsistence use (ERM/EMC 2018) and rice fields dominate the landscape in many coastal areas in these regions (Figure 8.1-7).

Figure 8.1-7: Rice Field in Region 2 Pomeroon-Supenaam

Rice farming is the predominant agricultural activity in the coastal areas of Regions 2, 3, 5, and 6, accounting for an estimated 85 percent of the overall economy in Region 2, and 55 to 60 percent in Region 3 (ERM Personal Communication 1). Region 5 has the largest rice industry, with more than 80,000 hectares harvested in 2018 compared with approximately 28,800, 15,400, 7,000, and 40,000 hectares harvested in Regions 2, 3, 4 and 6, respectively. Consequently, annual rice production is highest in Region 5. In 2018, rice production grew in all of these regions (Figure 8.1-8).



Source: Ministry of Agriculture 2018

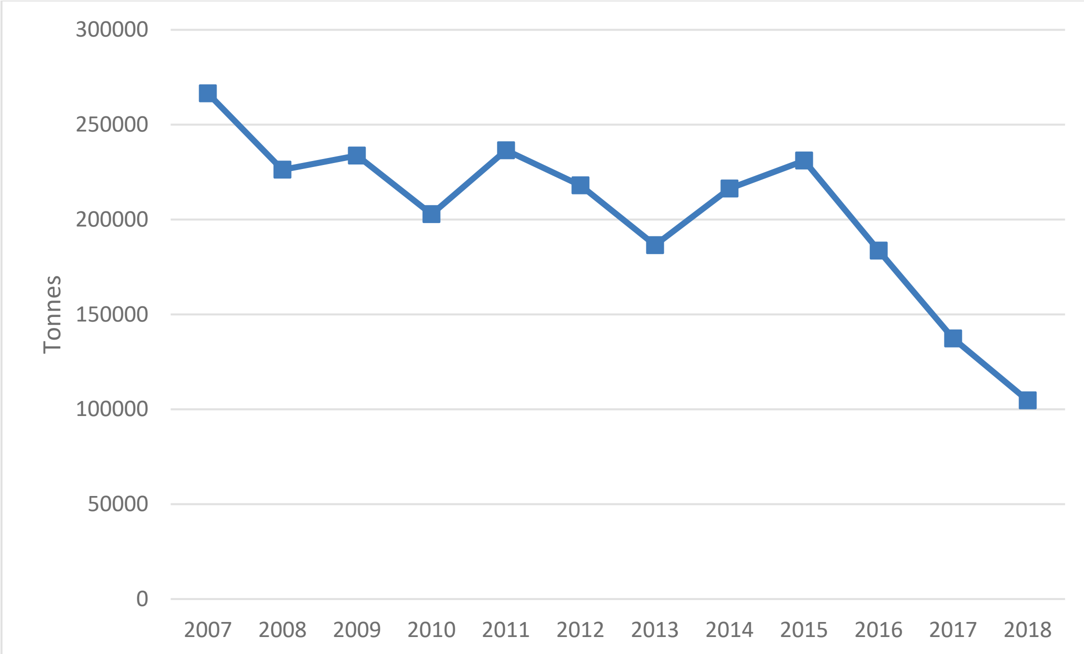
Figure 8.1-8: Annual Rice Production in Regions 2 to 6

According to the president of the Guyana Rice Producers' Association, industrial rice production requires the ability to precisely control water levels in the rice fields. The rice growers in coastal Guyana achieve this by operating two separate systems of canals, one dedicated to irrigation and another dedicated to drainage. The irrigation canals convey fresh water from water conservancies or rivers via gravity to the rice fields. The rice fields are contained within a dike system that has separate gates for irrigation and drainage systems. The fields drain to a separate network of canals constructed to provide general drainage to the surrounding coastal landscape (ERM Personal Communication 1). These canals drain to the Atlantic Ocean via manually operated mechanical sluice gates (locally called *kokers*; see Figure 8.1-9) or by pump stations installed along the coastline. The drainage canals are generally constructed at or very near sea level to achieve the gradient necessary for drainage of the surrounding landscape. Therefore, the drainage canals are tidally influenced and the kokers control inflow from the sea. This system ensures that the rice fields remain upgradient of tidally influenced water in the drainage canals and prevents salt water from intruding into the fields (ERM Personal Communication 1; ERM/EMC 2018).

Figure 8.1-9: Sluice Gate (Koker) in Charity (Region 2) at High Tide

Sugar

Sugar production declined from 2016 to 2018, after a 2-year increase in 2014 and 2015. In 2018, sugar production declined to 104,642 tonnes, down from 137,307 tonnes in 2017, 183,491 tonnes in 2016, and 231,076 tonnes in 2015 (Figure 8.1-10). Sugar production in 2018 represented the lowest quantity of sugar produced over the last decade. This outcome can be attributed to the government's downsizing of the Guyana Sugar Corporation, unfavorable weather conditions, and lower supplies of quality canes (Bank of Guyana 2019).



Sources: Ministry of Agriculture 2018; Bank of Guyana 2019

Figure 8.1-10: Annual Sugar Production, 2007–2018

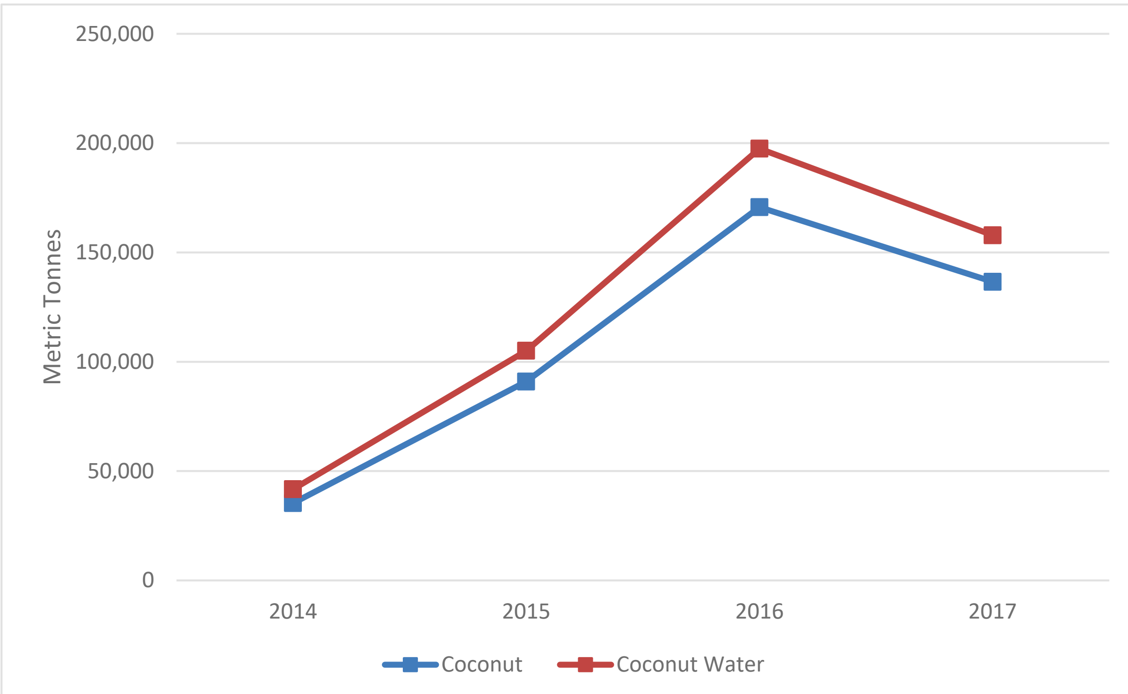
Due to the reduction in production, the volume of sugar exported in 2018 was 30,191 tonnes less than the quantity exported in 2017. Further, the average export price for sugar declined to $72,899.2 GYD ($348.8 USD) per tonne as compared to $92,566.1 GYD ($442.9 USD) per tonne in 2017. The combination of lower volumes exported and reduced price per tonne resulted in a 44.1 percent dip in export earnings in 2018 as compared to the previous year (Ministry of Agriculture 2018). Guyana's Demerara sugar is exported to markets in the European Union, United States, and CARICOM countries. Commercial farms growing sugarcane are found primarily along the coastal areas in Regions 4 and 6 (see Figure 8.1-11; ERM/EMC 2018).

Figure 8.1-11: Aerial View of Sugar Plantations

Coconut

The coconut industry in Guyana has grown in recent years (Figure 8.1-12) and shows potential for continued growth due to high international demand for products such as coconut oil and coconut water. As of 2015, approximately 10,000 hectares of coconuts were being cultivated, and the National Agricultural Research and Extension Institute estimates that acreage dedicated to coconut cultivation could quadruple by 2025 (Stabroek News 2018). In 2016, a Coconut Festival was held in Guyana through a collaborative effort of the Ministry of Business, the Ministry of Agriculture, the International Trade Centre (ITC) and the Caribbean Research and Development Institute to build awareness of the coconut industry and to promote investments (NAREI 2017). Following this, a Coconut Board was convened by the ITC to focus on the development of Guyana's coconut industry and promote collaboration with the government and private sector operators (ERM/EMC Personal Communication 6).

The coconut industry ranks third after rice and sugar in terms of acreage; coconut is grown primarily in the coastal regions, including along the Pomeroon River and the Essequibo Coast in Region 2. According to news media articles, the amount of land in the Pomeroon area being converted to coconut cultivation is increasing (Guyana Chronicle 2016; Stabroek News 2016). In 2017, coconut production was 136,603 tonnes, of which 9,068 tonnes were exported. Value-added coconut products exported in 2017 included coconut choka, grated coconut, coconut water, and crude coconut oil (Ministry of Agriculture 2018).



Source: Ministry of Agriculture 2018

Figure 8.1-12: Annual Production of Coconuts and Coconut Water, 2014–2017

The coconut industry is active in all six of the coastal regions (ERM/EMC 2018), including those coastal NDCs/CDCs listed in Table 8.1-4.

Figure 8.1-13: Coconut Plantation, Region 2

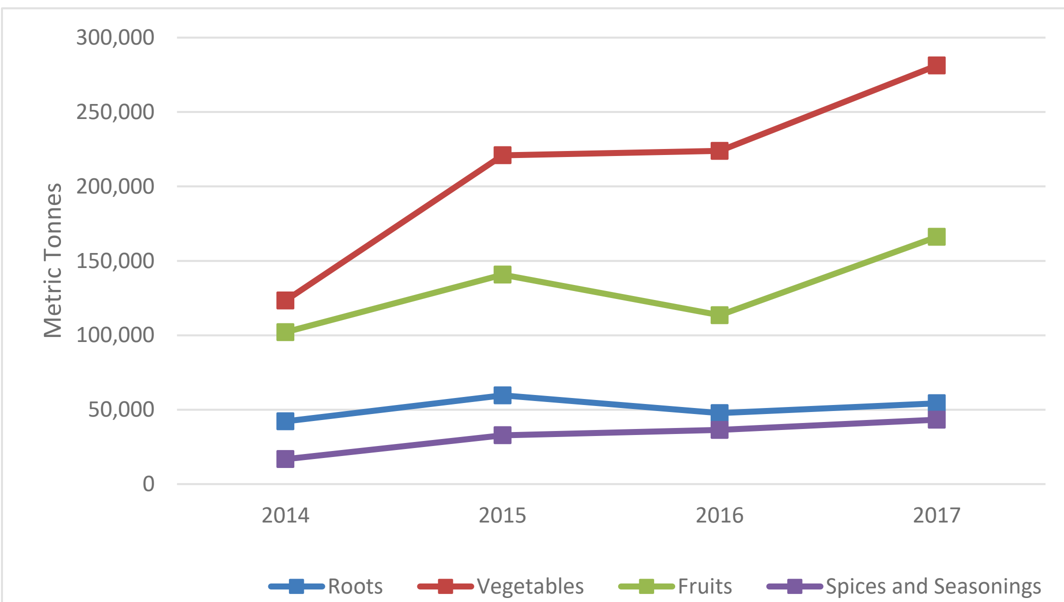
Table 8.1-4: Coastal NDCs/CDCs with Coconut Farming

Region	NDC/CDC Name
Region 1	Father's Beach
	Almond Beach
Region 2	Charity/Urasara
	Anna Regina Town Council
Region 3	Wakenaam (island)
	Leguan
	Mora/Parika
	Tuschen/Uitvlugt
	Stewartville/Cornelia Ida
Region 4	Industry/Plaisance
	Unity/Vereeniging
Region 5	Seafield/Tempie
	Union/Naarstigheid
	Bath/Woodley Park
	Woodlands/Bel Air
Region 6	No. 52/No. 74 Villages

In most cases, coconut farming is conducted for commercial reasons and subsistence, and ranges in reported importance by stakeholders from low to essential. However, there are instances where the expansion of coconut estates has resulted in the clearing of large swathes of mangrove forests, as is the case at the mouth of the Pomeroon River. That said, coconut farming supports Guyana's sea defense along sea dams through vegetative stabilization of the earthen coastal seawall.

Other Cash Crops

Non-traditional crops (crops other than sugar cane and rice) grown in Guyana include tubers such as cassava, sweet potato, and eddo; vegetables such as bora, eggplant, pumpkin, plantains, tomatoes, and okra; spices such as hot peppers, eschallot, and ginger; and fruits including banana, papaya, mango, watermelon, and pineapple. Data from the Ministry of Agriculture (2018) show that production for most tuber and vegetable crops has increased in recent years, while yields for fruits and vegetables have been more variable. However, categories of non-traditional crops increased in 2017 compared to 2016 (Figure 8.1-14).



Source: Ministry of Agriculture 2018

Figure 8.1-14: Production of Other Cash Crops, 2014–2017

Similar to coconut farming, cash crops are grown in all six of the coastal regions (ERM/EMC 2018). In some cases, farmers, who are usually squatters, use the sea defense walls for agricultural purposes for subsistence and small-scale commercial sale. In Region 1, cassava is a primary staple in the diet, and villages that grow cash crops typically only sell them within their own villages (as transportation challenges restrict access to other markets). In many villages, cash crops are a primary source of both income and subsistence, supplementing fishing activities (ERM/EMC 2018).

Value-added Agricultural Products

According to various interviewed stakeholders, establishing manufacturing operations to develop value-added products such as pepper sauce, beverages, and canned fruit are priorities at both community and strategic policy levels (ERM Personal Communications 5, 10, 12, and 13; ERM/EMC Personal Communication 8). Several agricultural co-ops in Regions 2 and 3 have achieved varying levels of success in producing and marketing such products. National-level agencies such as the Ministry of Agriculture and the PSC emphasize the importance of developing markets for such products to provide better stability and security to farmers. However, there are a number of challenges associated with this, including high energy costs, difficulty locating or establishing markets for products, maintaining quality control and standards, packaging and labeling, and obtaining financing for start-up costs.

The private sector, through the Guyana Manufacturing and Services Association, in partnership with the Ministry of Business, has been executing the *UncappeD initiative*, which has provided the opportunity for large and small agro-producers and processors from across the country to showcase their products at national-level expos and regional marketplace events. Several other related initiatives are also underway, including an Inter-American Development Bank (IDB)-supported project to improve the quality of national infrastructure, which would assist agro-processors.

According to the Ministry of Agriculture, value-added products are less volumetric and therefore, easier to transport to markets. Consequently, promoting value-added production is an integral element of developing large-scale agriculture in hinterland areas. The Ministry of Agriculture, with support from the International Fund for Agricultural Development, is implementing a *Hinterland Environmentally Sustainable Agricultural Development Project* in Mabaruma and Moruca (Region 1), which includes provision of support to local and regional councils to develop and implement investment plans through local value chains (ERM/EMC Personal Communication 8; IFAD undated). The Ministry of Agriculture is also pursuing other initiatives including the creation of a research arm of the Guyana Rice Development Board to explore options for value-added rice products, encouraging blending of wheat flours with locally manufactured flours (cassava, sweet potatoes, rice), and establishment of a milk pasteurization plant in partnership with private operators (ERM/EMC Personal Communication 8).

Fisheries and Aquaculture

Marine Fisheries

There are four main types of marine fisheries in Guyana (Ministry of Agriculture 2013), as differentiated by the species targeted, gear types used, and the depth of water where the fishery takes place. Table 8.1-5 summarizes the characteristics of these fisheries. Tuna, such as yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*), have also been identified as a potential oceanic target species of commercial interest (Isaac and Ferrari 2017).

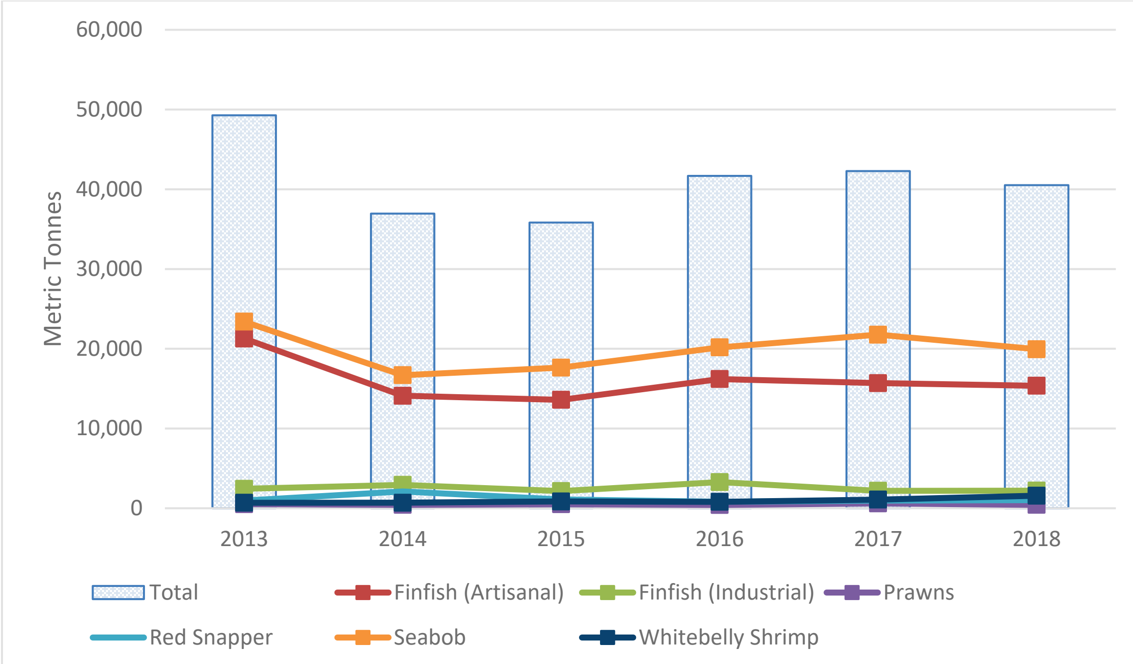
Table 8.1-5: Primary Characteristics of Marine Fisheries in Guyana

Type of Fishery	Species	Gear	Depth
Industrial	Seabob, shrimps, and prawns	Trawls	Primarily from 13–16 meters, but can occur from 0–75 meters
Semi-industrial	Red snapper and vermillion snapper	Fish traps and lines	Edge of continental shelf
Artisanal	Mixed fish and shrimp	Gillnets, drift seines, fyke nets/Chinese seines, and others (e.g., Caddell line)	0–28 meters
Shark	Various	Trawls, gillnets, and hook and line	Throughout the continental shelf waters

According to data from the PSC and the Ministry of Agriculture, fishery yields declined between 2014 and 2015. The PSC attributes this to El Niño-related weather phenomena, while the Ministry of Finance characterizes this as part of a longer-term decline caused by unsustainable overfishing, including illegal fishing by foreign vessels (Ministry of Finance 2015). However, the sector recovered in 2016 with growth in both fish and shrimp outputs. Fish output improved by 20.5 percent, and (total) shrimp output grew by 9 percent. However, prawn output fell by 17.8 percent (PSC 2017). In 2017, production continued with a very modest one percent overall increase. Shrimp and fish catch decreased by 6.2 percent and 1.2 percent, respectively, while prawn catch increased from 25 tonnes in 2016 to 26 tonnes in 2017. Small shrimp catch grew from 124 tonnes in 2016 to 135 tonnes in 2017. However, fish catch declined to 73 tonnes in 2017 from 78 tonnes in 2016 (Bank of Guyana 2018). Fish catch continued to decline in 2018 with a 6.2 percent reduction compared with 2017 (Bank of Guyana 2019). These changes were attributed to market challenges arising from rigorous international certification requirements and an intrusion of Sargassum seaweed (Bank of Guyana 2019).

According to the Fisheries Department, reasons for the decline in fish catch could be attributed to either the depletion or the migration of stock. The Fisheries Department is continuing a program of reviewing stock assessments of seabobs and bycatch to further understand recent trends (ERM/EMC Personal Communication 5). Fishing interests and the Fisheries Department personnel also acknowledged the prevalence of illegal fishing by both foreign and domestic vessels, but did not specifically implicate illegal fishing in the decline of stock in recent years (ERM Personal Communications 2, 12, 13, and 14).

Fishing catches for 2013 to 2018 are shown on Figure 8.1-15. The data indicate a declining trend for artisanal finfish, prawns, and seabob shrimp catches in recent years, although the recent decline follows an increasing trend for 2010 through 2012. The prawn industry has been voluntarily scaled back in response to limited catches resulting from overfishing in previous years, with approximately 15 Guyanese-registered boats in operation in 2016. Prawn fishing boats operate from the coast out to about 40 fathoms (ERM Personal Communication 2).



Source: Ministry of Agriculture 2018, EMC Personal Communication 4

Note: Whitebelly is a species of shrimp and is included in the artisanal shrimp fishery in Table 8.1-5.

Figure 8.1-15: Commercial Fisheries Catch Volumes, 2013–2018

The industrial seabob shrimp sector continues to be an important commercial fishery, and industry leaders are currently in the process of applying for Marine Stewardship Council certification (an internationally recognized voluntary process used to assess and certify the sustainability of wild-capture marine and freshwater species). The seabob fleet currently operates under a voluntary management plan (the only fishery-specific management plan for fisheries operating in Guyana's territorial waters) that calls for a 7-week-long closed season each year. Seabob sector representatives expect the management plan to be adopted by the government and made compulsory in the near future (ERM Personal Communication 2).

Bycatch of endangered turtles, sharks, and rays as a result of fishing operations represents a recognized challenge for the industry and is the subject of increasing targeted study (Kolmann et al. 2017; Garstin and Oxford 2018).

In Region 1, fishing is important for subsistence across most villages, as well as small-scale commercial sale where there is access to markets. At the indigenous villages of Smith's Creek and Waramuri in Region 1, where the principal livelihood activity is fishing, drift seines are used by most fisherfolk, but longline and pole seines are also used. Fisherfolk from Smith's Creek spend approximately 5 to 6 days per week fishing in the Waini Region. Fisherfolk from Waramuri use fishing grounds in several locations in Region 1 and 2, including Kamwatta, Moruca River mouth, Pomeroon River mouth, Iron Punt, Charo Beach, and Danfore, spending up to 14 days at sea for each fishing trip. Fisherfolk from Waramuri dry/smoke fish during fishing trips since ice is unavailable for cold storage. Boats will usually dock at beaches along the coastline daily where this is done (EMC/ERM 2019b).

Fishing is also important to the all of the coastal NDCs in Regions 2 through 6, providing direct employment and income for numerous fisherfolk and indirect employment for numerous others in supporting services. The importance of fishing to local communities as well as the scale of fishing activities varies across regions. For example, one of the largest landing sites in Region 6 is Complex 66, where up to 200 vessels land during peak fishing seasons; a typical small landing site, like Rose Hall in Region 6, may only have four vessels which operate routinely (EMC/ERM 2019). Table 8.1-6 provides information on the estimated size of the vessel fleets at various coastal landing sites across Regions 1 to 6. These sites were selected as they provide a good representation of the entire coastline.

Table 8.1-6: Estimated Size of Vessel Fleet at Coastal Landing Sites

Region	Landing Site	Approximate Number of Vessels During Peak Season
Region 1	Smith's Creek	6
	Waramuri	20
Region 2	Charity	100
	Hampton Court	15
	Lima	30
Region 3	Zeeburg	30
	Windsor Forest	12
	La Grange	8
Region 4	Ogle	30
	Riverview	30
Region 5	Mahaicony Bridge	15
	Rosignol	40
	Bushlot	40
Region 6	Rose Hall	4
	Albion	70
	Complex 66	200

Source: EMC/ERM 2019

Drift seines and fyke nets (also referred to in Guyana as Chinese seines) are the most frequently used gear type. In general, small artisanal vessels, characterized by having engine sizes of less than 40 horsepower and using fyke nets, are used in daily fishing trips. Fishing tends to occur along the coastlines at "pens" located near landing sites. For example, one vessel exclusively using fyke nets at the Ogle landing site makes daily trips to pens located between 2 and 4 kilometers offshore from the landing site. Small artisanal vessels that use drift seines frequently make daily trips but may stay at sea for up to 8 days. These vessels also focus on fishing along the coastline near respective landing sites. For example, fishing vessels from Hampton Court landing site (Region 2) travel along the Essequibo Coast and vessels from the Bushlot landing site (Region 5) target the Region 5 coastline. Smaller vessels typically do not travel more than 12 kilometers from shore, where fishing occurs at depths ranging from 2 to 31 meters (6.6 to 101.7 feet) (EMC/ERM 2019).

Larger artisanal vessels that have engine sizes of greater than 40 horsepower travel greater distances and have fishing trips of longer durations. For example, most of the vessels at the Charity landing site (Region 2) spend approximately 18 days at sea per trip fishing along the Essequibo Coast, frequently traveling as far east as the Waini River in Region 1. Larger artisanal vessels at the Rosignol (Region 5) and Complex 66 (Region 6) landing sites travel along the coastlines of Regions 5 and 6; in addition, some vessels are also licensed to fish in Surinamese waters. Larger vessels are reported to travel up to 25 kilometers from shore with fishing at depths of up to 28 meters (91.9 feet).

Table 8.1-7 provides an overview of the commercial fishing communities identified as part of the late 2017 and early 2018 field work by the Consultant team.

Table 8.1-7: Estimated Size of Commercial Fishing Communities in Coastal Regions

Region	NDC Name	Fishing Community
Region 1	Morawhanna	3 boats/1 person
Region 2	Charity/Urasara	20 persons
Region 3	Wakenaam (island)	60 persons
Region 4	Georgetown City	20 boats
	Better Hope/La Bonne Intention	35 boats
	Enmore/Hope	20 boats
Region 5	Hamlet/Chance	30 boats
	Profit/Rising Sun	60 boats
	Bath/Woodley Park	12 boats
	Zeelust/Rosignol	175 boats
Region 6	Macedonia/Joppa	100 persons

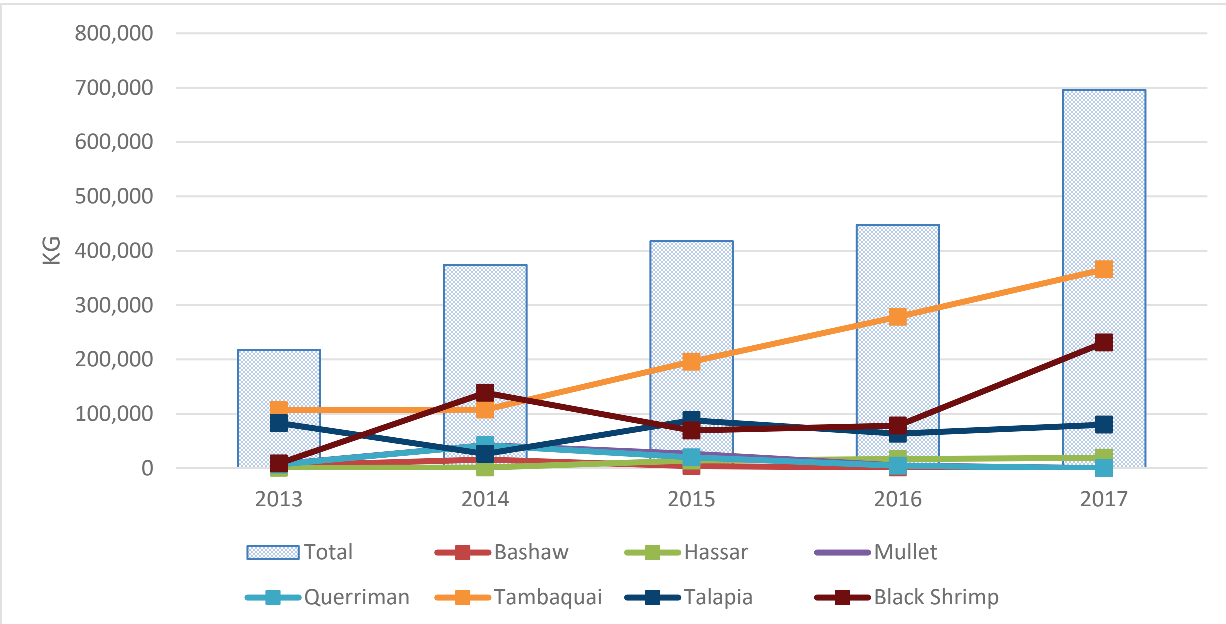
Source: ERM/EMC 2018

Data obtained during informal engagement with fisherfolk suggest that the economies of Regions 5 and 6 are generally more dependent on commercial fishing than those coastal NDCs in other regions (ERM/EMC 2018).

A large percentage of fish captured using artisanal methods is sold to third parties. Sale prices are subject to short-term fluctuations. According to the fisherfolk interviewed as part of the Liza Phase 1 post-permitting fish study, the price of fish is seasonally influenced. Interviewees commented that the prices generally decline during the rainy season due to higher catches and increased supply (ERM 2018). According to data from the Ministry of Agriculture (2018), seasonally influenced fish were being sold at the following retail prices ($209 GYD=$1 USD): shark $400 GYD per pound; small grey snapper: $250 to $800 GYD per pound; cuffum: $280 to $400 GYD per pound; cuirass: $160 to $300 GYD per pound; gillbacker: $500 to $2,000 GYD per pound; small trout: $250 to $500 GYD per pound; red snapper: $300 to $1,000 GYD per pound; highwaterman catfish: $200 to $300 GYD per pound; bangamary: $200 to $300 GYD per pound; butterfish: $200 to $400 GYD per pound; pacu: $200 to $300 GYD per pound; unpeeled whitebelly shrimp: $100 to $500 GYD per pound; and unpeeled seabob: $100 to $500 GYD per pound.

Aquaculture

According to data from the Ministry of Agriculture (2018), the main species produced in aquaculture establishments are the bashaw, hassar, mullet, querriman, tambaqui, tilapia, and black shrimp. Data show that tilapia once dominated aquacultural yields, but have declined in production, while yields of tambaqui and black shrimp have increased considerably in recent years. The total yield of aquaculture product has been variable in the period from 2013–2017 (Figure 8.1-16).



Source: Ministry of Agriculture 2018

Figure 8.1-16: Fish Yields from Aquaculture, 2013–2017

According to the president of the National Aquaculture Association, aquaculture is still a small industry in Guyana and establishments are typically set up in abandoned rice fields. By using the same water supply and drainage configuration used for rice production, the aquaculture operations avoid dependency on brackish water and can raise freshwater species despite their coastal locations. Freshwater species currently being raised in rehabilitated rice fields include hassa, arapaima, tilapia, and tobaki (pacu) (ERM Personal Communication 16).

Although aquaculture is considered a small industry by the National Aquaculture Association, it was assessed by stakeholders as critical to livelihoods in many coastal NDCs throughout Regions 2 through 5 (ERM/EMC 2018). It appears to be most important to Regions 5 and 6, and can provide a livelihood for farmers. For example, in Bloomfield/Whim (Region 6) it was reported that six crabs can be sold for $500 GYD ($2.39 USD) in season, while one bucket of shrimp can be sold for $10,000 GYD ($48 USD).

Mining and Quarrying

The mining sector is an important sector for Guyana and contributed more than half of exports in 2017. Most notably, raw gold, bauxite, and diamonds equated to 56.8 percent, 7.3 percent, and 0.9 percent, respectively, of export totals in 2017 (BSG 2017). This represented a reduction of 8.8 percent compared with 2016 due to lower production of bauxite, gold, and diamonds. This decline was linked to adverse weather conditions, operational challenges, and volatile commodity prices (Bank of Guyana 2018). The sector rebounded in 2018 with 2.9 percent growth as compared to 2017. This increase was attributed to higher outputs from bauxite and quarrying, which offset reduced gold declarations (Bank of Guyana 2019). In 2013, this sector employed more than 17,363 persons directly and almost 21,626 indirectly, which accounted for 14 percent of the total labor force (ITA 2018). Due in large part to the mining sector, Guyana's economy in recent years has reflected the path of global commodity prices. Real GDP growth decelerated to 3.8 percent in 2014 and to 3 percent in 2015, as global commodity prices collapsed for Guyana's major mining exports (World Bank 2016).

Wholesale and Retail Trade

Wholesale and retail trade grew by 8.7 percent in 2017, compared with a 1.8 percent reduction in 2016. This was due to increased imports of consumer goods (Bank of Guyana 2018). Growth continued in 2018 with an 8.1 percent increase. These increases were attributed to a 1.8 percent growth in imports of consumption goods (Bank of Guyana 2019).

Manufacturing

Manufacturing contributed 7.4 percent of GDP in 2015 and grew by 5.3 percent from 2014 to 2015. However, it contracted by 9.5 percent in 2016 due mainly to the considerable underachievement in both the sugar and rice industries. The sector rebounded in 2017, growing by 4 percent, which was attributed mainly to a 17.3 percent recovery in rice milling activities. However, sugar value-added manufacturing decreased by 25.2 percent (Bank of Guyana 2018). Manufacturing grew marginally by 1 percent in 2018. This increase was due to the higher rates of production of light manufacturing products and rice milling. However, sugar value-added manufacturing was 28.6 percent lower in 2018 as compared to 2017 (Bank of Guyana 2019). The most important manufactured products in terms of volume include laundry soap, detergent, paints, putty, whitewash, oxygen, and acetylene, as well as edible goods including rice, sugar, and rum (PSC 2015). Many of the country's manufacturing facilities are located in coastal areas (ECLAC 2005).

Tourism

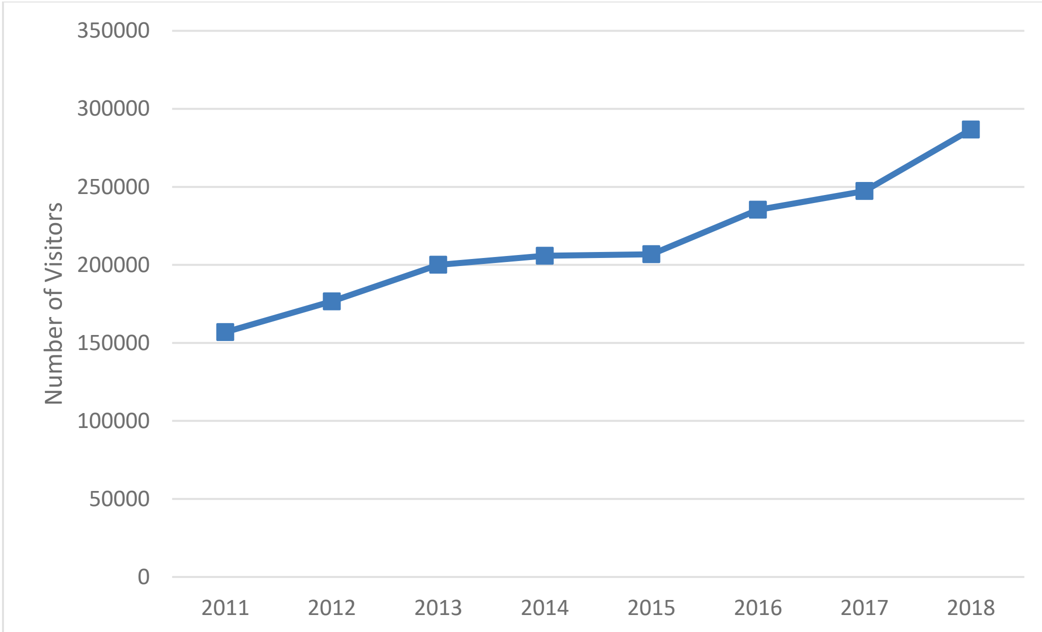
According to the World Travel and Tourism Council (2018), tourism directly contributed 2.6 percent of the country's GDP in 2017. Although most tourism infrastructure (e.g., hotels) is located in the more populated townships such as Georgetown, Linden, and Berbice, many of Guyana's tourist attractions are located in the country's hinterland. These attractions offer nature, culture, and adventure-based experiences such as trips to waterfalls and Amerindian villages. These trips range from same-day to multiple-night excursions.

Guyana is not a popular destination for cruise ships and receives only a few small ships each year. The country does not have the berthing capacity for large cruise ships (ERM Personal Communication 3).

Sediment deposition from the mouth of the Amazon River along Guyana's coast means that there are few beach offerings for tourists. The highly turbid water along the coast also likely contributes to the relatively small numbers of tourists that visit Guyana relative to other locations in the region with clearer water. Some tourism occurs at the Shell Beach Protected Area (SBPA) during the marine turtle nesting season, but this is limited because infrastructure and systems have not yet been established to facilitate travel or provide convenient accommodations. In general, however, Guyana is thought to have considerable ecotourism potential, and development of tourism infrastructure at the country's protected areas, including SBPA in Region 1, is considered a key part of the Protected Areas Commission's current strategic plan (PAC 2014).

Data from the Guyana Tourism Authority (2018a) indicate that the number of international visitors to Guyana has more than doubled since the early 2000s (see Figure 8.1-17). In 2018, 15.9 percent more visitors arrived in Guyana compared to 2017 (Ministry of Business 2019). The largest number of visitors originates from the United States, followed by the Caribbean, Canada, and Central and South America. Because the majority of visitors consist of Guyanese expatriates returning to visit family, visitor numbers peak during the summer vacation (July and August) and key holidays (e.g., Christmas in December). However, the Guyana Tourism Authority has been increasing its efforts to raise Guyana's profile as a nature- and adventure-based tourism destination. In 2018, these activities included the launch of a "Destination Guyana" website and a social media strategy (Guyana Tourism Authority 2018b); hosting several tourism agency trips to familiarize tour guides with Guyana; and securing representation in core tourism markets such as the United States, Canada, the United Kingdom, and Germany (Ministry of Business 2019). In 2019, Guyana was awarded the "Best Ecotourism Destination" at the ITB Travel and Trade Show Berlin (Stabroek News 2019).

According to representatives of the Department of Tourism, increases in tourism in recent years are also attributable to increased regional sporting tournaments in the Georgetown area, particularly cricket events. This has brought many international visitors, particularly those from the Caribbean. During major events such as the Cricket World Cup, increased traffic congestion has been observed in the Georgetown area (ERM Personal Communication 3).



Source: Guyana Tourism Authority 2018a, Ministry of Business 2019

Figure 8.1-17: Annual International Visitors to Guyana, 2011–2018

According to personnel from the Department of Tourism, the oil and gas sector may be considered a catalyst to Guyana's tourism sector. The discoveries of oil and gas have raised Guyana's profile internationally, increasing exposure in potential tourism markets and attracting international events. Furthermore, tourism sector operators have anticipated increased business travel associated with the oil and gas sector, which has increased interest in upgrading existing services such as accommodations, and establishing new services such as flights on unserved routes (ERM/EMC Personal Communication 4).

Most of the major tourist attractions are located in Georgetown, such as museums, the zoo, parks, public gardens, and the Stabroek Market. Georgetown and surrounding areas are known for their many historic buildings, which date from the late eighteenth century through the mid-nineteenth century, when Guyana was first a Dutch colony and then an English colony (National Trust of Guyana 2018). Guided tours of Georgetown's historic buildings and sites are available, as are guided tours of the Essequibo River, the El Dorado Rum Factory, the Georgetown City Centre, and other attractions.

The Department of Tourism is piloting a *Development of Regional Tourism Bodies* project that aims to integrate regional and local authorities in tourism planning at the regional level. Regional initiatives will depend on the available resources, particularly beaches and waterfront infrastructure and development (ERM/EMC Personal Communication 4). Local tourism and recreation is important to the local economy in the coastal NDCs in Regions 2 through 6, including those outside Georgetown. Some regions are less dependent on tourism (e.g., Region 2), with their coastline and beaches being frequented by ten or fewer locals daily. Other regions have economies that are more established and well-linked to local tourism. Region 3 and 4, specifically Best/Klien/Pouderoyen and Haslington/Grove, respectively, are known for their eco-tourism, with diverse bird species and protected mangroves. Regions 5 and 6, on the other hand, have beaches or other recreational areas (e.g., horse tracks) frequented by hundreds weekly (ERM/EMC 2018).

Some NDCs are looking to invest in local tourism and expand its economic return. For example, Rose Hall Town Council (Region 6) has control over a long stretch of beach that is frequented daily by 20 to 50 persons and hundreds on weekends, and is seeking development of further tourism opportunities.

8.1.3. Impact Assessment—Socioeconomic Conditions

8.1.3.1. Relevant Project Activities and Potential Impacts

The Project will not have any direct impact on the administrative divisions, population distribution, or education systems described in Section 8.1.2, Existing Conditions—Socioeconomic Conditions; any influx of population to the Georgetown area for work would be small and thus would not result in any change in the overall population distribution. Therefore, this section focuses on assessment of potential Project impacts on economic conditions in the Project AOI. The key potential impacts considered for planned Project activities include the following:

- Project-related revenue generation and increased tax revenues for the government, potentially resulting in increased government spending (typically on social services and infrastructure);
- Potential increased local business activity and related employment as a result of Project procurement and employment;
- Potential increased Project worker spending levels; and
- Potential increased cost of living to citizens due to higher demand for goods and services.

The Project will contribute directly and positively to increased national revenues through a Production Sharing Agreement between the Government of Guyana and EEPGL. As such, development of the oil and gas sector represents a critical point in Guyana's development trajectory, with the government pledging to use funds accrued from the sector for development of the country's infrastructure, including investments in health, education, agriculture, and power for domestic and industrial use (in alignment with Guyana's Green State Development Strategy) (DPI Guyana 2018; Oil Now Guyana 2018).

The Project will also benefit the economy through local procurement of select goods and services, limited direct local employment, and spending in local communities by Project workers. As of the first quarter of 2019, EEPGL's Liza Phase 1 Development Project employed a total of 1,183 Guyanese nationals (up from 585 in 2018), constituting 49 percent of its total workforce. Modest increases in total employment, including an increase of EEPGL's office staff to about 227 workers (for all EEPGL activities), are expected with the development of the Payara Development Project, and EEPGL intends to continue hiring Guyanese nationals to the extent reasonably practicable, in alignment with its Local Content Plan, which outlines EEPGL's strategy and multi-tiered approach to building Guyanese workforce and supplier capabilities in conjunction with strategic investments in the local community.

These potential local jobs will contribute positively to economic conditions by generating income taxes, increasing household purchasing power, and generating increased sales tax revenue. In terms of local procurement, the majority of EEPGL's (and subcontractors') suppliers supporting in-country work scopes in 2018 were Guyanese-owned (499 total) and CARICOM-owned (38 total). Similarly, in the first quarter of 2019, more than 88 percent of EEPGL's 296 suppliers were Guyanese-owned (227 total) and CARICOM-owned (35 total). Business with Guyanese-owned suppliers amounted to $11.2 billion GYD ($54 million USD) in 2018 and $4.8 billion GYD (USD $23 million) in the first quarter of 2019. As part of the Payara Development Project, EEPGL intends to continue procuring select Project goods and services from Guyanese businesses to the extent reasonably practicable.

As part of its efforts to optimize local content during the Liza Phase 1 and Liza Phase 2 Development Projects, EEPGL and its contractors have implemented a range of training programs for workforce and local business-capacity building in 2018. This included close to 50,000 workforce training hours on administration, leadership and management, health and safety, technical, and trade and crafts training courses for Guyanese workers during the second half of 2018. During the first quarter of 2019, more than 30,000 hours of training were provided to Guyanese personnel—57 percent in the areas of professional, technical, craft, and trade. In addition, approximately 2,500 people from local businesses attended energy literacy courses that included Offshore Oil and Gas; Procurement; and Health, Safety and Environment modules through the Centre for Local Business Development (CLBD). More than 1,500 locally registered businesses (more than 90 percent of which are Guyanese-owned) have taken advantage of the CLBD's Supplier Registration Portal and registered to receive alerts on business opportunities with EEPGL and its contractors (ERM/EMC Personal Communication 2).

It is anticipated that, beyond direct employment and service to EEPGL and its contractors, these capacity-building efforts will contribute to improved employment and business opportunities for participants over the long term. Similarly, a range of government capacity-building programs on topics such as waste management, oil spill response, protective species observer training, marine turtle telemetry and tracking, gas and power, energy literacy, local content, etc., have been conducted as part of the Liza Phase 1 and Liza Phase 2 Development Projects, and these should contribute to enhanced administrative efficiency that will further facilitate business activity in Guyana. As part of the Payara Development Project, EEPGL intends to continue on the same course with its workforce, supplier, and government capacity-building efforts. In addition to direct expenditures and employment, the Project will also likely generate induced economic benefits, as other non-Project-related businesses benefit from direct Project purchases. Worker spending and increased purchase power by locals with additional income will likely expand spending in the local area. This will generate more local value-added tax. These beneficial "multiplier" impacts will occur throughout the Project life.

Potential adverse impacts of the Project on economic conditions associated with planned Project activities could include potential cost of living increases due to a higher demand for some goods and services, either through direct Project procurement or through Project worker purchases (see Section 8.5 for potential impacts on social infrastructure and services). Additionally, increased competition for skilled workers and support services could result from EEPGL and its contractors' hiring and procurement activities, and could present a potential adverse impact for other companies and sectors that may not be able to pay salaries comparable to those of the oil and gas sector. It is therefore likely that other sectors and the economy overall will need to adjust to the changes brought about by the growing oil and gas sector, which may include upward pressure on salaries. While this may cause short-term challenges for other sectors, the long-term effects should be positive overall; Guyana is known for having a high level of "brain drain," whereby a large percentage of the tertiary-educated population emigrates from the country, mostly to Organisation for Economic Co-operation and Development nations (World Bank 2000; World Bank 2016; Guyana Chronicle 2015). Provided that a more robust employment environment can be demonstrated, an increase in high-skilled, high-paying jobs associated with the oil and gas sector should contribute to the attenuation of this phenomenon, creating a larger pool of advanced workers for all areas of the economy. EEPGL's ongoing capacity-building and training initiatives will remain attentive to the need to foster a more qualified workforce and to enhance the capacity of local suppliers to serve a larger and more diverse clientele, rather than focusing only on the immediate needs of the oil and gas sector.

Table 8.1-8 summarizes the Project stages and activities that could result in potential Project impacts on economic conditions, as well as the receptors that could potentially experience these impacts.

Table 8.1-8: Summary of Relevant Project Activities and Key Potential Impacts—Socioeconomic Conditions

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project stages	Guyanese population—principally in the Georgetown Area	Project revenue generation	• Potential government investment in social services and economic development/diversification • Potential government infrastructure projects
		Project hiring and workforce training	• Direct hiring of Guyanese nationals for a limited number of positions • Hiring of Guyanese nationals by Project contractors and subcontractors • Increased experience, capacity and skills of local workers and subcontractors • Competition with other local businesses for qualified workers
		Project procurement of selected goods and services	• Increased sales tax revenues

Stage	Receptor(s)	Project Activity	Key Potential Impacts
		Project capacity building programs for prospective local suppliers	• Increased local business activity and growth • Increased demand for services and infrastructure, potentially leading to increased cost of living and/or procurement challenges for other companies
		Project worker spending	
		Limited local direct employment and increased opportunities through indirect employment	

8.1.3.2. Magnitude of Impact—Socioeconomic Conditions

The Project has the potential to impact economic conditions both positively and adversely. Project revenues to the government through its Petroleum Agreement with EEPGL can allow for increased government spending on social infrastructure, services, and programs, as well as investment in infrastructure programs and different economic sectors. Economic conditions can also be impacted positively by local hiring for a limited number of new positions, local Project procurement, and Project worker spending.

A potential adverse impact could occur from increases in the cost of living due to higher demand for some goods and services. However, given the Project's small workforce and predominantly offshore footprint, such increases are expected to be limited.

Although the Project's local hiring and procurement will be overwhelmingly positive for the country, it could present challenges for other companies and sectors if it creates competition with other local businesses for workers, goods, and services. This potential adverse effect is expected mostly over the short to medium term. As the oil and gas sector adds more jobs and increased demand for workers and services exerts upward pressure on salaries in some sectors, it is expected that the availability of a more robust and high-paying employment situation will contribute to reduced emigration of tertiary educated and otherwise qualified workers from the country. This should provide a more qualified workforce for all sectors of the economy over the medium to long term.

Considering the factors above, potential economic benefits of the Project are expected to outweigh potential negative impacts such that overall impact on the economy is expected to be **Positive**. As described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, this assessment does not develop magnitude ratings for positive impacts.

8.1.3.3. Sensitivity of Receptors—Socioeconomic Conditions

The receptors with the potential to be affected by potential impacts on economic conditions include the full Guyana population, but those most likely to be potentially impacted are residents in the Georgetown area. As discussed below, vulnerable (lower-income) populations are considered to be more sensitive to these potential impacts and are therefore considered separately. The receptor sensitivity ratings for economic conditions are defined in Table 8.1-9.

Table 8.1-9: Definitions for Receptor Sensitivity for Potential Impacts on Socioeconomic Conditions

Criterion	Definition
Sensitivity	Low: The local and regional economies are highly diversified and not highly dependent on any one sector. The workforce is highly skilled, would not experience major challenges in shifting to different occupations, and is well positioned to benefit from the Project.
	Medium: The local and regional economies are somewhat diverse and dependent on a few key industrial sectors that are not all natural resources-based. Alternate economic opportunities, including from the Project, are possible, but the workforce may require additional training to be able to pursue such opportunities.
	High: The local and regional economies are highly dependent on one or a few industrial sectors that are largely natural resources-based. There are few alternate economic opportunities in the area and/or the workforce does not have the skills to shift to pursue alternate economic opportunities.

Receptors in the Georgetown area (Region 4) are considered to have a **Medium** level of sensitivity to economic impacts, since the economy in this region is relatively diverse and less dependent on natural resources than in other areas of the country, with 12 percent of jobs in the primary sector, 21 percent in the secondary sector, and 67 percent in the tertiary sector[1].

Individuals and households of lower socioeconomic status are considered to have a **High** level of sensitivity to economic impacts due to their lower capacity to benefit from the Project and the business opportunities it may bring, and to their higher level of vulnerability to an increased cost of living. However, this vulnerable population will stand to benefit from increased government revenues along with the general population, should such government revenues be invested in social infrastructure, services, and programs, as well as investment in infrastructure programs and different economic sectors.

8.1.3.4. Impact Significance—Socioeconomic Conditions

Based on the discussion above, the potential impacts on economic conditions are rated as **Positive** overall for both the general population and the low-income subpopulation, with potential impacts on receptors in the Georgetown area likely to be more highly impacted (i.e., benefitted). As described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, this assessment does not develop significance ratings for positive impacts.

8.1.4. Mitigation Measures—Socioeconomic Conditions

As the expected potential impact on economic conditions is net positive, no mitigation measures are required. However, to enhance the benefits from this positive impact, the Project intends to continue its current local hiring and procurement practices, with ongoing capacity-building

[1] According to the Bureau of Statistics Guyana (BSG 2002) (the most recent dataset broken down at the city level), the primary industrial sectors (e.g., agriculture, fishing, forestry, and mining) make direct use of natural resources and include the production of raw materials and basic foods. The secondary sector is engaged in manufacturing using raw products from the primary sector and includes processing, construction, textile production, brewing and bottling, etc. The tertiary sector provides services to the general population and businesses, including retail and wholesale trade, transportation and distribution, entertainment, tourism, healthcare, etc.

initiatives to optimize local content to the extent practicable. Table 8.1-10 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 8.1-10: List of Embedded Controls and Monitoring Measures

Embedded Controls
Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practicable. Partner with select local institutions and agencies to support workforce development programs and proactively message Project-related employment opportunities.
Procure Project goods and services locally when available on a timely basis and when they meet minimum standards and are commercially competitive.
Monitoring Measures
Monitor percentage of Project Workforce made up of Guyanese nationals on a quarterly basis.
Monitor percentage of Project goods and services expenditures procured locally on a quarterly basis.

Table 8.1-11 summarizes the assessment of potential pre-mitigation and residual Project impacts on economic conditions. The potential impacts are rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the economic conditions-specific methodology described in Sections 8.1.3.2 and 8.1.3.3.

Table 8.1-11: Summary of Potential Pre-Mitigation and Residual Impacts—Socioeconomic Conditions

Stage	Potential Resource/ Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Guyanese population including lower income subpopulation (in particular Georgetown population) - increased government revenues, increased employment, increased local business activity, potential for increased cost of living, potential for competition with other local businesses for qualified workers.	Not rated (Positive) [a]	Medium (general population) High (lower income groups)	Positive	None	Positive

[a] While some of the identified potential impacts are adverse and some are positive, the overall potential impact on socioeconomic conditions is expected to be (net) positive.

8.2. EMPLOYMENT AND LIVELIHOODS

8.2.1. Administrative Framework—Employment and Livelihoods

Table 8.2-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on employment and livelihoods.

Table 8.2-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Employment and Livelihoods

Title	Objective	Relevance to the Project
Legislation		
Occupational Safety and Health Act (1997) Cap. 99:06.	Legally defines the responsibilities of workers and management with respect to keeping workplaces safe.	Generally applies to Project workers and Project-related activities.
Food & Drug Regulations (Food and Drug Act, 1971) Cap. 34:03.	Regulates the sale, advertisement, preparation, and handling of food products; regulates the manufacture, advertisement, trade, and administration of pharmaceuticals; provides the Ministry of Health authority to inspect facilities to establish compliance with sanitation standards.	Governs the preparation of food and provision of medications at Project facilities.
Prevention of Discrimination Act (1997) Cap. 99:08.	Provides for the elimination of discrimination in employment, training, recruitment, and membership in professional bodies and the promotion or equal remuneration to men and women in employment who perform work of equal value.	Prevents discrimination in employment practices.
National Insurance and Social Security Act (1969) Cap. 36:01.	Establishes a system of national insurance and social security providing pecuniary payments by way of old age benefit, invalidity benefit, survivor's benefit, sickness benefit, maternity benefit, and funeral benefit, and to substitute for compensation system of insurance against injury or death caused by accident arising in the course of employment or resulting from disease due to the nature of employment; establishes a National Insurance Fund.	Provides the overarching framework for workers' insurance and other benefits.
Employment of Young Persons and Children Act. Cap. 99:01.	Seeks to implement certain conventions relating to the employment of young persons and children.	Restricts the ages of young persons who may be employed by the Project.
Termination of Employment and Severance Pay Act (1997, 1999) Cap. 96:01.	Makes provision for the conditions governing termination of employment and grant of redundancy or severance payment to employees.	Governs payments to employees or the termination of employment. This could be relevant to contractors and sub-contractors to the Project.

Title	Objective	Relevance to the Project
Policies		
Occupational Safety and Health Policy (under development)	Aims to promote and improve the quality of life of workers by preventing social and economic losses, work-related accidents, and injury to health by eliminating hazards, reducing the number of accidents, and injuries, and combating stresses and incidence of occupational diseases. Its implementation will be supported by the International Labour Organization.	When completed, will generally apply to the Project and Project workers.
Local Content Policy (under development)	Makes provisions for preferential treatment of Guyanese where capability exists; building local capacities for the sector; international partnerships to enable technology and knowledge transfer and access to investment opportunities; extending Guyanese participation to support national development; and leveraging the hydrocarbon sector's strategic assets, and skills for the lateral development of other sectors.	Would provide government guidance on Guyanese participation in the petroleum sector. Expected to directly influence Guyanese service provision and employment in the sector. A second draft of the policy is under consideration by the government.

8.2.2. Existing Conditions—Employment and Livelihoods

Results from the most recent Labour Force Survey indicate that as of the end of 2017, the unemployment rate was 12.2 percent (36,416 persons), a 0.3 percent decrease since 2012 (BSG 2018b; BSG 2012). As of 2017, Guyana's working-age population (aged 15 and above) was 547,928 persons, of which approximately 73.5 percent were based in rural areas. Women accounted for 52 percent and men represented approximately 48 percent of the working-age population. However, men represented 60.5 percent of the total labor force[2]. In addition, the labor force participation rate[3] was only 54.5 percent of the total working-age population. This has been attributed to low labor-force participation rates in rural areas, with a rate of 53.4 percent for all persons, and women with a rate of 41.5 percent. The employment-to-population ratio was 47.9 percent, with a significant difference between the rate of men (61.7 percent) and women (35.1 percent) (BSG 2018b)[4].

The unemployment rate did not change significantly when compared with the 2002 census data (BSG 2018b; BSG 2012; BSG 2002). Approximately 22.9 percent of youth (aged 15 to 24) are unemployed, down from 25.3 percent in 2012.

The private sector accounts for 68 percent of employment, with the public sector and not-for-profit organizations accounting for 22 percent and 10 percent, respectively. A larger share of women than men is employed in the public sector. The majority of employed persons,

[2] The labor force is defined as the sum of employed persons and unemployed persons (BSG 2018a).

[3] The labor force participation rate is defined as a percentage of the working age population (BSG 2018b).

[4] The employment-to-population ratio is defined as the proportion of a country's working age population that is employed (ILO 2015).

18.9 percent, work in the agricultural sector, which is consistent with the findings of the 2012 census. Wholesale and retail trade employs 16.1 percent of the working age population representing an increase from 15.4 percent in 2012. Public administration and defense account for 9.3 percent of employed workers, and the manufacturing sector accounts for 8.4 percent. Table 8.2-2 presents employment in Guyana by economic sector for 2012 compared to results from the final quarter of 2017 (BSG 2018b).

Table 8.2-2: Employment in Guyana by Economic Sector in 2012 and 2017

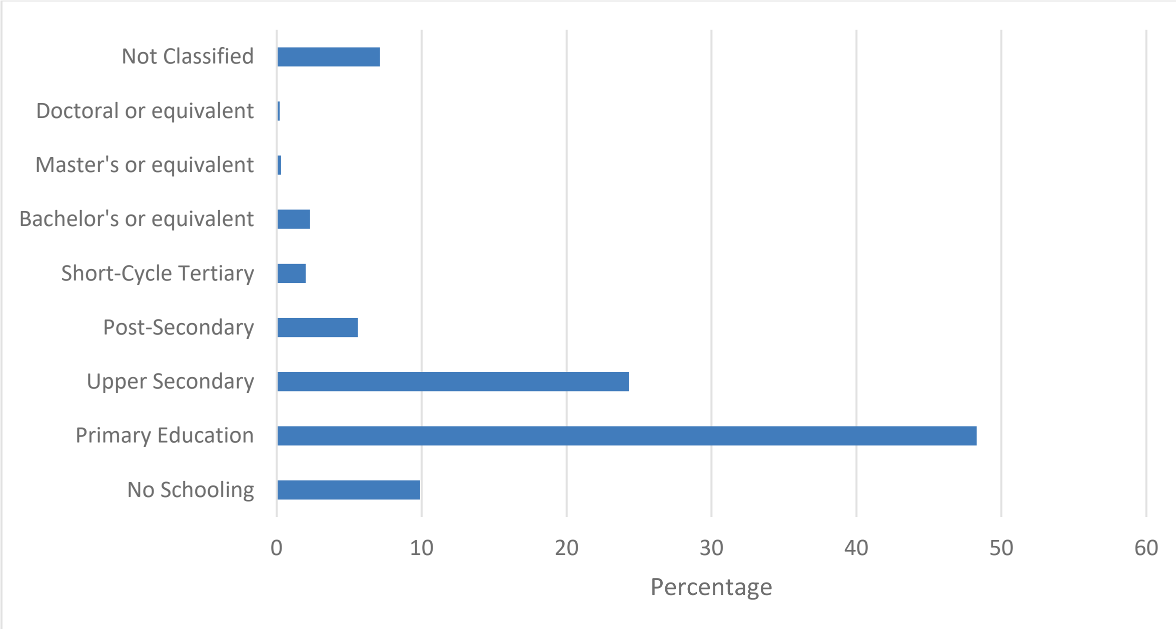
Economic Sectors	2012	2017 [a]
Agriculture, forestry, and fishing	17.5	18.9
Wholesale and retail trade	15.4	16.1
Public administration and defense	7.2	9.3
Construction	10.4	7.7
Manufacturing	8.6	8.4
Transportation and storage	7.7	7.3
Education	5.3	6.3
Mining and quarrying	8.2	4.2
Administrative and support services	3.7	4.3
Accommodation and food service activities	2.8	4.4
Human health and social work activities	2.7	1.2
Activities of households as employers	2.3	2.8
Other service activities	2.7	2.6
Financial and insurance activities	1.3	1.2
Professional, scientific, and technical services	1	0.97
Water supply, sewerage, and waste management	0.5	1.24
Information and communication	1	0.84
Electricity, gas, steam, and air conditioning	1	0.82
Activities of extraterritorial organizations	0.2	0.8
Arts, entertainment, and recreation (not statistically significant)	0.6	0.5
Real estate activities (not statistically significant)	0.1	0.04
Not classifiable by economic activity	0.3	0.0

Source: BSG 2018b

[a] Results from the Labour Force Survey for the final quarter of 2017

Approximately 52.7 percent of employed persons are informally employed, of which 8.8 percent are within the public sector. Of this total, 57.6 percent are men and 44.8 percent are women. Informal employment is characterized by a low level of organization and labor relations have no contractual arrangements or formal guarantees (BSG 2018b).

The majority of Guyana's working age population has attained primary education (BSG 2018a), as shown in Figure 8.2-1.



Note: Results for 'Masters or equivalent' and 'Doctoral or equivalent' categories were not considered statistically significant
Source: BSG 2018a

Figure 8.2-1: Percentage Share of Working Age Population by Education Completed

The most recent employment data available by region are from the 2012 national census (BSG 2016), which found that the Region 1 unemployment rate was the highest in the country, at 19.3 percent of the labor force. Region 2 had the lowest unemployment rate, at 10.6 percent. Regions 3 and 4 had rates of 11.8 percent and 11.3 percent, respectively.

Statistics from the 2012 census indicate the following employment percentages for workers 15 years of age or over in the agriculture, forestry, and fishing sector: 23 percent in Region 1, 27.9 percent in Region 2, and 18.8 percent in Region 3 (BSG 2016). This sector employed the largest number of workers in Regions 2 and 3; in Region 1, the sector was second to mining and quarrying. The mining and quarrying sector employed the second largest group in Region 2 (14.9 percent), while in Region 3, the construction sector employed the second largest group (12.1 percent). In general, the primary sector industries in these regions[5] are dominated by male workers, with female workers making up less than 10 percent of the workers.

Census data show that tertiary (service) sector jobs such as wholesale and retail trade, public administration, and accommodation and food services are dominant in Region 4 (including Georgetown), making up 67 percent of jobs. Female representation in this sector is high, with

[5] According to the Bureau of Statistics Guyana, the primary sector industries (e.g., agriculture, fishing, forestry, and mining) make direct use of natural resources and include the production of raw materials and basic foods. The secondary sector is engaged in manufacturing using raw products from the primary sector and includes processing, construction, textile production, brewing and bottling, etc. The tertiary sector provides services to the general population and businesses, including retail and wholesale trade, transportation and distribution, entertainment, tourism, healthcare, etc.

women making up 48.2 percent of workers (BSG 2016). Secondary and primary sector jobs make up 21 percent and 12 percent of employment, respectively, in Region 4.

Due to the recent emergence of Guyana's oil sector, employment impacts associated with the sector are not currently well characterized. However, it is understood that oil production operations generate a much larger number of indirect jobs than direct employment (Oil Now Guyana 2017). Furthermore, it is understood that EEPGL's employment of Guyanese nationals for a limited number of positions, as well as EEPGL's local procurement—including a diverse range of goods and services such as transportation, catering, office supplies, accommodations, security, engineering, and housekeeping—have had positive impacts on employment, particularly in the tertiary sector.

The issues facing indigenous groups are typically related to lack of empowerment and inclusion into the mainstream economy. The standard of living for the indigenous minority continues to be lower than for the majority of the country's citizens. A larger proportion of the Amerindian population is classified as socioeconomically disadvantaged (Minority Rights Group International 2008) due to a lack employment opportunities in their villages and few persons with formal qualifications (UNICEF 2017). Income-generating opportunities in the indigenous coastal communities of Regions 1 and 2 are scarce and include heart of palm harvesting and the wildlife trade, including sale of aquarium fish (IDB 2007). In the past, the Region 2 village of Mainstay operated an organic pineapple farm and processing facility; however, the plant was shut down several years ago (ERM Personal Communication 4). Some residents of indigenous communities in Regions 1 and 2, particularly men, also work in mining and logging camps in the hinterland (IDB 2007). Many of these men migrate from their villages for periods of a few weeks to a few months if there is no mining or logging camp in the vicinity (UNICEF 2017).

Many of the residents in the coastal NDCs/CDCs or TCs in Regions 1 through 6 are directly employed by or linked to the fishing industry due to their proximity to the coast. For example, the primary provisioning service in all six regions is fishing, and fishing accounts for approximately 25 percent of the ecosystem services in the study area based on field assessments in these communities (ERM/EMC 2018; Appendix V, Interim Ecosystem Services Validation Data Summary).

Similarly, fishing support services include boat building and repairs, fuel services, entertainment, and household products needed by sailors and fisherfolk—and these provide numerous employment opportunities to residents.

8.2.2.1. Fishing

Fishing along the Guyanese coast varies in scale and type. In Region 1, a significant share of all fishing activity is artisanal, which is used for sustenance, although there are some villages that collectively own "community boats" and use the catch for sustenance as well as commercial sale. There is only one formal landing site in Region 1 (Morawhanna) for vessels engaged in industrial-scale fishing activity (see Figure 8.2-2) and two landing sites with larger fish markets located in Mabaruma and Santa Rosa. Artisanal fishing vessels from nearby communities frequently visit these three landing sites to sell their catch. Commercial species sold at these sites include bangamary, trout, cuirass[6], snook, sea catfish, and gillbacker. Due to limited options for cold storage of catch, a significant amount of fish is dried or smoked before sale in Region 1 (Appendix T, Participatory Fishing Survey Quarterly Report).

Figure 8.2-2: Industrial-Scale Landing Site, Morawhanna, Region 1

Most fisherfolk in Regions 2 to 6 are involved in artisanal fishing. Artisanal boats are still used because the coastal mudflats in these regions typically do not allow for the use of larger boats. Landing sites in these coastal regions vary in the size of their vessel fleets. As described in Section 8.1, Socioeconomic Conditions, one of the largest coastal landing sites is the Village 66 Complex in Region 6, with an artisanal fleet of 200 vessels during peak fishing seasons. Smaller landings sites with fewer vessels are found throughout the coast from Region 2 to 6, the most commonly known being Hampton Court (Region 2), Windsor Forest and La Grange (Region 3), Mahaicony Bridge (Region 5) and Rose Hall (Region 6) (see Section 8.4.2, Existing Conditions—Marine Use and Transportation).

Smaller artisanal vessels typically have crews of 1 to 3 persons per trip. Small artisanal vessels that use fyke nets (also referred to in Guyana as Chinese seines) or pin seines make daily trips. However, vessels using drift seines also make daily trips but may stay at sea for up to 8 days. Fishing using small vessels is focused along the coastline near respective landing sites. Larger artisanal vessels that have engine sizes of greater than 40 horsepower travel greater distances and have fishing trips of longer durations. They also have larger crews of six to eight persons per trip. Larger artisanal vessels from landing sites in Rosignol (Region 5) and the Complex 66 (Region 6) are also licensed to fish in Surinamese waters.

[6] Presumed to be *Arius proops*

Species caught by artisanal vessels in Regions 2 to 6 include whitebelly shrimp, seabob, gillbacker, trout, bangamary, butterfish[7], cuirass, snook, sea catfish, cuffum, snapper, shark, and bashaw[8], among others. Some fish are sold locally to ice trucks that visit the landing sites on a daily basis to purchase fresh catch from fisherfolk; other fish are sold in the villages. Some fisherfolk, such as those from the La Grange landing site (Region 3) and Riverview landing site (Region 4), visit the Meadowbank Wharf and others visit the Stabroek Market in Georgetown to sell their catch (ERM Personal Communications 14, 17, 18, and 19; Appendix T, Participatory Fishing Survey Quarterly Report). Fishing yields vary by season, with fisherfolk reporting the highest yields in June through September. From October to early February, catches are at their lowest due to seasonally colder waters coming from the north.

Industrial fishing operators in Guyana are based mainly in Region 4 and have private wharfs where their vessels dock. The industrial vessels largely target seabob and prawns but also catch red snapper, shark, and tuna. The deepwater tuna fleet is currently at 12 vessels (ERM/EMC Personal Communication 5; ERM Personal Communication 24).

Figure 8.2-3: Salted Fish Drying outside a Fisherperson's Home in Region 2

[7] Presumed to be *Nebris microps*; the colloquial names "butterfish" and "butterhead" are used interchangeably for this species.
[8] Presumed to be *Micropogonias furnierei*

Figure 8.2-4: Fresh Fish Being Sold at Stabroek Market in Georgetown

Challenges for the Fishing Industry

When asked about changes in fishing yields over the years, responses from Region 2 artisanal fisherfolk varied, with most reporting no noticeable change in catch volume. However, an individual with a relatively large-scale operation of three boats operating out of Charity in 2018 stated that catches are declining and attributed this to an over-allocation of fishing licenses by the government (ERM Personal Communication 15). As indicated in Section 8.1.2.4, Economic Conditions, annual yields in the fishery sector have declined in the last 6 years for fish, and in 4 of the last 6 years for seabob, although seabob yields recovered slightly between 2016 and 2017. Although there are no data available to quantify the impact of Illegal, Unreported, and Unregulated[9] fishing in Guyana, its role in threatening the sustainability of the country's fishery is considered to be significant (Ministry of Finance 2015; Ministry of Agriculture 2016).

Another challenge faced by fisherfolk is piracy. Most of the fisherfolk interviewed by the Consultants have been victimized by pirates at some time. This typically consists of the theft of boats and/or engines, and fisherfolk are sometimes assaulted in these confrontations. In Region 2, most respondents perceived that piracy had gone down in the last 5 or 10 years. Some believe the recent establishment of a Coast Guard Station at the mouth of the Pomeroon River has influenced the decrease in piracy. Of those who have encountered pirates, they were typically unsure of their assailants' nationalities, but speculated that they could be Venezuelan, Guyanese, Surinamese, or a mixed group from different countries. Most respondents in Region 1 indicated that piracy from Venezuelan vessels has increased over the last 2 to 3 years (Appendix T, Participatory Fishing Survey Quarterly Report). There are reported incidents of piracy from

[9] Illegal, Unreported, and Unregulated fishing takes place where vessels operate in violation of the laws of a fishery. This can apply to fisheries that are under the jurisdiction of a coastal state or to high-seas fisheries regulated by regional organizations.

villagers and fisherfolk in Region 1 on the remote and hard-to-access coastal plains in SBPA, from Tigers Beach to Almond Beach (ERM/EMC 2018).

The economics of the fishing industry can pose challenges to fisherfolk, especially artisanal fisherfolk who tend to operate their businesses on a cash basis and are more susceptible to short-term downturns due to a lack of cash reserves. In interviews conducted as part of the Liza Phase 1 post-permit marine fish survey, some fisherfolk mentioned their operating costs as an economic challenge. Several indicated that fuel represents the most significant expense, which can vary from $1,200 to $3,000 GYD ($5.80 to $14.40 USD) per trip for coastal fishing (less than 5 nautical miles from shore), while for more distant operations (greater than 5 nautical miles from shore), fuel cost can vary from $10,000 to $50,000 GYD ($48 to $240 USD) per trip. In addition to fuel, ice, bait, food, net repairs, and miscellaneous expenses were mentioned as contributing to operating costs (ERM 2018).

Gross income per fishing trip is significantly dependent on the species caught and the prevailing market prices for these species. In March and April 2019, trout was sold for at least $660 GYD ($3.17 USD) per kilogram, shark for $748 GYD ($3.58 USD) per kilogram, and snapper for $880 GYD ($4.22 USD) per kilogram at the Riverview landing site in Region 4. Lower-priced species included bashaw and cuirass for $132 GYD ($0.63 USD) per kilogram, catfish for $176 GYD ($0.84 USD) per kilogram, bangamary for $220 GYD ($1.06 USD) per kilogram, and butterfish for $375 GYD ($1.80 USD) per kilogram. One vessel had a daily catch of 485 kilograms (1,069 pounds), which was comprised of 217.2 kilograms (443.6 pounds) of trout and 190.5 kilograms (420 pounds) of snapper, and had gross earnings of $63,465 GYD ($304.63 USD). By contrast, another vessel had a haul of 878 kilograms (1,935.7 pounds), almost twice the quantity of the previous vessel, which was comprised of 362 kilograms (798 pounds) of bangamary, 217 kilograms (478.4 pounds) of butterfish, and 290 kilograms (693.3 pounds) of trout/other species, and had gross earnings of $69,946 GYD ($335.74 USD) (Appendix T, Participatory Fishing Survey Quarterly Report). The period of March/April 2019 was considered to be a "good season" as the peak fishing period is expected to start in June. Many fisherfolk indicated that it is necessary to raise the sale price of fish in order to improve their family economies. Additionally, there was a general consensus that the catch size of the fish have not varied much in recent years, so the economic pressures being felt by fishing families may be related to macroeconomic factors that are external to the fishing industry, rather than the condition of fisheries resources or other industry-related factors (ERM 2018).

The dynamic accretion and erosion of the Guyanese coastline as a result of natural forces can also pose challenges for fisherfolk. During field visits in August/September 2016, late-2017, early-2018, and early-2019, the Consultants observed considerable mudflat and beach accretion at most coastal access points along the coastline, which prevents fisherfolk from landing their boats in some areas (Figure 8.2-5). Saltwater intrusion also occurs up the Moruca and other smaller rivers in Region 1 in the dry season. It was noted as having impacts on fishing livelihoods in several villages in Region 1 (ERM/EMC 2018). The spread of mangrove vegetation along the shoreline has also impacted the fishing sector. As a result of the new mangrove growth and subsequent loss of access to shore, some landing sites had to close and fisherfolk had to relocate to other landings sites (Appendix V, Interim Ecosystem Services Validation Data Summary).

Figure 8.2-5: Coastal Mudflat at Bushlot Landing Site in Region 5, March 2019

The proliferation of sargassum in fishing grounds has also posed significant challenges to fisherfolk (ERM/EMC Personal Communication 5; Appendix T, Participatory Fishing Survey Quarterly Report; Bank of Guyana 2018). The sargassum fills the seine (instead of catch) and lowers yields. During one trip, a fyke net vessel at the Ogle landing site reported approximately 400 kilograms (882 pounds) of sargassum in catch from three pens. The sargassum also results in loss of productive time as fisherfolk have to clean the sargassum from their seines (Figure 8.2-6) and from their catch before sale, as seen in Figure 8.2-7 (Appendix T, Participatory Fishing Survey Quarterly Report).

Figure 8.2-6: Sargassum Tangled in a Fishing Seine

Figure 8.2-7: Fisherfolk Separating Sargassum from Catch at the Zeeburg Landing Site in Region 3

8.2.2.2. Farming and Agricultural Processing

As discussed above, agriculture is a major livelihood activity in Regions 2 to 6. Rice farming dominates agricultural production in these regions, but other crops, such as red beans, plantains, bananas, eggplants, and other vegetables, are grown on a smaller scale as well. In general, it appears that agriculture is very important in Region 6, with the highest employment opportunities for agriculture as compared to other coastal NDCs in Regions 1 through 5 surveyed as part of the Consultant field studies in late 2017 to early 2018 (ERM/EMC 2018).

In Region 2, most households also raise livestock, such as cattle, hogs, poultry, and small ruminants. The Amerindian community of Mainstay, located approximately 6 kilometers (approximately 3.5 miles) from the coast in Region 2, is known for its organic pineapples, which for a number of years were processed into canned chunks for export to European markets (ERM Personal Communication 4). Coconut cultivation is becoming increasingly popular in the Pomeroon area, as demand for coconut water and other value-added coconut products continues to grow. A number of farms produce coconut water for export to Trinidad and Tobago, while others produce coconut oil. A group established in 2001, the Pomeroon Women's Agro-Processors Association, also produces a number of value-added products, including virgin coconut oil, pepper sauce, cooking sauce, wine, and carambola cake mix (ERM Personal Communication 5).

In the Amerindian communities of Region 1, agricultural activities occur on a small scale and include cultivation of tubers, corn, cucumber, eggplant, ginger, peppers, plantains, bananas, watermelon, beans, okra, pumpkin, and coconut. At least one community engages in cassava processing, including cassava bread, starch, and cassareep (PAC 2014), but lack of access to markets prevents larger-scale development of this commercial activity

Challenges for Farmers and Agricultural Processors

Climate change is perceived as a challenge for some agricultural producers. For example, changes in sunshine and rain patterns are thought to have contributed to decreased pineapple yields in recent years (ERM Personal Communication 4). Sea-level rise potentially associated with climate change is also considered a threat for coastal farmers, given that the coastal plains, where the majority of the country's agricultural activity occurs, lie below sea level (ECLAC 2011). Outside of flood events, saltwater sometimes enters into the irrigation canals through sluice gates at high tide or up the Pomeroon River during the dry season. This can adversely impact some crops, such as most vegetables, but may be beneficial to others, such as fruit trees (ERM Personal Communication 5). However, the irrigation canal system for rice fields and fish farms are separated from the drainage system and draw from the water conservancies (see Section 8.1.2.4, Economic Conditions).

8.2.2.3. Speedboat Operation

Guyana's unique geography means that boating is an important mode of transport for travel between the coastal regions. Other than air travel, the most rapid and direct means of accessing Region 2 from the east coast of the Essequibo River is by speedboat, although a ferry service is also available. Speedboat operators servicing the route between Parika in Region 3 and Supenaam in Region 2 belong to the Supenaam-Parika Speedboat Owners' Association, which currently numbers 91 boats (see Figure 8.2-8). According to a member of the association, the majority of customers for this route are business owners, such as shopkeepers who travel to Georgetown for supplies (ERM Personal Communication 6). Speedboats are also used for transportation to communities upriver on the Essequibo and Pomeroon rivers, and to areas of Regions 1 and 2 that are not accessible by road (i.e., areas west of Charity). In Regions 3 and 4, speedboats are used for transportation across the Demerara River. More information on speedboat use in the coastal areas is provided in Section 8.4, Marine Use and Transportation

Figure 8.2-8: Speedboats Docked in Parika, Region 3

Challenges for Speedboat Operators

Although natural forces (e.g., wind, waves, sea currents, and sediments transported from the mouth of the Amazon River) create a dynamic and ever-changing coastline, speedboats are typically able to maneuver through mud and sandbanks, where ferries would be unable to traverse (ERM Personal Communication 6). As a result, there are no notable seasonal factors that impact business or safety for speedboat operators. However, some stakeholders noted that along the Pomeroon River, where there are many coconut plantations and processing plants, the practice of discarding coconut shells in the river poses a danger to speedboat operators and passengers (ERM Personal Communication 5 and 6). For speedboat operators plying the Region 1 route, and through the Moruca Sub-Region in particular, the dry season conditions, which can include low water levels in the creeks, can pose a challenge and cause considerable delays.

8.2.3. Impact Assessment—Employment and Livelihoods

This section assesses potential impacts from the Project's planned activities on employment and livelihoods in the Project's AOI. The following are the key impacts considered for planned Project activities:

- Potential increased local business activity and employment due to select Project employment and select Project procurement and due to Project worker spending;
- Potential for restricted access to remote offshore fishing locations, and damage to fishing vessels and equipment from Project vessel movements; and
- Potential occupational health and safety impacts on Project workers.

8.2.3.1. Relevant Project Activities and Potential Impacts

The primary Project activities will occur approximately 207 kilometers (approximately 128 miles) northeast of the coastline of Georgetown and are not expected to significantly impact non-Project activities occurring on the Guyana coast. The only planned Project activities that will be perceptible from the shore will be support vessel trips originating from and returning to shorebase facilities in Georgetown, and helicopter transits between onshore aviation bases and the FPSO and drill ships offshore.

With respect to increased local business activity and employment, the Project will have direct and indirect potential impacts resulting from employment of Guyanese nationals and use of local companies to supply various goods and services. The local workforce and local suppliers will also benefit from capacity-building training programs currently being undertaken by EEPGL. As described in Section 8.1, Socioeconomic Conditions, EEPGL intends to continue the current approach to optimizing use of local content and continue capacity-building training programs to the extent practicable.

Planned Project activities and the presence of Project vessels are not expected to have significant impacts on fishing livelihoods given the remote location of the activities. Potential impacts on fishing vessels as a result of unplanned events (e.g., collisions between Project vessels and non-Project vessels) are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Project workers onboard the FPSO and other Project vessels will be exposed to occupational hazards typical of offshore oil and gas operations. As discussed in Chapter 2, Description of the Project, as well as in the Environmental and Socioeconomic Management Plan (ESMP), these will be managed through implementation of EEPGL's Operations Integrity Management System (OIMS), a robust and effective management system to protect its Project workforce.

Table 8.2-3 summarizes the Project stages and activities that could result in potential Project impacts on employment and livelihoods, as well as the receptors that could potentially experience these impacts.

Table 8.2-3: Summary of Relevant Project Activities and Key Potential Impacts—Employment and Livelihoods

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project stages	Population of Georgetown and vicinity	Project procurement of select goods and services	• Increased local business activity and growth • Increased employment
		Worker spending	
		Limited local employment (direct and indirect)	
	Fishing vessel operators in the Project AOI	Transit of Project vessels between the PDA and shorebases in Georgetown and in Guyanese waters between the PDA and shorebase in Trinidad and Tobago; establishment of marine safety exclusion zones around major Project vessels in the PDA	• Disruption of fishing activities due to presence of Project vessels • Minor limitations on fishing access in remote offshore areas due to marine safety exclusion zones (500 meters [1,640 feet] around the drill ships and 2 nautical miles around the FPSO during offloading)

8.2.3.2. Magnitude of Impact—Employment and Livelihoods

The assessment of the Project's magnitude of potential impacts on employment and livelihoods is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on employment and livelihoods is defined according to the definitions provided in Table 8.2-4. The following paragraphs discuss the characteristics of each of the potential impacts assessed, and the resultant magnitude ratings. These are summarized in Table 8.2-5.

Table 8.2-4: Definitions for Intensity Ratings for Potential Impacts on Employment and Livelihoods

Criterion	Definition
Intensity	Negligible: The changes do not bring about any loss of livelihood or employment.
	Low: The changes impact some individual receptors' ability to engage in their current livelihood(s) at the same level of productivity.
	Medium: The changes impact some receptors' ability to engage in their current livelihood(s) at the same level of productivity, and/or cause a loss of working days. The changes impact up to an entire sector within a community in this way.
	High: The changes cause the receptors to cease their current livelihood activities for an extended period of time, or indefinitely. The changes impact up to an entire sector within a region in this way.

Increased Employment

The Project will have limited direct local employment. According to EEPGL, as of the first quarter of 2019, EEPGL employed a total of 1,183 Guyanese nationals (up from 585 in 2018), constituting 49 percent of its total workforce. Modest increases in total employment, including an increase of EEPGL's office staff to about 227 workers (for all EEPGL activities), are expected with the development of the Payara Development Project, and EEPGL intends to continue hiring Guyanese nationals to the extent reasonably practicable, in alignment with its Local Content Plan. This impact is considered to be **Positive** and as such, a magnitude rating is not assigned.

Increased Business Activity and Economic Growth

In addition to direct employment, the Project will result in the indirect employment of workers through procurement of select local goods and services. Local and foreign workers that are off-shift also will spend a portion of their salaries in the Georgetown area on local accommodations, food, transportation, and entertainment. This increase in business for these local service providers could potentially lead to increased incomes, additional hiring, and continued investment in these local businesses, allowing for further growth. Additionally, beyond ensuring appropriate capacity to perform work or deliver services to EEPGL and its contractors, the capacity-building initiatives delivered to workers and local suppliers will strengthen local workers' and entrepreneurs' skills and employability, providing employment and livelihood benefits over the longer term. The Bureau of Statistics anticipates that Guyanese will become wealthier as a result of the oil and gas sector and this may result in improved quality of living. For example, as people become wealthier, they are likely to be interested in owning their own home, resulting in an increase in the number of households (ERM/EMC Personal Communications 10). This impact is considered to be **Positive** and as such, a magnitude rating is not assigned.

Limitations on Industrial Fishing in Remote Offshore Areas

Few potential adverse impacts on employment or livelihoods are expected as a result of planned Project activities. Current fishing activities (both industrial and artisanal) rarely occur as far offshore as the PDA, and according to various members of the industrial and artisanal fishing community as well as the Fisheries Department, the marine safety exclusion zones are expected to have little or no impact on existing fishing activity (ERM Personal Communication 22). There is one commercial fishing company, Pritipaul Singh Investments, with 12 vessels capable of partaking in deepwater tuna fishing (ERM/EMC Personal Communication 5; ERM Personal Communication 24) that may approach the southern boundary of the PDA, and abandoned fishing gear was found in 2018 entangled in the mooring lines for metocean instruments installed by EEPGL in the same general vicinity. There are also reportedly Venezuelan vessels that fish on occasion at depths as far out as 190 kilometers (118 miles) near the PDA, but no further information was obtained by the Consultants to confirm these reports (ERM Personal Communication 23). If deepwater fishing continues to develop in the vicinity of the PDA, the number of industrial fishing vessels affected by Project-related activities offshore may increase modestly in the future, but would still be a relatively small amount of vessels compared to the overall fishing fleet in Guyana.

Considering the small number of operators that are currently participating in deep-sea fishing (no more than 12 vessels) and the ability to provide information in advance about EEPGL operations and marine safety exclusion zones, the intensity of the related impact in the **Direct AOI** is rated as **Low**. Situations resulting in the inability for deep-sea fishing vessels to use the relatively small area of ocean that will be affected, will be **Episodic,** but the potential for such situations will extend across the life of the Project (at least 20 years), and are therefore considered to be **Long-term**. Consequently, the magnitude of the Project-related potential impacts on industrial fishing operations is considered **Small**.

Disruption of Artisanal Fishing Activities in Nearshore Areas

The highest potential for Project interactions with fisherfolk may be encounters with support vessels transiting between the PDA and shorebases in Georgetown. This could result in some limited and temporary disruption to fishing activity. Unlike deepwater industrial fisheries, the artisanal fisheries will not lose access to any fishing areas as a result of marine safety exclusion zones within the PDA (as these are in areas where artisanal fishing does not occur). However, increased Project-related vessel traffic near the coast and within the Demerara Harbour carries a small increase in the potential for support vessels to disrupt fishing vessel activities and the intensity of the related impact in the **Direct AOI** is thus rated as **Low**. Situations resulting in the inability of artisanal fishing vessels to continue normal operations as a result of increased vessel activity will be **Episodic**, but the potential for such situations will extend across the life of the Project (at least 20 years), and are therefore considered to be **Long-term**. Consequently, the magnitude of the Project-related potential impacts on artisanal fishing operations is considered to be **Small**.

Table 8.2-5: Magnitude of Impact—Employment and Livelihood

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
All Project Stages	General population of Georgetown and vicinity—Increased employment	Direct AOI (Georgetown and vicinity)	NA	NA	NA	NA
	General population of Georgetown and vicinity—Increased local business activity and growth	Direct AOI (Georgetown and vicinity)	NA	NA	NA	NA
	Fishing vessel operators (primarily artisanal) in the Direct AOI—Disruption of fishing activities nearshore due to presence of Project vessels	Direct AOI (Nearshore and Demerara Harbor)	Low	Episodic	Long-term	Small
	Fishing vessel operators (industrial) in the Direct AOI—Minor limitations on fishing access in remote offshore areas due to marine safety exclusion zones	Direct AOI (Offshore in PDA)	Low	Episodic	Long-term	Small

NA = not applicable (Positive impact, so no magnitude rating assigned)

8.2.3.3. Sensitivity of Receptors—Employment and Livelihoods

Potential receptors for employment and livelihood impacts are the general population in Georgetown and its vicinity (for positive impacts related to increased business and employment) in the Direct AOI; and subsistence and commercial fisherfolk operating on the Guyanese coast in the Indirect AOI (for impacts related to fishing activity). The receptor sensitivity ratings for employment and livelihoods are defined in Table 8.2-6.

Table 8.2-6: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Employment and Livelihood

Criterion	Definition
Sensitivity	Low: The receptor can easily adapt to the change without assistance or can shift to alternate livelihood opportunities without impacting ability to subsist and/or earn income.
	Medium: The receptor may adapt to the change or shift to alternate livelihood activities with assistance and with some disruption to ability to subsist and/or earn income.
	High: The receptor cannot adapt to the change without difficulty and cannot easily transition to alternate livelihood activities. Impacts on current livelihood activities will pose a threat to the receptor's ability to subsist, earn income, and maintain current quality of life.

Receptors in the Georgetown area (Region 4) are considered to have a **Medium** level of sensitivity to the Project's potential positive employment and livelihood impacts, since the workforce in this region has a comparatively higher likelihood to take advantage of increased employment activities, relative to the greater Guyanese population.

Artisanal fisherfolk engaging in fishing on the Guyanese coast have a limited ability to adapt to potential fishing disruption impacts from Project activities and are thus considered to have a **Medium** level of sensitivity to such impacts.

Industrial fisherfolk are generally better able to adapt to increased vessel activity and limited decreases in accessibility to offshore areas for fishing. However, as a conservative measure and in recognition of the variability in ability to adapt across the sector, industrial fisherfolk are considered to also have a **Medium** level of sensitivity to potential impacts on fishing activity.

8.2.3.4. Impact Significance—Employment and Livelihoods

As discussed above, the potential impacts on employment and livelihoods that will result from Project employment, procurement, and worker spending are considered to be **Positive**. As described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, this assessment does not develop significance ratings for positive impacts.

Based on the magnitude of impact and the receptor sensitivity ratings, the significance of potential adverse livelihood and employment impacts on industrial and artisanal fisherfolk operating in the coastal area and industrial fisherfolk operating offshore near the PDA is rated as **Minor**.

8.2.4. Mitigation Measures—Employment and Livelihoods

The Project will seek to enhance positive benefits to employment and livelihoods by procuring select goods and services locally (potentially leading to enhanced local employment and livelihood benefits) to the extent reasonably practicable. Table 8.2-7 summarizes the embedded controls, mitigation measures, and monitoring measures relevant to this receptor.

Table 8.2-7: List of Embedded Controls, Mitigation Measures, and Monitoring Measures

Embedded Controls
Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practicable. Partner with select local institutions and agencies to support workforce development programs and proactively message Project-related employment opportunities.
Procure Project goods and services locally when available on a timely basis and when they meet minimum standards and are commercially competitive.
Mitigation Measures
Issue Notices to Mariners via the Maritime Administration Department, the Trawler's Association, and fishing co-ops for movements of major marine vessels (including the FPSO, drill ship, and installation vessels) to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.
Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.

Monitoring Measures
Monitor percentage of Project Workforce made up of Guyanese nationals on a quarterly basis
Monitor percentage of Project goods and services expenditures procured locally on a quarterly basis
Monitor frequency of engagement with stakeholders, including fisherfolk, coastal communities, vulnerable groups and Indigenous populations

As a mitigation measure to address the potential for adverse impacts on fishing activities, the Project intends to issue notices to mariners via the Maritime Administration Department (MARAD), as well as via the Fisheries Department, Trawler's Association, and fishing co-ops for major marine vessel movements, including movements of the FPSO, drill ships, and major installation vessels. The Project will also continue to communicate major vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators, including those vessels known to operate in the vicinity of the PDA, who might not ordinarily receive Notices to Mariners, and where possible, communicate Project activities to those individuals to aid them in avoiding Project vessels through the stakeholder engagement process. This will allow fishing boat operators to adjust their fishing locations if needed to avoid these offshore locations with higher densities of Project vessels. With implementation of this mitigation measure, the significance of potential impacts on industrial fisherfolk is considered to be reduced to **Negligible**.

Many of the artisanal craft engaged in subsistence fishing activities do not carry radios, may use remote ports, and/or may not receive notices of increased vessel activity issued by the Project through the channels described above. Accordingly, this mitigation measure is likely to be somewhat less effective for artisanal fisherfolk. For this reason, while the same mitigation measure described above will be applied to address potential impacts on artisanal fisherfolk, including regular engagement on Project-related activities, the significance of potential impacts is maintained at a rating of **Minor**.

Table 8.2-8 summarizes the assessment of potential pre-mitigation and residual Project impacts on employment and livelihoods. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the employment and livelihoods-specific methodology described in Sections 8.2.3.2 and 8.2.3.3.

Table 8.2-8: Summary of Potential Pre-Mitigation and Residual Impacts—Employment and Livelihoods

<table>
<tr><th>Stage</th><th>Resource/ Receptor Impact</th><th>Magnitude</th><th>Sensitivity</th><th>Pre-Mitigation Significance Rating</th><th>Proposed Mitigation Measures</th><th>Residual Significance Rating</th></tr>
<tr><td rowspan="3">All Project stages</td><td>Population of Georgetown and vicinity—increased employment, local business activity, and household incomes</td><td>Positive</td><td>Medium</td><td>Positive</td><td>None</td><td>Positive</td></tr>
<tr><td>Industrial Fisherfolk—impacts on fishing livelihoods (marine safety exclusion zones within the PDA for commercial fishing operations; nearshore navigation and safety for subsistence fishing operations)</td><td>Small</td><td>Medium</td><td>Minor</td><td rowspan="2">• Notices to Mariners and other communication materials regarding major vessel movements and marine safety exclusion zones
• Augment ongoing stakeholder engagement process to communicate Project activities to the fishing community, including individuals who might not ordinarily receive Notices to Mariners</td><td>Negligible</td></tr>
<tr><td>Artisanal Fisherfolk—impacts on fishing livelihoods (marine safety exclusion zones within the PDA for commercial fishing operations; nearshore navigation and safety for subsistence fishing operations)</td><td>Small</td><td>Medium</td><td>Minor</td><td>Minor</td></tr>
</table>

8.3. COMMUNITY HEALTH AND WELLBEING

8.3.1. Administrative Framework—Community Health and Wellbeing

Table 8.3-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on community health and wellbeing.

Table 8.3-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Community Health and Wellbeing

Title	Objective	Relevance to the Project
Legislation		
Food & Drug Regulations (Food and Drug Act, 1971)	Regulates the sale, advertisement, preparation, and handling of food products; regulates the manufacture, advertisement, trade, and administration of pharmaceuticals; provides the Ministry of Health authority to inspect facilities to establish compliance with sanitation standards.	Governs the preparation of food and provision of medications at Project facilities.
Occupational Safety and Health Act, 1997	Legally defines the responsibilities of workers and management with respect to keeping workplaces safe.	Generally applies to Project workers and Project-related activities.
Ministry of Health Act (2005)	Sets out the functions of the Ministry of Public Health (previously the Ministry of Health) and the duties of the Minister. Among the responsibilities conferred to the Ministry by the act are to provide oversight of health care services including mental health; provide advice to government and establish policies on health; develop and ensure the implementation of the National Health Plan and other action plans and directives including human and all other resource requirements; enter into service agreements with the Regional Health Authority and review and approve their health plans and budgets; and facilitate the accreditation and regulation of the health care professionals, hospitals, and other health facilities in the public and private sectors.	Generally applies to health care services supplied to Project workers.
Regional Health Authority Act (2005)	Provides the Regional Health Authority with the responsibility for providing for the delivery and administration of health services and health programs in specified geographic areas and for matters incidental thereto or connected therewith.	Establishes the regional regulations under which health services would be provided to Project workers.
Health Facilities Licensing Act (2007)	Under the act, all health facilities must be licensed by the Minister of Public Health. The act also provides for inspectors who are authorized to enter any facility and conduct inspections. Offenses are outlined with fines and imprisonment upon summary conviction. Importantly, the act also provides for the Minister to make regulations related to licenses, renewals, standards for health facilities, record keeping, prescribing and governing the	Sets the requirements for health facilities at which services would be available to Project workers.

Title	Objective	Relevance to the Project
	construction, establishment, location, equipment, maintenance, and repair of, additions and alterations to, and operations of health facilities.	
Policies		
Health Vision 2020: National Health Strategy for Guyana (2013)	Creates an enabling framework for the integrated delivery of quality, effective, and responsive health services and prevention measures to improve the physical, mental, and social wellbeing of all people in Guyana.	Seeks to improve service delivery; managing communicable and non-communicable diseases; and improving health outcomes.
Workers' Health Policy (under development)	Intended to align with the Occupational Safety and Health guidelines of the World Health Organization. The policy is expected to encompass the Sustainable Development Goals related to the health sector; non-communicable diseases and workers' health; and occupational safety and health, among others.	The draft of this policy is not publicly available, but when completed, it is expected to guide the government's approach to workers' health.

8.3.2. Existing Conditions—Community Health and Wellbeing

8.3.2.1. Health Status

According to the Ministry of Public Health, health outcomes in Guyana continue to improve steadily (Persaud 2013). From 2000 to 2016, there was a 0.9 percent increase in personal healthcare access and quality. Life expectancy for all births increased from 64 years (during the period 1990 to 2002) to 73.4 years for females and 67.8 years for males in 2017 (IHME 2017). The crude death rate[10] decreased from 6.6 per 1,000 persons in 2003 to 6.1 per 1,000 persons in 2011 (Persaud 2013). The leading causes of mortality in 2017 were chronic diseases (including cardiovascular and cerebrovascular diseases), cancers, diabetes, and hypertension [IHME 2017]). Road injuries, interpersonal violence, and self-harm were the most prevalent causes of injury in 2017 (IHME 2017).

Burden of Disease

As with many other developing countries, Guyana is undergoing an epidemiological transition by which non-communicable diseases are beginning to replace communicable diseases as the leading causes of illness and mortality, although communicable diseases are still prominent in the disease profile. This shift is largely due to trends toward more sedentary occupations and lifestyles, as well as unhealthy diets and habits such as tobacco and alcohol use. Non-communicable diseases are the most significant public health challenge facing Guyana (Ministry of Finance 2018) and are estimated to account for approximately 68 percent of all deaths (WHO 2018). The most common non-communicable diseases and causes of illness/mortality in 2013 were diabetes, cardiovascular diseases, heart diseases, hypertension, cancers, chronic lung diseases, gastroenteritis and liver disease, accidents, violence-related injuries, and mental illnesses (Persaud 2013). The disease profile was similar in 2017, with the

[10] The crude death rate is the number of deaths occurring among the population of a given geographical area during a given year, per 1,000 mid-year total population of the given geographical area during the same year (OECD 2013b).

most common mortality-causing non-communicable diseases being heart diseases (ischemic and hypertensive), stroke, diabetes, chronic kidney diseases, and cirrhosis. Specifically, in 2017 compared to 2007, there were 32 percent more deaths from hypertensive heart disease, 31.5 percent more deaths from chronic kidney disease, 17.8 percent more deaths from stroke, 16.6 percent more deaths from ischemic heart disease, and 10.3 percent more deaths from diabetes.

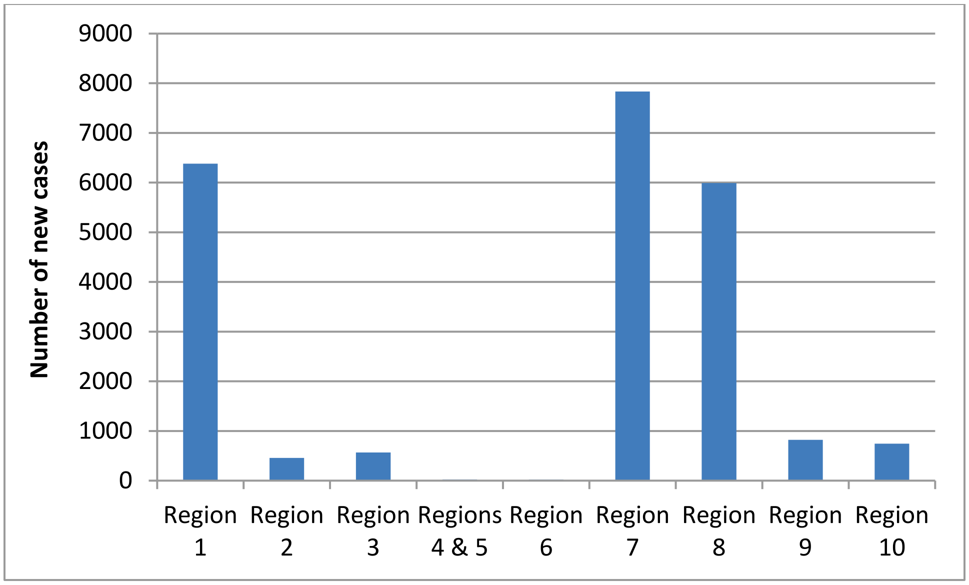
Obesity is on the rise in the country, along with other forms of malnutrition. Although Guyana is considered self-sufficient for food, accessibility and utilization of the right types of food to maintain health are of concern, leading the Ministry of Agriculture to develop the Guyana Food and Nutrition Security Strategy 2011-2020 Plan. This plan aims, among other goals, to integrate agricultural practices with improved food security and nutrition (Ministry of Public Health 2013a). According to the Ministry of Public Health, in 2013, 6.2 percent of the population had been diagnosed with diabetes, with an estimated incidence rate of 4,000 new cases annually. Type 2 (non-insulin dependent) diabetes accounted for 92 percent, with Type 1 (insulin-dependent) making up the other 8 percent (Persaud 2013). In 2018, incidence of diabetes continued to increase (Ministry of Finance 2018).

Hypertension is also on the rise, with a 2013 prevalence rate of 9 percent of the population over 30 years old and with an estimated 16,000 new cases reporting annually. Hypertension is the major contributing cause of strokes for persons over 40, as well as for heart attacks, disability, and other health issues affecting productivity of working age adults (Persaud 2013). In 2018, incidence of hypertension continued to increase (Ministry of Finance 2018).

Communicable diseases also continue to impact productivity, quality of life, and wellbeing in Guyana, particularly in the hinterland regions. This is due to a number of interrelated factors including poverty, nutritional deficiency, and inadequate access to health services. In 2012, the most common communicable diseases were malaria (31,876 cases), tuberculosis (TB; 725 cases), and human immunodeficiency virus (HIV; 8,263 cases out of 106,492 tested) (Persaud 2013).

Malaria is found in much of Guyana and is most prevalent in Regions 1, 7, 8, and 9. Malaria control efforts, such as distribution of insecticide-treated bed nets and indoor residual spraying[11], have been ongoing in these regions for decades. After an initial reduction in malaria prevalence in the early 2000s, the number of cases increased from 2007 to 2012. Data indicate a correlation with mining activities in the hinterland areas, and the country's Central Vector Control Service now sends mobile teams to work directly with populations residing in mining camps (USAID 2014). There was a decrease in 2013, with figures released by the Ministry of Public Health showing that in 2013, there were 23,489 reported cases of malaria, compared to 31,876 for the previous year (Persaud 2013). Figure 8.3-1 shows the number of reported new malaria cases for each region in 2010, the most recent year for which data broken down by region are available.

[11] Indoor residual spraying involves coating the walls and other surfaces of a house with an insecticide that has residual activity (i.e., continues to work over several months, killing mosquitos on contact with the sprayed surfaces) (Centers for Disease Control and Prevention 2012).



Source: Ministry of Public Health 2013b

Figure 8.3-1: Malaria Incidence by Region, 2010

Dengue fever, chikungunya, lymphatic filariasis, and Zika are also locally transmitted in Guyana (i.e., they are present in the community and passed from Guyanese to Guyanese). Unlike malaria, transmission of these diseases tends to be common in populated and urbanized areas.

Lymphatic filariasis and soil-transmitted helminthiasis continue to be problematic in Guyana, leading to deformity, malnutrition, and social stigma in impacted populations. In 2017, lymphatic filariasis was the tenth most common cause of disability from illness in Guyana (IHME 2017). Efforts to combat these diseases include mass drug administration campaigns and improvements in sanitation in endemic areas.

TB continues to be a priority health concern in Guyana. It was nearly eradicated in the 1980s, but saw a resurgence in the 1990s due to its association with the HIV/acquired immunodeficiency syndrome (AIDS) epidemic. In 2017, there were 592 recorded cases of TB, 86 percent of which were people who were HIV positive (86 recorded cases per 100,000 population, versus the global average of 133) (WHO 2017a). The estimated burden of TB in 2017 is shown in Table 8.3-2.

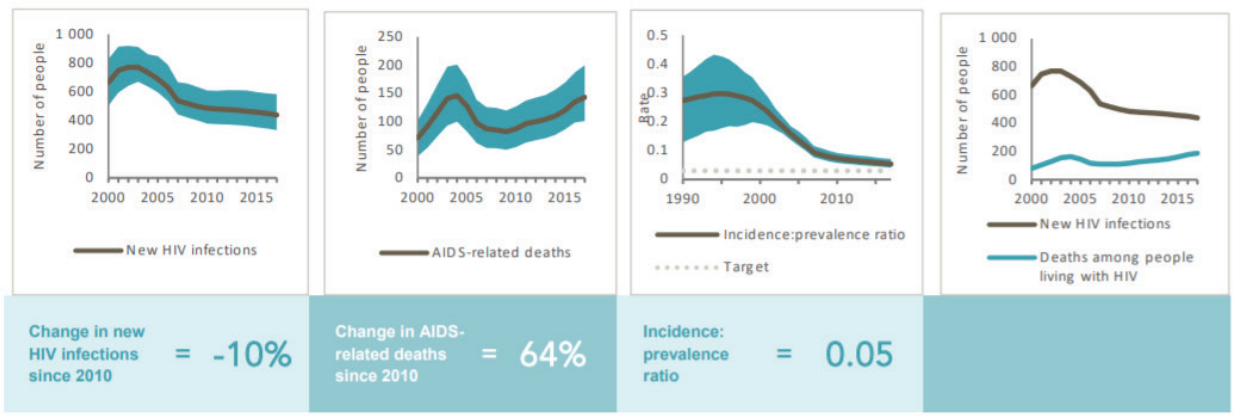
In 2016, the number of people living with HIV in Guyana was estimated at 8,500, and the prevalence rate in the population aged 15 to 49 was 1.6 percent. Progress has been made in addressing the HIV epidemic in the country, with a 10 percent reduction in the number of HIV cases reported since 2010 (Figure 8.3-2). However, there has been a 64 percent increase in AIDS-related deaths since 2010, as shown in Figure 8.3-2 (UNAIDS 2018).

Table 8.3-2: Estimates of TB Burden in Guyana, 2017

Estimates of TB Burden [a]	Number (thousands)	Rate (per 100,000 population)
Mortality (excludes HIV+TB)	0.14 (0.13–0.15)	18 (17–20)
Mortality (HIV+TB only)	0.039 (0.028–0.051)	5 (3.6–6.6)
Incidence (includes HIV+TB)	0.67 (0.51–0.85)	86 (66–109)
Incidence (HIV+TB only)	0.18 (0.14–0.23)	23 (18–30)

Source: WHO 2017a

[a] Ranges represent uncertainty intervals



Source: UNAIDS 2018

Figure 8.3-2: Guyana HIV Transition Metrics

Maternal and Child Health

Guyana has made improvements in maternal and child health in recent years, but did not achieve the Millennium Development Goal targets of reducing child mortality rates by two-thirds, and maternal mortality ratio by three-quarters between 1990 and 2015 (UNDP undated_a). Over the period 2015 to 2030, Guyana is working towards achieving the targets for the Sustainable Development Goal (SDG) for maternal and child health (UNDP undated_b). This includes reducing maternal mortality to less than 70 per 100,000 live births. In 2018, Guyana's maternal mortality ratio was estimated at 116.7 per 100,000, a significant improvement from 229 per 100,000 in 2015 (Green State Development Strategy 2019). SDG targets also include ending preventable deaths of newborns and children under 5 years of age, reducing neonatal mortality to at least as low as 12 per 1,000 live births, and reducing under-5 mortality to at least as low as 25 per 1,000 live births. Guyana's neonatal mortality rate was 20.8 per 1,000 live births and under age 5 mortality was 20.8 per 1,000 live births in 2018 (Green State Development Strategy 2019).

The crude birth rate[12] is down from 22.8 per 1,000 persons in 2003 to 17.7 per 1,000 persons in 2011, and the infant mortality rate has also declined from 17 to 15.1 per 1,000 live births during this same time period (Persaud 2013). However, marked disparities exist in rural and hinterland areas, with the rate of under-5 mortality at 48 per 1,000 live births in rural areas and 11 per 1,000 live births in urban areas (BSG et al. 2015).

The primary causes of infant death at birth include premature birth and respiratory distress, both of which are preventable, with the secondary causes being congenital deformity and birth defects that are not preventable (Persaud 2013). According to interviews with health workers as part of the late 2017 and early 2018 Consultant field work, home deliveries are common in many remote areas due to lack of ambulatory services and general access to transportation to neighboring healthcare facilities. In some remote healthcare facilities, the lack of basic medical supplies means that health workers must rely on rudimentary equipment to perform births (e.g., scalpel to cut umbilical cords, no electricity) (ERM/EMC 2018).

Mental Health

Guyana has a high suicide rate. According to the World Health Organization (WHO), Guyana had the highest rate of suicide of any country in the world. In 2014, the suicide rate was 44.2 deaths per 100,000 people, versus the global average of 16 deaths per 100,000 people (WHO 2014). This dropped to 29 deaths per 100,000 people in 2015, against a global average of 10.7 deaths per 100,000 people (WHO 2016). However, this rate significantly increased in 2016, with a reported 46.6 deaths per 100,000 people (WHO 2017b) and then declined again in 2017, with 24.6 deaths per 100,000 people, making it the third major cause of death in the 15 to 44 age group (Green State Development Strategy 2019). According to Guyana's Chief Medical Officer, rates are particularly high in Regions 2, 3, and 6, with the most common method being ingestion of poisons such as pesticides. No single reason is pinpointed for this phenomenon, but the shortage of mental health workers and the stigma associated with mental illness—leading to untreated depression—are thought to be contributing factors, as well as the ease of access to pesticides and other toxic agricultural substances (ERM Personal Communication 7).

8.3.2.2. Healthcare System

The Ministry of Public Health is responsible for setting national policy, regulation, and standards; building and refurbishing of healthcare facilities; and financing the employment of doctors, nurses, and emergency response workers. At the regional level, the Regional Health Authorities have the autonomy to assess, plan, and implement health services and manage the facilities for a defined population in a defined geographic area, including day-to-day management of the facilities and employment of all other staff working in the health sector. The country's main framework for health is the Health Vision 2020, which sets the strategy and overall planning for the health sector.

[12] The crude birth rate is the number of live births occurring among the population of a given geographical area during a given year, per 1,000 mid-year total population of the given geographical area during the same year (OECD 2013a).

Government health spending compares favorably with that of other Latin American and Caribbean countries and has averaged about 3.3 percent of GDP in 2014 (PAHO/WHO 2017). In the 2019 budget, $35.9 billion GYD ($171.8 million USD) was allocated to the health sector, representing 11.9 percent of the total budget (DPI Guyana 2018). The healthcare system in the country is highly decentralized, with RDCs and Regional Health Authorities managing, financing, and providing health services. However, the system continues to have a number of challenges related to human resources capacity and infrastructure capacity, which is especially acute in remote areas, such as Region 1.

The Ministry of Public Health established priorities in 2013 for the national healthcare system to increase financial and technical support to improve the following (Persaud 2013):

- Family health (child, adolescence, women, men, elderly);
- Disease eradication and mental health;
- Violence, accidents, and injury rates;
- Healthcare facilities at all levels (community centers to city hospitals);
- Nutrition and food security; and
- Access to health for frontier, migrant, remote, and vulnerable populations.

Health Care Facilities

Health care facilities in the coastal regions are summarized in Table 8.3-3 below. In addition to these facilities, there is one National Ophthalmology Center and one National Psychiatric Hospital in the country, both located in Region 6.

Table 8.3-3: Health Care Facilities in the Coastal Regions

Region	Regional Hospital	District Hospital	Diagnostic Center	Health Center	Health Post
Region 1	1	4	-	4	44
Region 2	-	2	1	11	17
Region 3	1	2	1	17	22
Region 4	1	1	1	39	7
Region 5	-	1	1	14	1
Region 6	1	3	-	21	2

Source: Ministry of Public Health 2016

According to Guyana’s Chief Medical Officer, one of the biggest health system shortfalls for Guyana is unreliable emergency care services. This includes the lack of a functioning air ambulance system, which is needed to adequately respond to mining injuries in the country’s interior and to the large number of vehicle accident-related injuries. There are also shortages of blood at times, and capacity in hospitals is inadequate. The public hospital in Georgetown once had 900 beds, but due to fires and dilapidation over the years, this has been reduced to 450 (ERM Personal Communication 7). In 2012, there were 28 hospital beds per 10,000 people in the country, up slightly from 25 beds per 10,000 people in 2003 (Persaud 2013; ERM/EMC 2018). The most common reasons for clinic visits were hypertension, diabetes, antenatal, and family planning. Medical supplies, including medicines, are in short supply and those that are provided to village health centers from larger cities (such as Mabaruma and Georgetown) are typically close to, if not past, the expiration date.

Health Human Resources

Retention of healthcare professionals in Guyana is a challenge, as in many other developing countries that see emigration of skilled workers to developed countries. The most recent available statistics from the Ministry of Public Health indicate that there were nine physicians and 13.3 nurses per 10,000 people in the country in 2012 (Ministry of Public Health 2013a). Guyana currently has a Health Human Resource Action Plan for Guyana 2011-2016 that is aimed at addressing this issue.

8.3.2.3. Quality of Life

Water and Sanitation

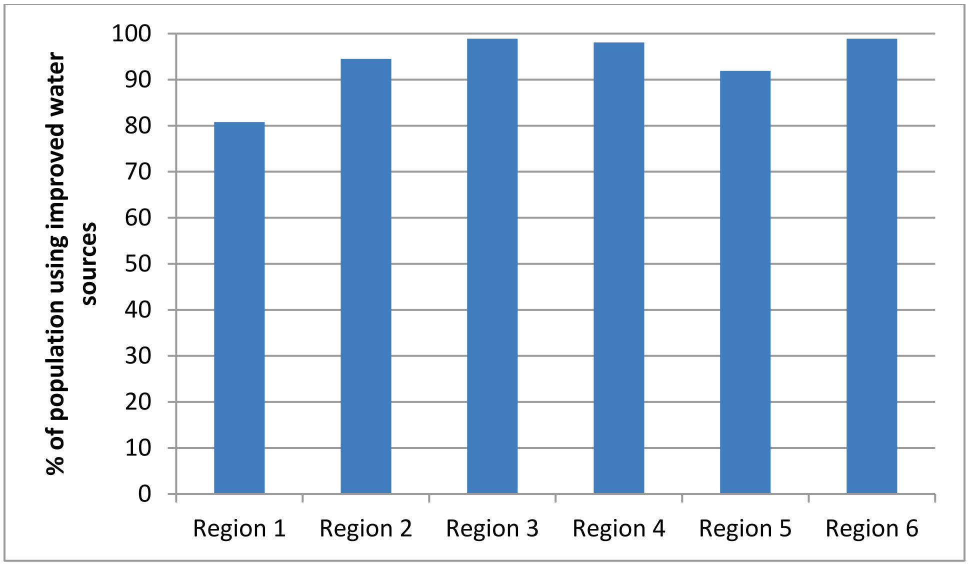
According to the most recent Guyana Multiple Indicator Cluster Survey (MICS)[13], 94 percent of Guyana's population had sustainable access to improved drinking water sources[14] as of 2014, and 95.4 percent used an improved sanitation facility[15] (UNICEF 2014). According to the Green State Development Strategy, 96 percent of the population is noted as having access to potable water (Green State Development Strategy 2019). Figure 8.3-3 shows the percentage of the population with access to improved sources of drinking water, by region. However, while access to improved water sources has improved over the years, wastewater and sanitation coverage and infrastructure in the country are limited, thus hampering efforts to improve health conditions (World Bank 2016).

In 2012, approximately 97 percent of the population in both urban and rural areas used an improved drinking-water source (as compared to 83 percent in rural areas in 2000). However, an assessment conducted by multilateral partners in 2014 points out that the quality of water supply services is hindered by decaying distribution networks, with 50 percent to 70 percent of wastewater going unaccounted for at the national level (and more than 70 percent in Georgetown) (World Bank 2016).

[13] The MICS program was developed by the United Nations Children's Fund and serves as an international household survey program to collect internationally comparable data on a wide range of indicators on the situation of children and women. MICS data will next be updated in late 2019.

[14] Improved water sources refer to any of the following types of supply: piped water into dwelling, compound, yard, to neighbor, or to public tap/standpipe; tube well/borehole; protected well; protected spring; and rainwater collection. Bottled water is considered as an improved water source only if the household is using an improved water source for handwashing and cooking.

[15] An improved sanitation facility is defined as a facility that flushes or pour-flushes to a piped sewer system, a septic tank, a pit latrine, a ventilated improved pit latrine, or a pit latrine with slab.



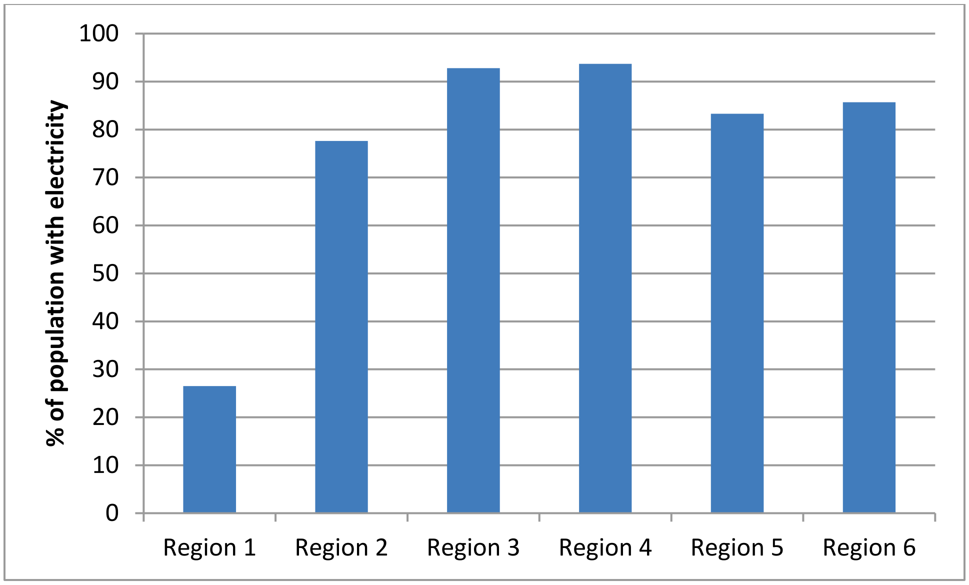
Source: UNICEF 2014

Figure 8.3-3: Percent of Population with Access to Improved Water Sources by Region, 2014

According to representatives from the Ministry of Communities, projects are being implemented in hinterland regions to significantly increase access to potable water and improved sanitation (ERM/EMC Personal Communication 7). Under the *Hinterland Sustainable Housing Programme*, the Ministry of Communities intends to provide better access to housing, potable water, and sanitation to four communities in Region 1 and nine communities in Region 9 (Ministry of Communities 2016). In addition, Guyana Water Inc. (GWI) has established wells in Koboremo, Kamwatta, and Toko, and rehabilitated water catchment areas in Matthew's Ridge and Mabaruma in Region 1. New wells were also established at Silver Hill, Waikabra, and Hill Foot in Region 4. GWI is working toward increasing access to treated water in Mabaruma and Matthew's Ridge in Region 1. In addition, new water treatment plants are planned for several locations in Region 4, including Diamond, Timehri North, Bladen Hall, Sparendaam, and Sophia (Guyana Chronicle 2018).

Electricity

Results of the MICS indicate that an estimated 91.2 percent of the coastal population and 56.2 percent of the interior population have access to electricity. Figure 8.3-4 shows the percent of the population with electricity in each of the coastal regions.

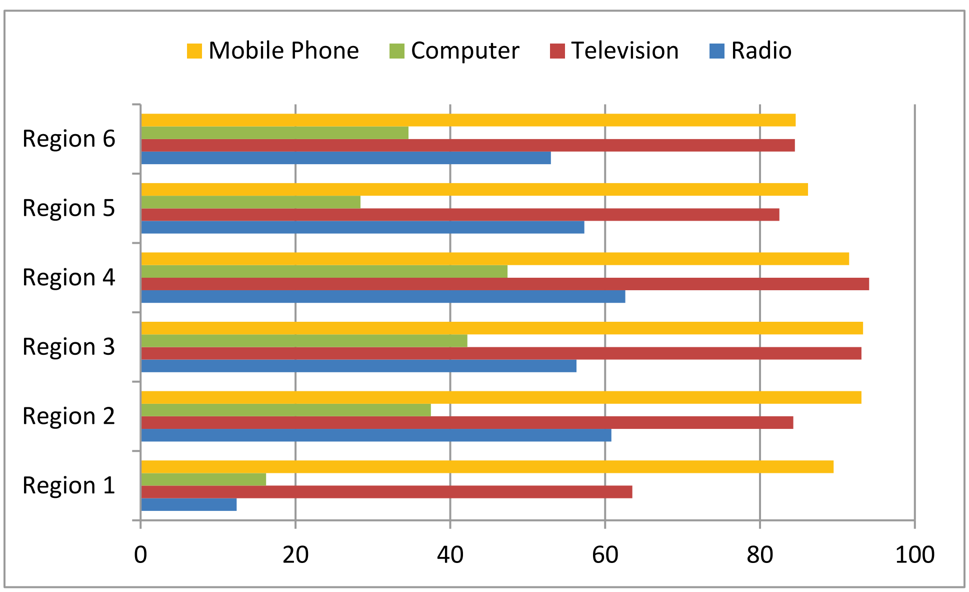


Source: UNICEF 2014

Figure 8.3-4: Percent of Population with Electricity by Region, 2014

Telecommunications

In terms of telecommunications, mobile telephone coverage is quite comparable among coastal regions, and an average (across the coastal regions) of 88.6 percent of households in the country has at least one member with a mobile phone. There is more disparity in other forms of telecommunications, with Region 1 in particular showing lower levels of access to computers, television, and radio, relative to other regions (Figure 8.3-5).



Source: UNICEF 2014

Figure 8.3-5: Household Access to Telecommunications, 2014

8.3.2.4. Natural Hazards

Guyana is not threatened by many natural hazards, but due to its low-lying coastal plain, the northern areas of Regions 1 to 6 face severe risk of flooding. The World Bank (2016) estimates that Guyana is one of the countries most vulnerable to global climate change due to the amount of low-lying coastal areas, many below mean sea level, and a high percentage of population and critical infrastructure located along the coast. A recent study identified Guyana as exhibiting high climate vulnerability to effects on marine fisheries and food security (Ding et al. 2017). Both changes in rainfall patterns and predicted sea-level rise associated with climate change pose threats to the Guyanese population and its livelihoods. As such, the country invests continuously in the construction and maintenance of sea and river defense infrastructure, as well as a system of reclaimed lands, drainage and irrigation canals, pumping stations, and conservancy dams to protect agriculture in the vulnerable coastal areas. In addition, significant efforts are being made to protect and enhance natural sea defense mechanisms, in particular mangrove ecosystems.

Despite this investment, floods continue to threaten public safety and infrastructure along the coast. In 2005, torrential rains caused many rivers and water conservancies in the coastal plain to overflow, causing severe flooding in Regions 1, 2, 3, 5, and 6. The floods resulted in the direct or indirect deaths of 19 people, from either drowning, acute dehydration, or succumbing to an outbreak of leptospirosis that occurred in the aftermath of the flooding (PAHO 2005). Direct economic losses of agricultural crops, livestock, fisheries, forestry, and roads in the coastal area were estimated to total over $10 billion GYD (approximately $48 million USD) (ECLAC 2005). More recently, in early March 2018, floodwaters breached the sea defense network in the West Coast Demerara area, damaging local businesses and homes and forcing the temporary evacuation of some residents. Annual flood damage in Georgetown is estimated to be $1.3 billion GYD ($6.2 million USD) (Guyana Times 2019).

8.3.3. Impact Assessment—Community Health and Wellbeing

This section assesses potential impacts from the Project's planned activities on community health and wellbeing in the Project AOI. The key potential impacts considered as a result of planned Project activities are increased risk of communicable disease transmission, decreased public safety as a result of the presence of Project workers, increased public anxiety, and decreased availability of emergency medical and health services.

Some of the mitigation measures proposed in other EIA sections address other potential impacts on community health and wellbeing. Therefore, these potential impacts have been scoped out of the community health and wellbeing impact assessment. A summary of these "scoped out of community health and wellbeing" potential impacts and the sections where they are discussed is presented in Table 8.3-4.

Table 8.3-4: Potential Impacts Discussed in Other EIA Sections and Scoped out of the Community Health and Wellbeing Impact Assessment

Potential Impact	Relevant EIA Section
Air quality emissions from Project sources	Air Quality (Section 6.1)
Offshore Project activity-related discharges to water column (altering water chemistry and turbidity)	Marine Water Quality (Section 6.4)
Local job creation, contributing to positive physical and mental health outcomes	Socioeconomic Conditions (Section 8.1)
Waste generation, storage, and disposal	Waste Management Infrastructure and Capacity (Section 8.6)
Hydrocarbon spills from Project vessels operating near shore or off shore	Unplanned Events (Chapter 9)
Marine or vehicle accidents involving non-Project individuals	Unplanned Events (Chapter 9)
Workforce exposure to occupational hazards and risks	Worker Health and Safety (Section 2.14)

In determining the potential community health and wellbeing impacts of the Project, the WHO's definition of *health* was applied: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO 2006). Factors that affect health are commonly called "determinants of health," which are defined by the International Finance Corporation (IFC 2009) as "individual, social and environmental, and institutional factors that are directly, indirectly, or cumulatively affected by the proposed project" as described in Table 8.3-5.

Table 8.3-5: Determinants of Health

Categories of Determinants of Health	Examples of Specific Health Determinants
Individual factors: genetic; biological; lifestyle; behavioral; and/or circumstantial, of which some can be influenced by proposals and plans	Gender; age; dietary intake; level of physical activity; tobacco use; alcohol intake; personal safety; sense of control over own life; employment status; educational attainment; self-esteem; life skills; stress levels; etc.
Social factors: community, economic and/or financial conditions	Access to social and health-related services and community; social support or isolation; housing; income; distribution of wealth; sexual customs and tolerance; racism; attitudes to disability; trust; sites of cultural and spiritual significance; local transport options available; etc.
Environmental factors: physical	Quality of air, water and soil; access to safe drinking water and adequate sanitation; disease vector breeding places; land use; urban design
Institutional factors: the capacity, capabilities and jurisdiction of public sector services	Availability of services, including health, transport and communication networks; education and employment; environmental and public health legislation; environmental and health monitoring systems; laboratory facilities; etc.

8.3.3.1. Relevant Project Activities and Potential Impacts

The Project will involve a range of activities that could potentially impact community health and wellbeing across the aforementioned categories of determinants of health. Shifts in demographic patterns, including the influx of foreign workers or the spatial concentration of working-age populations, has the potential to cause changes in disease transmission patterns, impact public safety, and increase the burden on medical and health infrastructure. The potential for these impacts are limited due to the Project's limited onshore footprint. Table 8.3-6 summarizes the Project stages and activities that could result in potential Project impacts on community health and wellbeing, as well as the receptors that could potentially experience these impacts.

Table 8.3-6: Summary of Relevant Project Activities and Key Potential Impacts—Community Health and Wellbeing

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project Stages	General population of Georgetown and vicinity	Project worker presence Project use of medical and health resources in the Georgetown area	• Increased risk of communicable disease transmission • Impacts on public safety • Overburdening of medical and health services
	General population throughout coastal communities	Overall presence of oil and gas development activities, principally related to the perceived risk of an oil spill	• Public anxiety over oil and gas sector risks

8.3.3.2. Magnitude of Impact—Community Health and Wellbeing

In the case of community health and wellbeing, there is a wide range of illnesses and disabilities already present in the population and this comprises a baseline prevalence rate. However, as people value their health, even a small increase in the prevalence rate of a disease or disability that is attributed to the Project would be considered significant. The assessment of the Project's magnitude of impacts on community health and wellbeing is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on community health and wellbeing is defined according to the definitions provided in Table 8.3-7. The following paragraphs discuss the characteristics of each of the potential impacts assessed, and the resultant magnitude ratings. These are summarized in Table 8.3-8.

Table 8.3-7: Definitions for Intensity Ratings for Potential Impacts on Community Health and Wellbeing

Criterion	Definition
Intensity	Negligible: No discernible change in health status of the population. Anticipated incidence of a health-related risk at an individual level is "very rare."
	Low: Changes to health status occur in some individuals and households, but changes are minor, temporary, and reversible even without medical or public health intervention. Anticipated incidence of a health-related risk at an individual level is "rare."
	Medium: Changes to health status occur at the population level, but are reversible over time or with medical or public health intervention. Anticipated incidence of a health-related risk at an individual level is "occasional."
	High: Profound and measurable changes to health status are evident at the population level. Some health impacts may be severe or permanently debilitating, requiring medical or public health intervention or other forms of assistance for treatment and recovery. Anticipated incidence of a health-related risk at an individual level is "frequent."

Communicable Disease Transmission

Population shifts caused by the influx of workers from other parts of the country or from foreign countries have the potential to cause changes in transmission patterns of some communicable diseases, particularly if workers originate from countries with higher rates of diseases that are transmitted person-to-person, such as TB and sexually transmitted infections. At this time, the countries of origin of the Project workers are primarily the United States, various European countries, and a few countries in southeast Asia, including Malaysia and the Philippines. Guyana has a lower rate of TB incidence than the global average (86 cases per 100,000 population, versus the global average of 133) but has a higher rate than most developed countries. Guyana's rate of HIV prevalence is comparable to the global average. Potential communicable disease transmission risks will vary according to the workforce's primary countries of origin; however, as an embedded control, regardless of worker origin, the Project will establish a worker health-screening program and take precautions to avoid both internal and external communicable disease risks.

Given the small size of the Project workforce in comparison with the receiving community (less than 1 percent of the population of Georgetown) and the Project workers' limited onshore presence, the intensity of potential impacts on rates of communicable disease transmission is rated as **Negligible.** Foreign workers will move through Georgetown on an **Episodic** basis (primarily before and after offshore work cycles when they are entering/leaving the country). Regardless of the intensity or frequency of foreign workers coming to Guyana, expatriate labor will constitute some portion of the Project workforce for the entire life of the Project, so the duration of the impact is rated **Long-term**. Therefore, the magnitude of potential impacts related to communicable disease transmission is rated as **Negligible**.

Impacts on Public Safety

Increases in population and the presence of transient populations have the potential to contribute to increased rates of crime. Criminal activity in Georgetown is common and is attributed largely to poverty and unemployment. The influx of Project workers to/through the Georgetown area is not expected to contribute significantly to an increase in local crime rates. Furthermore, the Project workforce will represent less than 1 percent of the population of Georgetown, and workers' onshore presence will be limited and occasional. Given the small size of the Project workforce in comparison with the receiving community (less than 1 percent of the population of Georgetown) and the Project workers' limited onshore presence, the intensity of potential impacts on public safety is rated **Negligible.** The bulk of foreign workers will move through Georgetown on an **Episodic** basis (primarily before and after offshore work cycles when they are entering/leaving the country). Regardless of the intensity or frequency of foreign workers coming to Guyana, expatriate labor will constitute some portion of the Project workforce for the entire life of the Project, so the duration of the impact is rated **Long-term**. Therefore, the magnitude of potential impacts related to public safety is rated as **Negligible**.

Public Anxiety Regarding Oil and Gas Risks

Oil and gas represents the newest sector in Guyana's economy and concerns naturally exist among those living in coastal communities about Project activities and their perceived potential impact on livelihoods and the environment. Certain vulnerable sub-populations (e.g., indigenous populations in Region 1 coastal communities who are concerned about potential oil spills affecting the SBPA, people with existing mental health or anxiety type disorders, etc.) may be more concerned about these perceived impacts than others, and may experience an associated increase in level of anxiety. Any changes in health as a result of anxiety are expected to be minor and reversible, especially as more Project information continues to be made available to mitigate such concerns; however, because the effect is based on perception and those perceptions may affect a wider area than that which could potentially be affected by physical health changes, the geographic extent of the anxiety-related impacts is predicted to be larger than other community-health related impacts (i.e., across the **Indirect AOI** rather than just the Georgetown area). Given the small number of people who are expected to experience measurable increases in anxiety that then manifests as measurable health problems, the intensity of potential impacts on anxiety-related health indicators is rated as **Low.** These effects are predicted to occur on an **Episodic** basis over the life of the Project, and are therefore considered to be **Long-term**. As such, the intensity of Project-related impacts on public anxiety is rated magnitude of potential impacts related to public anxiety is considered **Small**.

Overburdening of Medical and Health Services

The Project will have a medical facility onboard the FPSO to treat minor medical issues. Major installation vessels will also have their own medical facilities and onboard medical professionals. In the event of more serious illness or injury that cannot be handled by the offshore medical professionals, patients will be medically evacuated to a healthcare facility in Georgetown and potentially outside of Guyana, depending on the type of medical issue. In the event an offshore worker requires medical evacuation/referral onshore, Project-dedicated medical professionals will be available offshore and onshore to support the response/referral. While these provisions will limit the degree to which Project needs will increase the burden on Georgetown medical and health services, Project use of Guyanese healthcare facilities could potentially compromise availability and access for the Guyanese local population. The Project currently utilizes a designated local private Guyanese clinic supported by an international medical provider, as well as hospitals in Georgetown, in the event of both work-related and non-work-related medical and health emergencies. However, for the most part, these hospitals will be relied upon only for initial evaluations or, in the case of life-threatening emergencies, stabilization before evacuation of foreign workers out of country to another facility.

Given that reliance on local Guyanese medical facilities will be limited, the intensity of the potential impact is rated as **Low**. Situations resulting in Project use of existing medical and health facilities will be **Episodic**, but the potential for such situations will extent across the life of the Project (and are therefore considered to be **Long-term**). Consequently, the magnitude of potential impacts related to Project use of medical services is considered **Small**.

Table 8.3-8: Magnitude of Impact—Community Health and Wellbeing

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
All Project Stages	General population of Georgetown and vicinity—Increased risk of communicable disease transmission	Direct AOI (Georgetown and vicinity)	Negligible	Episodic	Long-term	Negligible
	General population of Georgetown and vicinity—Impacts on public safety	Direct AOI (Georgetown and vicinity)	Negligible	Episodic	Long-term	Negligible
	General population throughout coastal communities—Public anxiety over oil and gas sector risks	Indirect AOI (Coastal communities)	Low	Episodic	Long-term	Small
	General population of Georgetown and vicinity—Overburdening of medical and health services	Direct AOI (Georgetown and vicinity)	Low	Episodic	Long-term	Small

8.3.3.3. Sensitivity of Receptors—Community Health and Wellbeing

The receptor sensitivity ratings for community health and wellbeing are defined in Table 8.3-9.

Table 8.3-9: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Community Health and Wellbeing

Criterion	Definition
Sensitivity	Low: The population does not have many areas of health vulnerability. Individuals and households have the personal resources and capacity to protect and promote health. The community is well equipped with resources and infrastructure to provide routine medical and health care and address medical and health emergencies. There is a predominant absence of concern regarding the impact of the Project on personal wellbeing.
	Medium: The population has multiple areas of health vulnerability, due either to environmental or social factors. Portions of the population face socioeconomic challenges that act as barriers to health protection and promotion. There are shortfalls in local medical and health resources and infrastructure that compromise ability to provide timely and appropriate medical and health care in some situations. The population contains some who express concerns regarding the impact of the Project on their wellbeing.
	High: The population has many areas of health vulnerability due to environmental and social factors. A large proportion of the population is disadvantaged, which acts as a barrier to protecting and promoting health. Adequate medical health resources and infrastructure are lacking, often not allowing for timely and appropriate medical and health care. The population contains a significant proportion of individuals who express concerns regarding the impact of the Project on their wellbeing.

The Guyanese population is in epidemiological transition whereby the burden of illness has begun to shift from communicable disease to non-communicable (chronic) diseases and injury. However, communicable diseases, including HIV/AIDS, TB, pneumonia, and arboviruses, still also make up a considerable burden of illness. This transition is characteristic of most developing countries as they experience demographic changes including lower fertility and longer life expectancy, as well as improvements in health and sanitation systems. In general, urban populations have measurably higher health status than rural populations. They have better access to health services, higher levels of immunization coverage, and are less likely to suffer from some communicable diseases such as malaria, lymphatic filariasis, and soil-transmitted helminths. However, densely populated urban settings, including Georgetown, are disproportionately affected by other types of communicable diseases such as dengue fever, HIV/AIDS, and TB. As such, sensitivity of the population of Georgetown to communicable disease risks is considered **Medium**.

The Guyana Police Service is responsible for maintaining security and order in the greater Georgetown area. Georgetown tends to have high-crime "hotspots," where Guyana Police Service officials experience challenges ensuring sufficient manpower and other resources. The majority of crimes are robberies and break-ins and are believed to be related to high rates of poverty and unemployment (ERM Personal Communication 21). The sensitivity of the Georgetown population to public safety-related risks is therefore considered **Medium**.

Public anxiety related to perceived impacts from oil and gas operations has been evident in isolated instances during communications with community members and during one-on-one meetings with key stakeholders. These can reasonably be expected to decrease as the local population begins to better understand the nature of the Project and the system of embedded controls to prevent unplanned events, and to experience the lack of significance of potential impacts from planned activities. For example, fisherfolk may no longer fear impacts on their livelihoods as Notice to Mariners and other communication materials show that marine safety exclusion zones do not affect their fishing zones. Continued disclosure of Project-related activities, as well as continuous engagement with the fishing community and targeted engagement with certain vulnerable populations including those coastal communities in Region 1, will help lessen anxiety. Georgetown residents have relatively high levels of literacy and multiple means of accessing information on the Project and the country's developing oil and gas sector on a continual basis, which will help to reduce anxiety related to misconceptions about Project risks. Residents of Georgetown are also relatively well positioned to experience socioeconomic benefits of the Project, which will serve to counteract anxiety related to the Project and oil and gas sector in general. For these reasons, sensitivity of the Georgetown population to anxiety-related concerns is considered **Low**. However, as there may be some residents in other regions, including Region 1, who may still express concerns and anxieties regarding the impact of the Project on their wellbeing, the sensitivity of the population outside Georgetown is considered **Medium.**

Georgetown has a high concentration of medical and health facilities relative to other parts of Guyana, although emergency care capacity and health-related human resources are considered lacking throughout the country. Guyana's emergency medical system is in transition at this time; until recently, the country did not have an ambulance system to respond to emergencies. As of 2014, an ambulance pilot program had been established through the Georgetown Public Hospital Corporation, with assistance from Vanderbilt University, and had seven ambulances and 21 trained emergency medical technicians. According to Guyana's Chief Medical Officer, the country's emergency medical services are still insufficient to respond to the needs of the population. The country does not have an air ambulance to respond to serious vehicle collisions that occur on Guyana's roads. Hospital capacity is also lacking; as of 2018, the hospital has 450 beds but requires about 600 beds to adequately serve the population (ERM Personal Communication 7). Given these health system gaps in several critical areas, sensitivity to health services impacts is considered to be **Medium**.

8.3.3.4. Impact Significance—Community Health and Wellbeing

Based on the magnitude of impact and receptor sensitivity ratings, the significance of increased potential impacts on community health and wellbeing are rated as **Negligible** for communicable disease transmission and public safety, and **Minor** for public anxiety and overburdening of medical health services.

8.3.4. Mitigation Measures—Community Health and Wellbeing

Given the **Negligible** significance of potential impacts on community health and wellbeing for communicable disease transmission, and public safety, mitigation measures are not required. That said, EEPGL is committed to working closely with police and other public safety authorities as needed to address concerns regarding Project linkages to these types of impacts. With respect to public safety concerns, EEPGL will require Project workers to adhere to a worker code of conduct, including when they are onshore (residents, visitors, transits). With respect to public anxiety concerns, EEPGL's ongoing stakeholder engagement programs and oil spill response training programs will continue to provide means of informing the community about the Project; this is expected to contribute to decreasing public anxiety about perceived Project risks, including in Region 1. Although this sensitivity is expected to decrease over time as the country becomes more accustomed to the presence of the oil and gas industry, it may not be possible to alleviate concerns across the entire population.

With respect to potential impacts on community health and wellbeing related to overburdening of medical facilities due to Project use, EEPGL has reduced the magnitude of this potential impact to the extent reasonably practicable (i.e., through the embedded control of having trained medical personnel on board the FPSO and major installation vessels to minimize reliance on medical infrastructure and facilities in Guyana). In addition, the Project will use an international medical provider to complement the services of the local private medical clinic utilized by the Project, and will procure a dedicated ambulance to avoid overwhelming the local medical infrastructure. Table 8.3-10 summarizes the embedded controls, mitigation measures, and monitoring measures relevant to this receptor.

Table 8.3-10: List of Embedded Controls, Mitigation Measures, and Monitoring Measures

Embedded Controls
Provide health screening procedures to Project workers to reduce risks of transmitting communicable diseases.
Develop and implement a Stakeholder Engagement Plan.
Implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) early on, prior to onset of Project activities. Ensure CGM is well publicized and understood by the public.
Monitor grievances received and resolved by the CGM; adjust CGM and other management measures, as appropriate.
Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to vehicle incidents.
Mitigation Measures
Require Project workers to adhere to a Worker Code of Conduct, which will address shore-leave considerations.
Use a dedicated medical provider to complement the services of the local private medical clinic used by the Project, and procure a dedicated ambulance to avoid overwhelming the local medical infrastructure.
Monitoring Measures
Track number and types of complaints received via the Project CGM.
Monitor average time for processing and resolution of grievances.
Track percentage of grievances resolved.
Monitor Project workers' occupational exposure to sound.
Test for diseases that are communicable through normal medical screening/surveillance.
Monitor frequency of engagement with stakeholders, including fisherfolk, coastal communities, vulnerable groups, and Indigenous populations

Table 8.3-11 summarizes the assessment of potential pre-mitigation and residual Project impacts on community health and wellbeing. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the community health and wellbeing-specific methodology described in Sections 8.3.3.2 and 8.3.3.3.

Table 8.3-11: Summary of Potential Pre-Mitigation and Residual Impacts—Community Health and Wellbeing

Stage	Resource/Receptor Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	**Social Factors**					
	General population of Georgetown and vicinity—increased risk of communicable disease transmission	Medium	Negligible	Negligible	None	Negligible
	General population of Georgetown and vicinity—impacts on public safety	Medium	Negligible	Negligible	Worker code of conduct, including when workers are onshore	Negligible
	Individual Factors					
	Public anxiety over oil and gas sector risks, including perceived impacts associated with oil spills and seismic events	Low (Georgetown) Medium (Outside Georgetown)	Small	Negligible (Georgetown) Minor (Outside Georgetown)	None	Negligible (Georgetown) Minor (Outside Georgetown)
	Institutional Factors					
	General population of Georgetown and vicinity—reduced access to emergency and health services	Medium	Small	Minor	Onshore medical provider with international medical provider support, and dedicated ambulance	Minor

8.4. Marine Use and Transportation

8.4.1. Administrative Framework—Marine Use and Transportation

Table 8.4-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on marine use and transportation.

Table 8.4-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Marine Use and Transportation

Title	Objective	Relevance to the Project
Legislation		
Guyana Shipping Act (1998) Cap. 49:01.	Establishes the framework for the regulation of vessels and sets out MARAD and its functions.	MARAD is the principal regulator for vessels operating in the marine environment and all vessels associated with the Project will fall under the purview of MARAD.
Maritime Zones Act (2010) Cap. 63:01.	Incorporates certain provisions of the United Nations Convention on the Law of the Sea and the United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage, to provide for marine scientific research, maritime cultural area, eco-tourism, marine parks and reserves and mariculture, the protection and preservation of the marine environment and for related matters.	Relevant to the Project as it makes provisions for passage in the territorial sea, and the discharge of harmful substances and hazardous waste. In addition, relevant when specific maritime zones are established for the protection and preservation of the marine environment and also for mariculture activities, for which one project is currently being pursued by others.
International Agreements Signed/Acceded by Guyana		
International Convention for the Safety of Life at Sea (1974)	Specifies minimum standards for the construction, equipment, and operation of vessels compatible with their safety; allows governments of participating states to inspect vessels flagged in other participating states to ensure compliance.	Affects construction, operation, and equipment on board the drill ships, FPSO, installation vessels, and support vessels. Guyana acceded in 1997.
Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (1988)	Promotes safety at sea by criminalizing actions that would endanger a vessel or its cargo, or that contribute to activities that would do so.	Would apply to any activity intended to endanger vessels while conducting Project-related activities. Guyana acceded in 2003.
Dock Work Convention (1973)	Regulates activities associated with the loading and unloading of cargo onto/from oceangoing vessels when at port.	Applies to loading and offloading activities at shorebases used by the Project. Guyana acceded in 1983.

Title	Objective	Relevance to the Project
Convention on the International Regulations for Preventing Collisions at Sea (1972)	Officially recognizes the importance of traffic separation in the marine environment and codifies basic measures to accommodate traffic separation, including safe speed, signalling conventions, and general vessel conduct.	Governs maritime operation of drill ships, FPSO, installation vessels, and support vessels. Guyana acceded in 1997.
International Convention on Standards of Training, Certification and Watchkeeping (1978)	Obligates crews operating vessels flagged in signatory states to adhere to minimum standards relating to training, certification, and watchkeeping; requires signatory states to submit detailed information to the International Maritime Organization concerning administrative measures taken to ensure compliance with the convention.	Impacts required capabilities of crew on board the drill ships, FPSO, installation vessels, and support vessels, and provides for inspection by authorities to ensure compliance. Guyana acceded in 1997.
Convention on Facilitation of International Maritime Traffic (1965)	Prevents unnecessary delays in maritime traffic arising from burdensome documentation requirements and establishes uniform formalities and other procedures to permit transboundary maritime commerce and travel.	Facilitates entry of drill ships, FPSO, installation vessels, and support vessels into Guyana. Guyana acceded in 1998.

8.4.2. Existing Conditions—Marine Use and Transportation

This section describes Guyana's existing marine and coastal transportation infrastructure, with particular focus on the Project AOI. Data and information in this section were obtained from key informant interviews, reports, studies, and other publicly available information, as well as direct observations of vessel activity in Georgetown Harbour.

8.4.2.1. Regional Setting

The Environmental Protection Act requires EIAs to assess impacts on material assets. Nearly all the Project-related activities will occur at designated shorebases on the coast, in coastal marine waters, or offshore. Therefore, for the purposes of this EIA, "material assets" include marine infrastructure within the Project AOI, which consists of waterways, coastal shipping channels, ports, and offshore shipping lanes. Guyana has approximately 1,000 kilometers (approximately 620 miles) of navigable rivers, which provide water access to most population and economic centers. Subsea telecommunications cables are also present in the Project AOI.

8.4.2.2. Existing Conditions in the Project Area of Influence

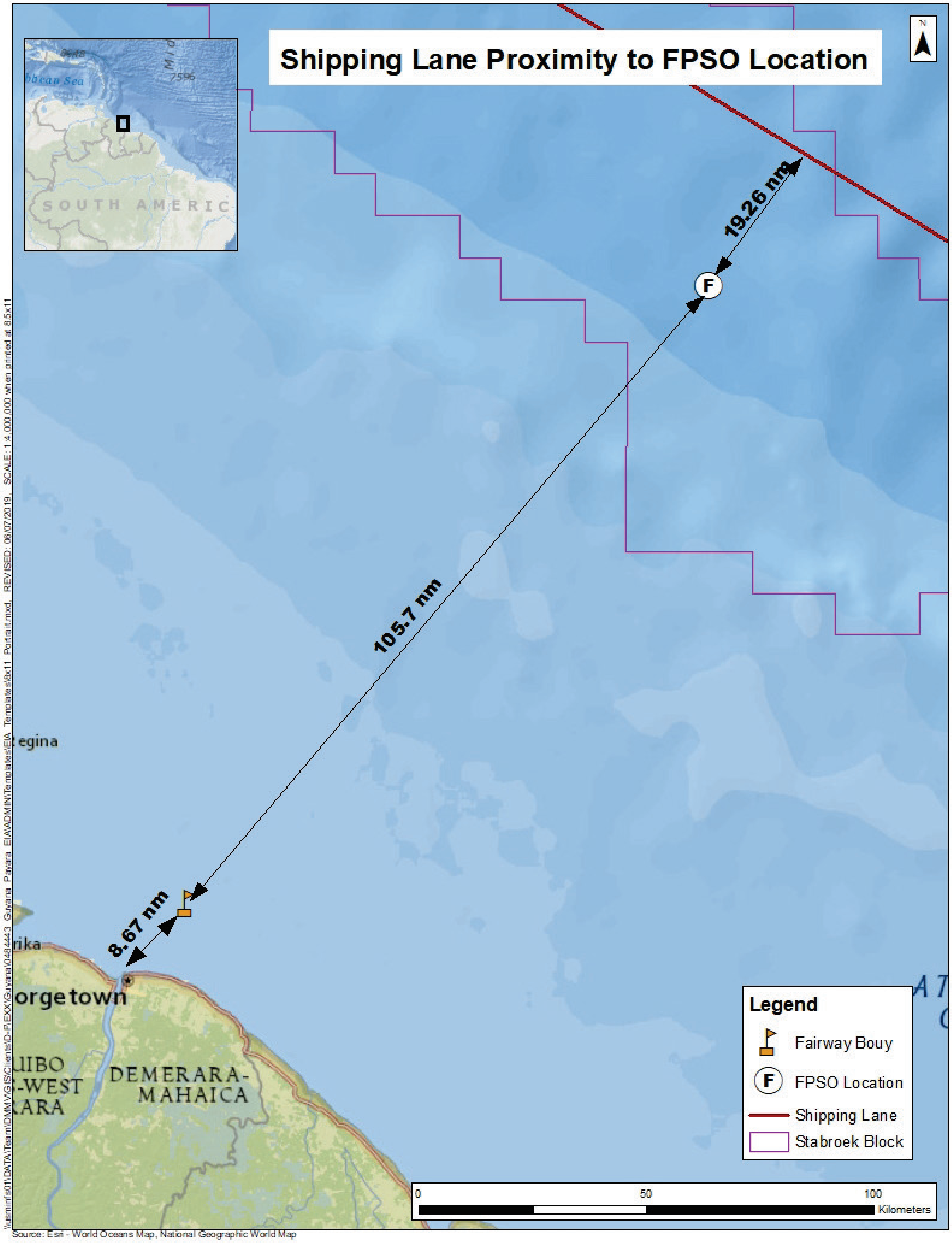
Marine Transportation

MARAD is responsible for ensuring the safe and efficient operation of shipping activities in Guyana territorial waters. Representatives from MARAD have advised EEPGL that Jamaican and Trinidadian shipping lanes cross the Stabroek Block. Figure 8.4-1 shows the location of the identified shipping lane in the Stabroek Block, as indicated on the pilot chart for the Caribbean and Gulf of Mexico.

As described in Section 8.1.2.4, Economic Conditions, fisheries are of significant importance to Guyana's economy, particularly in coastal areas. Marine fisheries and subsistence fishing occur throughout Guyana coastal waters, from the shore to the edge of the continental shelf, approximately 150 kilometers (approximately 93 miles) from shore, although most fishing activity occurs well inshore from the edge of the continental shelf. Deep-sea pelagic fishing commenced in 2016 and according to personnel from the Fisheries Department, expanding deep-sea fishing is an important long-term objective for the fisheries sector. In addition, the Fisheries Department can license vessels to fish outside Guyana's territorial waters, and is exploring how this industry can be developed (ERM/EMC Personal Communication 5). Figure 8.4-2 depicts the primary fishing zones offshore Guyana, by fishery type, and the primary fishing ports or fish landing sites in Regions 1–6.

The Port of Georgetown contains more than 40 separate wharves, including six primary cargo wharves, ranging from approximately 127 to 247 meters [approximately 417 to 810 feet] in length, with depths alongside ranging from 4.8 to 7.4 meters [15.7 to 24.3 feet], as well as four tanker berths, with depths of 3.1 to 6.7 meters [10.2 to 22.0 feet] alongside (NGIA 2017). Other privately owned docks and portside facilities near Georgetown and the mouth of the Demerara River have staging areas or storage yards, although these facilities are congested and space is limited.

A shipping channel is maintained on the lower Demerara River for the use of private, commercial, and military vessels. Pilotage is required to access the channel, and is provided by the Harbour Master. Vessels arrive in or depart from the Port of Georgetown in the vicinity of the Fairway Buoy, which is located approximately 9 nautical miles from the port (Figure 8.4-1). Departing vessels then proceed eastward or westward of the buoy depending on the destination port. The Demerara River channel has a dredged depth of 5.9 meters (approximately 19 feet), and has historically been dredged weekly to maintain this depth (ERM Personal Communication 27). The total number of vessels piloted by the Harbour Master in the Demerara River increased by 1.9 percent in 2017 compared to 2016. Over that period, cargo vessels increased by approximately 5 percent and tankers by approximately 8 percent. However, container vessels declined by approximately 18 percent (Table 8.4-2).



nm = nautical miles

Figure 8.4-1: Proximity of Payara FPSO to Offshore Shipping Lanes

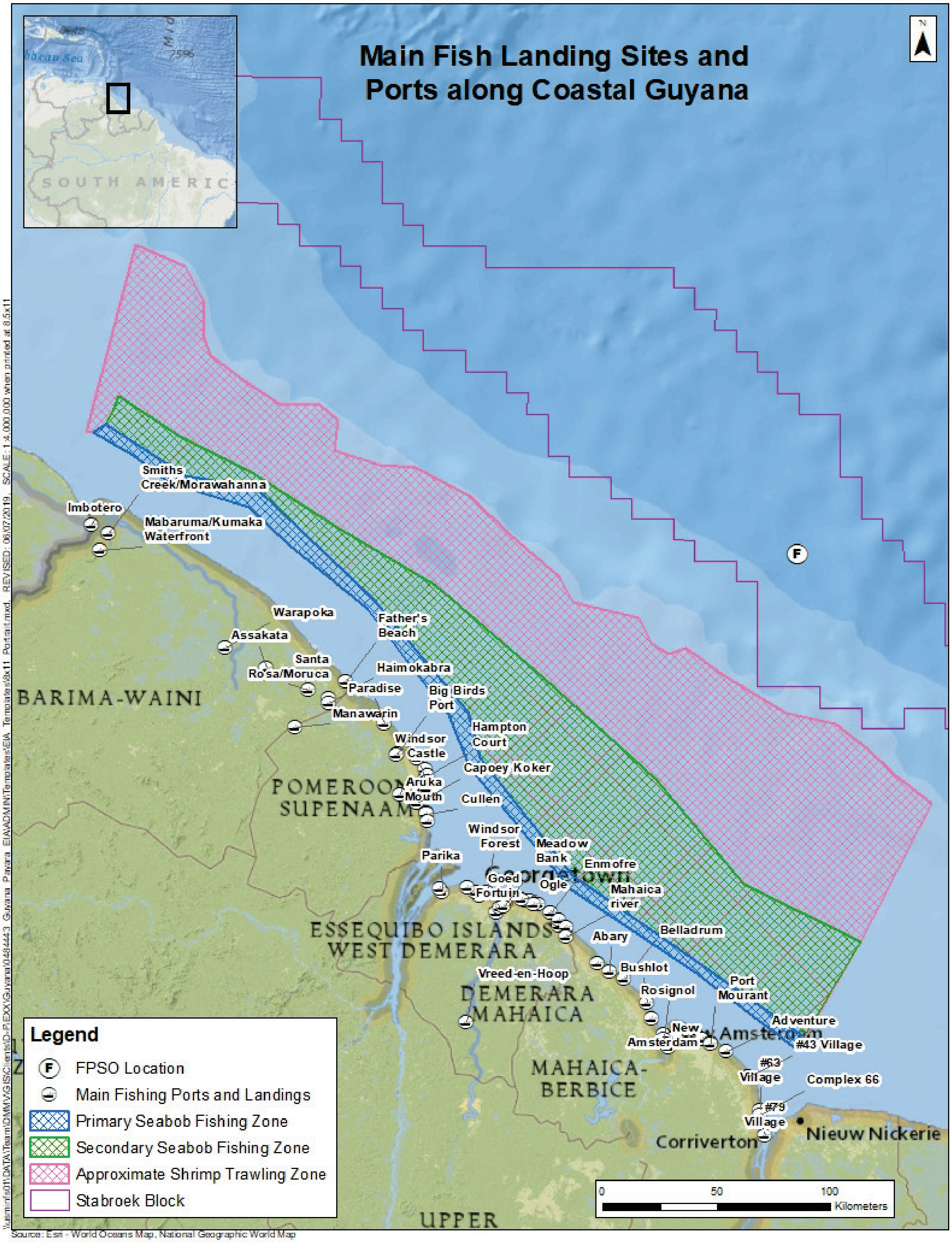


Figure 8.4-2: Fishing Zones and Main Fish Landing Sites and Ports

Table 8.4-2: Vessels Piloted by Harbour Master in the Demerara River in 2016 and 2017

Month	2017					2016				
	Cargo	Container	Tanker	Other	Total	Cargo	Container	Tanker	Other	Total
January	25	24	18	29	96	22	25	16	18	81
February	20	19	18	30	87	16	25	17	29	87
March	25	30	19	31	105	29	29	18	32	108
April	20	30	20	26	96	18	31	21	28	98
May	20	28	20	30	98	28	35	17	18	98
June	22	26	19	21	88	23	31	19	19	92
July	29	24	21	30	104	27	34	17	26	104
August	22	23	23	36	104	18	32	15	25	90
September	22	25	20	31	98	25	33	17	28	103
October	31	25	18	25	99	29	34	21	32	116
November	33	27	23	30	113	26	31	21	15	93
December	35	23	21	24	103	28	32	23	16	99
Total	304	304	240	343	1,191	289	372	222	286	1,169

Source: ERM/EMC Personal Communication 5

From 16 April to 30 April 2018, a study was undertaken to record vessel traffic in Georgetown Harbour between the mouth of the harbor and an existing shorebase that is planned to be used by the Project. Observations were made from two locations: one at the Kingston Outfall Channel near the mouth of the harbor, and one at the Quick Shipping Wharf (Figure 8.4-3). Observations were made on a 24-hour basis, recording the time of day, type of vessels observed, and direction of travel.

Table 8.4-3 summarizes the vessel traffic recorded during this period. Almost 1,800 vessel movements were counted at the Kingston Outfall observation location, yielding an average of 126 vessels per day. More than 2,100 vessel movements were recorded at the Quick Shipping Wharf observation location, yielding an average of 153 vessels per day. The Quick Shipping Wharf count included 178 east-west movements across the harbor, primarily from speedboat trips, small private boats, and barges travelling across the river. Many of the vessels movements were “linked,” meaning they were counted at both locations during the same movement (i.e., as they passed them successively). While some of these instances were definitively linked, the difficulty in accomplishing this linking (in particular at night) prevents a precise count of these instances.

Fishing vessels accounted for most of the marine traffic. At the Kingston Outfall observation location, 76 percent of vessel movements were either trawlers or other kinds of fishing boats. At the Quick Shipping Wharf observation location, fishing boats and trawlers accounted for 71 percent of the traffic, while passenger boats and “other” vessels (primarily small, private boats) made up 11 percent of the traffic. Larger vessels, including ocean-going vessels, coastal vessels, and oilfield service vessels, comprised a higher proportion of the vessel traffic at the Kingston Outfall observation location, totaling 14 percent of the vessels counted at this location.

Figure 8.4-3: Georgetown Harbour Vessel Observation Points (16–30 April 2018) and Speedboat Stellings

Table 8.4-3: Vessel Traffic Observed in Georgetown Harbour, 16–30 April 2018

	Kingston Outfall Channel			Quick Shipping Wharf [a]				
Vessel Type	**Northbound (Outbound)**	**Southbound (Inbound)**	**Total**	**Northbound (Outbound)**	**Southbound (Inbound)**	**Eastbound (across channel)**	**Westbound (across channel)**	**Total**
Oceangoing (cargo, tanker, etc.)	42	59	101	38	32	1	1	72
Coastal vessel	51	70	121	34	33	1	4	72
Oilfield service vessel	12	12	24	12	11			23
Tug and barge	31	27	58	23	24	18	17	82
Tug alone	20	20	40	1	4			5
Trawler	195	204	399	155	155	1	1	312
Fishing vessel (other than trawler)	484	454	938	617	566	13	17	1,213
Government vessel (Coast Guard, police, Guyana Revenue Authority, harbor boat)	7	8	15	21	26	7	9	63
Pilot boat	26	34	60	32	37	1	1	71
Passenger boat (speedboat)	0	0	0	17	13	26	27	83
Other vessel	5	3	8	56	62	14	19	151
Total	873	891	1,764	1,006	963	82	96	2,147

[a] In addition, the Quick Shipping Wharf site counted 73 movements in which a Coast Guard vessel moved out of its dock and into the channel, and then immediately returned to dock. These are not included in the counts in this table.

Marine traffic activity was nearly continuous throughout each day. The highest volumes of marine traffic consistently occurred between 9:00 a.m. and 6:00 p.m. daily, although other times were also quite active. From 10:00 p.m. until 6:00 a.m., local fishing boats made up 78 percent of the marine traffic observed from the Quick Shipping Wharf location.

Day-to-day variations, particularly in fishing vessel movements, resulted from tides and weather. The local fishing boats tend to go to sea on a rising tide so that they can set their nets at the high tide, and return with their catch when the tide is falling. The observations period included a neap tide that resulted in lower volumes of fishing boats during the middle of the counting period, from 21 to 25 April. Tidal conditions resulted in high traffic volumes during some night or early morning hours.

The Transport and Harbours Department is responsible for the management of the national ferry service. The Department has ten ferry vessels, three of which operate the Georgetown (Region 4) to Northwest (Region 1) route. The other seven ferries operate in the Essequibo River (ERM/EMC Personal Communication 5). The ferries on the Essequibo River serve several ports (also known as stellings) on either side of the Essequibo River and on Leguan and Wakenaam Islands and Bartica, as shown on Figure 8.4-4.

In addition to the national ferry service, many smaller vessels provide transportation between Regions 2 and 3 across the Essequibo River, as well as across the Demerara River, between the Stabroek Market stelling in Georgetown (Region 4) and Vreed-en-Hoop stelling (Region 3) on the west bank of the river. These smaller vessels are collectively and informally known as "speedboats" because they typically travel faster than the ferries. These speedboats vary in size, power, and capacity, but can typically carry from 13 to 30 passengers. Across the Essequibo River, speedboats operate at the same ports as the national ferry service, and may also call at smaller informal landings as clients demand and conditions warrant.

Speedboats are an important element in the transportation system between Georgetown and West Demerara. Speedboats serving the Demerara River crossing operate from 6:00 a.m. to 8:00 p.m. There are 57 speedboats registered with the Speedboat Association, of which 50 to 53 are operational on any given day. Registered Demerara River speedboats generally share a common design, with a legal capacity of 33 passengers in a covered compartment, plus two crewmembers. Monitors at the Vreed-en-Hoop and Stabroek Market stellings record speedboat crossings and are meant to ensure that registered boats adhere to a set of rules developed by the Speedboat Association. The locations of the speedboat stellings on the Demerara River are shown on Figure 8.4-3. Rules and regulations for the safe operation of speedboats are developed by MARAD and enforced with the assistance of the Speedboat Association. The Speedboat Association has also developed and enforces a disciplinary system that requires registered speedboats to take turns, and also requires passengers to be seated and wearing a life vest before the boat casts off from the dock (Gonsalves 2018).

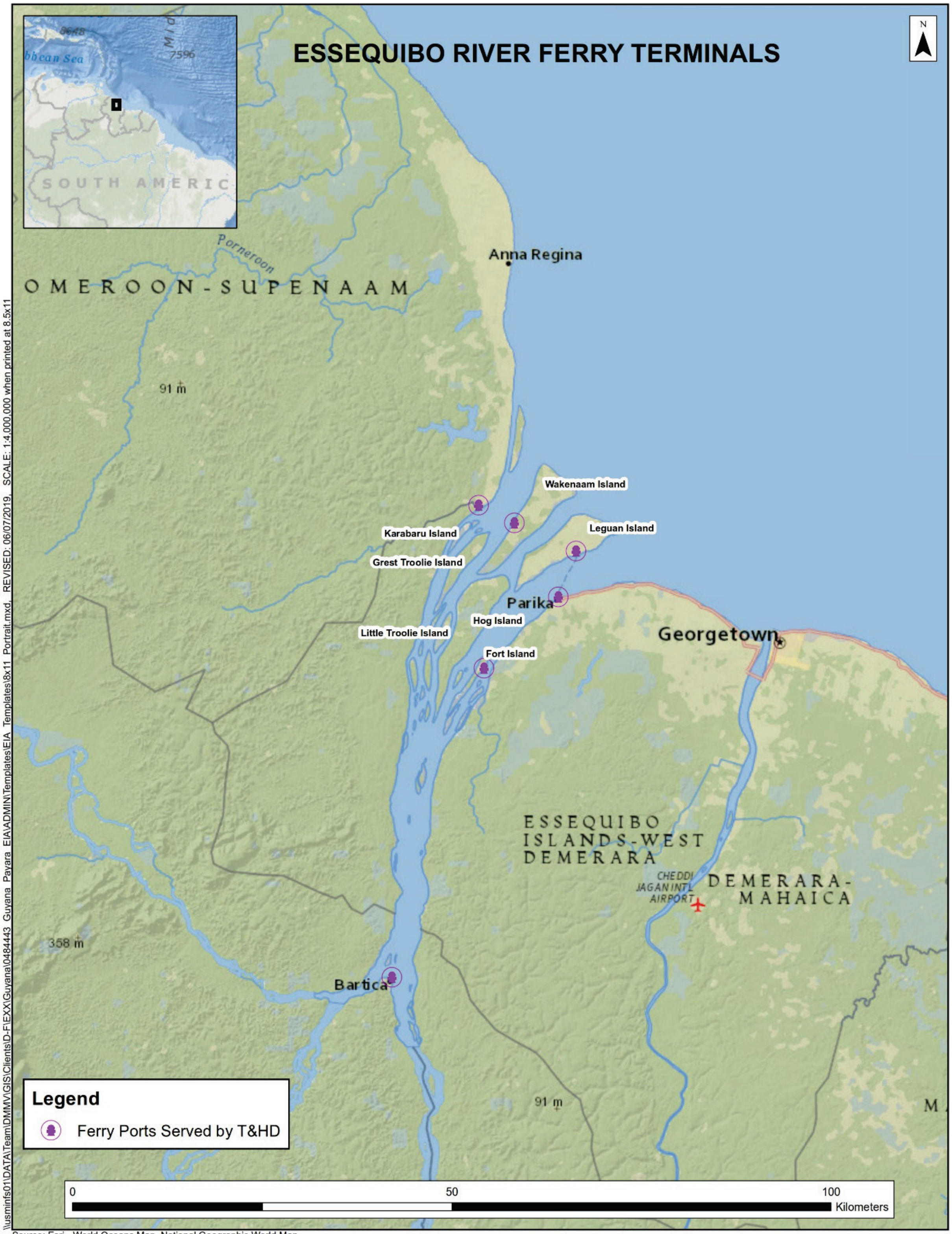
During the morning rush period, at least five speedboats load simultaneously at Vreed-en-Hoop and discharge at Stabroek. Table 8.4-4 summarizes 2017 speedboat passenger volumes. Passenger volumes are substantially lower on Saturdays and Sundays. In 2017, approximately 590 school children commuted daily from Vreed-en-Hoop to Georgetown. This represented a 5 percent increase over 2016. Docking facilities at both Vreed-en-Hoop and especially at Stabroek Market are generally considered to be inadequate (Gonsalves 2018). In 2018, tenders were being evaluated for improvements to both docks (Gonsalves 2018; MoPI 2018).

Table 8.4-4: 2017 Stabroek Market Weekday Speedboat Passenger Activity

Vessel Type	All Weekdays	Mondays
Average daily disembarkations	9,233	10,211
Rush hour (0600-0900 hours) disembarkations	5,225	5,808
Afternoon embarkations	1,815	ND

Source: Gonsalves 2018

ND: No data available



Source: Esri - World Oceans Map, National Geographic World Map

Figure 8.4-4: Essequibo River Ferry Terminals

Telecommunications

A Guyana Telephone & Telegraph subsea telecommunications cable, which is part of the Suriname Guyana Submarine Cable System (SGSCS), runs through the Stabroek Block, but is outside of the PDA. Figure 8.4-5 shows the mapped route of the SGSCS compared to the planned location of the Payara Development Project FPSO. Since the SGSCS is outside the PDA, planned Project activities will not interact with it; accordingly, the SGSCS is not discussed further in this EIA.

8.4.3. Impact Assessment—Marine Use and Transportation

This section assesses potential Project impacts on marine use and transportation in the Project AOI. The Project will involve the drilling of development wells, installation, and long-term operations of an FPSO and SURF, and transit of Project support vessels between the PDA and the Guyana shorebases, as well as between the PDA and shorebases in Trinidad and Tobago. The assessment of potential impacts on marine use and transportation from these Project activities was based on the following assumptions:

- Most Project support vessel trips will originate from (and return to) shorebase facilities in Georgetown, while larger-draft vessels could transit between the PDA and shorebases in Trinidad and Tobago.
- The development well drilling stage could potentially use up to two drill ships on station simultaneously, with occasional short-term periods (i.e., several months) when a third drill ship could potentially be used to drill 1 to 2 wells on an opportunistic basis.
- The marine safety infrastructure available in Guyana (e.g., navigation aids) is adequate.

8.4.3.1. Relevant Project Activities and Potential Impacts

The FPSO will be anchored to the seafloor for the duration of the production operations stage, which is planned to last at least 20 years. During this stage, the FPSO will have a 2-nautical mile radius marine safety exclusion zone (covering approximately 4,300 hectares [10,600 acres]), in which no unauthorized vessels will be allowed to enter during offloading. In addition, the drill ships will each have a 500-meter (1,640-foot) radius marine safety exclusion zones during drilling operations and well workovers, and a 500-meter (1,640-foot) radius marine safety exclusion zone will be maintained around each major installation and decommissioning vessel during the installation and decommissioning stages, respectively. Notices to mariners will be issued via MARAD to the Trawler's Association and fishing co-ops for planned Project marine vessel movements, including the FPSO, drill ships, and major installation/decommissioning vessels. Additionally, through the stakeholder engagement process, EEPGL will also communicate plans for major Project vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners, to aid them in avoiding Project vessels.

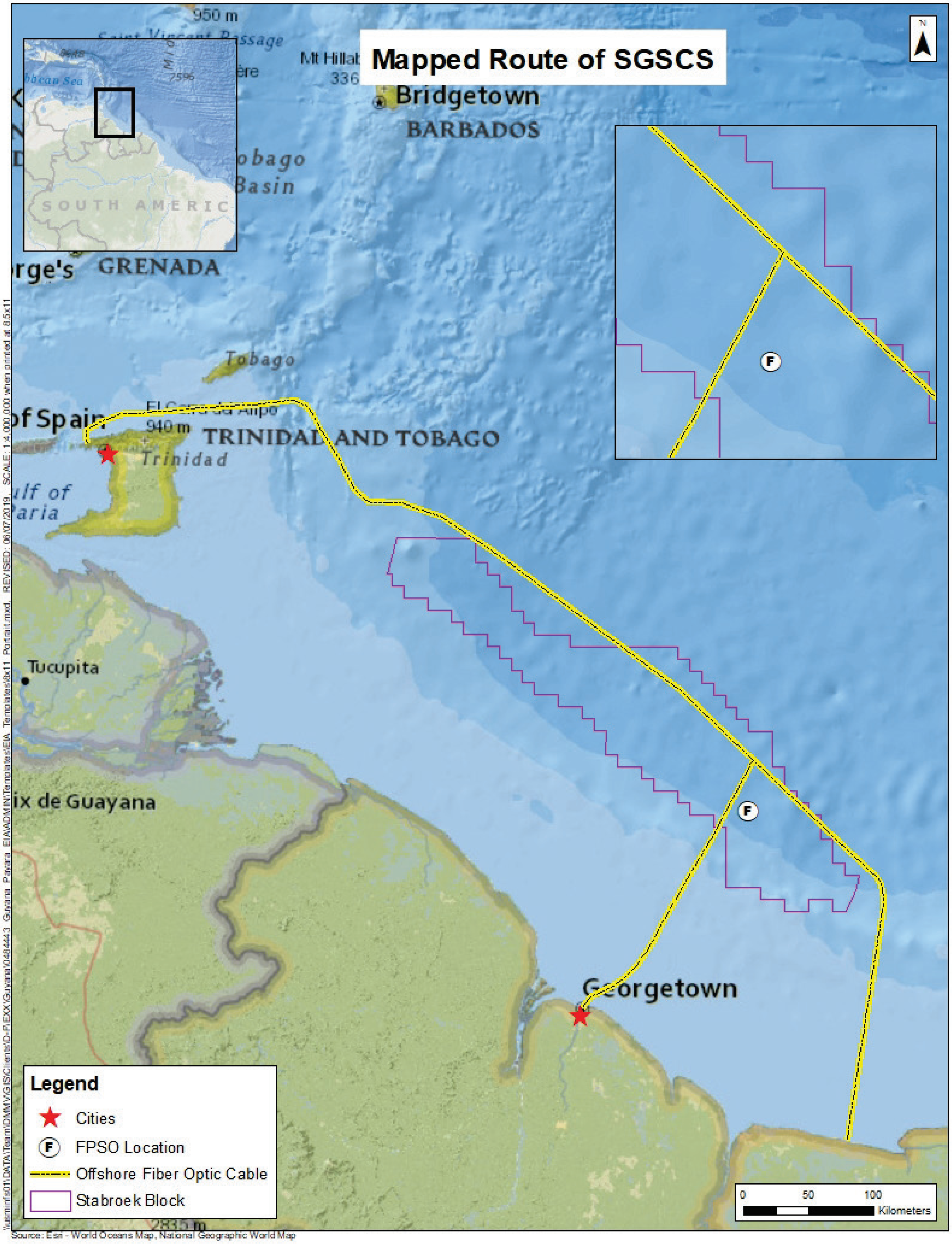


Figure 8.4-5: Mapped Route of SGSCS in Relation to Payara FPSO

Based on current drilling activities and past experience with similar developments, it is estimated that the Project will generate a variety of marine support vessel trips throughout the Project life. Support vessel activities will consist of:

- Multiple platform-supply vessels and a single fast-supply vessel conducting re-supply trips to the FPSO and drill ships;
- Tug vessels supporting tanker offloading activities;
- Multi-purpose vessels supporting subsea installation and maintenance activities; and
- Multi-purpose vessels supporting decommissioning activities.

Based on current drilling activities and past experience with similar developments, it is estimated that during development drilling and FPSO/SURF installation, installation and support vessels could average 12 to 15 round trips per week between the Payara PDA and shorebases. During the production operations stage, it is estimated that this number will be reduced to approximately 5 to 10 round-trips per week. These vessel round-trips will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad and Tobago.

As described in Section 2.11, End of Payara Operations (Decommissioning), EEPGL has not prepared detailed plans for the decommissioning stage. As such, the number of vessel trips associated with decommissioning cannot be reliably estimated at this time. For the purposes of the impact analysis, vessel traffic associated with Project decommissioning is assumed to be similar to that for the drilling and installation stage (i.e., on the order of 12 to 15 vessel round-trips per week).

For the purposes of the impact assessment, marine safety exclusion zones are considered an embedded control (i.e., part of the Project design). Accordingly, the "pre-mitigation" impact significance ratings consider the inclusion of this measure.

Table 8.4-5 summarizes the Project stages and activities that could result in potential Project impacts on marine use and transportation, as well as the receptors that could potentially experience these impacts.

Table 8.4-5: Summary of Relevant Project Activities and Key Potential Impacts—Marine Use and Transportation

Stages	Receptor(s)	Project Activity	Key Potential Impacts
Development Well Drilling SURF/FPSO Installation	• Commercial cargo vessels • Commercial fishing vessels • Subsistence fishing vessels	Maritime transport of Project materials, supplies, and personnel	Increased vessel traffic in Georgetown Harbour, coastal waters between Georgetown and the PDA, and along transit routes leading to Georgetown
	• Commercial cargo vessels • Commercial fishing vessels	Presence of FPSO, drill ships, and major installation vessels	Reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around the FPSO, drill ships, and major installation vessels
Production Operations	• Commercial cargo vessels • Commercial fishing vessels • Subsistence fishing vessels	Maritime transport of Project materials, supplies, and personnel	Increased vessel traffic in Georgetown Harbour, coastal waters between ports and the PDA, and along transit routes leading to Georgetown
	• Commercial cargo vessels • Commercial fishing vessels	Presence of FPSO, tanker, drill ships, and workover vessel	Reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around the FPSO, tanker, drill ships, and workover vessels
Decommissioning	• Commercial cargo vessels • Commercial fishing vessels • Subsistence fishing vessels	Maritime transport of Project materials, supplies, and personnel	Increased vessel traffic in Georgetown Harbour, coastal waters between ports and the PDA, and along transit routes leading to Georgetown
	• Commercial cargo vessels • Commercial fishing vessels	Presence of decommissioning vessels	Reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around major decommissioning vessels

8.4.3.2. Magnitude of Impact—Marine Use and Transportation

The assessment of the Project's magnitude of potential impacts on marine use and transportation is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on marine use and transportation is defined according to the definitions provided in Table 8.4-6. The following paragraphs discuss the characteristics of each of the potential impacts assessed and the resultant magnitude ratings. These are summarized in Table 8.4-7.

Table 8.4-6: Definitions for Intensity Ratings for Potential Impacts on Marine Use and Transportation

Criterion	Definition
Intensity	Negligible: No discernible change in transportation activity or demands on other infrastructure.
	Low: Increased transportation activity or marine infrastructure demand may be perceptible, but does not measurably impact the capacity of transportation or other infrastructure.
	Medium: Increased transportation activity or marine infrastructure demand is widely perceptible and reduces transportation system or infrastructure capacity, but impacts do not require a change in typical travel behavior by non-Project marine users.
	High: Increased transportation activity or marine infrastructure demand is significant and causes substantial delay or congestion on waterways, to the point where vessel operators or other users of infrastructure must consistently and frequently change their typical daily behavior.

Increases in Marine Traffic and Resultant Impacts to Navigation

The Project's marine activities will potentially impact vessel traffic into and out of Georgetown Harbour, open-ocean shipping in the vicinity of the PDA, the limited commercial fishing activity that occurs as far out as the PDA, and commercial and subsistence fishing activity within the portion of the Direct AOI that connects the PDA to Georgetown Harbour. As described above, Project-related vessel traffic will be higher during the development well drilling stage than during the production operations stage.

The Harbour Master has advised EEPGL that Jamaican and Trinidadian vessel shipping lanes cross the Stabroek Block (ExxonMobil Personal Communication 1). As such, commercial shipping traffic could potentially intersect the PDA as well. However, shipping lane maps indicate the FPSO will likely be on the order of 19 nautical miles from the nearest generalized shipping lane (see Figure 8.4-1). More important, the shipping lanes in question are traditional, and are not precisely demarcated. Accordingly, even if Project vessels are in close proximity to mapped lanes, shipping lane users will have ample warning and space to navigate, and there is no reason to believe Project activities in the PDA will meaningfully impede non-Project shipping traffic. No interference with shipping traffic was reported during previous seismic surveys or exploration drilling activities.

The highest potential for interactions between non-Project vessels and Project vessels in Guyana waters is near Georgetown Harbour and the Demerara River mouth, where vessel traffic is already concentrated and increasing. The Project's potential impacts on marine use and transportation for subsistence activity are likely to be limited, but challenges in communicating with the subsistence fishing fleet may limit the effectiveness of efforts to advise the fleet of Project operations. The potential social and economic impacts of the Project's marine safety exclusion zones on commercial and subsistence fishing and recommendations to manage these impacts are described in Sections 8.1.3, Impact Assessment—Socioeconomic Conditions, and 8.2.3, Impact Assessment—Employment and Livelihoods.

During development well drilling and again during decommissioning, the Project could generate one or two daily vessel departures and arrivals from the Port of Georgetown. Based on the vessel surveys summarized in Section 8.4.2, Existing Conditions—Marine Use and Transportation, this frequency of activity is a small fraction of the existing vessel activity in Georgetown. Additionally, Project support vessels will typically be smaller and more maneuverable than the cargo or tanker vessels that call on the Port of Georgetown or ports in Trinidad and Tobago, further supporting the conclusion that Project vessels will not present significant incremental navigation hazards within or near these ports.

Considering the information presented above, potential impacts related to increased marine traffic and resultant impacts to navigation will be limited to the **Direct AOI**. Based on the marine vessel survey count conducted in Georgetown Harbour, Project-related vessel activity in Georgetown Harbour will increase the existing marine traffic by 1 to 4 percent. On this basis, and the intensity of the potential impacts to marine traffic is rated as **Low**. Project-related marine traffic will occur on a routine basis continue throughout the Project life cycle, yielding a frequency designation of **Continuous** for all stages and a duration of **Long-term** for drilling, installation, and production operations phases and **Medium-term** for the decommissioning stage. This yields a magnitude rating of **Low** for potential impacts on marine traffic and resultant impacts to navigation.

Loss of Use of Marine Safety Exclusion Zones

Vessels transiting the PDA will need to avoid the marine safety exclusion zones around the drill ships, major installation or decommissioning vessels, and the FPSO. The FPSO marine safety exclusion zone will require non-Project vessels to avoid approximately 4,300 hectares (approximately 10,600 acres) (approximately 0.2 percent) of the Stabroek Block's approximately 2.7 million hectares (approximately 6.7 million acres) for at least 20 years. Because the FPSO will be anchored to the seafloor, its marine safety exclusion zone will essentially be a permanent navigation feature until the Project components are decommissioned. The marine safety exclusion zones around each of the drill ship(s) will be comparatively smaller (approximately 79 hectares [195 acres]), and will be in force only during development drilling activities, which is anticipated to last up to 5 years, and occasionally during well workover activities in later years. Similar-sized marine safety exclusion zones around major installation vessels will occur only during the FPSO/SURF installation stage, or in the event repairs or maintenance are required.

Fishing vessels near the PDA will lose use of the defined marine safety exclusion zones for fishing activities. As described in Section 8.1.2, Existing Conditions—Socioeconomic Conditions, and Section 8.2.2, Existing Conditions—Employment and Livelihoods, most subsistence fishing occurs in nearshore areas and most commercial fishing occurs between the coast and the edge of the continental shelf (i.e., shoreward of the PDA). As described in Section 8.2.3.2, Magnitude of Impact—Employment and Livelihoods, there is only one commercial fishing company, with 12 vessels, that engages in deepwater tuna fishing that may approach the southern boundary of the PDA, and abandoned fishing gear has been found entangled in the mooring lines for metocean instruments installed by EEPGL in the same area. There are also reportedly Venezuelan vessels that fish on occasion at distances as far out as 190 kilometers (118 miles) from shore, but no further information about Venezuelan fishing activity on the outer continental shelf or slope is available. If deepwater fishing continues to develop in the vicinity of the PDA, the number of industrial fishing vessels affected by Project-related activities offshore may increase modestly in the future, but would still be a relatively small amount of vessels compared to the overall fishing fleet in Guyana.

With respect to commercial fishing, most of the PDA is in waters deeper than those used most often for commercial fishing, and in any case the size of the FPSO marine safety exclusion zone is insignificant relative to the area available for fishing. As a result, the Project's potential impacts on marine use and transportation for current commercial fishing activities also are likely to be limited.

Impacts related to loss of the use of the marine safety exclusion zones by non-Project marine users will be limited to a portion of the **Direct AOI** (i.e., a portion of the PDA). While the amount of area affected will be less than 1 percent as compared to the available marine waters in the Guyana Exclusive Economic Zone (EEZ), the fact that the marine safety exclusion zones will represent essentially permanent avoidance areas results in an intensity rating of **Low**. The marine safety exclusion zones will be in place throughout stages yielding a frequency designation of **Continuous** for all stages. Duration will be **Long-term** for drilling, installation, and production operations phases and **Medium-term** for the decommissioning stage. Therefore, the magnitude of this potential impact is rated as **Small**.

Table 8.4-7: Magnitude of Impact—Marine Use and Transportation

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Development Well Drilling SURF/FPSO Installation	Commercial vessels (cargo and fishing) and subsistence fishing vessels—increased traffic and resultant impacts on navigation	Direct AOI (Georgetown Harbour, PDA)	Low	Continuous	Long-term	Small
	Commercial vessels—Reduced availability due to marine safety exclusion zones	Direct AOI (PDA)	Low	Continuous	Long-term	Small
Production Operations	Commercial vessels (cargo and fishing) and subsistence fishing vessels—increased traffic and resultant impacts on navigation	Direct AOI (Georgetown Harbour, PDA)	Low	Continuous	Long-term	Small
	Commercial vessels—Reduced availability due to marine safety exclusion zones	Direct AOI (PDA)	Low	Continuous	Long-term	Small
Decommissioning	Commercial vessels (cargo and fishing) and subsistence fishing vessels—increased traffic and resultant impacts on navigation	Direct AOI (Georgetown Harbour, PDA)	Low	Continuous	Medium-term	Small

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
	Commercial vessels—Reduced availability due to marine safety exclusion zones	Direct AOI (PDA)	Low	Continuous	Medium-term	Small

8.4.3.3. Sensitivity of Receptors—Marine Use and Transportation

Potential receptors for marine use and transportation impacts include current users of Georgetown Harbour and Guyanese coastal and offshore waters. The receptor sensitivity ratings for marine use and transportation are defined in Table 8.4-8.

Table 8.4-8: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Marine Use and Transportation

Criterion	Definition
Sensitivity	Low: The receptor is accustomed to or specifically anticipates the type of activity proposed by the Project; existing transportation activities can easily adapt to additional transportation activity with no outside assistance or mitigation.
	Medium: The receptor is not specifically accustomed to the type of activity proposed by the Project. The receptor can adapt to additional transportation activity and maritime safety risks with outside assistance or mitigation.
	High: The receptor is poorly suited to the type of activity proposed by the Project, and cannot fully adapt to increased transportation activity and maritime safety risks, even with outside assistance or mitigation.

Table 8.4-9 summarizes the sensitivity ratings assigned for the various types of receptors that could potentially experience marine use and transportation impacts from planned activities of the Project.

Table 8.4-9: Sensitivity Ratings for Receptors of Potential Impacts on Marine Use and Transportation

Receptor	Definition and Rationale for Inclusion	Sensitivity Rating	Rationale for Rating
Commercial cargo vessels	Includes all international and regional commercial cargo vessel activity making calls at Georgetown Harbour, as well as traversing the northern coast of South America. Project activities will occur in areas potentially used by commercial shipping organizations, and will require use of Georgetown Harbour.	Low	Georgetown Harbour is an active commercial port, where vessel traffic—such as Project-related traffic—is expected. Commercial vessels in international waters are expected to be able to safely navigate around other vessels (whether in transit or stationary).
Commercial fishing vessels	Includes commercial fishing vessels (i.e., those who sell their product to local or international markets) that operate in Guyana coastal and offshore waters. These vessels may interact with Project vessels, or may currently conduct fishing operations in or near defined	Medium	Commercial fishing vessels will lose access to some fishing areas that are currently available to them, and will have to avoid Project-related vessel traffic where none currently exists; however, operators are likely to be aware of Project activities, or at least of commercial shipping activity in the

Receptor	Definition and Rationale for Inclusion	Sensitivity Rating	Rationale for Rating
	marine safety exclusion zones in the PDA.		vicinity of Georgetown, and can alter their fishing grounds to avoid defined marine safety exclusion zones in the PDA.
Subsistence fishing vessels	Includes individuals whose fishing activity is primarily or solely to feed themselves, their family, or their community, and not for commercial sales. These individuals generally operate near shore.	Medium	Subsistence fishing vessels are usually small, with limited ability to identify or avoid Project vessels. They will not lose access to existing fishing areas or encounter Project-related vessel traffic outside of existing areas of high vessel traffic, but may not receive notice of Project-related activities.

8.4.3.4. Impact Significance—Marine Use and Transportation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential Project impacts on marine use and transportation ranges from **Negligible** to **Small**.

8.4.4. Mitigation Measures—Marine Use and Transportation

To reduce the magnitude of potential marine use and transportation impacts, EEPGL will issue Notices to Mariners via MARAD, the Trawler's Association, and fishing co-ops for movements of major marine vessels (including the FPSO, drill ship, and installation vessels) to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active. Additionally, EEPGL will augment its ongoing stakeholder engagement process (and will work with government authorities through their existing notification/control processes) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners, and communicate planned Project activities to those individuals/entities to aid them in avoiding major Project vessels where possible, as further mitigation.

In the case of commercial fishing vessel loss of access to the marine safety exclusion zones, these measures are expected to be effective means of communicating with the relatively limited number of potentially impacted stakeholders. Accordingly, the magnitude of impact considering implementation of mitigation measures will be reduced to **Negligible**. While these mitigations are expected to reduce the magnitude of navigation-related impacts on commercial and subsistence fishing vessels, it may not be possible to communicate with all potentially impacted stakeholders. Therefore, the significance of potential impacts on both receptors is conservatively maintained at **Minor**.

Table 8.4-10 summarizes the embedded controls, mitigation measures, and monitoring measures relevant to this receptor.

Table 8.4-10: List of Embedded Controls, Mitigation Measures, and Monitoring Measures

Embedded Controls
Maintain marine safety exclusion zones to be issued through the Maritime Administration Department with a 500-meter (approximately 1,640-foot) radius around drill ships and major installation vessels, to prevent unauthorized vessels from entering areas with an elevated risk of collision.
Maintain marine safety exclusion zones to be issued through the Maritime Administration Department with a 2-nautical-mile (approximately 12,150-foot) radius around FPSO during offloading operations, to prevent unauthorized vessels from entering areas with an elevated risk of collision.
Equip Project vessels with radar systems and communication mechanisms to communicate with third-party mariners.
Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.
Mitigation Measures
Issue Notices to Mariners via the Maritime Administration Department, the Trawler's Association, and fishing co-ops for movements of major marine vessels (including the FPSO, drill ship, and installation vessels) to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.
Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.
Monitoring Measures
Record instances of marine vessels entering marine safety exclusion zones.
Monitor frequency of engagement with stakeholders, including fisherfolk, coastal communities, vulnerable groups and Indigenous populations

Table 8.4-11 summarizes the assessment of potential pre-mitigation and residual impacts on marine use and transportation. The significance of impacts was rated based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine use and transportation-specific methodology described in Sections 8.4.3.2 and 8.4.3.3.

Table 8.4-11: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Use and Transportation

Stage	Resource/ Receptor Impact	Embedded Controls	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Drilling and Installation Decommissioning	Commercial cargo vessels—port and channel operations	Marine safety exclusion zones around FPSO, drill ship, and major installation vessels.	Small	Low	Negligible	• Notices to Mariners and other communication materials regarding major vessel movements and marine safety exclusion zones • Augment ongoing stakeholder engagement process to communicate Project activities to the fishing community, including individuals who might not ordinarily receive Notices to Mariners	Negligible
	Commercial fishing vessels—exclusion from PDA		Small	Medium	Minor		Negligible
	Commercial cargo vessels—offshore navigation		Small	Low	Negligible		Negligible
	Commercial fishing vessels—offshore navigation		Small	Medium	Minor		Minor
	Subsistence fishing vessels—nearshore navigation		Small	Medium	Minor		Minor
Production Operations	Commercial cargo vessels—port and channel operations	Marine safety exclusion zones around FPSO and major installation vessels.	Small	Low	Negligible		Negligible
	Commercial fishing vessels— exclusion from PDA		Small	Medium	Minor		Negligible
	Commercial cargo vessels—offshore navigation		Small	Low	Negligible		Negligible
	Commercial fishing vessels—offshore navigation		Small	Medium	Minor		Minor
	Subsistence fishing vessels—nearshore navigation		Small	Medium	Minor		Minor

8.5. SOCIAL INFRASTRUCTURE AND SERVICES

8.5.1. Administrative Framework—Social Infrastructure and Services

Table 8.5-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on social infrastructure and services.

Table 8.5-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Social Infrastructure and Services

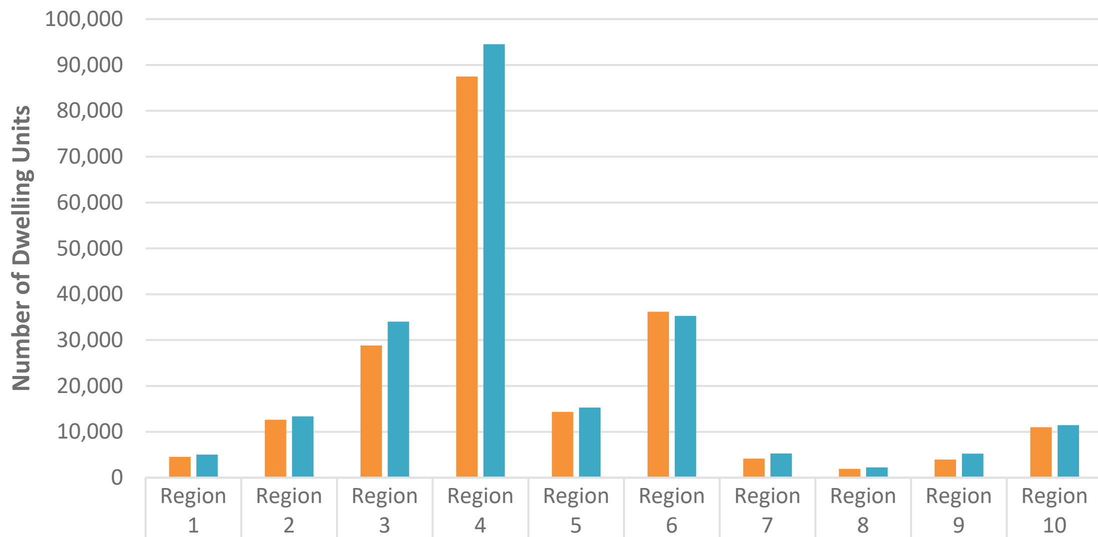
Title	Objective	Relevance to the Project
Legislation		
Town and Country Planning Act (1996) Cap. 20:01.	Provides for the orderly and progressive development of urban and rural lands and the preservation and improvement of amenities pertaining to such development. Development under the act is restricted to buildings and roadworks incidental to buildings.	Would be relevant if the Project builds commercial, industrial, or residential structures. It would also be relevant for the land use clearance process (within the building permit process) within the Central Housing and Planning Authority.
Sea Defence Act (1953, 1988, 1992) Cap. 64:03.	Aims to make better provision for the maintenance and construction of sea defenses in Guyana.	Covers the protection of mangroves, which serve as a natural sea defense mechanism; there are fines and penalties for the unpermitted destruction of mangroves. Relevant to the Project in the unlikely event of an oil spill reaching the shore and causing mangrove damage.
Water and Sewerage Act (2002) Cap. 30:01.	Provides for the ownership, management, control, protection, and conservation of water resources, the provision of safe water, sewerage and advisory services and the regulation thereof.	Has no direct applicability to the Project, as water resources are defined as water systems, conservancies, canals, and water from rainfall or runoff from the land.
Ministry of Health Act (2005)	Outlines the responsibilities and functions of the Ministry of Public Health, including responsibilities in relation to health care facilities.	Generally applies to health care services supplied to Project workers.

8.5.2. Existing Conditions—Social Infrastructure and Services

This section describes existing conditions for social infrastructure and services in the Project AOI. The section addresses two broad aspects of social infrastructure services: housing, utilities, and other social services (excluding medical services, which are addressed under in this EIA under Section 8.3, Community Health and Wellbeing); and ground and air transportation. The existing conditions associated with these two aspects are assessed separately in this section.

8.5.2.1. Housing

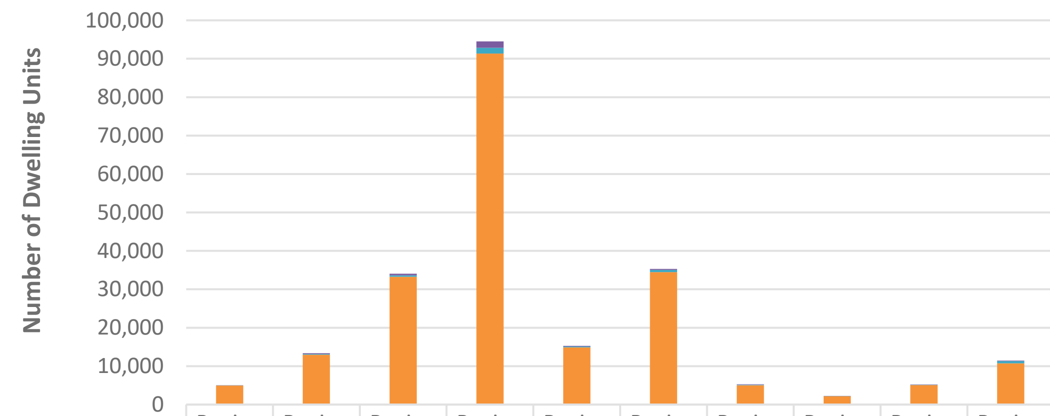
According to the 2012 census results (BSG 2012), a total of 221,741 dwelling units were recorded in the country, which was an increase of 8.1 percent in comparison to the 2002 census results. Regions 3, 4, and 6 contain the largest proportion of the population and, as expected, recorded the highest number of dwelling units in both the 2002 and 2012 census years. Figure 8.5-1 shows the number of dwelling units by region. According to the 2012 data, 214,999 of the total 221,741 dwelling units were occupied, suggesting that only 3 percent were either vacant or closed dwelling units, compared to 8.8 percent in the 2002 census. Occupancy rates were high for all ten administrative regions according to the 2012 census (see Figure 8.5-2).



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
2002	4,556	12,629	28,819	87,475	14,347	36,189	4,173	1,933	3,963	11,013
2012	5,042	13,368	34,042	94,531	15,274	35,297	5,266	2,227	5,257	11,437

Source: BSG 2012

Figure 8.5-1: Regional Distribution of Dwelling Units: 2002 and 2012



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
Closed Dwellings	57	203	411	1,663	166	221	107	31	104	127
Vacant Dwellings	44	158	362	1,497	205	589	138	13	64	582
Occupied Dwellings	4,941	13,007	33,269	91,371	14,903	34,487	5,021	2,183	5,089	10,728

Source: BSG 2012

Figure 8.5-2: Number of Occupied, Closed and Vacant Dwelling Units: 2012

The results of the 2002 census indicate that detached houses are the most common type of housing in all regions, and a majority of homes in the coastal area are owned by their occupants. However, the census data report that Regions 3 and 4 have a higher proportion of rented and squatted homes, which is consistent with data obtained during the late 2017 and early 2018 ecosystem services field work completed by the Consultants (ERM/EMC 2018). In addition, according to an IDB study on the housing sector of six Caribbean countries, Guyana has a housing deficit of 20,000 units for the low-income category (IDB 2016b).

Georgetown has a population density of 104.4 people per square kilometer (km^2) as compared with the six coastal regions—which have a combined population density of 9.6 people per km^2, and the four hinterland regions—which have a combined population density of less than one person per km^2 (IDB 2016b). According to several realtors based in Region 4, the residential market in Georgetown is mainly comprised of families with children and up to 70 percent of these residences are rentals. The realtors indicated that households with multi-generational families and extended families are not common in Georgetown. The main constraints to home ownership were identified as low incomes, high interest rates, and low availability of preferred locations. In the more affluent areas of Georgetown, where gated communities and secure homes are available, single-family home values currently range from $50 million to $70 million GYD ($239,000 to $335,000 USD) (EMC Personal Communications 7, 8, 9).

The relators interviewed claim that the residential market in Georgetown is small and since oil was discovered in 2015 there have been increases in both demand and price for purchases or rentals of homes and apartments in Georgetown. There are reported shortages in the rental markets at price points between $50,000 and $85,000 GYD per month ($239 to $406 USD per month) and in the home-buying markets at price points ranging from $15 million to

$40 million GYD ($71,770 to $191,387 USD) in Georgetown. The realtors have also observed increased investments in executive housing, apartment complexes, and office spaces that may be linked to the oil and gas sector (EMC Personal Communications 7, 8, 9).

Informal housing settlements increased in the 1980s and 1990s due to housing supply constraints, causing many people to squat on vacant parcels (IDB 2016a). The Ministry of Communities has worked in recent years to regularize informal settlements, particularly in the Georgetown area, by providing services such as paved streets, drainage, septic tanks, and water supply. If settlement sites are not suitable for permanent neighborhoods, they are moved to other locations (ERM Personal Communication 8; IDB 2016a, 2016b). There are currently 216 squatting areas in the country, of which 154 have been brought under the regularization program (IDB 2016a).

Data from the Bureau of Statistics' Multiple Indicator Cluster Survey (Bureau of Statistics et al. 2015) indicate that the majority of homes in Guyana have a finished floor (81.2 percent), roof (97.0 percent), and walls (93.2 percent). However, housing stock in some regions is aging and in need of upgrade (IDB 2016a). According to the 2002 census, more than 30 percent of the housing stock in Regions 3, 4, 5, and 6 were built before 1970.

8.5.2.2. Lodging

In Guyana, lodgings include hotels, guest houses, and resorts—the latter of which are located mainly in hinterland areas. Accommodation capacities are relatively small and occupancy rates tend to be low. In addition, there are several small-scale lodgings that are not graded or certified (IDB 2015). According to data from the Guyana Tourism Authority, accommodation capacity in Guyana has been steadily increasing, with room capacity increasing by more than 90 percent in 2017 (3,338 rooms) as compared with 2006 (1,716 rooms). The majority of visitors in Guyana stay in private homes and hotels. However, over the period 2015 to 2017, the data from the Guyana Tourism Authority suggest the number of visitors staying in private homes declined, while there were increases in visitors staying in hotels, guest houses, and apartments. The number of visitors to Guyana staying in resorts also declined. This could be related to the number of reported business travelers, which has increased from 15,543 in 2012 to 24,855 in 2017 (GTA 2018).

Most hotels in Georgetown offer similar basic amenities, including Wi-Fi, restaurants, bars, fitness centers, swimming pools, en-suite bathrooms, free parking, laundry services, and television. In addition, some also provide business centers and conference facilities. However, there is significant variability in the daily rates for the hotels due to their being international brands. These hotels offer additional services and have higher ratings. The majority of accommodation capacity is centralized in Region 4, particularly in Georgetown, where several major internationally branded hotels are located. A list of the most commonly frequented hotels located in Region 4 and their capacities as of 2016 and 2019 is presented in Table 8.5-2.

Table 8.5-2: Principal Hotels in Region 4 and Their Numbers of Rooms

Name of Lodging	Number of Rooms	Source
Guyana Marriott Hotel	197	Explore Guyana undated
Ramada Georgetown Princess Hotel	191	EEPGL Personal Communications 1
Pegasus Hotel Guyana	130	EMC Personal Communication 16
Tower Hotel	76	EEPGL Personal Communications 1
Regency Suites	64	EMC Personal Communication 14
Grand Coastal Hotel	43	EMC Personal Communication 15
Signature Inn	39	EEPGL Personal Communications 1
Sleep Inn Hotel	38	EEPGL Personal Communications 1
Brandsville Hotel	37	EMC Personal Communication 12
Cara Lodge	34	EMC Personal Communication 11
Herdmanston Lodge	24	EEPGL Personal Communications 1
El Dorado Inn	18	EMC Personal Communication 13
Kanuku Suites	18	EMC Personal Communication 10
Kings Hotel and Residences	16	EEPGL Personal Communications 1
Roraima Duke Lodge	15	EMC Personal Communication 17

Over the period April to May 2019, the Consultants requested feedback from 14 hotels in Region 4 on the facilities they offer and general demand forecasting, including any influence from the increased activity in the oil and gas sector and received responses via questionnaire from seven hotels: Pegasus Hotel Guyana, Regency Suites, Grand Coastal Hotel, Brandsville Hotel, Cara Lodge, El Dorado Inn, and Kanuku Suites. Based on the responses, the Pegasus Hotel Guyana and Grand Coastal Hotel reported average capacity rates of more than 70 percent. Disaggregated data on the origins of their guests are not available, but they indicated that a majority are foreigners.

The room rates at the Pegasus Hotel Guyana were the highest among the hotels that provided feedback. At the time of the survey, daily room rates varied from $40,750 to $52,250 GYD ($195 to $250 USD) at the Pegasus Hotel Guyana and $16,500 to $29,051 GYD ($70 to $139 USD) at the Grand Coastal Hotel.

The Pegasus Hotel Guyana is expanding, with the construction of a 200-suite hotel, conference centers, and executive office space expected to be operational by early 2021. The Grand Coastal Hotel indicated that there are no current plans for expansion. Neither of these hotels reported that the oil and gas sector has influenced their vacancy rates or origin of guests (EMC Personal Communications 15, 16).

The remaining five responding hotels reported average capacity rates that fluctuate from 40 to 70 percent based on the season. In particular, the Brandsville Hotel indicated that capacity rates vary based on peak seasons for business travel. Seasons and availability of rooms also influence the rates of rooms. The majority of the guests at these hotels are foreigners. Cara Lodge, Brandsville Hotel, and El Dorado Inn all reported changes in vacancy rates and origin of guests over the last 2 to 3 years that they suggested could be linked to the oil and gas sector. Regency Suites observed lower vacancy rates, but this was attributed to the facilities which they provide.

Of the hotels surveyed, only Regency Suites has disaggregated data on the origins of the guests, with approximately 25 percent of guests being Guyanese, 30 percent from CARICOM countries, and the remaining 45 percent from other foreign countries. At the time of the survey, Regency Suites reported the lowest daily room rates at $11,400 GYD ($54.50 USD) and also offered options for permanent housing. In addition, Cara Lodge, Kanuku Suites, Brandsville Hotel, and Regency Suites indicated that works expansion and upgrades are planned or are underway (EMC Personal Communications 10, 11, 12, 13, 14).

It should be noted that the Marriott Hotel is a popular hotel for both Guyanese visiting Georgetown and travelers affiliated with the oil and gas sector. Although the Marriott declined to be interviewed for this study, there is anecdotal evidence that suggests that short-term stays at the Marriott can be challenging due to capacity constraints, especially during conferences. According to TripAdvisor.com, the average price range for a standard room at the Marriott is between $43,263 and $94,886 GYD ($207 and $454 USD) (TripAdvisor 2019).

8.5.2.3. Water and Sanitation

According to the Food and Agriculture Organization, 95 percent of water usage in Guyana in 2010 was for irrigation and livestock, with 4 percent used by municipalities and 1 percent by industry (FAO 2015).

Potable Water

Most potable water is obtained from the deeper aquifers that underlie Georgetown and the coastal plain. GWI, a commercial public enterprise, distributes water in five service areas along the coast, and has a separate program to serve communities in the Hinterlands. GWI derives 90 percent of its water from groundwater sources and the remaining 10 percent from surface water sources. Groundwater is extracted from 137 wells and is processed in 24 treatment plants (GWI 2017). The Ministry of Communities and GWI have established several new wells in the Hinterland regions, including communities in Regions 1 and 9. New wells were also established in Region 4. In addition, GWI is working to increase access to treated water in Region 1 and intends to establish several water treatment plants in Georgetown (Guyana Chronicle 2018).

In rural areas not served by GWI, domestic water is obtained from a mix of groundwater, surface water, and rainwater sources. Rainwater is often used for potable household use, while river water is typically used for cleaning and other non-potable uses. The Food and Agriculture Organization estimated that in 2012, 98 percent of the population had access to improved water sources (FAO 2015)

Businesses that use large quantities of water, such as beverage bottling and food processing plants, generally have their own wells to meet their needs (FAO 2015).

Agricultural-Use Water

Declared Drainage and Irrigation Areas (areas with fully developed drainage and irrigation systems) are found in Regions 2, 3, 4, 5, and 6. In these regions, irrigation is conducted via gravity flow from surface water resources trapped by shallow earthen dams known as "conservancies." These are located in the upper stream catchment areas and store water at elevations higher than those of the surrounding fields. In other schemes, water is pumped from rivers into the irrigation canals. In addition, there are several engineered conservancies that supply water to agricultural lands in coastal regions. The Tapakuma Conservancy serves Region 2 and has been designed to provide irrigation to about 12,000 hectares (29,650 acres). During times of water shortage, this conservancy is supplemented by pumping from the Pomeroon River (FAO 2015). The Boeraserie Conservancy supplies Region 3, the East Demerara Water Conservancy supplies Region 4, and the Mahaica-Mahaicony-Abary/Agricultural Development Authority supplies water to Region 5.

The National Drainage and Irrigation Authority has responsibility for the maintenance and delivery of the irrigation water supply throughout the country. This authority works with the conservancies' boards, water users associations, farmer groups, and local government bodies to maintain irrigation and drainage systems in an operational and efficient manner.

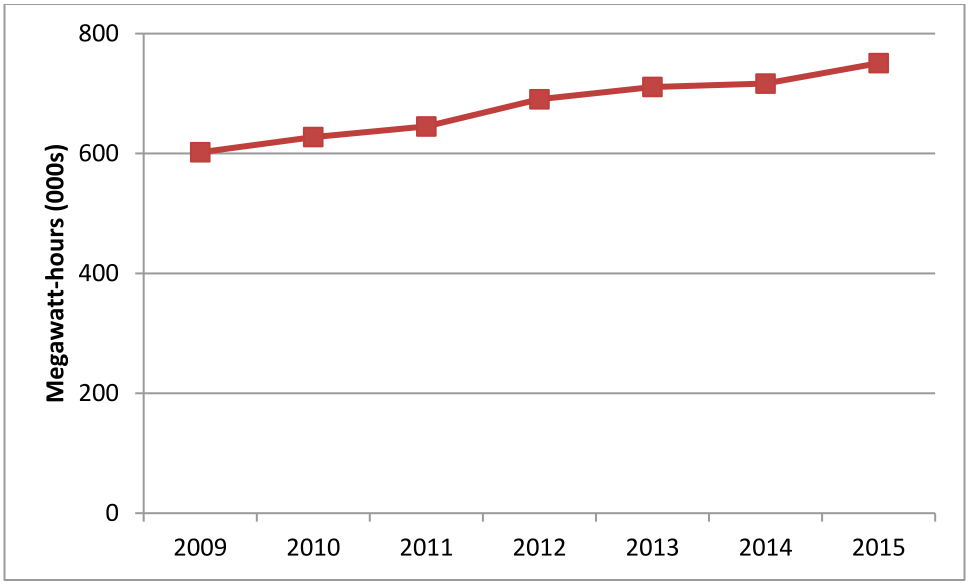
8.5.2.4. Power

Most of the electricity in the coastal plain of Guyana is generated, transmitted, and distributed by the state-owned utility Guyana Power & Light. However, due to poor reliability, many users also have their own diesel generators. Coastal areas that are not serviced by Guyana Power & Light are the Region 2 area west of Charity, and Region 1. Most areas of the Hinterlands do not have electric service, and the government has implemented a number of Hinterland energy development projects in recent years, including solar system installations and feasibility studies for hydropower and wind projects (GPL 2011).

The PSC has noted that the high cost of electricity in Guyana is a major challenge for business. During the late 2017 and early 2018 ecosystem services field work, this was raised as an issue by representatives of agricultural processing associations as well as local community leaders (ERM Personal Communications 1, 5, 10; ERM/EMC 2018).

According to the PSC, hydroelectricity development should be a major priority for the country. The plan for the 165-megawatt Amaila Falls hydroelectric plant was cancelled in 2015 due to delays and the potential for cost overruns (ERM Personal Communication 10).

Figure 8.5-3 shows the total electricity generation output in Guyana in thousands of megawatt-hours for the period 2009 through 2015.



Source: Ministry of Finance 2015

Figure 8.5-3: Electricity Generation in Guyana, 2009–2015

Although Guyana has significant potential for hydroelectric, solar, and biomass-fueled electricity generation, in 2015, 85 percent of its installed generation capacity was thermal, relying on expensive imported liquid fuels and making average electricity prices among the highest in Latin America and the Caribbean. The remaining 15 percent of installed capacity was biomass-based, using bagasse (sugarcane fibers remaining after cane juice is extracted) as fuel to self-generate power at Guyana Sugar Corporation's sugarcane factories. There are plans to enhance the generation capacity of the factories such that excess power is available and can be exported to the national electrical grid, and the government is working toward a strategy to diversify Guyana's energy mix with renewable energy technologies focused on wind, solar, and small hydroelectric (GEA 2016; ClimateScope 2017).

During 2017 and 2018, the government implemented a Green Public Sector Programme, which saw the installation of a combined capacity of 3.02 megawatts of solar photovoltaic systems on the rooftops of 175 public or government buildings, and 64 solar-powered light-emitting diode street lights (GEA undated). In addition, the installation of a 400-kilowatt solar farm in Mabaruma (Region 1) will reportedly soon be completed and similar solar farms are planned for other areas in the Hinterlands including Port Kaituma and Matthew's Ridge in Region 1 (GEA undated). In January 2019, a $1.6 billion GYD ($8 million USD) low-cost loan was approved by the Abu Dhabi Fund for Development and the International Renewable Energy Agency for the installation of a 5.2-megawatt grid-connected solar photovoltaic system in Guyana (DPI 2019b). In June 2019, Norway approved the release of $16.7 billion GYD ($80 million USD) to fund 30-megawatt solar farms with storage in Hinterland communities (DPI 2019a). Further, in 2019, private developer Guyana Wind Farm Inc. indicated that the Hope Beach Wind Farm at Hope, East Coast Demerara in Region 4 is expected to become operational by the end of 2020. The wind farm will comprise four turbines, which are intended to supply 13 megawatts of power to the national grid (Stabroek News 2019).

8.5.2.5. Telecommunications Infrastructure

The majority of households in the coastal regions have access to mobile phone service. However, the lack of 4G network access has been a major barrier to increased business investment in Guyana, and is an issue that the PSC has prioritized. In 2016, the first 4G network in the country was installed. Fiber optic cable is also a pressing need to improve reliability and accessibility (PSC 2015) of mobile phone services. In addition, the government is prioritizing the economic liberalization of Guyana's telecommunications market so as to encourage greater investment in the sector (Guyana Chronicle 2019).

8.5.2.6. Educational Facilities

Table 8.5-3 shows the number of nursery, primary, secondary, and post-secondary schools in each of the coastal regions. The majority of post-secondary institutions (technical schools, colleges, and universities) are found in Georgetown.

Table 8.5-3: Number of Educational Facilities in Guyana's Coastal Regions

	Nursery	Primary	Secondary	Technical/ Vocational	Special Schools	College/ University
Region 1	17	53	3	0	0	0
Region 2	36	42	8	1	0	0
Region 3	45	58	13	1	0	0
Region 4	58	55	48	10	2	15
Region 5	31	30	7	3	0	0
Region 6	57	56	18	2	0	2

Source: EMC Personal Communication 1, 2, 3; NAC 2018; Ministry of Education 2013, 2018

The distribution of schools in the coastal regions compared with other areas reflects population trends along the coast. Schools are found all along the coast of Regions 3, 4, 5, and 6, which are the most populated regions. In Region 2, schools are found along the coast until the coastal road ends, and there are fewer schools in Region 2 areas west of Charity and in Region 1.

At the tertiary level, the country has one national higher education institution, the University of Guyana. The university has two campuses in the country, the Turkeyen Campus in Region 4 and the Tain Campus in Region 6, both of which offer undergraduate and graduate programs. In addition, through its Institute of Distance and Continuing Education, the university offers extramural classes and online programs in Regions 2, 4, 6 and 10. Approximately 20,000 students (including both local and international) have graduated from this institution (University of Guyana 2018).

8.5.2.7. Security Facilities

The Guyana Defense Force is the military service of Guyana and has land, sea (Coast Guard), and air (Air Corps) units responsible for defending the territorial integrity of Guyana. In terms of internal security, the Guyana Police Service operates as a semiautonomous agency under the Ministry of Public Security. The Guyana Police Service has seven geographic policing divisions, each with its own headquarters, stations, and outposts, as summarized in Table 8.5-4.

Table 8.5-4: Policing Divisions in Guyana

Division	Geographic Area	Headquarters Location	Number of Stations	Number of Outposts
A	City of Georgetown and the East Bank of the Demerara River, including the Cheddi Jagan International Airport, Timehri, 40 kilometers (25 miles) from Georgetown	Brickdam, Georgetown	9	7
B	County of Berbice but excluding Kwakwani	Coburg Street, New Amsterdam	12	5
C	County of Demerara, east of the Demerara River but excluding A Division	Cove & John, East Coast Demerara	8	4
D	County of Demerara, west of the Demerara River and a portion of the East Bank of the Essequibo River	Leonora, West Coast Demerara	6	1
E & F	Upper Demerara including the area surrounding the bauxite holdings of Linden, Ituni, and Kwakwani, and the interior	Rabbit Walk, Eve Leary, Georgetown	30	6
G	Essequibo Coast including the islands of the Essequibo and Pomeroon Rivers	Anna Regina, Essequibo Coast	6	0

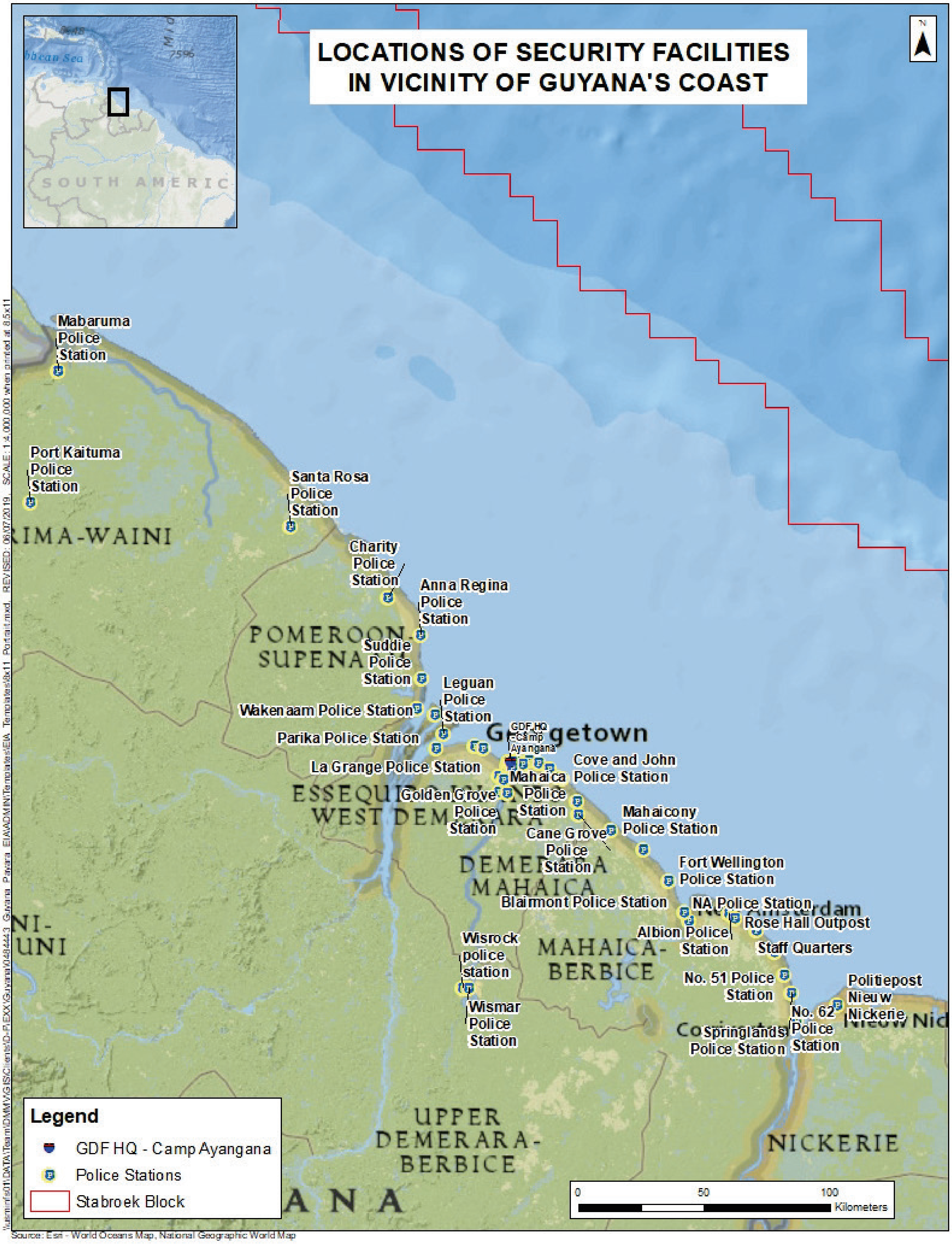
Figure 8.5-4 shows the locations of 35 (approximately 50 percent) of the total reported police stations in Guyana listed in the table above (locational data were not available for the interior outpost locations).

8.5.2.8. Ground Transportation Infrastructure

Road Network

Guyana has an approximately 3,990-kilometer (approximately 2,480-mile) road network serving a country of 214,920 km^2, for a ratio of 0.018 kilometer of road per km^2 (IDB 2019). There are six main national paved roads that each has two lanes, except for four-lane segments along the East Bank and East Coast Demerara roads. The road network is dependent on a system of bridges and culverts that provide crossings over a dense system of canals, drains, and sluices throughout the coastal lowlands.

Georgetown has a compact, grid-based street network. Road conditions vary widely and can be poor in some locations. The port area is linked to central Georgetown via the East Bank Demerara Road. Most intersections are not signal-controlled; where signals do exist, they can be frequently out of service. Pedestrian overpasses were recently installed at several areas along the East Bank Demerara Road to improve pedestrian safety and assist in reducing traffic congestion.



Note: Map does not represent a depiction of the maritime boundary lines of Guyana.

Figure 8.5-4: Locations of Security Facilities in Immediate Vicinity of Guyana's Coast

Existing Traffic Volumes and Congestion

Traffic congestion is a chronic problem in and around Georgetown. Many different types of vehicles, including cars, large commercial vehicles, mini-buses, horse-drawn carts, bicycles, mopeds, scooters, and motorcycles, all share the same travel lanes. Traffic congestion occurs frequently, in particular just before and just after school hours.

Driving behavior in Guyana contributes to poor and dangerous land transportation conditions. Speeding, aggressive driving, and driving under the influence of alcohol contribute to traffic accidents in Georgetown. Driving at night poses additional concerns due to poor street lighting and road conditions, as well as livestock and pedestrians congregating near the roadside or, in the case of livestock, occasionally standing in the traffic lanes (OSAC 2016).

The Ministry of Public Infrastructure is working with the IDB to develop a Sustainable Urban Transport Plan for Georgetown. This will focus more on management of current traffic than on addition of significant new infrastructure (e.g., separation of slower-moving traffic from vehicular traffic in designated lanes; ERM Personal Communication 9).

In March 2018, the Consultants retained Caribbean Transportation Consultancy Services Company Limited (CARITRANS) to complete a survey of existing traffic conditions along the East Bank Demerara Road, in the general vicinity of an existing shorebase facility that is planned to be used by the Project. The study involved five turning movement counts and two average daily traffic counts along the East Bank Demerara Road.

Table 8.5-5 provides a summary of traffic volume information collected from the 2018 survey, specifically focused on morning and afternoon peak hour (maximum hour of activity) traffic volumes at each survey location. Morning peak hours generally occur between 7:00 and 8:00 a.m., while afternoon peak hours vary considerably between 1:15 and 7:45 p.m. Morning peak-hour traffic volume is generally higher than during the afternoon peak hour.

Table 8.5-5: Peak Hour Traffic, East Bank Demerara Road (Surveyed March 2018)

Location	Morning Peak Hour		Afternoon Peak Hour	
	Time	Traffic Volume	Time	Traffic Volume
Houston Split (Intersection)	7:30–8:30	5,324	4:30–5:30	4,484
Houston Village [a]	7:00–8:00	3,705	2:00–3:00	3,107
Eccles Intersection	7:00–8:00	3,627	4:15–5:15	3,328
Demerara Harbour Bridge	6:30–7:30	2,752	1:15–2:15	2,709
Nandy Park Intersection	7:00–8:00	2,678	1:45–2:45	2,309
Massey Intersection	6:45–7:45	2,850	6:45–7:45	2,259
Providence Village [a]	9:00–10:00	2,087	6:00–7:00	2,179

Source: CARITRANS 2018

[a] Traffic counts at Houston Village and Providence Village measured only straight-line traffic (counts at all other locations measured all intersection turning movements). Data for Houston Village and Providence Village reflect the average weekday traffic recorded between 15 March and 20 March 2018.

In 2019, the Consultants retained CARITRANS to complete a survey of existing traffic conditions along additional road segments within the greater Georgetown area. The study involved turning movement counts at 50 intersections around six key locations within the Georgetown area that were expected to potentially be used by EEPGL-related vehicles (either related to the Project or to other non-Project EEPGL-related activities):

- Marriott
- EEPGL Office Complex/Ogle
- Contractor Commercial Port A
- Contractor Inland Storage Yard
- Contractor Shorebase B
- Ramada Intersection

Figure 8.5-5 shows these key locations and the 50 study intersections. Results for the study intersections are presented below, grouped by key location.

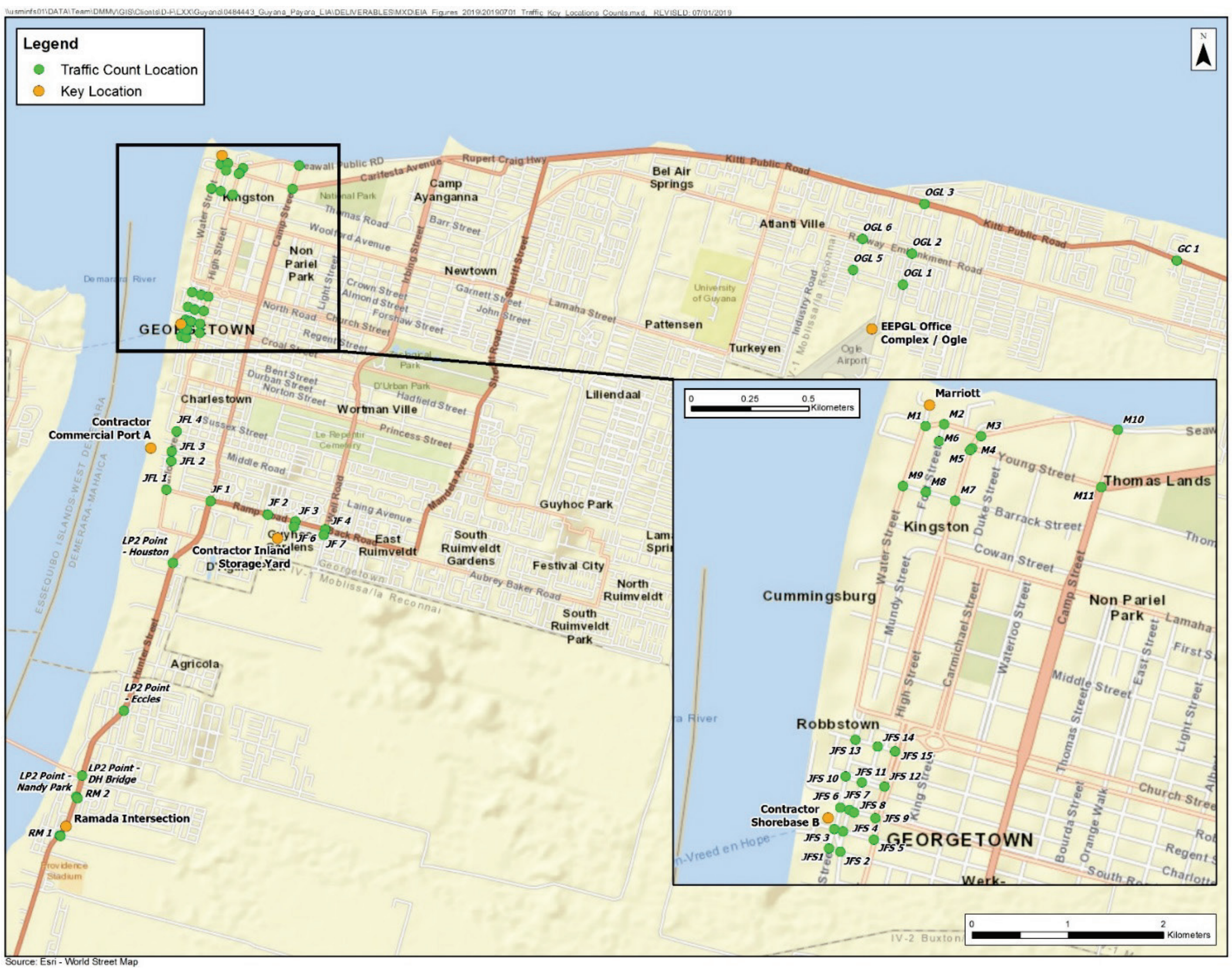


Figure 8.5-5: Key Locations and Traffic Count Locations for 2019 Traffic Study

Table 8.5-6 provides a summary of traffic volume information collected from the 2019 survey, specifically focused on morning and afternoon peak hour (maximum hour of activity) traffic volumes at each survey location. Morning peak-hour traffic volume is generally higher than during the afternoon peak hour. The full report containing these data is included as Appendix U, Traffic Impact Assessment.

Table 8.5-6: Peak Hour Traffic, 2019 Georgetown Area Traffic Count Locations

Traffic Count Location	Morning Peak Hour		Afternoon Peak Hour	
	Time	Traffic Volume	Time	Traffic Volume
JFL-1	7:15 AM - 8:15 AM	960	4:45 PM - 5:45 PM	1,253
JFL-2	8:45 AM - 9:45 AM	293	2:15 PM - 3:15 PM	291
JFL-3	10:15 AM - 11:15 AM	852	4:00 PM - 5:00 PM	757
JFL-4	9:30 AM - 10:30 AM	1,380	3:30 PM - 4:30 PM	1,318
JF-1	8:45 AM - 9:45 AM	1,220	5:00 PM - 6:00 PM	1,221
JF-2	7:15 AM - 8:15 AM	946	5:00 PM - 6:00 PM	841
JF-3	9:45 AM - 10:45 AM	990	3:00 PM - 4:00 PM	877
JF-4	7:00 AM - 8:00 AM	1,220	5:00 PM - 6:00 PM	1,189
JF-6	7:00 AM - 8:00 AM	161	4:45 PM - 5:45 PM	128
JF-7	10:30 AM - 11:30 AM	370	1:15 PM - 2:15 PM	322
JFS-1	7:00 AM - 8:00 AM	182	5:00 PM - 6:00 PM	145
JFS-2	7:15 AM - 8:15 AM	1,041	4:15 PM - 5:15 PM	878
JFS-3	7:00 AM - 8:00 AM	315	4:15 PM - 5:15 PM	368
JFS-4	7:45 AM - 8:45 AM	580	4:00 PM - 5:00 PM	609
JFS-5	10:45 AM - 11:45 AM	859	3:30 PM - 4:30 PM	879
JFS-6	7:30 AM - 8:30 AM	347	1:00 PM - 2:00 PM	213
JFS-7	6:30 AM - 7:30 AM	519	3:45 PM - 4:45 PM	368
JFS-8	7:30 AM - 8:30 AM	320	5:00 PM - 6:00 PM	239
JFS-9	8:00 AM - 9:00 AM	898	3:30 PM - 4:30 PM	618
JFS-10	7:00 AM - 8:00 AM	591	3:45 PM - 4:45 PM	411
JFS-11	8:45 AM - 9:45 AM	266	4:45 PM - 5:45 PM	209
JFS-12	10:30 AM - 11:30 AM	322	5:00 PM - 6:00 PM	264
JFS-13	7:30 AM - 8:30 AM	774	4:30 PM - 5:30 PM	581
JFS-14	9:00 AM - 10:00 AM	189	4:00 PM - 5:00 PM	160
JFS-15	10:30 AM - 11:30 AM	478	5:00 PM - 6:00 PM	396
M-1	7:45 AM - 8:45 AM	680	4:00 PM - 5:00 PM	121
M-2	7:45 AM - 8:45 AM	516	1:00 PM - 2:00 PM	108
M-3	7:45 AM - 8:45 AM	871	4:15 PM - 5:15 PM	108
M-4	7:45 AM - 8:45 AM	1,017	4:15 PM - 5:15 PM	125
M-5	7:45 AM - 8:45 AM	823	2:45 PM - 3:45 PM	107
M-6	8:00 AM - 9:00 AM	112	2:45 PM - 3:45 PM	59
M-7	7:45 AM - 8:45 AM	1,261	4:15 PM - 5:15 PM	378
M-8	8:15 AM - 9:15 AM	462	4:15 PM - 5:15 PM	207
M-9	7:45 AM - 8:45 AM	635	4:15 PM - 5:15 PM	248

Traffic Count Location	Morning Peak Hour		Afternoon Peak Hour	
	Time	Traffic Volume	Time	Traffic Volume
M-10	7:30 AM - 8:30 AM	828	4:30 PM - 5:30 PM	250
M-11	7:30 AM - 8:30 AM	1,580	4:15 PM - 5:15 PM	475
GC-1	8:30 AM - 9:30 AM	1,057	4:45 PM - 5:45 PM	1,086
OGL-1	8:30 AM - 9:30 AM	631	1:30 PM - 2:30 PM	518
OGL-2	10:00 AM - 11:00 AM	1,605	2:45 PM - 3:45 PM	1,497
OGL-3	8:45 AM - 9:45 AM	1,309	1:30 PM - 2:30 PM	1,433
OGL-5	7:45 AM - 8:45 AM	716	4:30 PM - 5:30 PM	560
OGL-6	9:30 AM - 10:30 AM	1,662	2:30 PM - 3:30 PM	1,458

Source: Appendix U, Traffic Impact Assessment

In addition to surveying existing traffic volumes, CARITRANS used the traffic analysis model VISSIM to complete an assessment of the existing Level of Service (LOS) for each of the 2018 and 2019 study intersections, for each direction of travel through the intersections and for the various movements (through, right turn, left turn, U-turn) completed at each intersection. LOS is a standard numerical measure of the delay expected to be experienced at an intersection, compared to expected norms; it is expressed as a letter grade between A (least delay) and F (most delay, gridlock). The results of LOS modeling for the 2018 and 2019 study intersections are presented below.

LOS Modeling for 2018 Intersections

For the 2018 study, LOS modeling for existing conditions was completed for morning peak hours, afternoon peak hours, and afternoon peak hours when the Demerara Harbour Bridge was closed. The detailed modeled LOS ratings for these scenarios are summarized in the Traffic Impact Assessment Report (CARITRANS 2018) provided as an appendix to the Liza Phase 2 Development EIA. Table 8.5-7 summarizes the findings of the LOS modeling for existing conditions at the 2018 study intersections.

Table 8.5-7: Results of Level of Service Modeling for Existing Conditions; 2018 East Bank Demerara Road Study Intersections

Location	Direction	Movement	Level of Service		
			Morning	Afternoon	Afternoon, Bridge Closed
Massey Intersection	Northbound	Through	A	A	A
		Right	A	A	A
		U-Turn	A	A	A
	Southbound	Left	A	A	A
		Through	A	A	A
	Westbound	Right	A	A	A
		U-Turn	A	A	A
		Left	A	A	A

Location	**Direction**	**Movement**	**Level of Service**		
			Morning	**Afternoon**	**Afternoon, Bridge Closed**
Demerara Harbour Bridge	Demerara Harbour Bridge (Exit)	Right	F	C	NA
		Left	D	A	NA
	Northbound	U-Turn	C	NA	A
		Left	A	F	A
		Through	D	A	A
	Southbound	Through	E	A	A
		Right	F	F	A
		U-Turn	F	A	A
Houston Split (Intersection)	Southbound	Through	A	A	A
	Northbound	Right	E	A	A
		Left	F	A	A
Nandy Park Intersection	Northbound	Through	B	A	A
		Right	D	B	A
	Southbound	U-Turn	C	A	A
		Through	A	A	A
		Left	A	A	A
	Westbound	Right	A	B	A
		Left	F	A	A
Eccles Intersection	Southbound	Through	D	B	C
		Left	E	D	C
	Northbound	Right	F	D	C
		Through	D	A	C
	Westbound	Left	F	E	B
		Right	F	E	A

Source: CARITRANS 2018

NA = LOS data not available

East Bank Demerara Road is particularly susceptible to congestion due to backups at the Demerara Harbour Bridge, the only road crossing of the Demerara River (Figure 8.5-6). Daily retraction of the bridge for a period of about 1 hour causes severe traffic congestion at both ends of the bridge. As shown in Table 8.5-7, when the bridge is open (i.e., when vehicles cannot cross), several movements at the intersection of the Demerara Harbour Bridge with the East Bank Demerara Road operate at an LOS rating of “F”, indicating significant delays and near-gridlock conditions. When the bridge is closed, the entire East Bank Demerara Road system operates at an LOS rating of “C” or better, typically considered acceptable conditions for urban traffic.

Figure 8.5-6: Demerara Harbour Bridge

The limited number of bridge openings causes delays and inconvenience to ocean going vessels. The Government of Guyana has investigated replacing the existing bridge with a new bridge (with an elevated central span that would reduce or eliminate the need for drawbridge openings) further downstream. A feasibility study for the proposed new bridge was completed in August 2017 (LievenseCSO 2017). The proposed new bridge would be located further north than the existing bridge and would connect Houston on the East Bank with Versailles on the West Bank; the feasibility study indicates the new bridge would consist of three lanes, one of which would be reversible.

LOS Modeling for 2019 Intersections

For the 2019 study intersections, LOS modeling for existing conditions was completed for morning peak hours and afternoon peak hours. Tables 8.5-8a through 8.5-8e summarizes the findings of the LOS modeling for the 2019 study intersections. The full report containing these data is included as Appendix U, Traffic Impact Assessment.

Table 8.5-8a: Results of Level of Service Modeling for Existing Conditions; 2019 Georgetown Area Study Intersections—Marriott Key Location

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
M1	Southbound	Right	A	A
		Left	A	A
		Through	A	A
	Eastbound	Through	A	A
		Right	A	A
	Westbound	Right	A	A
		Through	A	A
		U-Turn	A	A
		Left	A	A
	Northbound	Through	A	A
		Right	A	A
		U-Turn	A	A
M2	Eastbound	Through	A	A
	Westbound	Through	A	A
	Northbound	Left	C	A
		Right	C	A
M3	Eastbound	Through	F	C
		Right	F	D
	Westbound	Through	C	A
		Left	C	B
	Northbound	Left	A	A
		Right	A	A
		U-Turn	E	D
M4	Southbound	Through	C	C
		Left	C	B
	Northbound	Through	A	A
		Left	A	A
	Westbound	Right	B	A
		Left	B	A
M5	Southbound	Right	A	A
		Through	A	A
	Northbound	Through	A	A
		Right	A	A
M6	Northbound	Through	C	A
	Westbound	Right	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
M7	Northbound	U-Turn	A	A
		Right	A	A
		Left	A	A
		Through	A	A
	Westbound	Left	A	A
		Through	A	A
		Right	A	A
	Eastbound	Right	A	A
		Through	A	A
		Left	A	A
	Southbound	Through	A	A
		Left	A	A
		Right	A	A
		U-Turn	A	A
M8	Northbound	Through	A	A
		Right	A	A
		Left	A	A
	Westbound	Left	A	A
		Right	A	A
		U-Turn	A	A
		Through	A	A
	Eastbound	Right	A	A
		Left	A	A
		Through	A	A
M9	Northbound	Through	A	A
		Right	A	A
	Southbound	Through	A	A
		Left	A	A
	Westbound	Left	A	A
		Right	A	A
M10	Westbound	Through	A	A
		Left	A	A
	Eastbound	Through	A	A
		Right	A	A
	Northbound	Right	A	A
		Left	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
M11	Northbound	Right	D	D
		Through	D	D
		Left	A	A
	Westbound	Left	D	D
		Right	E	E
		Through	E	E
	Southbound	Through	D	F
		Left	D	E
		Right	D	F
	Eastbound	Right	C	C
		Through	C	C
		Left	A	A

Table 8.5-8b: Results of Level of Service Modeling for Existing Conditions; 2019 Georgetown Area Study Intersections—EEPGL Office Complex/Ogle Key Location

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
OGL 6	Eastbound	Left	C	C
		Through	C	C
		Right	D	D
	Westbound	Right	C	C
		Through	C	B
		Left	B	B
	Northbound	Through	F	D
		Left	F	C
		Right	F	C
OGL 5	Northbound	Left	A	A
		Right	A	A
		Through	A	A
	Eastbound	Right	A	A
		Through	A	A
		Left	A	A
	Westbound	Left	A	A
		Through	A	A
		Right	A	A
	Southbound	Through	A	A
		Right	A	A
		Left	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
OGL 1	Northbound	Right	A	A
		Left	A	A
	Westbound	Left	A	A
		Through	A	A
		Right	A	A
	Southbound	Left	A	A
		Right	A	A
	Eastbound	Through	A	A
		Left	A	A
OGL 2	Westbound	Right	B	A
		Through	A	A
		Left	A	A
	Southbound	Left	E	D
		Right	F	E
		Through	E	E
	Eastbound	Through	A	A
		Left	A	A
		Right	A	A
	Northbound	Right	D	D
		Through	D	C
		Left	C	B
OGL 3	Southbound	Right	F	F
		Through	F	F
		Left	F	F
	Eastbound	Left	D	E
		Right	E	E
		Through	E	E
	Northbound	Through	D	D
		Left	B	B
	Westbound	Right	C	C
		Through	C	C
		Left	B	B

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
GC 1	Southbound	Through	A	A
		Left	A	A
		Right	A	A
	Northbound	Through	A	A
		Right	A	A
		Left	A	A
	Westbound	Right	A	A
		Left	A	A
		U-Turn	A	A
		Through	A	A
	Eastbound	Left	A	A
		Right	A	A
		Through	A	A
		U-Turn	A	A

Table 8.5-8c: Results of Level of Service Modeling for Existing Conditions; 2019 Georgetown Area Study Intersections—Contractor Commercial Port A and Contractor Inland Storage Yard Key Locations

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
JFL4	Southbound	Left	B	B
		Through	B	B
	Northbound	Through	A	A
JFL3	Westbound	Left	A	A
	Northbound	Through	A	A
	Southbound	Left	A	A
		Through	A	A
JFL2	Westbound	Right	A	A
		Left	A	A
	Southbound	Through	A	A
JFL1	Northbound	Right	A	A
		Left	A	A
	Southbound	Through	A	A
		Right	A	A
	Westbound	Left	A	D
		Through	C	E
	Eastbound	Right	A	A
		Through	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
JF1	Southbound	Through	F	F
		Right	F	F
		Left	F	F
	Northbound	Through	D	D
		Left	A	A
		Right	D	D
	Eastbound	Left	A	A
		Right	D	D
		Through	D	D
	Westbound	Right	C	C
		Left	C	B
		Through	C	C
JF2	Northbound	Right	A	A
	Eastbound	Right	A	A
		Left	A	A
		Through	A	A
	Southbound	Right	A	A
		Left	A	A
	Westbound	Left	A	A
		Through	A	A
		Right	A	A
JF3	Northbound	Right	A	A
		Left	A	A
	Westbound	Left	A	A
		Through	A	A
	Eastbound	Right	A	A
		Through	A	A
JF6	Northbound	Through	A	A
		Right	A	A
	Southbound	Left	A	A
	Westbound	Left	A	A
		Right	A	A
JF4	Westbound	Right	A	A
		Through	A	A
		Left	A	A
	Eastbound	Left	A	A
		Through	A	A
		Right	A	A
	Northbound	Through	A	A
		Right	A	A
		Left	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
JF7	Northbound	Left	A	A
		Through	A	A
	Westbound	Left	A	A
		Through	A	A
		Right	A	A
	Eastbound	Right	A	A
		Through	A	A
		Left	A	A
	Southbound	Through	A	A
		Left	A	A
		Right	A	A

Table 8.5-8d: Results of Level of Service Modeling for Existing Conditions; 2019 Georgetown Area Study Intersections—Contractor Shorebase B Key Location

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
JFS5	Northbound	Right	F	F
		Left	F	F
		Through	F	F
	Westbound	Left	F	F
		U-Turn	F	F
		Through	F	F
		Right	F	F
	Eastbound	Right	F	F
		Through	F	F
		Left	F	F
	Southbound	Through	E	E
		Left	D	D
		Right	D	E
JFS9	Southbound	Left	F	F
		Through	F	F
		Right	F	F
	Westbound	U-Turn	F	F
		Right	F	F
		Through	F	F
		Left	F	F
	Northbound	Right	F	F
		Through	F	F
JFS12	Eastbound	Left	A	A
	Northbound	Through	A	A
JFS11	Southbound	Right	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
		Left	A	A
	Eastbound	Through	A	A
JFS10	Northbound	Left	A	A
		Right	A	A
		Through	A	A
	Southbound	Left	A	A
JFS13	Southbound	Right	A	A
		Through	A	A
		Left	A	A
	Eastbound	Left	A	A
		Through	A	A
	Northbound	Through	A	A
		Left	A	A
		Right	A	A
JFS14	Eastbound	Left	A	A
		Through	A	A
JFS4	Eastbound	Right	A	C
		Through	C	E
	Westbound	Left	A	A
	Southbound	Right	E	F
		Through	D	F
		Left	F	F
JFS3	Eastbound	Through	A	D
		Left	A	C
	Northbound	Right	B	D
		Through	A	A
	Westbound	Right	A	A
JFS2	Northbound	Right	A	A
		Left	A	A
JFS11	Eastbound	Left	A	A
		Through	A	A
	Westbound	Left	A	A
JFS7	Westbound	Left	E	F
		Through	F	F
	Southbound	Right	D	C
JFS6	Northbound	Through	A	A
	Westbound	Right	A	A
JFS1	Westbound	Left	A	A
		Through	A	A
		Right	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
JFS15	Eastbound	Left	A	A
	Northbound	Through	A	A
		Right	A	A

Table 8.5-8e: Results of Level of Service Modeling for Existing Conditions; 2019 Georgetown Area Study Intersections—Ramada Intersection Key Location

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
Site	Direction	Movement	LOS	LOS
LP2 Point Massy	Northbound	Through	A	A
		Right	A	A
		U-Turn	A	A
	Southbound	Left	A	A
		Through	A	A
	Westbound	Right	A	A
		U-Turn	A	A
		Left	A	A
LP2 Point DH Bridge	Eastbound	Right	E	C
		Left	B	A
	Northbound	Through (Ln3)	A	B
		Left	A	B
		Through	A	B
	Southbound	Through	D	F
		Right	E	A
		U-Turn	E	A
LP2 Point Houston	Southbound	Through	A	A
	Northbound	Through (Ln3)	F	A
		Through	E	A
		Left	F	A
LP2 Point Nandy Park	Northbound	Through	A	A
		Right	A	A
	Southbound	U-Turn	A	A
		Through	A	A
		Left	A	A
	Westbound	Right	A	B
		Left	A	B

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
LP2 Point Eccles	Southbound	Through	B	E
		Left	D	F
	Northbound	Through (Ln3)	C	C
		Through	C	F
		Right	D	E
	Westbound	Left	E	
		Right	E	

Some of the existing road networks observed were characterized by less than ideal conditions, in particular the signalized intersections. It was observed that at all of the signalized intersections included in the study, police officers were present during peak periods to regulate traffic and alleviate congestion at the intersections. The high delays and LOS F ratings for these intersections indicate a need for the appropriate authorities to optimize signal timings to allow for more efficient operations at the intersection and network levels. The following was therefore noted:

- The Contractor Shorebase B location is in an area where there is already a high level of activity that directly affects traffic flows, resulting in substantial delays on the surrounding streets and spill-over congestion into a number of major intersections.
- The Ramada Intersection location features high levels of northbound traffic into Georgetown in the morning and the reverse in the afternoon, resulting in significant delay and congestion.
- The EEPGL Office Complex/Ogle location shows high volumes of east-west traffic as vehicles go to and from Georgetown. The signalized intersection is observed to not efficiently handle the elevated volumes.
- Some of the high volumes from the future EEPGL Office Complex/Ogle location lead into the Marriott location and result in significant delay, especially at the signalized M11 intersection.

8.5.2.9. Air Transportation Infrastructure

Air transportation in Guyana supports a variety of sectors including agriculture, tourism, and the extractive sectors. Air transportation infrastructure is therefore critical to sustain and enhance economic competitiveness. Guyana ranks 131 out of 211 countries on the Air Connectivity Index (World Bank 2011), and 49 out of 141 economies for the quality of its air transportation infrastructure (World Economic Forum 2015). In 2017, at the World Aviation Forum, Guyana was awarded for moving from 44.24 percent to 64.66 percent effective implementation of the Standards and Recommended Practices of the International Civil Aviation Organization (Stabroek News 2017). Compliance with the standards advances Guyana's efforts to be classified as a Federal Aviation Administration International Strategy Assessment Programme Category 1 country and facilitates direct flights to the United States.

Guyana's air transportation infrastructure comprises two international airports: the Cheddi Jagan International Airport (CJIA) and the Eugene F. Correira International Airport (ECIA; also commonly referred to as Ogle Airport). In addition, nearly 100 aerodromes serve smaller towns and villages, principally in the Hinterland regions (IDB 2016c). The CJIA and ECIA provide direct international flights to English- and Dutch-speaking Caribbean, South America, Central America, and North America countries. A 2016 IDB tender document for development of a National Civil Aviation Master Plan for Guyana notes that approximately 478,000 passengers and 6,148,000 kilograms of cargo moved through the CJIA and approximately 43,700 passengers moved through the ECIA (IDB 2016c). In 2017, the most recent year for which data are available, 664,000 international passengers used Guyana's airports, representing a 6 percent annual growth rate from the prior year (GCAA 2018).

The CJIA is located at Timehri, 40 kilometers (25 miles) south of Georgetown. The CJIA is managed by a Chief Executive Officer who reports, through a Board of Directors, to the Minister of Public Infrastructure (GoG 2006). The airport's existing terminal building has been operational since the 1970s, runways are short, and parking facilities congested. Over the period 2000–2012, passenger traffic at the CJIA increased 42 percent, from 384,000 to 544,000 (MoPI 2018). Given these circumstances, in 2013 a project for the expansion and modernization of the CJIA commenced. The expansion project includes extension of the North and South runways, construction of new departure and arrival terminals, passenger boarding bridges, new aircraft parking bays, a diesel generator room, and a fire pump station. Upgraded sections of the airport are currently in use, but expansion and renovation works are ongoing.

The ECIA is located approximately 6 kilometers (3.7 miles) from Georgetown. In late 2001, the government leased the management and operation of the aerodrome to a local consortium of airline operators, Ogle Airport Inc. The lease is for a minimum period of 25 years with extension periods of 25 years on request of the lessee. The objective of the lease is to ensure compliance with International Civil Aviation Organization standards and to serve as a back-up to the CJIA in the event of an emergency, disaster, accident or other unserviceable situation (GoG 2006). The ECIA has developed into the principal domestic air hub, providing commercial and cargo transport services, primarily between Georgetown and the Hinterland regions. In 2009, ECIA received International Port of Entry certification and now serves direct flights to three CARICOM states: Barbados, Suriname, and Trinidad. ECIA is capable of handling small aircraft, such as business jets, and the ATR-72 operated by Leeward Islands Air Transport (EMC Personal Communication 17). In 2018, ECIA's domestic operations/flight landings totaled 16,500 and international operations/flight landings totaled 2,100 (EMC Personal Communication 17). ECIA is also the base of EEPGL's local air transportation contractor, Bristow. By comparison, when completed, the CJIA runways will measure up to 3,200 meters (approximately 2 miles), making it a Code 4E runway able to accommodate a Boeing 747-400 (MoPI 2018).

Only a small number of the nearly 100 aerodromes principally serving smaller towns and villages in the Hinterland region have asphalt, concrete, or bitumen surfaces, including Bath, Bimichi, Ebini, Hampton Court, Holiptu, Kaieteur, Kamarang, Kimbia, Lethem, Linden, Mabaruma, Mahdia, and Maards. Along the coast, there are other airstrips at Skeldon, Albion, Rose Hall, Von Betta, Bath, Maards, Hampton Court, Kwebanna, and Mabaruma.

8.5.3. Impact Assessment—Social Infrastructure and Services

This section assesses potential Project impacts on social infrastructure and services in the Project AOI. The planned Project activities that have the potential to impact social infrastructure and services are Project worker presence (with the potential to impact availability or cost of lodging and/or of housing and utilities) and Project-related ground and air transportation activities (with the potential to increase traffic congestion). Potential impacts to lodging, housing and utilities, and ground and air transportation are assessed separately in this section.

Potential impacts related to decreased availability of emergency medical and health services as a result of Project use of these services are assessed in Section 8.3.3, Impact Assessment—Community Health and Wellbeing. Potential impacts related to vehicle accidents involving non-Project individuals are assessed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

In mid-2019, the Consultants conducted a housing and accommodation demand survey to better facilitate an assessment of the potential impacts of EEPGL's operations on the local lodging and housing markets in and around Georgetown. EEPGL and their eight primary onshore and offshore support companies were asked to provide existing and forecasted data on housing purchases, housing rentals, and lodging demand. It should be noted that these data represent demand by staff and workers for all of EEPGL-related activities across Guyana, so the data are not specific to the Project. The survey data have been compiled and presented in Section 8.5.3.1, Lodging, and Section 8.5.3.2, Housing and Utilities.

8.5.3.1. Lodging

Relevant Project Activities and Potential Impacts

Although the Project will have limited onshore planned activities, the presence of Project workers has the potential to increase demand for lodging in the Georgetown area. Table 8.5-9 summarizes the Project stages and activities that could result in potential impacts on lodging, as well as the receptors that could potentially experience these impacts.

Table 8.5-9: Summary of Relevant Project Activities and Key Potential Impacts—Lodging

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project Stages	Leisure and business travelers to Guyana, specifically Georgetown and vicinity	Project-related worker presence in Georgetown area	Increased demand or use of lodging, leading to reduced availability and/or increased cost

Magnitude of Impact—Lodging

The assessment of the Project's magnitude of impacts on lodging is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on lodging is defined according to the definitions provided in Table 8.5-10.

Table 8.5-10: Definitions for Intensity Ratings for Potential Impacts on Lodging

Criterion	Definition
Intensity	Negligible: There is no discernible change in demand for lodging.
	Low: Limited increases in demand for lodging are perceptible, causing slight changes in the availability, quality, and/or cost of these resources and services.
	Medium: Increases in demand for lodging are evident and lead to frequent and widespread shortfalls in availability or quality of lodging, or measurable increases in costs.
	High: Increases in demand for lodging are sufficient to cause conditions of chronic shortage and inflated costs.

EEPGL applies a vetting process for lodging options against EEPGL's health, safety, and security criteria, and several hotels in Georgetown are considered "approved" for use by Project-related personnel (although EEPGL approval status does not apply to EEPGL's primary support companies). As of mid-2019, the demand for hotel rooms in Georgetown by EEPGL and its primary support companies averaged a total of 600 rooms per month, for an average stay of 2.5 nights per booking. The hotels (some of which are "EEPGL-approved") most commonly rented by EEPGL staff and many of its primary support companies include Guyana Marriott Hotel, Grand Coastal Hotel, Pegasus Hotel Guyana, Ramada Georgetown Princess Hotel, Kings Hotel and Residences, Cara Lodge, and Herdmanston Lodge. The average stay for offshore workers, which make up a majority of the demand (over 400 rooms per month), is one night per month. The remainder of the lodging demand is for company management and staff visiting Georgetown for a short duration, usually no more than five nights per stay, and typically on the order of one trip per month.

In the highly improbable event that the monthly demand of 600 rooms were to occur on the same night, this would have a significant impact on the lodging market, as this demand represents more than 100 percent of the bed capacity at the aforementioned five Georgetown hotels typically used by EEPGL and its primary support companies (but only approximately 18 percent of the 3,338 current Guyana-wide hotel bed capacity). However, according to the raw data, it is more typical for the monthly demand of 600 rooms to be spread out over the course of the month, with a maximum of 200 beds in demand by EEPGL or its primary support companies at any one time. This constitutes approximately 37 percent of the 577-bed capacity of the aforementioned five Georgetown hotels typically used by EEPGL and its primary support companies. It should be noted that the survey results also indicate that two of the primary support companies that currently rely on hotels for their management or expatriate staff travel to Guyana will be moving their staff into more permanent accommodations (e.g., house or apartment rentals, guest houses) in the coming 3 years. Project-specific staff demand will also decrease as the Project moves from drilling and installation and into the production operations stage (see Section 8.5.3.2, Housing and Utilities).

Considering the information presented above, potential impacts on non-Project related users of lodging as a result of Project-related demand or use of lodging will be limited to the **Direct AOI**. Given the current demand on lodging is focused primarily on five hotels and not spread across all lodging options in Georgetown, and several of these hotels reported no change in occupancy rates as a result of the oil and gas sector, the intensity of the potential impacts on lodging is rated as **Low** for drilling and installation stages (when Project workforces are highest). This intensity is expected to decrease to **Negligible** during later stages of the Project considering hotel expansion projects should be complete and the number of Project-required workers seeking hotel space will decrease. Project-related demand for lodging will occur on a routine basis throughout the Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages and a duration of **Long-term**. This yields a magnitude rating of **Small** for potential impacts on lodging.

Table 8.5-11: Magnitude of Impact—Lodging

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Development Drilling SURF and FPSO Installation	Leisure and business travelers to Guyana, specifically Georgetown and vicinity—Increased demand or use of lodging, leading to reduced availability and/or increased cost	Direct AOI (Georgetown and vicinity)	Low	Continuous	Long-term	Small
Production Operations Decommissioning	Leisure and business travelers to Guyana, specifically Georgetown and vicinity—Increased demand or use of lodging, leading to reduced availability and/or increased cost	Direct AOI (Georgetown and vicinity)	Negligible	Continuous	Long-term	Negligible

Sensitivity of Receptors—Lodging

The receptors that potentially could experience impacts on lodging are leisure and business travelers to Guyana, specifically those staying within Georgetown and vicinity. The receptor sensitivity ratings for lodging are defined according to the definitions provided in Table 8.5-12.

Table 8.5-12: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Lodging

Criterion	Definition
Sensitivity	Low: Existing services have excess capacity and travelers have the resources and capability to seek alternative lodging options or meet the potential increase in price.
	Medium: Existing services have minimal excess capacity and travelers have limited resources or capability to seek alternative lodging or meet the potential increase in price.
	High: Existing services have little or no excess capacity and travelers have no resources or capability to seek alternative lodging or meet the potential increase in price.

Based on the accommodations survey conducted by the Consultants, existing lodging options, especially those most frequented by EEPGL and its primary support companies, appear to have excess capacity (30 percent or more) during peak periods, and this will potentially improve in the coming years considering current ongoing hotel expansion efforts.

Leisure and business travelers typically have the ability to respond to capacity constraints when booking their travel through use of hotel-specific and other online booking platforms. For

Guyana, a majority of the hotels discussed in Table 8.5-2 are included on the most popular hotel online booking platforms. This instant access to capacity, price, and comparison of hotel amenities allows travelers to either adjust travel dates or hotel preferences. Business travelers also typically have the ability to absorb increases in price as a result of capacity constraints, while leisure travelers may have less ability. However, the sensitivity of travelers to this potential impact is individual-traveler dependent and accordingly a conservative approach is taken. A **Medium** level of sensitivity to increased demand and/or price for lodging is given.

Impact Significance—Lodging

Based on the magnitude of impact and receptor sensitivity ratings, the significance of lodging for all Project stages is **Minor** for development drilling and SURF and FPSO installation, and **Negligible** for production operations and decommissioning.

8.5.3.2. Housing and Utilities

Relevant Project Activities and Potential Impacts

Although the Project will have limited onshore planned activities, the presence of Project workers and of those seeking Project-related work has the potential to increase demand for housing and utilities in the Georgetown area. Table 8.5-13 summarizes the Project stages and activities that could result in potential impacts on housing and utilities, as well as the receptors that could potentially experience these impacts.

Table 8.5-13: Summary of Relevant Project Activities and Key Potential Impacts—Housing and Utilities

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project Stages	General population of Georgetown and vicinity	Project worker presence in Georgetown area	Increased demand or use of housing and utilities and infrastructure, leading to reduced availability and/or increased cost
		(Induced) influx of job-seekers to Georgetown area	

Magnitude of Impact—Housing and Utilities

The assessment of the Project's magnitude of impacts on housing and utilities is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on housing and utilities is defined according to the definitions provided in Table 8.5-14.

Table 8.5-14: Definitions for Intensity Ratings for Potential Impacts on Housing and Utilities

Criterion	Definition
Intensity	Negligible: There is no discernible change in demand for housing or utilities.
	Low: Limited increases in demand for housing and utilities are perceptible, causing slight changes in the availability, quality, and/or cost of these resources and services.
	Medium: Increases in demand for housing and utilities are evident and lead to frequent and widespread shortfalls in availability or quality of housing and utilities, or measurable increases in costs.
	High: Increases in demand for housing and utilities are sufficient to cause conditions of chronic shortage and inflated costs.

The Project will require up to approximately 1,200 workers during the peak drilling and installation stages and up to a peak of approximately 140 workers during the production operations stage. The majority of the workforce for these stages will be based offshore; for these workers, the limited time spent onshore will predominantly be in temporary accommodations such as hotels or shared guest houses rented by their companies. Approximately 150 to 200 persons will be based onshore on a permanent basis, providing shorebase and marine logistical support as well as supporting EEPGL's other activities in Guyana (including those related to the Project and other EEPGL exploration and production activities). EEPGL will optimize the use of local content to the extent practicable, so it is likely that a significant portion of these permanent onshore jobs will be filled by individuals currently residing in the Georgetown vicinity.

Accommodation and housing data collected from EEPGL and its primary supply companies found that in 2019, these companies had 125 rentals in the Georgetown area: 49 houses and 76 apartments. This number is expected to increase in 2020 to a range of 155 to 175 rentals, and in 2021 to a range of 199 to 219 rentals. These rentals are primarily for expatriate staff living and office space, with a few of the guest house rentals specifically dedicated to offshore, rotational workforce (in lieu of hotels). This portion of the workforce is expected to decrease in later stages of the Project. Based on the survey, only four to seven houses are expected to be purchased in the coming 3 years. There were no significant concerns expressed by EEPGL or its major support companies related to the number and availability of rental houses on the market. Only one of the surveyed primary companies has Guyanese staff (seven in total) who relocated to the Georgetown vicinity from other regions as a result of their work with EEPGL. There have been no indications of large-scale influx of workers from other parts of Guyana to Georgetown in search of jobs.

The number of inhabitants in shared guest houses, apartments, or family homes is currently approximately 10 percent of the total workforce, with the potential to be approximately 20 percent by 2021. These reflect rentals only, with only one EEPGL major support company (representing less than 1 percent of the total workforce) expected to purchase several homes. This maximum estimated number (for 2021) of 219 rentals is insignificant (less than 1 percent) compared to the Georgetown population of more than 130,000.

Realtors interviewed during the housing and accommodation survey indicated that expatriates have a decided preference for residences in Georgetown and its immediate outskirts. Some realtors claim that an increase of more than 100 new residents seeking either new home purchases or long-term rentals in the Georgetown area is expected to increase demand in the rental and home buying markets and, consequently, increase prices. One realtor anticipates that the potential price impacts of an increase at this level will also have impacts in Region 3, while other realtors do not anticipate changes in rural areas or areas outside of Georgetown (EMC Personal Communications 7, 8, 9). Although stock numbers of available houses for rent in the Georgetown and vicinity markets were not available, the viewpoints of these realtors suggest there could be an impact on the housing rental market in specific locations. Considering that the Project workforce is not expected to impact for-sale or rental housing stock (e.g., there is no demand for new housing structures to be built), there will not be expected requirements for significant new utilities connections.

Furthermore, it is not anticipated that the Project's worker presence onshore at any given time will be enough to drive development of new temporary housing/hotel establishments outside of what is already currently being planned by some Georgetown hotels. Some induced population influx from other regions of Guyana may occur as job seekers move to the Georgetown area seeking direct or indirect employment from the Project, but this number to date has reportedly been insignificant. However, any future influx would be expected to be limited and short-term in nature, given EEPGL's continuous efforts to communicate the Project's limited workforce requirements to stakeholders.

Considering the information presented above, potential impacts on housing and utilities will be primarily limited to the **Direct AOI**. Given the current demand on housing and infrastructure in Georgetown is focused on the rental market and represents less than 1 percent of the Georgetown population, the intensity of the potential impacts on housing and utilities is rated as **Low** during drilling and installation stages. By the time of the production operations and decommissioning stages, many of EEPGL's primary supply companies will have completed their Project-related work and will no longer require housing rentals or purchases within Georgetown and the vicinity; therefore, the intensity will decrease to Negligible during production operations and decommissioning. Project-related demand for housing and utilities will occur on a routine basis throughout the Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages and a duration of **Long-term**.

Based on the definitions presented in Table 8.5-15, the magnitude of impact on housing and utilities is considered to be **Small** during the drilling and installation stages of the Project and **Negligible** during the production operations and decommissioning stages.

Table 8.5-15: Magnitude of Impact—Housing and Utilities

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Development Drilling SURF and FPSO Installation	General population of Georgetown and vicinity—Increased demand or use of housing and utilities and infrastructure, leading to reduced availability and/or increased cost	Direct AOI (Georgetown and vicinity)	Low	Continuous	Long-term	Small
Production Operations Decommissioning	General population of Georgetown and vicinity—Increased demand or use of housing and utilities and infrastructure, leading to reduced availability and/or increased cost	Direct AOI (Georgetown and vicinity)	Negligible	Continuous	Long-term	Negligible

Sensitivity of Receptors—Housing and Utilities

The receptors that potentially could experience impacts on housing and utilities are the current general population of the Georgetown vicinity. The receptor sensitivity ratings for housing and utilities are defined according to the definitions provided in Table 8.5-16.

Table 8.5-16: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Housing and Utilities

Criterion	Definition
Sensitivity	Low: Existing infrastructure and services have excess capacity and/or the community has the resources and capability to expand in a timely manner.
	Medium: Existing infrastructure and services have little excess capacity and the community has limited resources or capability to expand in a timely manner and thus would require assistance in upgrading or supplementing current infrastructure and service provision in the community.
	High: Existing infrastructure and services have little or no excess capacity and the community does not have the resources or capability to respond to a potential increase in population.

As the capital of Guyana, Georgetown has a relatively high concentration of social services and infrastructure; however, according to a study by the IDB, there are currently shortfalls of housing and appropriate utilities infrastructure in Georgetown, which the government is addressing with regularization initiatives for informal communities. The existing capacity of the housing rental market by area or community within Georgetown is also unknown. Given these shortfalls, a conservative approach is taken and the population is considered to have a **Medium** level of sensitivity to increased demand for housing and utilities infrastructure.

Impact Significance—Housing and Utilities

Based on the magnitude of impact and receptor sensitivity ratings, the significance of housing and utilities impacts for the drilling and installation stages is **Minor**. During the production operations and decommissioning stages, this is reduced to a **Negligible** level of significance.

8.5.3.3. Ground and Air Transportation

Relevant Project Activities and Potential Impacts

Planned Project activities will generate additional vehicular traffic in Georgetown, as well as additional air traffic (helicopters) between ECIA (Ogle Airport) and the PDA. Table 8.5-17 summarizes the Project stages and activities that could result in potential impacts on ground or air transportation.

Table 8.5-17: Summary of Relevant Project Activities and Key Potential Impacts—Ground and Air Transportation

Stage	Receptors	Project Activity	Key Potential Impacts
All Project stages	Road users, including drivers, cyclists, and pedestrians	Onshore movement of Project materials, supplies, and personnel	Increased vehicle traffic on public roads in and around Georgetown
All Project stages	Other aircraft and users of ECIA	Helicopter flights between ECIA and PDA	Increased air traffic leading to potential impacts on ECIA capacity

Magnitude of Impact—Ground Transportation

The assessment of the Project's magnitude of impacts on ground transportation is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on ground transportation is defined according to the definitions provided in Table 8.5-18.

Table 8.5-18: Definitions for Intensity Ratings for Potential Impacts on Ground Transportation

Criterion	Definition
Intensity	Negligible: There is no anticipated measurable change in traffic congestion.
	Low: Measurable but minor changes in traffic congestion, at only a limited number of locations.
	Medium: Measurable but minor changes in traffic congestion at multiple locations, and/or significant changes in traffic congestion at a limited number of locations.
	High: Significant changes in traffic congestion at multiple locations.

Intensity was assessed based on consideration of analyses performed by CARITRANS in 2018 (focused on the road segments immediately adjacent to one of the main shorebases that will be used by the Project) and in 2019 (covering multiple road segments across Georgetown considered to possibly be among the primary segments used by Project-related vehicles). To assess the intensity of Project-related impacts on ground transportation (i.e., increased traffic congestion), CARITRANS conducted additional LOS modeling for each of the same study intersections for which baseline traffic counts were established. This LOS modeling reflected the simulated addition of anticipated Project-related vehicle movements at the study intersections to assess whether LOS ratings were anticipated to change significantly with the addition of anticipated Project vehicle movements. Results for the 2018 and 2019 study intersections are described below.

2018 Study Intersections

While the 2018 LOS modeling conducted by CARITRANS was focused on the Liza Phase 2 Development Project, the following scenarios were modeled for what was considered a "cumulative traffic scenario":

- Existing conditions under the current road network, with the inclusion of additional Project traffic from Liza Phase 1, Liza Phase 2, exploration drilling, and Payara ("the Cumulative Project traffic");
- Conditions under the current road network in 2023—with assumed non-Project traffic growth—with the inclusion of additional Cumulative Project traffic (a.m. peak, p.m. peak, and Bridge Closed); and
- Conditions with the proposed New Demerara Harbour Bridge and bypass lanes in 2023—with assumed non-Project traffic growth—with the inclusion of additional Cumulative Project traffic (a.m. peak, p.m. peak, Bridge Closed).

The detailed modeled LOS ratings for these scenarios are summarized in the Traffic Impact Assessment Report (CARITRANS 2018) provided as an appendix to the Liza Phase 2 Development EIA. In summary, the LOS modeling for the various projected scenarios confirmed that the additional Project-related traffic scenarios, including the Cumulative Project traffic scenario, will not meaningfully change LOS ratings along the East Bank Demerara Road. This held true for existing traffic conditions, either currently or in 2023, as well as the scenario that envisions construction of a new Demerara Harbour Bridge, which is itself expected to improve traffic congestion along the East Bank Demerara Road. On this basis, the intensity of impact on ground transportation at the 2018 study intersections as a result of planned Project activities is considered to be **Negligible**.

2019 Study Intersections

The 2019 LOS modeling conducted by CARITRANS was focused on road segments across Georgetown, in particular those anticipated to potentially be among the road segments more heavily used by EEPGL-related vehicle movements. In contrast to the modeling performed for the 2018 study, the 2019 study modeled the anticipated overall EEPGL-related activities (i.e., the Payara Project, plus other non-Project EEPGL activities). This was done because existing data and future estimates regarding EEPGL-related vehicle movements are not readily divisible by specific Project activity.

To provide a basis for CARITRANS to simulate EEPGL-related vehicle movements in the LOS modeling, the Consultants worked with EEPGL to develop projections of EEPGL-related vehicle movements for three simulation years: 2021 (during which Project drilling activity prior to production operations will occur), 2023 (during which Project production operations activity, with continued drilling activity will occur), and 2025 (during which Project production operations activity, after completion of drilling activity will occur). Vehicle movement estimates were developed from two primary sources:

- Recorded EEPGL "fleet" vehicle movements over the period of 4 February 2019 through 28 April 2019 (EEPGL tracks the movements of its fleet vehicles—which are used for transport of EEPGL staff around Georgetown—using global positioning system devices); and
- Estimates of non-personnel EEPGL-related vehicle movements (i.e., for material, supply, waste transports, etc.).

Based on review of the fleet vehicle movements (comprising the bulk of the overall movements), the Consultants identified a list of "key points" within Georgetown, defined as a recorded "start" or "finish" point of a "key segment" recorded as being traveled at least 30 times in the 84-day period of record. These key points were then plotted on a map that included the intersections at which CARITRANS conducted its vehicle movement counts in 2019 (see Figure 8.5-7).

In some cases, the recorded "start" or "finish" points were not identifiable to a specific location, but rather could only be identified to within a particular street segment. In these cases, Figure 8.5-7 displays a "key street segment."

To estimate the potential impact of these fleet-vehicle trips on the specific intersections that were the subject of the 2019 study, the Consultants identified—for each key segment—the traffic count locations that could potentially be passed through while traveling the key segment. This generated a conservative estimate of the number of times an intersection could have been crossed by an EEPGL fleet vehicle during the period of record. In total, the 84-day period of record included data for 25,123 vehicle trips. Of these, 8,682 of the trips had a "start" and "end" point that were both identifiable (in many cases the "start" and "end" trip was the same, indicating a return to the start point with an unidentifiable route during the trip). Accordingly, the estimated numbers of intersection crossings were "scaled up" by a factor of (25,123/8,682), representing the estimated number of EEPGL fleet vehicle crossings of each study intersection during the period of record (i.e., February to April 2019).

To estimate the anticipated EEPGL fleet vehicle traffic for the selected modeling periods (2021, 2023, and 2025), the Consultants worked with EEPGL's transportation coordination group to develop estimates of the expected fleet growth across these time periods. The February to April 2019 counts reflected a fleet size of 36 vehicles. EEPGL's end-of-year estimates for fleet vehicle size for 2021, 2023, and 2025 were 92, 96, and 96, respectively. Accordingly, the estimated number of EEPGL fleet vehicle crossings of each study intersection for 2021, 2023, and 2025 were developed taking the estimated February to April 2019 crossings and increasing by factors of (92/36), (96/36), and (96/36), respectively.

For non-personnel EEPGL vehicle movements, EEPGL's logistics team identified key segments for these types of movements and provided direct estimates of trip-counts along these key segments for 2021, 2023, and 2025.

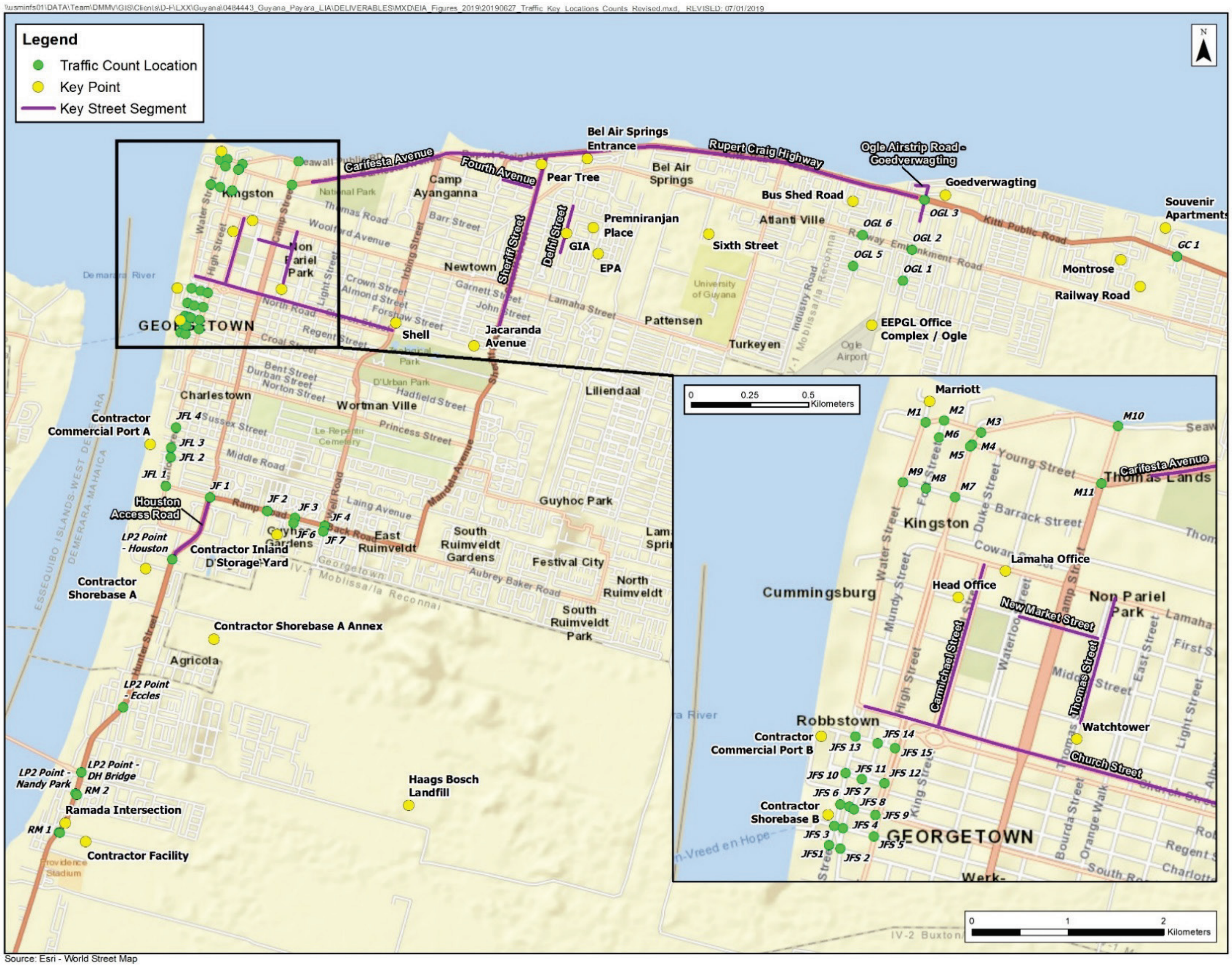


Figure 8.5-7: Key Points/Segments and Traffic Count Locations for 2021–2025 LOS Modeling

Combining the EEPGL personnel and EEPGL non-personnel vehicle movements, Table 8.5-19 provides a summary of the key segments and estimated additional EEPGL-related daily trip-counts along these key segments (i.e., beyond the trip-counts recorded for the February to April 2019 period – which would be reflected in the measured base traffic counts) for 2021, 2023, and 2025.

Table 8.5-19: Estimated Potential Additional EEPGL-related Intersection Crossings

Traffic Count Location	Estimated Potential Additional EEPGL-Related Intersection Crossings		
	2021	2023	2025
LP2 Point Nandy Park	10	11	11
LP2 Point DH Bridge	10	11	11
LP2 Point Eccles	8	13	13
LP2 Point Houston	73	78	78
JFL-1	71	77	79
JFL-2	73	79	81
JFL-3	73	79	81
JFL-4	62	67	68
JF-1	69	77	79
JF-2	56	65	67
JF-3	56	65	67
JF-4	49	53	53
JF-6	7	12	14
JFS-1	13	14	15
JFS-2	13	14	15
JFS-3	13	14	15
JFS-4	13	14	15
JFS-5	60	65	66
JFS-6	5	5	5
JFS-7	5	5	5
JFS-8	5	5	5
JFS-9	52	56	56
JFS-10	5	5	5
JFS-11	5	5	5
JFS-12	52	56	56
JFS-13	5	5	5
JFS-14	5	5	5
JFS-15	52	56	56
M-1	31	33	33
M-2	26	28	28
M-3	37	40	40
M-4	41	44	44
M-5	41	44	44
M-6	0	0	0

Traffic Count Location	Estimated Potential Additional EEPGL-Related Intersection Crossings		
	2021	2023	2025
M-7	36	38	38
M-8	0	0	0
M-9	23	25	25
M-10	5	6	6
M-11	194	208	208
GC-1	0	0	0
GC-2	259	277	277
GC-3	294	315	315
OGL-1	2	2	2
OGL-2	70	75	75
OGL-3	67	72	72
OGL-5	0	0	0
OGL-6	70	75	75

As Table 8.5-19 shows, the estimated additional crossings for 2023 and 2025 are very similar across the study intersections. Accordingly, the Consultants and CARITRANS decided to conduct "with EEPGL activity" LOS modeling for the following scenarios:

- Conditions under the current road network in 2021—with assumed non-Project traffic growth—with the inclusion of additional EEPGL-related traffic (a.m. peak, p.m. peak); and
- Conditions under the current road network in 2023—with assumed non-Project traffic growth—with the inclusion of additional EEPGL-related traffic (a.m. peak, p.m. peak)

The full report containing the results of LOS modeling for these scenarios is included as Appendix U, Traffic Impact Assessment.

In summary, the LOS modeling for the various projected scenarios confirmed that the additional EEPGL-related vehicle trip counts in 2021 and 2023 (the latter of which is also considered to be conservatively representative of 2025) will not meaningfully change LOS ratings at any of the 2019 study intersections. On this basis, the intensity of impact on ground transportation at the 2019 study intersections as a result of planned Project activities is considered to be **Negligible**.

Considering the information presented above, potential impacts on ground transportation will be primarily limited to the **Direct AOI**. Given the results of LOS modeling for "with Project" scenarios in 2021, 2023, and 2025, the intensity of potential impacts on ground transportation is rated as **Negligible** for all three time periods. EEPGL-related vehicle movements will occur on a routine basis throughout the Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages and a duration of **Long-term**.

Based on the definitions presented in Table 8.5-20, the magnitude of impact on housing and utilities is considered to be **Negligible** during all Project stages.

Table 8.5-20: Magnitude of Impact—Ground Transportation

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
All Project stages	Road users, including drivers, cyclists, and pedestrians—increased vehicle traffic on public roads in and around Georgetown	Direct AOI (Georgetown and vicinity)	Negligible	Continuous	Long-term	Negligible

Sensitivity of Receptors—Ground Transportation

The receptors that could potentially experience impacts on ground transportation include current users of the Georgetown road network. Existing drivers will have a **Medium** level of sensitivity. This rating reflects the relatively high existing traffic volumes and congestion in the vicinity of the shorebases, as well as the lack of travel alternatives (i.e., other travel routes or modes of transportation) for non-Project drivers. Drivers already experience substantial traffic congestion and road safety risks in parts of Georgetown. Additional traffic will likely be viewed as incremental, but not a fundamental shift in conditions.

Impact Significance—Ground Transportation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of ground transportation impacts on community stakeholders is **Negligible**.

Magnitude of Impact—Air Transportation

The assessment of the Project's magnitude of impacts on air transportation is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on ground transportation is defined according to the definitions provided in Table 8.5-21.

Table 8.5-21: Definitions for Intensity Ratings for Potential Impacts on Air Transportation

Criterion	Definition
Intensity	Negligible: There are no anticipated measurable impacts on heliport capacity.
	Low: Impacts on heliport capacity are perceptible, but causing only rare instances of availability shortfalls.
	Medium: Impacts on heliport capacity are evident and lead to periodic availability shortfalls.
	High: Impacts on heliport capacity are sufficient to cause persistent availability shortfalls.

Logistical support will be optimized and shared among Liza Phase 1, Liza Phase 2, and Payara. It is estimated that during development drilling and FPSO/SURF installation, helicopter flights may increase at peak to a total of approximately 45 to 55 round-trip flights per week. During FPSO/SURF production operations, an estimated maximum of 20 to 30 round-trip flights per week will be necessary to support FPSO/SURF production operations and continued development-drilling activities.

As described in Section 2.11, End of Payara Operations (Decommissioning), EEPGL has not prepared detailed plans for the decommissioning stage. As such, the level of air-transportation activity associated with decommissioning is not known. For purposes of impact analysis, air traffic associated with Project decommissioning is assumed to be similar to that of the drilling and installation stage.

During development drilling and FPSO/SURF installation, the level of helicopter activity (assuming a maximum of 55 round-trip flights per week or 2,860 flights per year) will represent approximately 15.4 percent of the total annual operational flight landings (using 2018 airport operational data as a the base case). On this basis, EEPGL's level of helicopter activity is unlikely to meaningfully impact ECIA's heliport capacity or operations, but there could be rare instances of availability shortfalls. Accordingly, the magnitude of potential impacts on air transportation as a result of the Project is considered **Small**.

Sensitivity of Receptor—Air Transportation

Receptors for air transportation impacts include airport and airspace users and commercial, cargo, and private pilots, crew, and passengers. The aviation environment is highly regulated. Other air traffic, such as Project-related flights, is expected. All pilots are expected to be able to navigate in the presence of the limited additional Project-related aircraft. On this basis, air transportation users at ECIA are considered to have a **Low** level of sensitivity to increased air traffic from the Project.

Impact Significance—Air Transportation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of air transportation impacts is **Negligible**.

8.5.4. Mitigation Measures—Social Infrastructure and Services

Table 8.5-22 summarizes the embedded controls and mitigation measures relevant to social infrastructure and services.

Table 8.5-22: List of Embedded Controls and Mitigation Measures

Embedded Controls
Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to vehicle incidents.
Coordinate with relevant aviation authorities and stakeholders to understand peak Project-related utilization rates.
Mitigation Measures
Proactively communicate the Project's limited staffing requirements as a measure to reduce the magnitude of potential population influx to Georgetown from job seekers.
Communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners.

8.5.4.1. Lodging

No mitigation measures are required to address potential impacts on lodging. However, the Project can proactively communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners across the Georgetown area. With this knowledge, hotels that have not traditionally been used by the Project workforce may be able to improve standards and be considered for future use. This could have the desired outcome of spreading Project workforce hotel room demand across a wider range of hotels and therefore decreasing the intensity of the potential impact on both hotel room demand and potential resultant increases in price.

Table 8.5-23 summarizes the assessment of potential pre-mitigation and residual Project impacts on lodging. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the lodging-specific methodology described above.

8.5.4.2. Housing and Utilities

No mitigation measures are required to address potential impacts on housing and utilities. However, the Project will proactively manage messaging about the Project's limited workforce needs to stakeholders to reduce the potential for induced population influx.

Table 8.5-24 summarizes the assessment of potential pre-mitigation and residual Project impacts on housing and utilities. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, as well as the housing and utilities-specific methodology described above.

8.5.4.3. Ground and Air Transportation

No mitigation measures are required to address potential impacts on ground and air transportation.

Table 8.5-25 below summarizes the assessment of potential pre-mitigation and residual Project impacts on ground and air transportation. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, as well as the ground and air transportation-specific methodology described above.

Table 8.5-23: Summary of Potential Pre-Mitigation and Residual Impacts—Lodging

Stage	Resource/Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Drilling SURF and FPSO Installation	Leisure and business travelers to Guyana, specifically Georgetown and vicinity—Increased demand or use of lodging, leading to reduced availability and/or increased cost	Small	Medium	Minor	Communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners	Minor
Production Operations Decommissioning	Leisure and business travelers to Guyana, specifically Georgetown and vicinity—Increased demand or use of lodging, leading to reduced availability and/or increased cost	Negligible	Medium	Negligible	Communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners	Negligible

Table 8.5-24: Summary of Potential Pre-Mitigation and Residual Impacts—Housing and Utilities

Stage	Resource/Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Drilling SURF and FPSO Installation	General population of Georgetown and vicinity—decreased availability/increased cost of housing and utilities	Small	Medium	Minor	Proactive messaging regarding Project employment opportunities	Minor
Production Operations Decommissioning	General Georgetown population and vicinity—decreased availability/increased cost of housing and utilities	Negligible	Medium	Negligible	None	Negligible

Table 8.5-25: Summary of Potential Pre-Mitigation and Residual Impacts—Ground and Air Transportation

Stage	Resource/Receptor - Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Non-Project drivers—increase in traffic congestion	Negligible	Medium	Negligible	None	Negligible
All Project stages	Non-Project users of ECIA—interference with airport use	Small	Low	Negligible	None	Negligible

8.6. WASTE MANAGEMENT INFRASTRUCTURE CAPACITY

8.6.1. Administrative Framework—Waste Management Infrastructure Capacity

Table 8.6-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on waste management infrastructure capacity.

Table 8.6-1: Legislation, Policies, Treaty Commitments and Industry Practices—Waste Management Infrastructure Capacity

Title	Objective	Relevance to the Project
Legislation		
Environmental Protection Act (1996)	Establishes the EPA and provides the legal and institutional framework for the management, conservation, and protection of the environment and the control of pollution.	Empowers the development of regulations for the handling and disposal of hazardous wastes.
Environmental Protection Hazardous Waste Regulations (2000)	Establishes requirements for generating, handling, and disposing of hazardous waste as well as penalties for violations of these requirements.	Identifies wastes subject to regulation, including several types of waste that could be generated as part of the Project.
Municipal and District Councils Act (1969)	Provides for improved local governance in the city of Georgetown, as well as in the other municipalities.	Empowers councils to establish, maintain, and carry out sanitary services for the removal and destruction or management of all types of refuse and effluent.
Pesticides and Toxic Chemicals Control Act Cap. 68:09 (2000, as amended in 2007)	Provides for the formation of a Pesticides and Toxic Chemicals Control Board; establishes requirements for registration, licensure, and trade in pesticides and toxic chemicals. Amended in 2007 to provide rules for the exportation of pesticides and toxic chemicals.	Establishes regulations pertaining to the use of toxic chemicals and pesticides. Pesticides will not be required for the Project, but small amounts of toxic chemicals may be used. Will regulate the importation, registration, and use of these chemicals.
Policies and Strategies		
National Solid Waste Management Strategy (Under Development)	Guides the Government of Guyana's agenda on waste collection, transportation, and disposal; goals include improving the waste management infrastructure, enforcing existing legislation, and promoting waste-to-energy initiatives. Will inform the country's integrated efforts at converting waste material into useful resources and aims to ensure their full utilization and eventual exploitation as by-products. Currently under development.	Once the strategy is approved, it is expected to apply to the collection, transportation, and disposal of Project-generated waste.

Title	Objective	Relevance to the Project
International Agreements Signed/Acceded by Guyana		
International Convention for Safe Containers (1972)	Promotes the safe transport and handling of containers through generally acceptable test procedures and related strength requirements, and facilitates the international transport of containers by providing uniform international safety regulations, equally applicable to all modes of surface transport.	Regulates the manufacture, use, and integrity of containers used on board the drill ships, FPSO, and support vessels. Guyana acceded in 1997.
International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (1969)	Confirms the right of coastal member states to take specific actions when necessary to prevent pollution from oil following a maritime casualty.	Would protect Guyana's rights to respond to an oil spill if such an event were to occur. Guyana acceded in 1997.
Basel Convention on the Transboundary Movement of Hazardous Wastes and Their Disposal (1989)	Reduces and controls the movements of hazardous waste between nations and discourages transfer of hazardous waste from developed to less developed countries.	Would apply to the Project only if hazardous waste generated in Guyana is disposed outside Guyana. Guyana acceded in 2001.
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998)	Provides a mechanism for formally obtaining and disseminating decisions of party nations as to whether they wish to receive future shipments of listed chemicals, and for ensuring compliance with these decisions by exporting party nations.	Would apply to the Project only if chemicals and/or pesticides used by the Project and listed under the Convention are shipped into or out of Guyana. Guyana acceded in June 2007.
Stockholm Convention on Persistent Organic Pollutants (2001, amended in 2009)	Requires party nations to take measures to eliminate or reduce the release of persistent organic pollutants.	Would apply to the Project only if persistent organic pollutants are released to the environment during the course of Project-related. Guyana acceded in September 2007.
International Convention on Oil Pollution Preparedness, Response and Cooperation (1990)	Establishes measures for dealing with marine oil pollution incidents.	Requires ships to have a shipboard oil pollution emergency plan. Guyana ratified in 1997.

8.6.2. Existing Conditions—Waste Management Infrastructure Capacity

8.6.2.1. Waste Management Entities

Currently, several public sector agencies are involved in waste management in Guyana, including the EPA, Ministry of Communities, Ministry of Public Health, RDCs, NDCs, and TCs, and there are some overlaps in roles and responsibilities. The two key organizations involved in waste management are the EPA and the Ministry of Communities; their roles in waste management are further elaborated below.

8.6.2.1.1. Environmental Protection Agency

The EPA is responsible for permitting waste disposal sites. In addition, waste management is one of the EPA's program areas. Under the EPA's Waste Management Program Area, the EPA manages the policies, guidelines, and standard operational procedures regarding waste management and resource recovery. The stated aim of the program is to realize maximum value from natural resources and ensure a "green environment."

The core function of the Waste Management Program Area is to manage waste entering into the environment in an environmentally sound manner. Through this program area, the EPA provides technical assistance in the development, management and operation of waste management facilities, conducts research and analysis on the recovery of useful energy from solid waste, and develops guidelines and standards for the disposal of hazardous waste and other types of waste. It also coordinates and implements the obligations of the Basel Convention and controls the import and export of hazardous waste through granting of authorizations. The program area focuses on three sub-program areas:

- Solid waste management
- Hazardous waste management
- Waste reduction and recovery

8.6.2.1.2. Ministry of Communities

The Ministry of Communities is the primary government agency that links the various authorities with the Government of Guyana. It facilitates, coordinates, and monitors the execution and implementation of a number of projects, programs, and activities in the various local government arms and ensures that these activities are in conformity with the legal framework and the policies of the government. This ministry is also leading development of the National Solid Waste Management Strategy referenced in Table 8.6-1. The Ministry of Communities has direct oversight over the Haags Bosch public landfill site, as well as the waste management activities of RDCs, NDCs, the Georgetown City Council, and TCs.

8.6.2.2. Municipal/Non-hazardous Waste Management Facilities

Most regions in Guyana rely on dumpsites for the disposal of municipal waste, with each region having at least one dumpsite. In addition to receiving municipal waste from household collections, these dumpsites are also used for the disposal of commercial and industrial waste. Although the dumpsites are intended only for the disposal of non-hazardous wastes, the control over incoming waste is generally not rigorous.

The Government of Guyana wants to develop a more coordinated approach to waste infrastructure planning that is compatible with land use planning and promotes coordination and optimization of waste management facilities across all regions. The Ministry of Communities' stated strategy is to progressively rehabilitate illegal dumpsites, disused dumpsites, and poorly operated dumpsites (Gilkes 2017).

In Region 4, the Haags Bosch engineered municipal landfill site was commissioned in 2011 (Guyana Times 2018). The site serves Georgetown and more than 25 NDCs from Mahaica to Parika and Timehri. The facility has experienced operational problems in the past, including a fire in 2015. It was also the subject of several non-compliance notices from the EPA relating primarily to leachate management. Since then, a new operator has been appointed and remediation of the site and upgrading of the operation is underway. In 2018, the landfill site benefitted from a $253 million GYD ($1.21 million USD) rehabilitation and upgrade (Guyana Times 2018). The landfill is lined and now has a leachate collection system and a leachate treatment system. Although waste pickers are operating at the site, controls have been put in place by the landfill operator to minimize the health and safety risks of their activities and to reduce their interference with the operation of the site. Other controls (e.g., safe venting of landfill gas) and environmental monitoring are also planned for the site. Approximately 350 to 400 tonnes of waste are disposed on a daily basis at the landfill (EMC Personal Communication 19).

8.6.2.3. Industrial/Hazardous Waste Management Facilities

There are a limited number of facilities for the treatment of hazardous waste in Guyana, although interest in developing such facilities is growing commensurate with the planned expansion of oil and gas activities. Currently, a private-sector contractor has the only existing facility in Guyana capable of treating hazardous wastes. EEPGL has been using this contractor to manage a range of wastes generated during the Liza Phase 1 Development Project, Liza Phase 2 Development Project, and exploration activities and has plans to continue using this contractor for the Project. The Project may also potentially use tank-cleaning services from other contractors out of Guyana and Trinidad.

The above-referenced hazardous waste treatment contractor has an authorization issued by the EPA and has been assessed by EEPGL as operating to good environmental, health, and safety standards, comparable with good international standards. The facility uses a vertical infrared thermal unit (VIR) for management of wastes. The VIR has the ability to treat solid and semi-solid/sludge wastes (drill cuttings, oily sludges, slops, and tank bottoms) with less than 6 percent oil and can manage small quantities of well completion fluids. The facility can also treat wastewater by injecting a limited amount of wastewater into the VIR. The contractor has also installed an incinerator that will have the ability to treat hazardous solid wastes.

Non-hazardous solid wastes and residuals from solid wastes treated with the above-referenced VIR or incinerator that are not recyclable are currently disposed at the Haags Bosch Landfill. Non-hazardous waste streams disposed at the Haags Bosch landfill include:

- Food waste
- Scrap wood and metal
- Glass (e.g., bottles)
- Plastic (e.g., scrap, shredded drums, buckets and kegs)
- Cardboard and paper
- Aerosol cans (depressurized)

8.6.3. Impact Assessment—Waste Management Infrastructure Capacity

Various Project waste streams generated offshore will be discharged directly to sea in accordance with applicable international environmental performance criteria (see ESMP, Volume III), including:

- Water-based drill cuttings and fluids
- Treated drill cuttings with residual non-aqueous base fluid content
- Excess cement from the first casing string of each well

- Well completion and treatment fluids
- Treated produced water
- Cooling water
- Brine from water purification (membrane) processes
- Drainage from topsides facilities (after passing through traps to remove hydrocarbons)
- Hydrostatic test water
- Commissioning fluids
- Ballast water
- BOP testing fluids
- Treated FPSO bilge water
- Treated FPSO slop tank water
- Gray water
- Treated black water and food waste

Further details about these wastes are presented in Section 2.12.3, Discharges. Potential impacts of Project discharges to sea are discussed in Section 6.4.3, Impact Assessment—Marine Water Quality, and Section 6.4.4, Mitigation Measures—Marine Water Quality. The remainder of this section focuses on Project-generated wastes that will not be discharged to the sea.

8.6.3.1. Relevant Project Activities and Potential Impacts

The types and quantities of Project-generated wastes that will not be discharged to the sea after appropriate treatment are detailed in Section 2.12.4, Wastes, and summarized below in Table 8.6-2.

Table 8.6-2: Summary of Estimated Annual Project Waste Generation and Management Methods

Waste Generated by Category	Volume By Year/Metric Tonnes [a]							
	2020	2021	2022	2023	2024	2025	2026-2043	2044
Non-Hazardous wastes (total) [b]	250	1070	1100	1320	1340	1340	530	530
Hazardous wastes (total) [b]	1530	6240	6270	6420	6430	6430	480	480
Totals by Management Method/Final Destination								
Landfill [c]	150	640	640	810	830	830	350	350
Recycle [d] (if feasible) or Landfill	130	570	590	650	660	660	210	210
Solids Thermal Treatment at Approved Third Party Facility/Landfill [e]	170	750	770	750	750	750	120	120
Liquids Wastewater Treatment/Thermal Treatment and/or Discharge Onshore at Approved Third Party Facility	1330	5340	5350	5500	5510	5510	290	290
Special Waste/Send to Approved Facility	2	20	20	30	30	30	40	40

[a] The annual totals reflect the current preliminary Project schedule, which could change.
[b] Totals may not sum exactly due to rounding.
[c] Onshore landfill volumes include estimated quantities of residue from treatment of hazardous waste.
[d] Includes items recycled into offshore operations process
[e] After treatment of hazardous wastes onshore, the residual non-hazardous solid wastes that are not recycled, reclaimed, or reused will be transported for disposal in an approved landfill.

All wastes generated by the Project will be managed in accordance with a Waste Management Plan (WMP) that has been developed by EEPGL, which is included as part of the ESMP. The WMP lists in detail the range of wastes that will be generated by the Project and their sources. It specifies primary and alternative treatment/disposal methods for each waste, as well as the associated monitoring and reporting requirements. The WMP also indicates the roles and responsibilities of the different organizations in terms of managing Project wastes, and details the national and international waste management regulations that are applicable to the Project.

The WMP states that the Project will follow the principles of the waste management hierarchy[16] and will, as far as practical, take steps to avoid and minimize the generation of waste, maximize the amount of waste that is reused and recycled, and minimize the amount of waste that needs to be disposed (and in particular landfilled). The WMP provides details as to how different types of waste are to be handled, stored, and transported to shore to avoid potential environmental, health, and safety issues. Specifically, it describes how different types of waste will be segregated, the types of containers that will be used, and the labeling requirements. All transfers of waste from offshore Project facilities to shorebases will be covered by marine transport manifests and will be undertaken in suitably licensed vessels. Any on-land transfers of waste will similarly be covered by use of waste transfer notes to ensure that all movements of waste can be tracked through to the point of final disposal.

A range of different treatment and disposal methods will be used for different types of waste as follows:

- Third-party waste contractor(s) will treat wastes onshore that cannot be treated offshore. The contractors will use thermal treatment methods, such as thermal desorption, and/or stabilization technologies to treat hazardous solid wastes, and thermal oxidation or filtration and separation to treat wastewaters. Only contractors that are appropriately licensed by the EPA and which have been assessed by EEPGL as being of a sufficient standard will be used to treat the Project's wastes.
- Ash from the incineration of waste, residual solid waste from treated hazardous solid wastes, and general non-hazardous wastes will be taken to a landfill that has been appropriately licensed by the EPA and assessed by EEPGL as being of a sufficient standard. Currently, the only Georgetown-based facility EEPGL has identified as meeting these requirements is the Haags Bosch landfill.
- Specific wastes that can be recycled locally, such as plastic, scrap metal, and used oil, will be taken to approved local recyclers.

Any new or unanticipated wastes, such as from an emergency response, will be assessed to determine the most appropriate handling/on-site management and treatment/disposal methods.

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[16] The waste management hierarchy used by EEPGL is as follows: (1) Generation of waste should be Avoided, Prevented, or Reduced at the source whenever feasible; (2) Wastes that are not Prevented should be Reused or Recycled in an environmentally safe manner, whenever feasible; (3) Wastes that are not Prevented or Recycled should be Treated in an environmentally safe manner, whenever feasible; and (4) Finally, Disposal should be employed as a last option and when employed, should be conducted in an environmental responsible manner (OGP 2009).

The proposed way in which Project wastes will be managed is in accordance with good international practice. Specifically, EEPGL is proposing to use waste contractors that are licensed by the authorities, and to undertake its own assessments to assess whether contractors are operating to good international environmental and health and safety standards.

8.6.3.2. Magnitude of Impact—Waste Management Infrastructure Capacity

The assessment of the Project's magnitude of potential impacts on waste management infrastructure capacity at all stages of the Project is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on waste management infrastructure and capacity is defined according to the definitions provided in Table 8.6-3.

Table 8.6-3: Definitions for Intensity Ratings for Potential Impacts on Waste Management Infrastructure Capacity

Criterion	Definition
Intensity	Negligible: Anticipated Project waste volumes are not a demand driver for the capacity of existing available waste management infrastructure or will drive a demand that is well within the existing available waste management infrastructure's capacity.
	Low: Anticipated Project waste volumes will drive a demand that is within the existing available waste management infrastructure's capacity, but significant increases in Project waste volumes beyond these anticipated volumes could drive a demand that surpasses this capacity.
	Medium: Anticipated Project waste volumes will drive a demand at or slightly beyond the existing available waste management infrastructure's capacity.
	High: Anticipated Project waste volumes will drive a demand that is well beyond the existing available waste management infrastructure's capacity.

As noted above, EEPGL routinely reviews its contracted waste management facilities to ensure they are of a sufficient quality to manage its wastes. These reviews include routine audits that cover a range of topics (e.g., financial, environmental, safety, security, health, etc.), as well as periodic assessments that are focused on more specific topics, such as infrastructure capacity as described further below. In 2018, EEPGL conducted audits of the above-referenced hazardous waste treatment contractor facility and the Haags Bosch landfill facility, and both facilities were assessed as operating at a sufficient quality level to continue managing EEPGL's wastes. Another audit of both facilities is planned for late 2019.

In May 2019, EEPGL conducted a capacity assessment of the above-referenced hazardous waste treatment facility, with the specific objective of assessing whether the facility had any potential constraints that could challenge its ability to accommodate EEPGL's anticipated waste streams. The results of the assessment indicated that, without modifications, the infrastructure capacity of the facility would likely be unable to keep up with treating the increased volume of EEPGL's hazardous solids and waste oil liquids generated by all EEPGL activities by late 2020.

The Haags Bosch landfill is currently operating a single landfill "cell," and the landfill operator has estimated that the capacity of this cell will be exhausted by the end of 2019 (EMC Personal Communication 19). Construction of a second cell within the existing landfill footprint is currently being planned by the Ministry of Communities.

Based on consideration of the above-noted current constraints and considering that the Project represents a significant portion of the total demand for Georgetown-based hazardous waste treatment facilities, the intensity of potential Project impacts on Georgetown-based hazardous waste treatment facilities (in the absence of capacity expansions and/or the introduction of additional facilities of a sufficient quality) is considered to be **High**. Potential impacts will be limited to the **Direct AOI** (i.e., Georgetown). Waste management and disposal will take place throughout the entire Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages. Duration will be **Long-term** for all Project stages. Therefore, the magnitude of this potential impact is rated as **Large** (see Table 8.6-4).

The Project's projected landfill demand (peaking on the order of approximately 200 tonnes per month; see Table 8.6-2) represents less than 2 percent of the total current demand on Georgetown-based landfill facilities (on the order of approximately 10,000 to 12,000 tonnes per month [EMC Personal Communication 19]). Accordingly, in consideration of the above-noted current constraints, the intensity of potential Project impacts on Georgetown-based landfill facilities (even in the absence of capacity expansions and/or the introduction of additional facilities of a sufficient quality) is considered to be no more than **Low**. Potential impacts will be limited to the **Direct AOI** (i.e., Georgetown). Waste management and disposal will take place throughout the entire Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages. Duration will be **Long-term** for all Project stages. Therefore, the magnitude of this potential impact is rated as **Small** (Table 8.6-4).

Table 8.6-4: Magnitude of Impact—Waste Management Infrastructure Capacity

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
All Project stages	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based hazardous waste treatment facilities)—exceedance of capacity	Direct AOI (Georgetown)	High	Continuous	Long-term	Large
All Project stages	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based landfill facilities)—exceedance of capacity	Direct AOI (Georgetown)	Low	Continuous	Long-term	Small

8.6.3.3. Sensitivity of Receptors—Waste Management Infrastructure Capacity

Potential receptors for waste management infrastructure capacity impacts include current users of Georgetown-based treatment facilities and landfills (the latter including the general community). The receptor sensitivity ratings for waste management are defined in Table 8.6-5.

Table 8.6-5: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Waste Management Infrastructure Capacity

Criterion	Definition
Sensitivity	Low: The receptor is able to adapt to impacts on waste management infrastructure capacity with no outside assistance or mitigation.
	Medium: The receptor is able to adapt to impacts on waste management infrastructure capacity, waste with outside assistance or mitigation.
	High: The receptor cannot adapt to impacts on waste management infrastructure capacity, even with outside assistance or mitigation.

Table 8.6-6 summarizes the sensitivity ratings assigned for the various types of receptors that could potentially experience impacts on waste management infrastructure and capacity from planned activities of the Project.

Table 8.6-6: Sensitivity Ratings for Receptors of Potential Impacts on Waste Management Infrastructure Capacity

Receptor	Sensitivity Rating	Rationale for Rating
Non-Project users of Guyana-based hazardous waste treatment facilities	Low	Non-project users of Guyana-based hazardous waste treatment facilities are largely limited to other oil and gas exploration and production companies. These companies have the ability to access alternate regional providers for this service, albeit likely at an increased cost and a commensurate reduction in their operational efficiency.
Non-Project users of Guyana-based landfills	High	Non-project users of Guyana-based landfills include other industrial waste generators, as well as the general Georgetown-area community. Focusing on the latter, the general Georgetown-area community has no feasible alternative options for the proper management of its municipal wastes.

8.6.3.4. Impact Significance—Waste Management Infrastructure Capacity

Based on the magnitude of impact and receptor sensitivity ratings, the pre-mitigation significance of potential Project impacts on waste management infrastructure capacity is **Moderate** for non-Project users of hazardous waste treatment facilities and **Moderate** for non-Project users of Georgetown-based landfills.

8.6.4. Mitigation Measures—Waste Management Infrastructure Capacity

Although the Project itself is not considered a receptor for the purpose of the EIA, the viability of its operations depends on reliable access to waste management infrastructure of a sufficient quality and with sufficient capacity. In view of this need, and in recognition of the pre-mitigation significance ratings for potential impacts on non-Project users, the Project has initiated the following mitigation measures:

- Enable increases to existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facility or facilities, or identify suitable alternative solutions; and
- Monitor the Ministry of Communities' planned construction of Cell 2 at the Haags Bosch landfill, and/or identify suitable alternative (interim) local solutions for non-hazardous waste management.

In addition to these mitigation measures, additional EEPGL waste management-related embedded controls are further summarized below and in the WMP, which is attached to the ESMP.

Assuming implementation of these mitigation measures and embedded controls, the intensity ratings for potential Project impacts on waste management infrastructure capacity will reduce to no more than **Low** for Georgetown-based hazardous waste treatment facilities and **Negligible** for Georgetown-based landfills. This results in reduced magnitude ratings of **Negligible** for both receptor types, yielding residual significance ratings of **Negligible** for both receptor types. However, in view of the fact that capacity expansions for the Haags Bosch landfill are not under EEPGL's control, the residual significance rating for potential impacts on Georgetown-based landfill capacity is maintained at a level of **Minor**.

Table 8.6-7 summarizes the embedded controls, mitigation measures (inclusive of the measures listed above), and monitoring measures relevant to this receptor.

Table 8.6-7: List of Embedded Controls, Mitigation Measures, and Monitoring Measures

Embedded Controls
For transport of hazardous wastes offsite for treatment or disposal, ensure the waste is accompanied by a manifest signed by the hazardous waste generator and transporter.
Provide for adequate onshore waste management equipment and facilities for the proper management of waste in accordance with local regulation and good international oil field practice.
For wastes that cannot be reused, treated, or discharged/disposed on the drill ships or FPSO, ensure they are manifested and safely transferred to appropriate onshore facilities for management.
Periodically audit waste contractors to verify appropriate waste management practices are being used.
Avoid, reduce, and reuse/recycle wastes preferentially prior to disposal in accordance with waste management hierarchy.
Perform onshore waste treatment for certain categories of waste, thereby reducing demand on landfill capacity.
Operate incinerators in accordance with the manufacturers' operating manuals and Waste Management Plan. Ensure that the incinerators are operated only by trained personnel.
Mitigation Measures
To address future waste capacity constraints in Georgetown relative to Project's predicted waste management needs: • Enable increases to existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facility or facilities, or identify suitable alternative regional solutions; and • Monitor the Ministry of Communities' planned construction of Cell 2 at the Haags Bosch landfill, and/or identify suitable alternative (interim) local solutions for non-hazardous waste management.
Monitoring Measures
Record type and quantity of each individual waste stream on board any time a new waste is generated.

Daily inspect waste storage area and containers; log inspections.
Document marine waste transfer.
Sample and perform analytical testing as needed to properly classify waste.
Complete Recoverable Material and Waste Summaries.
Complete and submit reports required per the Environmental Permit.
Conduct waste facility audits and inspections periodically.

Table 8.6-8 below summarizes the assessment of potential pre-mitigation and residual Project impacts on waste management infrastructure capacity. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the resource-specific methodology described above.

Table 8.6-8: Summary of Potential Pre-Mitigation and Residual Impacts—Waste Management Infrastructure Capacity

Stage	Resource/Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based hazardous waste treatment facilities) – exceedance of capacity	Large	Low	Moderate	See Section 8.6.4	Negligible
All Project stages	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based landfill facilities) – exceedance of capacity	Small	High	Moderate	See Section 8.6.4	Minor

8.7. CULTURAL HERITAGE

"Cultural heritage" is an umbrella term for many heritage-related resources defined by international organizations as well as national laws and regulations. Guyana's National Trust Act of 1972 protects national monuments, defined as resources of "historic, architectural or archaeological interest attaching to it or its national importance." According to this law, the National Trust of Guyana is responsible for declaring resources to be national monuments.

Cultural heritage can be both tangible and intangible (e.g., oral histories), and tangible cultural heritage can be both portable (i.e., objects) and non-portable (i.e., sites). Non-portable, tangible cultural heritage, the type typically most susceptible to impacts from development projects, can be further subdivided into archaeological, architectural, and living heritage sites. Archaeological sites are areas where human activity has measurably altered the earth or deposits of physical remains are found (e.g., artifacts). Archaeological sites can be prehistoric or historic, and can be underwater or terrestrial. Architectural sites include standing buildings, bridges, dams, and other structures of historic or aesthetic significance. Living heritage consists of resources of traditional, religious, or cultural significance. Living heritage sites can include archaeological resources, sacred sites, sacred structures, and prominent topographical features essential for the preservation of traditional cultures.

8.7.1. Administrative Framework—Cultural Heritage

Table 8.7-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Cultural Heritage

Title	Objective	Relevance to the Project
Legislation		
National Trust Act (1972) Cap. 20:03.	Stewardship of historic resources and places of cultural significance.	Governs the management of any building, structure, object, or other manmade or natural feature that is of historic or national cultural significance that could be impacted by the Project. Includes shipwrecks and other marine features. Would only apply to the Project in the event of a chance find, in which case the act would require EEPGL to work cooperatively with the National Trust of Guyana to manage any resources discovered.
Maritime Zones Act (2010) Cap. 63:01.	Incorporates certain provisions of the United Nations Convention on the Law of the Sea and the United Nations Educational, Scientific and Cultural Organization (UNESCO) Convention on the Protection of the Underwater Cultural Heritage, to provide for marine scientific research, maritime cultural area, eco-tourism, marine parks and reserves, the	Relevant to the Project as it makes provisions for passage in the territorial sea, and the discharge of harmful substances and hazardous waste. In addition, relevant when specific maritime zones are established for the protection and preservation of the marine environment and also for mariculture

Title	Objective	Relevance to the Project
	protection and preservation of the marine environment and for related matters.	activities, for which one project is currently being pursued by others.
International Agreements Signed/Acceded by Guyana		
United Nations Educational, Scientific and Cultural Organization Convention Concerning the Protection of the World Cultural and Natural Heritage (1972)	Created the UNESCO list of World Heritage Sites.	Would only apply if the Project had the potential to impact a World Heritage Site (it does not).
United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage (2001)	Protects “all traces of human existence having a cultural, historical, or archaeological character” that have been underwater for over 100 years.	Would apply to any shipwrecks or other submerged cultural heritage in the Project AOI. Guyana ratified in 2014.

8.7.2. Existing Conditions—Cultural Heritage

8.7.2.1. Underwater Cultural Heritage

Prior to EEPGL’s interest in the Stabroek Block, no previous cultural surveys had been undertaken within the vicinity of the PDA. In 2016, EEPGL retained Fugro Marine Geoservices, Inc. (Fugro) to conduct a geophysical and remote sensing survey of the seafloor within the Liza Field. In 2018, EEPGL retained Fugro to conduct a similar survey of the seafloor within the Payara Field (Fugro 2019). The 2018 survey encompassed the Payara Subsea PDA and the data from the survey are therefore relevant for the purpose of the Project. The objective of the study was to identify the occurrence of any potential cultural resources that may impact, or be impacted by, the design and placement of planned subsea equipment within the survey area. Submerged archaeological sites are not expected in waters deeper than approximately 125 meters (approximately 410 feet), which was the approximate sea level during the Last Glacial Maximum (20,000 years before present). Since all Project components with the potential to disturb the seafloor will be deeper than approximately 125 meters (approximately 410 feet), the only cultural resources with a reasonable potential to be present in the Project area are human-made objects that have sunk, most notably shipwrecks.

Remote sensing surveys employ various instruments that use high and/or low frequency sound waves to collect information from the seafloor. The 2018 Fugro survey used several of these including the following:

- Multi-beam echo sounders, which collect bathymetric data via a wide band of high-frequency sound waves and can detect abnormal shapes (which could potentially include objects of cultural interest) against the surrounding landscape (autonomous underwater vehicle [AUV]-mounted was used);
- Side-scan sonars (SSS), which employ high frequency sound waves to collect textural data from the seafloor and provide high resolution images of objects on the seafloor surface (AUV-mounted was used); and

- Sub-bottom profilers, which collect data on subsurface sediments and objects located beneath the seafloor via low frequency sound waves and are capable of locating buried shipwrecks beneath the seafloor surface (AUV-mounted was used).

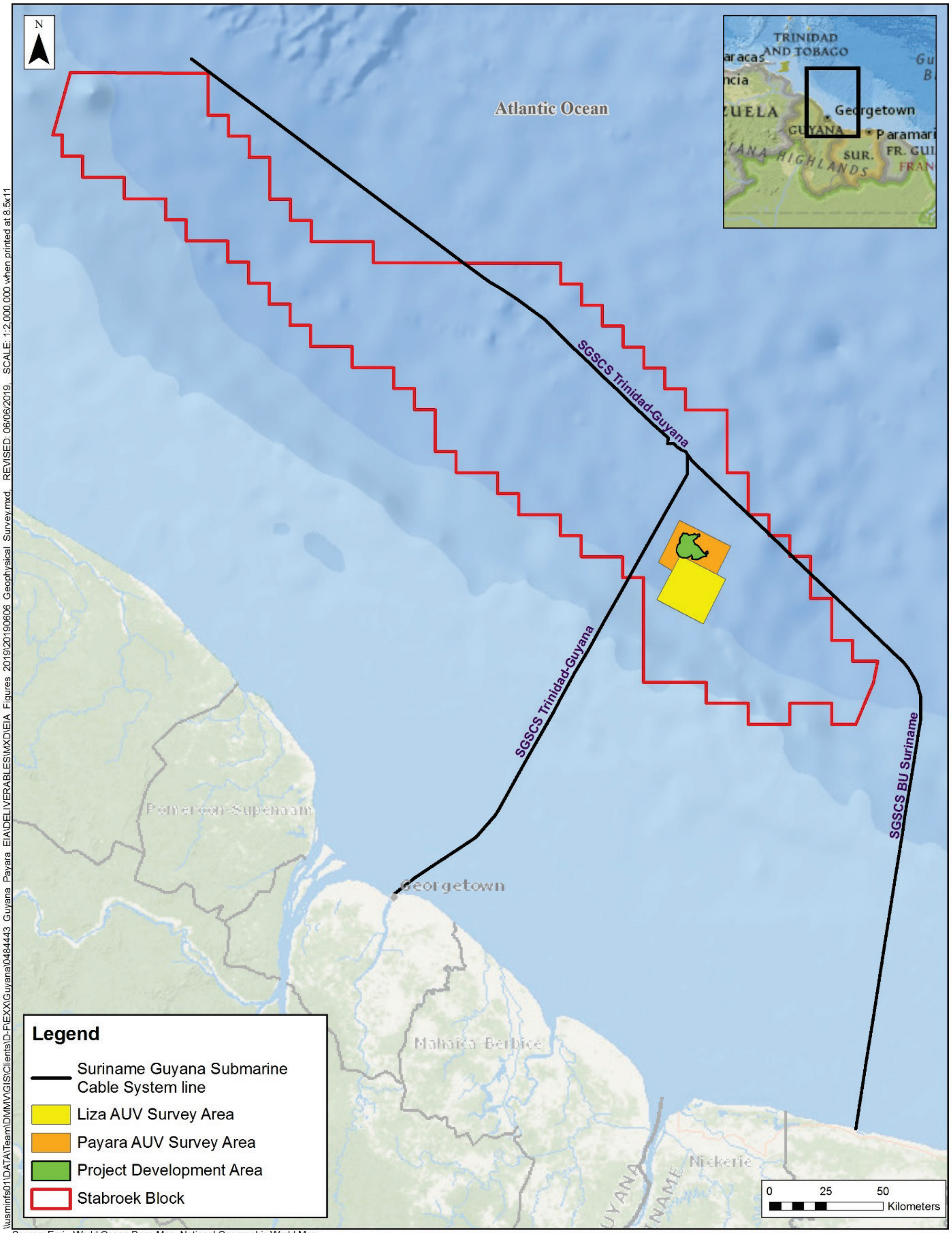
The model types of the remote sensing instruments used and the settings employed for each instrument are provided in Table 8.7-2. The AUV survey was conducted in the Payara PDA, which is located approximately 207 kilometers (128 miles) northeast of the coastline of Georgetown, on the continental slope, and directly north of the Liza Development areas. The AUV survey coverage was approximately 400 square kilometers (km^2) (98,842 acres) in extent. The survey area is shown on Figure 8.7-1 (see area labeled as the "Payara AUV Survey Area"; the prior Liza field survey is shown as the area labeled "Liza AUV Survey Area").

Table 8.7-2: Remote Sensing Instruments and Survey Settings

Type of Instrument	Model	Survey Settings	Hull- or AUV-Mounted	Survey Areas in which Equipment was Used
Multi-beam echo sounders	Kongsberg EM2040 bathymetric system	Frequency of 200 kHz swath coverage of 150 degrees Frequency of 400 kHz for the camera investigation	AUV-mounted	• Payara AUV Survey Area
SSS	EdgeTech model 2205 full-spectrum system	Dual frequencies of 240 kHz and 540 kHz Dual frequencies of 540 kHz and 1600 kHz for the camera investigation	AUV-mounted	• Payara AUV Survey Area
Sub-bottom profilers	EdgeTech model DW-106 full spectrum system	Frequency range of 1 kHz to 10 kHz	AUV-mounted	• Payara AUV Survey Area
	EdgeTech 3300 full spectrum system	Frequency range of 1 kHz to 10 kHz	AUV-mounted	• Payara AUV Survey Area
Underwater Digital Camera	Prosilica Allied Vision GE4000	35-millimeter digital imagery, approximately 6 meters (approximately 20 feet) above seafloor	AUV-mounted	• As needed for ground-truthing in survey areas

kHz = kilohertz

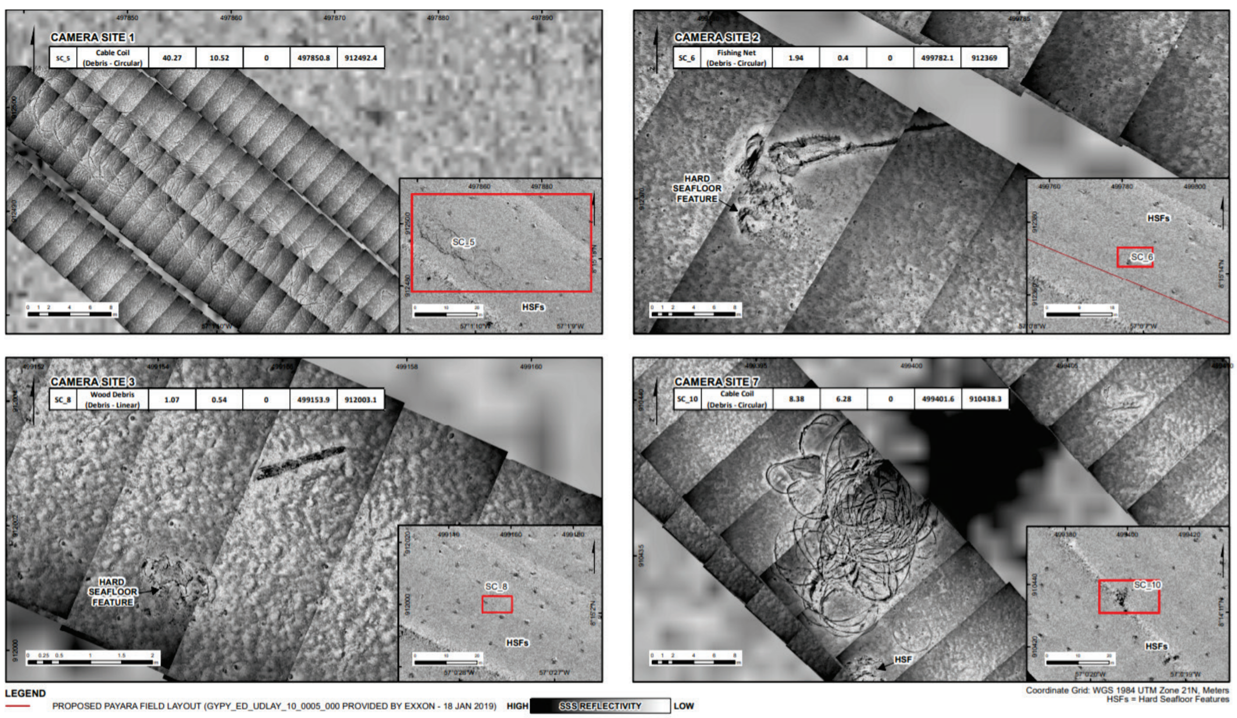
The Consultants assessed Fugro's remote sensing survey methodology, including the remote sensing equipment and instrument settings employed and the results produced, according to internationally recognized standards. The Consultants found that the methods used by Fugro and the results yielded by their survey are sufficient to provide existing cultural heritage data for the area of potential impact, as the methodology and quality of data produced met the guidelines and requirements for nearshore and offshore remote sensing cultural surveys as defined by the U.S. Bureau of Ocean Energy Management and Historic England. Together, these guidelines help frame "internationally recognized practices" for remote sensing surveys designed to locate and assess cultural heritage (BOEM 2017; Historic England 2013).



Source: Fugro 2019

Figure 8.7-1: Payara Geophysical Surveys in the Stabroek Block

Within the Payara AUV Survey Area, the low-frequency and high-frequency SSS survey identified 21 sonar contacts. These were assessed further as potential marine hazards and/or cultural resources. After reviewing the SSS imagery and data collected, the Consultants concluded that the 21 SSS contacts are likely to be anthropogenic debris, fishing nets, chain or cable coils, or geological features of no significant cultural value. Photographs of four of these contacts revealed discarded cable, a discarded fishing net, and wooden debris, as shown in Figure 8.7-2. No sonar contacts appear to be archaeologically significant. Note the presence of a feature labeled as "Hard Seafloor Feature." These features are biological in nature and were identified in multiple locations across the Payara AUV Survey Area, and are discussed in Section 6.3, Marine Geology and Sediments.



Source: Fugro 2019

Figure 8.7-2: AUV Photographs Showing Debris with High Resolution SSS Insets

In the prior survey of the Liza AUV Survey Area, an unidentified subsea cable was mapped across the Liza AUV Survey Area. The portions of discarded cable found in the Payara AUV Survey Area appear to be of similar age and to have the same diameter as the subsea cable that crosses the Liza Development area. With respect to cultural heritage, the subsea cable does not have any cultural significance.

8.7.2.2. Coastal Cultural Heritage

Data obtained from the National Trust of Guyana indicate that there are approximately 136 heritage sites in Georgetown comprising monuments, public buildings, schools, gardens, places of worship, and markets among others (EMC Personal Communication 6). There are several archaeological sites along the Guyana coast, including shell mounds, seashell deposits, quarries, pollen sections, tool/implements, and ceramic/pottery sites (i.e., scatters) as shown in Table 8.7-3 (EMC Personal Communication 6). These sites are of significant cultural value to both the people of Guyana and researchers, as they offer insight into the material culture of native peoples inhabiting the land before, during, and after contact with Europeans. However, only two of the ceramic/pottery sites on the maps are shown to be located near the shoreline.

Table 8.7-3: Archaeological Sites on the Guyana Coast

Region	Number of Sites	Type of Sites
1	68	Shell Mounds, Seashell Deposits, Ceramics, Tools/Implements, Quarries
2	12	Shell Mounds, Ceramics
3	5	Ceramics
4	17	Ceramics, Shell Mounds, Pollen Sections
5	13	Ceramics
6	21	Ceramics, Pollen Sections, Petroglyphs

As part of the late 2017 and early 2018 Ecosystem Services engagement fieldwork by the Consultants, coastal communities from Regions 1 to 6 were engaged about known archeological sites as well as any locations of cultural significance to each community (e.g., Hindu prayer flag locations, burial and cremation sites). In addition, in the Amerindian coastal communities in Regions 1 and 2, community members were asked about intangible forms of culture heritage along the coast (e.g., cultural knowledge, innovations, and practices of embodying traditional lifestyles). In addition, data obtained from the National Trust of Guyana includes information regarding archaeological sites in the Amerindian coastal communities in Regions 1 and 2. The information on cultural heritage related to this engagement are discussed in Section 8.9.2, Ecosystem Services—Existing Conditions.

8.7.3. Impact Assessment—Cultural Heritage

8.7.3.1. Relevant Project Activities

Planned Project drilling and FPSO/SURF installation activities that have the potential to adversely impact cultural heritage located on or beneath the seafloor include the drilling of development wells, the installation of FPSO anchoring structures, and the installation of SURF components.

Planned Project activities do not require ground-disturbance in onshore areas that have not already been disturbed by prior development. Onshore logistical support will involve use of Guyana port facilities, warehouses, pipe yards, and waste management facilities (e.g., landfills). Use of these non-Project dedicated facilities will not impact any archaeological sites, as these lands have already been disturbed and therefore are unlikely to contain intact archaeological sites.

According to personnel from the National Trust of Guyana, they anticipate that the burgeoning oil and gas sector may eventually require an expansion of the built environment in Georgetown. This is likely to bring about changes in the heritage sites located in Georgetown and may result in a loss of heritage including intangible aspects of heritage such as craftsmanship and connection to national identity. Consequently, if this should occur, the current system for managing preservation of historic heritage sites will have to be reconsidered to balance the expansion of the built environment with the protection of heritage sites (ERM/EMC Personal Communication 3). However, any construction/expansion of onshore facilities by others which could potentially disturb new onshore areas will be performed by the owners/operators of such facilities under separate approvals, and are thus outside of the scope of this EIA. In summary, planned Project activities will not impact any terrestrial cultural heritage resources, and the impact assessment in this section thus focuses on potential impacts on marine cultural heritage. Potential impacts on terrestrial (coastal) cultural heritage resources from unplanned events (i.e., an oil spill) are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Table 8.7-4 summarizes the Project stages and activities that could result in potential Project impacts on marine cultural heritage.

Table 8.7-4: Summary of Relevant Project Activities and Potential Key Impacts—Cultural Heritage

Stage	Project Activity	Key Potential Impact
Development Well Drilling	Drilling of development wells	Damage to shipwrecks or submerged archaeological sites (if present)
FPSO and SURF Mobilization, Installation, and Hook-up	Installation of FPSO anchoring structures	
	Installation of SURF components	

8.7.3.2. Magnitude of Impact—Cultural Heritage

The assessment of the Project's magnitude of potential impacts on cultural heritage in the Project AOI is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on cultural heritage is defined according to the definitions provided in Table 8.7-5. The following paragraphs discuss the characteristics of each of the potential impacts assessed and the resultant magnitude ratings. These are summarized in Table 8.7-6.

Table 8.7-5: Definitions for Intensity Ratings for Potential Impacts on Cultural Heritage

Criterion	Definition
Intensity	Negligible: No discernible change in the physical condition, setting, or accessibility of sites.
	Low: A small part of a site is lost or damaged, resulting in a loss of scientific or cultural value; setting undergoes temporary or permanent change that has limited impact on the site's perceived value to stakeholders; stakeholder/public or scientific access to the site is temporarily impeded.
	Medium: A significant portion of a site is lost or damaged, resulting in a loss of scientific value; setting undergoes permanent change that permanently diminishes the site's perceived value to stakeholders; site become inaccessible for the life of the Project (at least 20 years) to stakeholders, including traditional users or researchers.
	High: Entire site is damaged or lost, resulting in a nearly complete or complete loss of scientific or cultural value; setting is sufficiently impacted to cause the site to lose all, or nearly all, cultural value or functionality; site becomes permanently inaccessible to stakeholders, including traditional users or researchers.

Marine Cultural Heritage Resources

Based on the 2018 geophysical survey described above, there are no identified underwater cultural heritage features that will be impacted by the Project. However, previously unrecorded cultural remains, or "chance finds," could be encountered and impacted during Project drilling and installation activities. Underwater chance finds could include shipwrecks and associated artifact scatters that were not identified during the geophysical survey. It is conservatively assumed that the intensity of impact on a previously unidentified cultural resource could be as high as **Medium** if seabed-disturbing activities took place in the location of such a resource. If this were to occur, and depending upon the Project stage, the Project would most likely relocate the FPSO anchoring, SURF components, or precise drilling location (up to a few meters) to the extent practicable.

Considering the information presented above, potential impacts related to marine cultural heritage resources, if any, would be limited to the **Direct AOI**. If the resource could not be avoided, any disturbance to marine cultural heritage as a result of Project activities would have a **Long-term** duration. The frequency would be only occasional (if ever), yielding a frequency designation of **Episodic**. This yields a magnitude rating of **Small** for potential impacts on marine cultural heritage resources.

Table 8.7-6: Magnitude of Impact—Marine Cultural Heritage Resources

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
Development Well Drilling SURF/FPSO Mobilization, Installation, and Hook-up	Marine cultural heritage—damage from Project activities disturbing the seabed	Direct AOI	Medium	Episodic	Long-term	Small
	Marine cultural heritage—damage from Project activities disturbing the seabed	Direct AOI	Medium	Episodic	Long-term	Small

8.7.3.3. Sensitivity/Importance of Resource

The resource sensitivity/importance ratings for cultural heritage are defined in Table 8.7-7.

Table 8.7-7: Definitions for Sensitivity/Importance Ratings for Potential Impacts on Cultural Heritage

Criterion	Definition
Sensitivity	Low: Site is not specifically protected under local, national, or international laws or treaties; site can be moved to another location or replaced by a similar site, or is of a type that is common in surrounding region; site has limited or no cultural value to local, national, or international stakeholders; and/or site has limited scientific value or similar information can be obtained at numerous sites.
	Medium: Site is specifically or generally protected by local or national laws, but laws allow for mitigated impacts; site can be moved or replaced, or data and artifacts recovered in consultation with stakeholders; site has considerable cultural value for local and/or national stakeholders; and/or site has substantial scientific value but similar information can be obtained at a limited number of other sites.
	High: Site is protected by local, national, and international laws or treaties; site cannot be moved or replaced without major loss of cultural value; legal status specifically prohibits direct impacts or encroachment on site and/or protection zone; site has substantial value to local, national, and international stakeholders; and/or site has exceptional scientific value and similar site types are rare or non-existent.

Depending on the nature of the specific resources encountered, shipwrecks and/or submerged archaeological sites could be specifically protected by national laws such as Guyana's National Trust Act of 1972, or international conventions such as the 2001 United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage and could possess research and cultural value. For the purpose of this assessment, it was assumed that an as-of-yet unidentified cultural resource could have a sensitivity rating as high as **Medium**.

8.7.3.4. Impact Significance

Based on the magnitude of impact and the receptor sensitivity ratings, the significance of potential cultural resource impacts during the Drilling or FPSO/SURF Installation stages is rated as **Minor**.

8.7.4. Mitigation Measures—Cultural Heritage

As discussed in Section 8.7.2, Existing Conditions—Cultural Heritage, the planned seabed disturbance area for the Project has been subjected to a geophysical survey to assess the presence of any marine cultural heritage. After reviewing the survey data collected, the Consultants concluded that no resources of significant cultural value appear to be present within the planned seabed disturbance area. This has increased the level of certainty that planned Project activities will not disturb significant cultural heritage.

Nevertheless, as part of the ESMP developed in conjunction with the EIA, EEPGL will adopt a Chance Finds Procedure (approved by National Trust of Guyana; ERM/EMC Personal Communication 1), which requires temporary cessation of Project activities in the event of a chance find of a cultural heritage resource, assessment of the chance find by a cultural heritage specialist, and development of a treatment plan for significant chance finds in consultation with the National Trust of Guyana and other cultural heritage stakeholders, as appropriate. The Chance Finds Procedure also addresses monitoring and training requirements.

Considering the implementation of the measures outlined in the Chance Finds Procedure, the magnitude of the impact would be expected to be reduced to **Negligible**, as activities would be adjusted/curtailed upon discovery of a previously unidentified cultural resource. This would reduce the residual impact significance rating to **Negligible**.

Table 8.7-8 summarizes the mitigation and monitoring measures relevant to this receptor.

Table 8.7-8: List of Mitigation and Monitoring Measures

Mitigation Measures
Adopt and implement as needed a Chance Find Procedure that describes the requirements in the event of a potential chance find of heritage or cultural resources.
Monitoring Measures
Monitor frequency of engagement with stakeholders, including fisherfolk, coastal communities, vulnerable groups, and Indigenous populations.

Table 8.7-9 summarizes the assessment of potential pre-mitigation and residual Project impacts on cultural heritage. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the cultural heritage-specific methodology described in Sections 8.7.3.1 and 8.7.3.2.

Table 8.7-9: Summary of Pre-Mitigation and Residual Impacts—Cultural Heritage

Stage	Resource/Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling	Marine cultural heritage—damage from Project activities disturbing the seabed	Low	Medium	Minor	Implement Chance Finds Procedure as needed	Negligible
FPSO and SURF Mobilization, Installation, and Hook-up	Marine cultural heritage—damage from Project activities disturbing the seabed	Low	Medium	Minor	Implement Chance Finds Procedure as needed	Negligible

8.8. LAND USE

8.8.1. Administrative Framework—Land Use

Table 8.8-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on land use.

Table 8.8-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Land Use

Title	Objective	Relevance to the Project
Legislation		
Town and Country Planning Act (1996) Cap. 20:01.	Provides for the orderly and progressive development of urban and rural lands and the preservation and improvement of amenities pertaining to such development. Development under the act is restricted to buildings and infrastructure works incidental to buildings.	Would be relevant if the Project builds commercial, industrial, or residential structures. It would also be relevant for the land use clearance process (within the building permit process) within the Central Housing and Planning Authority.
Guyana Lands and Surveys Commission Act (1999)	Establishes a Guyana Lands and Surveys Commission to have charge of and act as guardian over all public lands, rivers and creeks of Guyana. Its mandate includes land administration, surveys, land information systems, land use policy, and land use planning.	Would be relevant to the Project if future leasing of sub-sea surfaces is required, as act defines land as “land covered by water and the seabed within the outer limits of the territorial waters of Guyana.”
State Lands Act	Provides for the regulation of state land, rivers, and creeks. It also provides for regulations prescribing fees, royalties, and rents.	Would be relevant if the Project constructs additional onshore facilities on state lands.
Policies		
National Land Policy (being developed)	Intended to serve as a guide for sustainable and equitable use of land for development by assisting in the management of both public and private lands under the purview of the Guyana Lands and Surveys Commission.	Will likely not be directly relevant to the Project as it is still in draft and also does not cover the marine environment.

8.8.2. Existing Conditions—Land Use

Guyana is bordered by Suriname to the east, Venezuela to the west, and Brazil to the southwest. Its 215,000 square kilometers (km^2) (83,012 square miles [mi^2]) of territory can be broadly divided into four regions:

- The coastal plain stretches 440 kilometers (273 miles) from the Corentyne River in the east to Waini Point in the west and ranges from approximately 5 to 65 kilometers (approximately 3 to 40 miles) wide along the coast. It accounts for less than 8 percent of the country’s land area and is approximately 1.4 meters (4.6 feet) below mean high tide level.

- The hilly sand region is a largely vegetated zone dominated by white, sandy soils and undulating terrain lying inland from the coastal zone. This zone ranges from approximately 150 to 250 kilometers (approximately 93 to 155 miles) wide, is largely forested, and contains most of the country's mineral deposits.
- The interior highlands, extending from the hilly sand region to the country's southern borders, is part of the pre-Cambrian Guiana Shield, and also contains mineral deposits. This zone makes up the largest land area in the country.
- The interior savannas consist of two main savanna complexes: the Rupununi Savannas and the Intermediate Savannas. The Rupununi Savannas cover 15,540 km^2 (6,000 mi^2) and lie in the southwestern part of the country. The Intermediate Savannas cover over 5,180 km^2 (2,000 mi^2) and lie 97 kilometers (60 miles) from the mouth of the Berbice River.

As described above, Guyana is a sparsely populated country, with the majority of the population and physical developments concentrated in the coastal plain region. This region has two wet and two dry seasons, and as a result is the main agricultural region of the country. This region is below sea level and is vulnerable to both inundation from the sea as well as intense rainfall runoff. The coastal areas are protected by mangrove forests and manmade concrete and earthen dykes.

In 2012, the area considered as agricultural lands in Guyana was 1,678,000 hectares (4,146,000 acres), with the cultivated area estimated at 448,000 hectares (1,107,000 acres). Most of the cultivated land is also concentrated in the coastal plain, where the majority of the population resides (FAO 2015).

Figure 8.8-1 shows land use patterns on the coastal and hilly sand areas. In the coastal plain areas, agriculture is dominant in Regions 2, 3, 4, 5, and 6 and occurs to a lesser extent in Region 1. The main crops are sugar, rice, and coconut plantations, interspersed with smaller-scale establishments of cash crops, non-traditional crops, and livestock. In the hilly sand region, the predominant land use is forestry and mining.

The SBPA is a notable feature in the coastal area of Region 1. It was designated a Protected Area with the passage of the Protected Areas Act of 2011, and is the only Protected Area on Guyana's coast. In addition, the Forests Act of 2009 protects mangrove forests along the coastline and in inland areas. More information on the SBPA and coastal mangrove forests is provided in Section 7.2.2, Existing Conditions—Coastal Habitats.

According to the Guyana Lands and Surveys Commission (GLSC), the oil and gas sector has directly influenced demand for land and has increased the value of land, specifically in Region 4. GLSC representatives claim that since the first discovery of oil was announced in 2015, demand from local and international investors for private and public lands has increased in Region 4, and with every new discovery, there are increased expressions of interest from international investors for public land. The GLSC is considering expanding the state land area available for lease; however, there is limited available land suitable for this purpose. Demand for state land outside Region 4 has also increased but not as dramatically (ERM/EMC Personal Communication 9).

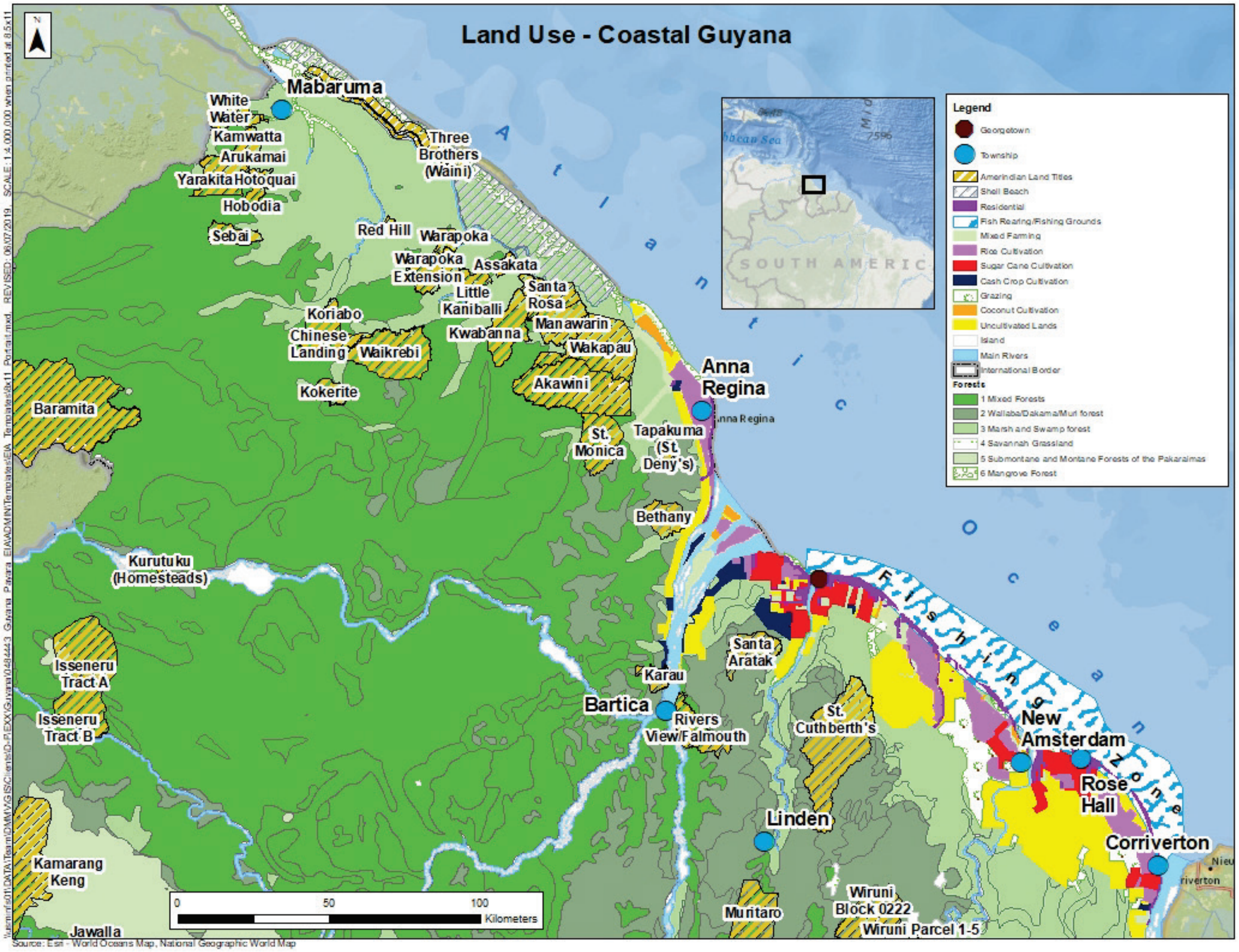


Figure 8.8-1: Land Use and Land Cover in Coastal Guyana

Several stakeholders also shared their expectation that current land uses in Region 4 are likely to change as the oil and gas sector continues to develop. The potential socioeconomic benefits of the oil and gas sector will increase demand for housing and more state lands are likely to be allocated as residential areas. It is also expected that agricultural lands may be converted to residential or commercial uses in coastal regions. Personnel from the GLSC also highlighted the importance of integrated land use planning involving the collaboration of various government agencies to forecast how demand for land is likely to evolve as a result of the oil and gas sector, and to facilitate informed decision making on leasing land. Guyana has a National Land Use Plan (GLSC 2013) that guides the GLSC in land management and administration. The GLSC is intending to revise this plan to include oil and gas sector considerations and is currently implementing a *Mainstreaming Sustainable Land Development and Management* project (FAO and GLSC 2017), which will strengthen institutional and human capacities for participatory and integrated land use planning (ERM/EMC Personal Communications 7 and 9).

8.8.2.1. Land Ownership

There are three types of land tenure in Guyana: public land, private land, and Amerindian land. Public land includes state land and government land (land owned by individual government entities). Public land accounts for approximately 85 percent of all land; Amerindian land held under communal title accounts for approximately 14 percent; and only approximately 1 to 2 percent of land is privately held. Amerindian lands are owned collectively and are not subject to transfer or sale.

On the coastal plain, most of the cultivated lands are held as sugar estates under the Guyana Sugar Corporation or as rice plots. The sugar lands consist of both freehold (lands owned privately) and leasehold (lands leased by the state) tenure. Most rice lands under 6 hectares (15 acres) have been converted to freehold tenure, while the larger plots are under leasehold, administered by the GLSC or other designated authorities. With the forest and mineral resources owned by the state, tenure in these sectors are in the form of limited term concessions from the Guyana Forestry Commission and the Guyana Geology and Mines Commission, respectively.

Leases of government-owned lands are issued by the GLSC or other designated authorities. Freehold titles are recorded by two separate agencies: the Deeds and Commercial Registries Authority and the Land Registry. The Deeds and Commercial Registries Authority is responsible for administering the laws enacted by Parliament affecting land. The Land Registry was established to simplify land registration and provide security of tenure to owners of titled public lands. According to a study of the land registration system in Guyana conducted by the IDB, the country’s dual property registration systems (title registration and deed registration) have regulations that overlap and conflict, and are considered complex and bureaucratic. The systems are also considered ineffective in managing and enforcing rights. As a result, a large number of land owners do not register their properties or do not keep their ownership rights up to date (IDB 2010). However, in recent years, the capacities of the Deeds and Commercial Registries Authority and Land Registry have improved to enable better execution of their legal mandates. In addition, the GLSC is continuously working to regulate land to provide security of tenure on public lands.

Land ownership in Guyana, particularly in hinterland regions, is guided by the government's policy on multiple uses of land, which seeks to harmonize surface and sub-surface uses of land. In 2013, approximately 95 percent of all mining leases were within the state forest estate and on lands that have been leased by the Guyana Forestry Commission. Under a policy of multiple uses of land, lessees who have surface rights are given priority access to the land.

8.8.3. Impact Assessment—Land Use

This section assesses potential Project impacts on land use and ownership. The key potential impacts considered are conversion of land from one use to another and change of land ownership type. Potential impacts on housing and accommodation demand as a direct result of the Project are covered in Section 8.5, Social Infrastructure and Services.

8.8.3.1. Relevant Project Activities and Potential Impacts

The majority of Project activities will occur offshore. Most of the major SURF equipment will be preassembled, pretested, and shipped directly to the Payara PDA from their points of origin. Other minor equipment, supplies, and materials may be temporarily staged at shorebases, laydown yards, and warehouses until transferred offshore for installation or use. Onshore facilities will not be owned or operated by EEPGL, and they will not be dedicated to the Project. If the owners/operators of such facilities find it necessary to expand the existing sites onto adjacent land or in separate, new areas, potential land use impacts associated with these expansions will be addressed by the owners/operators of such facilities, and would be out of the scope of this EIA. EEPGL's new office facility, to be located at Ogle in Region 4, will be covered under separate environmental authorization. There are no other known Project-specific demands for land, including for housing.

Table 8.8-2 summarizes the Project stages and activities that could result in potential Project impacts on land use, as well as the receptors that could potentially experience these impacts.

Table 8.8-2: Summary of Relevant Project Activities and Key Potential Impacts—Land Use

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project stages	Current owner(s) and/or user(s) of land in Georgetown	Use of land for onshore Project-related activities	Conversion of land from other use(s) Change of land ownership

8.8.3.2. Magnitude of Impact—Land Use

The assessment of the Project's magnitude of potential impacts on land use is based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on land use is defined in Table 8.8-3.

Table 8.8-3: Definitions for Intensity Ratings for Potential Impacts on Land Use

Criterion	Definition
Intensity	Negligible: No noticeable change in land use type or ownership type.
	Low: Land use change occurs for one or multiple parcels, but consists of change to a land use type similar to the current use (e.g., change from one type of agricultural activity to another or from industrial to commercial). No changes occur in ownership type (government-owned, Amerindian-owned or privately owned).
	Medium: Land use changes occur for multiple land parcels or tracts and may consist of profound changes (e.g., clearing of forest or other vegetation, loss of residential units). Changes to ownership type (government-owned, Amerindian-owned or privately owned) do not occur.
	High: Land use changes occur for large areas of land and may consist of profound changes (e.g., clearing of forest or other vegetation, loss of residential units). Changes may occur to ownership type.

The Project will require the use of onshore storage facilities and laydown areas for Project materials (e.g., drilling fluid, pipe joints). At this time, EEPGL plans to use the existing Guyana shorebases to support the Project but does not plan to occupy any facilities in a dedicated manner, so all shorebases that support the Project should remain capable of concurrently supporting other clients. Other potential storage facility locations are not known, but it is expected that any such facility will be located as near to the existing shorebases as reasonably practicable to minimize transit time between facilities. Although EEPGL is planning to use an existing waste management facility in Georgetown (permitted by EPA), alternative Guyanese or regional waste management services may also be considered in the future. No land use changes are planned as a part of the Project. While there may be some induced land use changes in the **Direct AOI** associated with other proponents converting land use to serve the needs of the Project (and other emerging oil and gas operators), the level of such conversion is expected to be limited to isolated instances, yielding an intensity of **Negligible**. Such induced land use changes would persist on a **Long-term** basis, but would be **Episodic** in nature. Considering these characteristics, the magnitude of potential (induced) impacts is rated as **Negligible** (see Table 8.8-4).

Table 8.8-4: Magnitude of Impact—Land Use

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude
All Project stages	Current owner(s) and/or user(s) of land in Georgetown—land conversion or change in land use	Direct AOI (Georgetown)	Negligible	Continuous	Long term	Negligible

8.8.3.3. Sensitivity of Receptors—Land Use

If the Project was intending to convert land use or change land ownership, receptors for this potential impact would be the current owner(s) of the land to be used for onshore Project-related activities, as well as the user(s) or beneficiaries of that land, if any. In this case, the receptor sensitivity ratings for land use would be determined as defined in Table 8.8-5.

Table 8.8-5: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Land Use

Criterion	Definition
Sensitivity	Low: Receptor(s) do not currently reside on the land or make use of it for subsistence or primary livelihood activities, or recreation.
	Medium: Receptor(s) do not currently reside on the land or make use of it for subsistence but may rely on it for income generation or recreation.
	High: Receptor(s) currently reside on the land and/or use it for subsistence, or for their primary/sole means of livelihood.

At this time, EEPGL does not intend to convert land use or change land ownership as part of the Project. In any case, it is likely that land use changes induced by the Project (or other emerging proponents') activities would affect properties in areas already associated with industrial or commercial use. On this basis, the sensitivity of receptors associated with any land use conversions is rated as **Low**.

8.8.3.4. Impact Significance—Land Use

Based on the magnitude of potential impact (irrespective of a potential receptor sensitivity rating), the significance of potential land use impacts is rated as **Negligible**.

8.8.4. Mitigation Measures—Land Use

Table 8.8-6 summarizes the assessment of potential pre-mitigation and residual Project impacts on land use. The significance of potential impacts was assessed based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the EIA, as well as the land use-specific methodology described in Section 8.8.3.2.

Table 8.8-6: Summary of Potential Pre-Mitigation and Residual Impacts—Land Use

Stage	Resource/ Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Current owner(s) or user(s) of land – conversion of land use or change in land ownership	Negligible	Low	Negligible	None	Negligible

8.9. ECOSYSTEM SERVICES

Ecosystem services are typically defined as the benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities, and provide cultural fulfilment. Ecosystem services are divided into provisioning, regulating, cultural, and supporting services, as defined below (Millennium Ecosystem Assessment 2005):

- **Provisioning services**: goods or products obtained from ecosystems such as food, fresh water, timber, fiber, and other goods;
- **Regulating services**: benefits obtained from an ecosystem's control of natural processes such as climate, water flow, disease regulation, pollination, and protection from natural hazards;
- **Cultural services**: non-material benefits obtained from ecosystems such as recreation, spiritual values, and aesthetic enjoyment; and
- **Supporting services**: natural processes such as erosion control, soil formation, nutrient cycling, and primary productivity that maintain other services.

The implementation of the ecosystem services approach played an important role in guiding other sections of the EIA. The ecosystem services screening process informed the services and types of information the Consultants incorporated into the other existing conditions and impact assessment studies and sections (e.g., coastal habitats, employment, and livelihoods).

8.9.1. Administrative Framework—Ecosystem Services

Table 8.9-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on ecosystem services.

Table 8.9-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Ecosystem Services

Title	Objective	Relevance to the Project
Legislation		
Forests Act (2009) Act. No. 6 of 2009	Consolidates the law relating to forests and makes provisions for sustainable forest management and forest conservation.	Covers mangroves, which are classified as a forest type and subject to protection measures under the act. Mangrove ecosystem makes up a significant portion of Guyana's coastal zone, and could potentially be affected in the unlikely event of an oil spill event which reaches the shore.
Sea Defence Act (1933)	Makes provisions for the construction, maintenance, and protection of sea defenses, which includes manmade structures as well as natural defenses.	Covers the protection of mangroves, including fines and penalties for the unpermitted destruction of mangroves. Relevant to the Project in the unlikely event of an oil spill reaching the shore and causing mangrove damage.

Title	Objective	Relevance to the Project
Protected Areas Act (2011)	Provides for the protection and conservation of Guyana's natural heritage and natural capital by the creation, management, and financing of a national system of protected areas; the maintenance of ecosystem services of national and global importance, including of climate regulation; the establishment of a protected areas commission; the establishment and management of a protected areas trust fund; and the fulfilment of Guyana's international environmental responsibilities.	Under this act, terrestrial and marine protected areas could be established. However, currently there are no known initiatives towards setting up marine protected areas.
Environmental Protection Act (1996)	Provides for the management, conservation, protection, and improvement of the environment; the prevention or control of pollution; the assessment of the impact of economic development on the environment; and the sustainable use of natural resources.	As part of its mandate, in addition to environmental permitting, the EPA also has the responsibility of coordinating Integrated Coastal Zone Management (ICZM) and implementing the ICZM Action Plan, which has provisions for shorezone monitoring, mangrove management, aerial photography, etc. Data from the Project EIA, such as the ecosystem services-related information, could support the enhancement of the ICZM Action Plan.
International Agreements Signed/Acceded by Guyana		
Bilateral Agreement between Guyana and the Kingdom of Norway (2009)	Supports Guyana's efforts at moving towards a low-carbon, climate-resilient economy by establishing a mechanism for payment for forest climate services, whereby Guyana receives performance-based payments for avoided deforestation.	Has no direct relevance to the Project since the agreement does not place a cap on Guyana's development aspirations or the extraction and/or use of fossil fuel resources.
United Nations Convention on Biological Diversity (1992)	Objectives are the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the use of genetic resources, including appropriate access to genetic resources and appropriate transfer of relevant technologies, considering all rights over those resources and technologies, and by appropriate funding.	In fulfilling obligations under this convention, Guyana has enacted Protected Areas legislation and established a National System of Protected Areas, which includes the SBPA. Under normal circumstances and operations, the Project will not have any impacts on Guyana's protected areas. However, in the unlikely event of an oil spill that reaches the shores of Guyana, the SBPA could be affected. One of the requirements is the setting up of marine protected areas. However, at this time there is no decision to proceed in this direction.

8.9.2. Existing Conditions—Ecosystem Services

A field team consisting of socioeconomic and biodiversity experts conducted an Ecosystem Services Screening, Scoping, and Assessment exercise involving all 63 coastal NDCs, CDCs, VCs, and TCs in Regions 1 through 6 (see Section 8.1.2.1, Administrative Divisions in Guyana, for a list of the NDCs, CDCs, VCs, and TCs). The purpose of the exercise was to identify the ecosystem services that are potentially present along the coastline and shore zones in Regions 1 to 6 using Community-based Participatory Research and traditional knowledge. The team interviewed more than 500 community leaders and members about the relationship between people and the environment along the shore zones, and about the locations of specific ecosystems services. Representatives from the groups of interviewees then aided the team in field-verifying the locations of the services and mapping the information in a geographic information system database. The team used a screening checklist to determine whether a service was likely to be present or not in each coastal or shore zone. For a service to be considered present, it needed to meet two criteria:

- Habitats present in the study area (immediate coastal area throughout Regions 1 through 6, up to a distance of 500 meters [1,640 feet] from the shoreline) are believed to provide the service or are similar to habitats elsewhere that provide the service; and
- People are believed to benefit from the service, either at the local, national, or global level.

Following completion of the screening exercise, the team, including members of the NDC and VCs, along with local community members, used the ecosystem services that were identified as present or potentially present as a guide for the field observations. This scoping step aimed to:

- Establish a list of ecosystem service beneficiaries;
- Establish the value of ecosystem services to beneficiaries;
- Identify and map the habitats and resources that provide ecosystem services in the study area; and
- Identify the existing condition and trends of natural resources providing ecosystem services.

The screening and scoping information provided an ecosystem services baseline, which revealed that the marine and coastal environments in Guyana provide all four of the aforementioned categories of ecosystem services, some of which are critical for the wellbeing and livelihoods of coastal communities. These are described by category and by region below.

Following the screening, scoping, and assessment exercise, the same team of socioeconomic and biodiversity experts returned to 61 of the same 64 coastal NDCs, RDCs, VCs, and TCs to conduct a validation effort of the ecosystem services baseline data collected during the previous assessment phase. (The Black Bush Polder NDC in Region 6 was not revisited due to its distance from the coastal zone; Georgetown City data were validated through informal engagement; and Haimokabra and Waramuri in Region 1 were visited simultaneously since Haimokabra is considered a satellite village of and shares leadership with Waramuri.) This additional validation step, in which over 500 community leaders and members participated, enhanced the scientific accuracy of the original reporting by allowing stakeholders to review and comment on the results of the screening, scoping, and assessment exercise. Any changes or additions to individual ecosystem services from the exercise were documented and larger trends that could have occurred over time as a result of specific ecosystem management interventions (e.g., mangrove programs) or extrinsic factors (e.g., population changes) were identified. Appendix V, Interim

Ecosystem Services Validation Data Summary, summarizes the data collected from the validation effort as of the date of EIA preparation.[17]

8.9.2.1. Provisioning Services

As described above, marine fishing for various species of fish and shellfish is a vital source of protein and income to coastal communities. In coastal areas, especially in Regions 5 and 6, nearshore inland fishing and shrimping is also significant. Agriculture is also prevalent in coastal areas in all regions, including cultivated coconuts, cash crops, and livestock grazing. Some communities in the coastal area (particularly Amerindian communities in Region 1) harvest a range of naturally occurring resources for household use and sale. This includes manicole (heart of palm), mangrove bark and wood, timber, medicinal plants, and crabwood seeds that are processed to make crabwood oil. The validation exercise revealed that the number of Venezuelans with Amerindian ties returning to Region 1 over the past 2 years has increased, and that many of these Venezuelans are harvesting naturally occurring resources.

In addition, trapping and hunting of local wildlife are also practiced. Throughout the coastal areas, the waterways facilitate transportation and trade, and in some situations are the only means of transportation available, especially in Region 1 and between Regions 2 and 3.

Based on the findings of the ecosystem services assessment exercise, provisioning services are the primary service provided by the coastal ecosystem throughout all regions. The most common provisioning services identified include:

- Fish, shrimp, and crabs caught for subsistence or commercial sale;
- Annual and permanent cultivated crops grown for subsistence use and commercial sale;
- Agricultural and grazing, including livestock farming supported by coastal grassland and plants; and
- Animals hunted primarily for food.

8.9.2.2. Cultural Services

Cultural services were the second-most prevalent ecosystem service. The most common cultural services identified include:

- Cultural value placed on traditional practices, such as use of a location for prayer services (primarily in Regions 2–6);
- Use of natural spaces and resources for local tourism or local recreation, such as use of coastal walls for walking, coastal parks for relaxing, and beaches for recreational fishing, picnicking, games, etc.; and
- Value placed on the aesthetics provided by landscapes and seascapes.

[17] Validation efforts in Regions 3 and 6 were ongoing as of the EIA preparation.

As mentioned above, throughout Guyana's populated coastal regions in Regions 2−6, the seashore is often used in religious Hindu funeral and cleansing ceremonies. The Hindu community in Guyana has a number of crematoriums along the coast, and ashes are disposed in the ocean as part of funeral ceremonies. In addition, prayer and bathing ceremonies are performed informally by members of the Hindu community year around, but especially during the holy festival of Kartik Snan, which occurs in October or November each year (ERM Personal Communication 11; ERM/EMC 2018).

In Region 1, the SBPA has high aesthetic and educational value and potential for ecotourism due to its importance as a marine turtle nesting area, even though infrastructure in the area is not well developed and tourism activity is limited. The community of Warapoka in Region 1 is actively engaged in ecotourism, with visitor counts on the rise over the past several years due in part to government-sponsored ecotourism programs. The caves, petroglyphs, shell mounds, harpy eagle nesting sites, and other eco-related attractions within the community, as well as sport fishing at Luri Creek, serve as attractions for tourists. Waramuri and Assakata are both actively developing plans to build ecotourism infrastructure and attract funding to enhance ecotourism activities (Appendix V, Interim Ecosystem Services Validation Data Summary).

8.9.2.3. Regulating Services

Regulating services represented the third most prevalent ecosystem service identified in the six regions. The most common regulating services identified include:

- Shoreline and riverbank protection and the role of mangroves in protecting crops, buildings, and recreation areas from waves, wind, and flooding; and
- Erosion protection and the role of vegetation in regulating erosion on slopes.

Guyana's coastal plain is vulnerable to coastal flooding due to its low elevation and mangrove forests, with their dense root systems, are an important component of the country's natural and manmade sea defense system. Mangroves also filter sediments, protecting sensitive seagrass beds from being smothered.

8.9.2.4. Supporting Services

Mangrove forests along the coast play an active role in nutrient cycling and act as nurseries for ecologically and commercially important fish and shellfish species. Mangrove and other coastal ecosystems, such as brackish lagoons, brackish herbaceous swamps, and swamp forests, also provide habitat for a diversity of flora and fauna, including those with tourism value and potential, such as migratory shorebirds (WWF 2016).

Supporting services are intermediate ecological outcomes that are not directly used, but rather support other ecosystem services. Supporting services may be under-identified relative to the other categories of ecosystem services because services that are directly used are better understood and more easily identified by stakeholders. Therefore, the relatively low prevalence of identified supporting services across the six regions is not atypical. The service “habitat provision” is an exception, because it is sometimes simultaneously valued as an “end-use” service in addition to its supporting role by stakeholders. In this analysis, stakeholders often valued mangroves for their maintenance of biodiversity (a supporting service) while also valuing their contribution to the resilience of coastal ecosystems and shoreline protection (both regulating services).

Figure 8.9-1 summarizes the distribution of identified ecosystem services across the four ecosystem service categories prior to the ongoing validation effort. The ecosystem services field validation efforts are ongoing in Regions 3 and 6 and Figure 8.9-1 will be updated after completion of these efforts and analysis of validation data, if necessary.

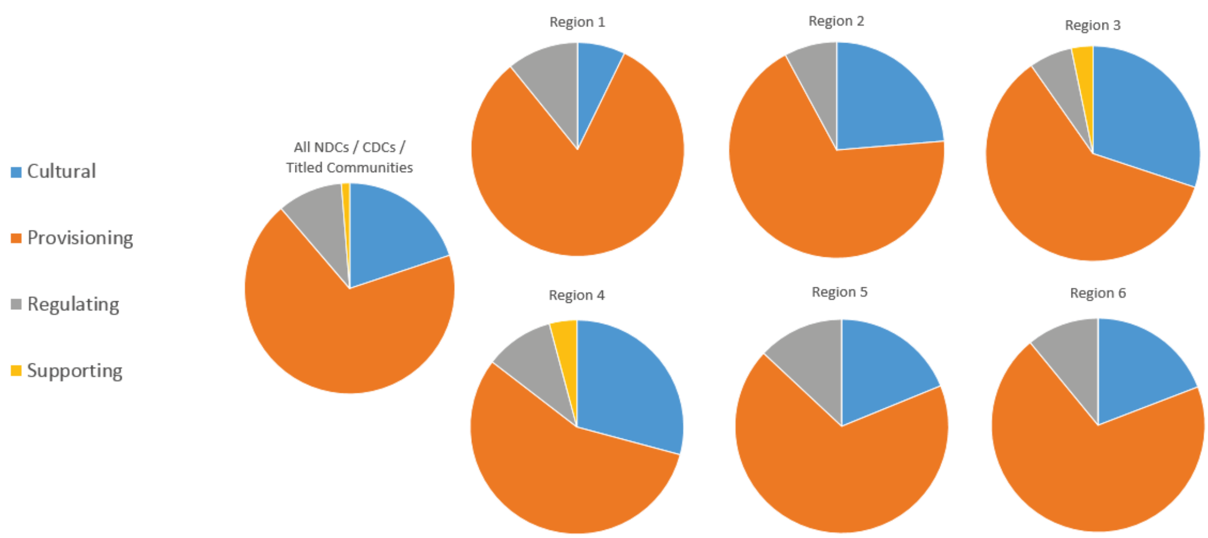


Figure 8.9-1: Distribution of Ecosystem Service Categories

After establishing the ecosystem services baseline, the Millennium Ecosystem Assessment 2005 methodology calls for an ecosystem services prioritization, which has been designed to be consistent with international best practice using the 2012 IFC Performance Standards as guidance (IFC 2012). The prioritization process focuses on identifying services that are important to local stakeholders and difficult to replace, where loss or degradation of the service could adversely affect local communities. The prioritization process considered the following criteria:

- **Importance of ecosystem services:** Importance to beneficiaries was assessed according to the following criteria and assigned one of four ratings from *low* to *essential* based on:
  - Intensity of use (e.g., daily, weekly or seasonal use); quantitative data were used if available and relevant;
  - Scope of use (e.g., household versus community level, commercial use only, subsistence only or both);
  - Degree of dependence (e.g., contribution of fish to total protein in the diet; contribution of fishing to employment in the community); and
  - The importance of the service, as expressed by stakeholders and beneficiaries, including cultural and historical importance.

  Determining the importance rating includes quantitative elements (intensity, scope, and degree); however, the actual importance expressed by stakeholders and beneficiaries takes precedence over other criteria. For example, if trapping appeared to occur at a location on a monthly basis for subsistence by a few villagers in a community, it may be rated as low based on frequency of the activity. However, if various beneficiaries and stakeholders claimed that trapping was of significant importance to them, the rating would be moderate. Where a service was of greater or lesser importance to different beneficiary groups, two (or more) ratings were assigned so that impacts on these groups could be assessed individually.

- **Availability of alternatives (replaceability):** Understanding the availability of spatial alternatives is critical to assessing the extent to which a community will be adversely impacted if that service declines due to Project activities. The "replaceability" of a service was assessed according to the following criteria and assigned one of three ratings from *high* (many alternatives) to *low* (few or no alternatives):
  - The existence of spatial alternatives, including both natural replacements (e.g., the replacement of one type of wild food with another) and manmade substitutes (e.g., availability of manmade items as an alternative to handicrafts);
  - The accessibility, cost, and sustainability of potential alternatives, including a consideration of other users and the existing status and threats to the resource(s) providing natural alternatives to the service; and
  - Preference/appetite for and cultural appropriateness of alternative services.

After compiling information on the importance and replaceability of each service, these ratings were combined to assign an overall priority rating to the service (see Table 8.9-2). Ecosystem services with *high* or *critical* priority ratings are considered to be "priority" ecosystem services. As noted above, some services may have different importance ratings for different beneficiary groups, and therefore may be rated priority services for some beneficiaries but not for others.

Table 8.9-2: Assigning a Priority Rating to Ecosystem Services

		Replaceability of Service		
		High (many spatial alternatives)	**Moderate** (some spatial alternatives)	**Low or Not Replaceable** (few to no spatial alternatives)
Importance of Service to Beneficiaries	Essential	High	Critical	Critical
	High	Medium	High	Critical
	Moderate	Low	Medium	High
	Low	Low	Low	Medium

Figure 8.9-2 summarizes the distribution of specific ecosystem service types depending upon priority ranking prior to the ongoing validation effort. The ecosystem services field validation efforts are ongoing in Regions 3 and 6 and Figure 8.9-2 will be updated after completion of these efforts and analysis of validation data, if necessary.

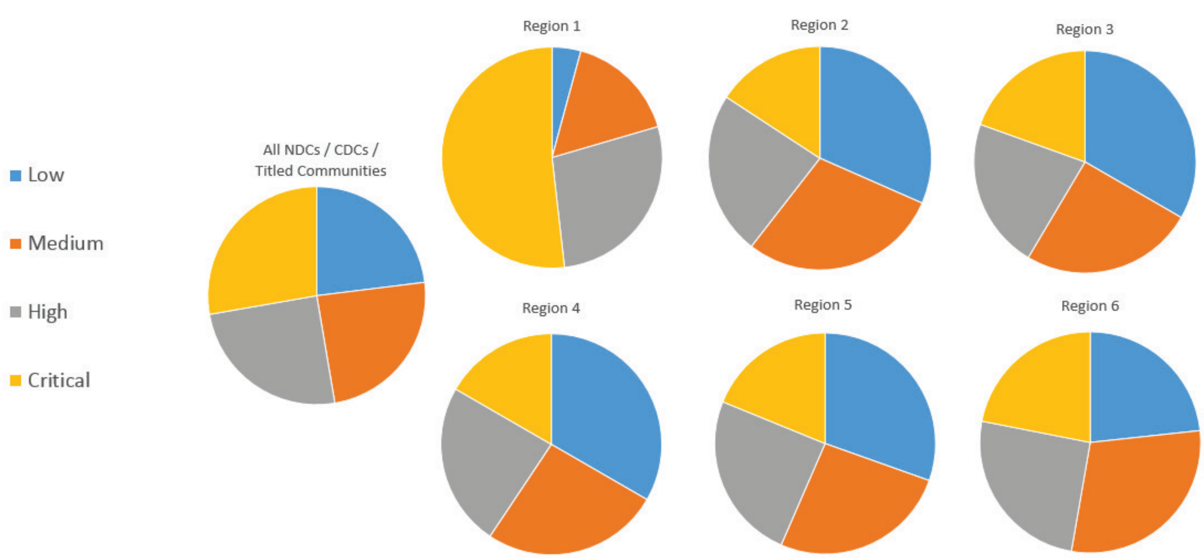


Figure 8.9-2: Distribution of Ecosystem Service Priorities

8.9.2.5. Summary of Findings by Region

As one of the primary goals of the baseline study was to understand the relationship between coastal communities and the natural environment along the entire coast in Regions 1−6, the ratings vary depending on the responses from each NDC or VC. For example, in one council in Region 2, livestock farming along the coastal wall was reported to be low priority, whereas in an adjacent council, the same service was considered a critical priority since a larger number of families rely on the livestock and there are no other locations for livestock to graze. Furthermore, some services may have different importance ratings for different beneficiary groups, and therefore may be rated as high priority services for some beneficiaries but not for others.

Figures 8.9-3 to 8.9-10 show how the ecosystem types are depicted in the aforementioned geographic information system database. The figures show the ecosystem service locations, by type, identified by the interviewees during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) using the methodology described above. Ecosystem service locations that were updated or added to date during the 2019 validation field effort are labeled accordingly. These figures also provide a location of each NDC/RDC/VDC/TC visited during both the 2017–2018 baseline collection field effort and during the 2019 validation field effort to date.

In the case of Region 1, Figure 8.9-4 shows the ecosystem service "general areas," by type, identified by Region 1 village leaders and villagers during the engagement process. The "general areas" map is provided for Region 1 because some areas identified by village leaders and villagers in Region 1 could not be field-verified (based on limitations to access along the SBPA and Region 1 coast). The general areas are intended to provide additional context for the location of ecosystem services in the region. This challenge was not encountered in other regions, so corresponding maps were not produced for the other regions.

Table 8.9-3 summarizes the highest priority rating assigned in each region for each ecosystem service prior to the ongoing validation effort. The ecosystem services field validation efforts are ongoing in Regions 3 and 6 and Figure 8.9-3 will be updated after completion of these efforts and analysis of validation data, if necessary.

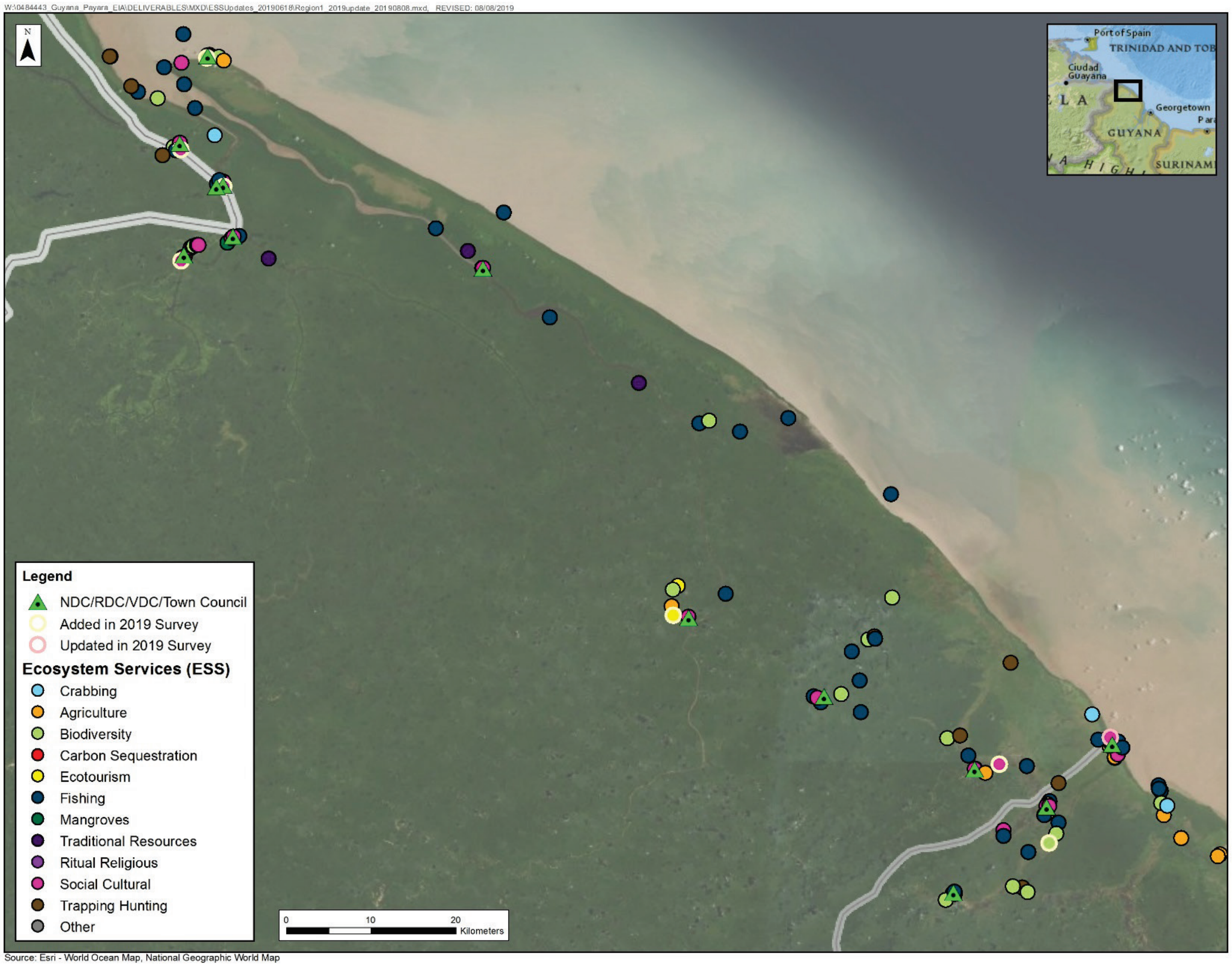


Figure 8.9-3: Region 1 Identified Locations of Ecosystem Services

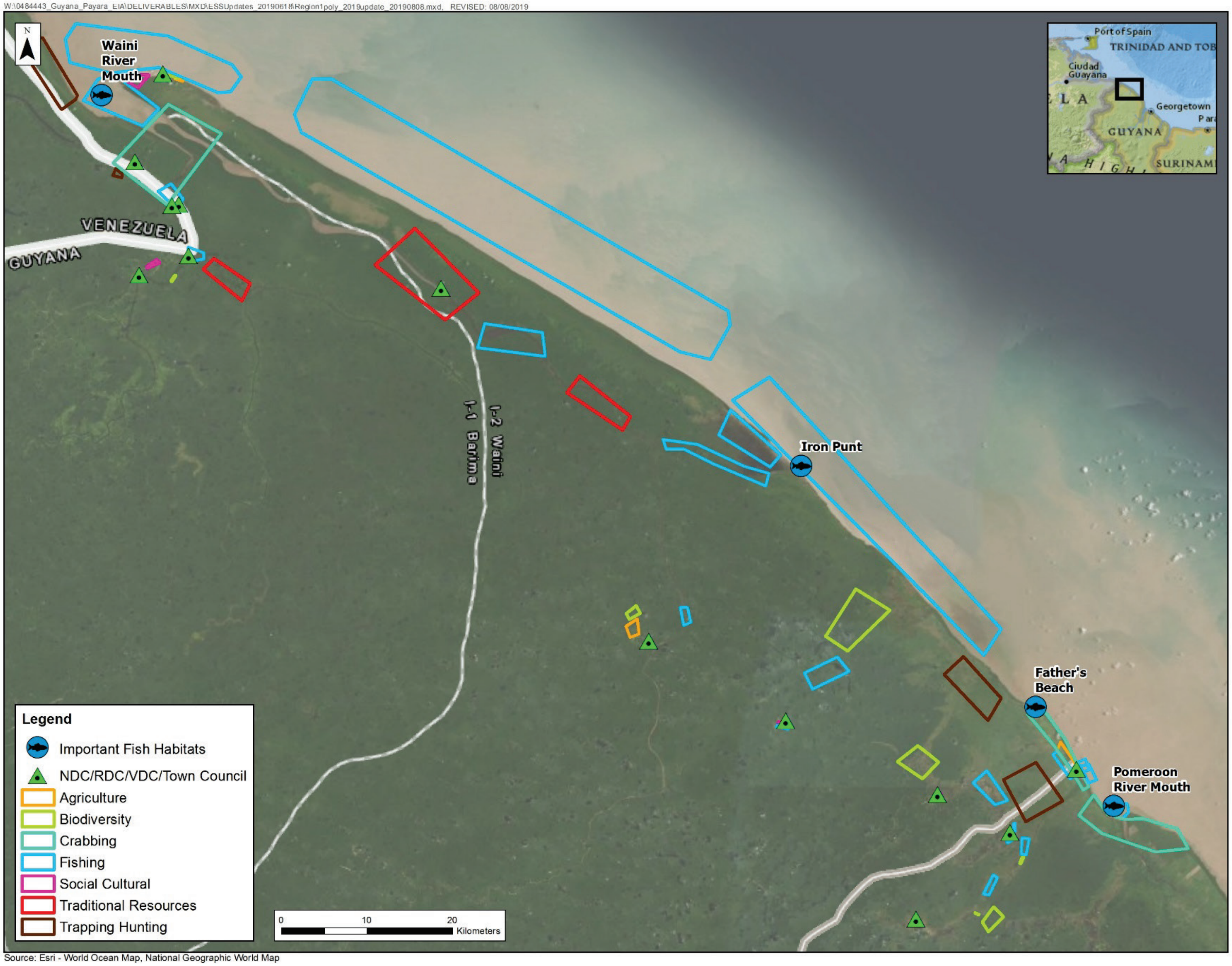


Figure 8.9-4: Region 1 Identified General Areas of Ecosystem Services

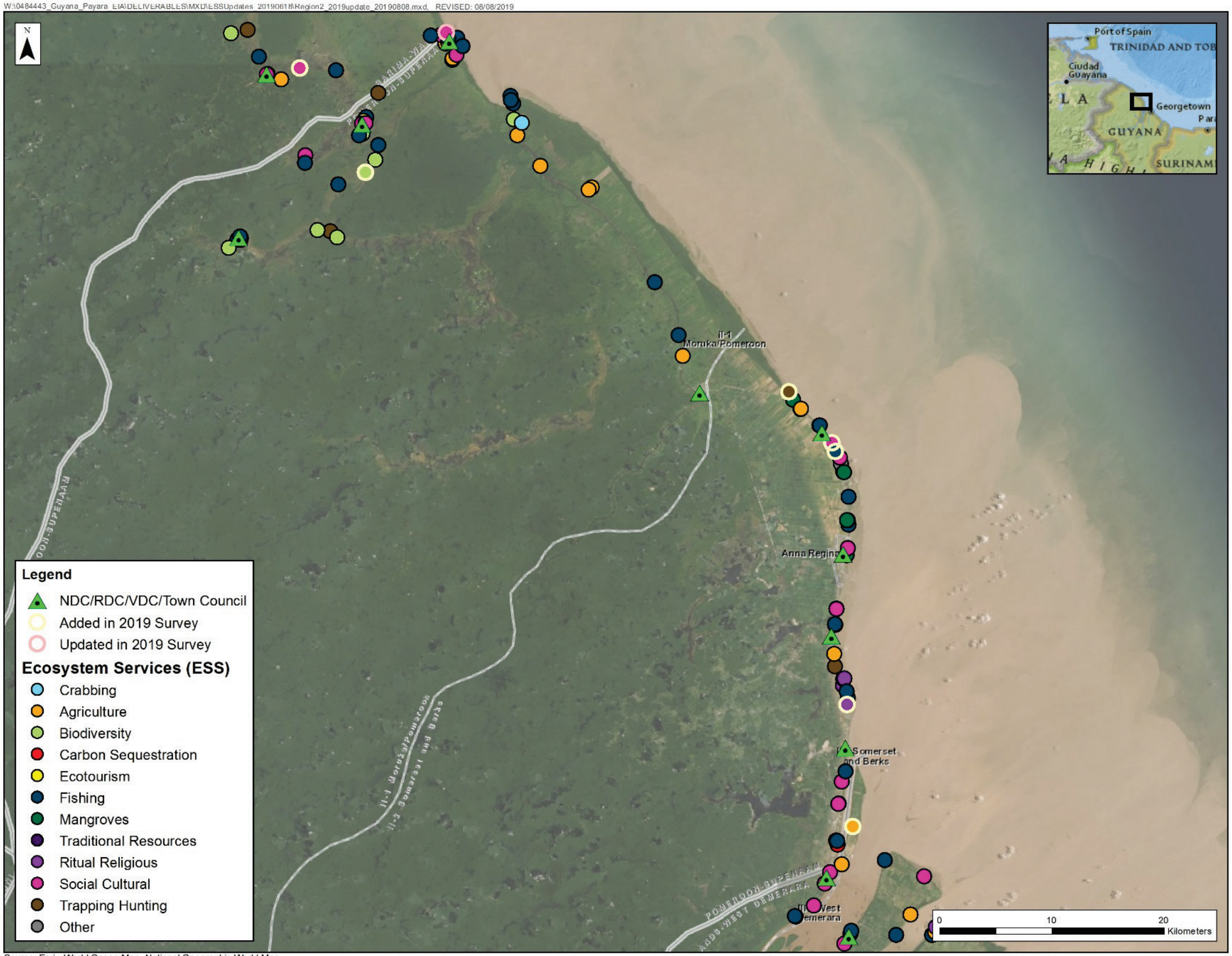


Figure 8.9-5: Region 2 Identified Locations of Ecosystem Services

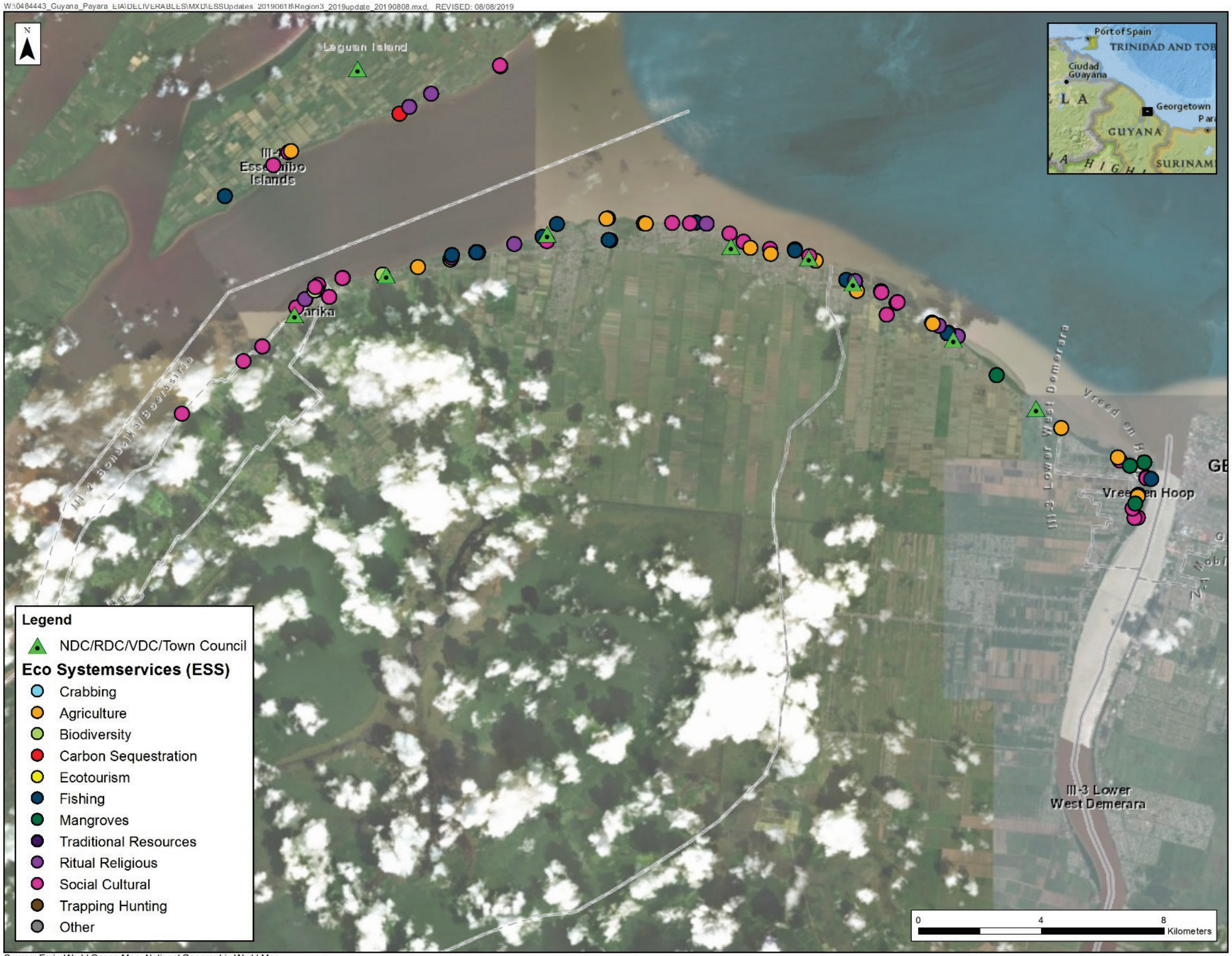


Figure 8.9-6: Region 3 Identified Locations of Ecosystem Services

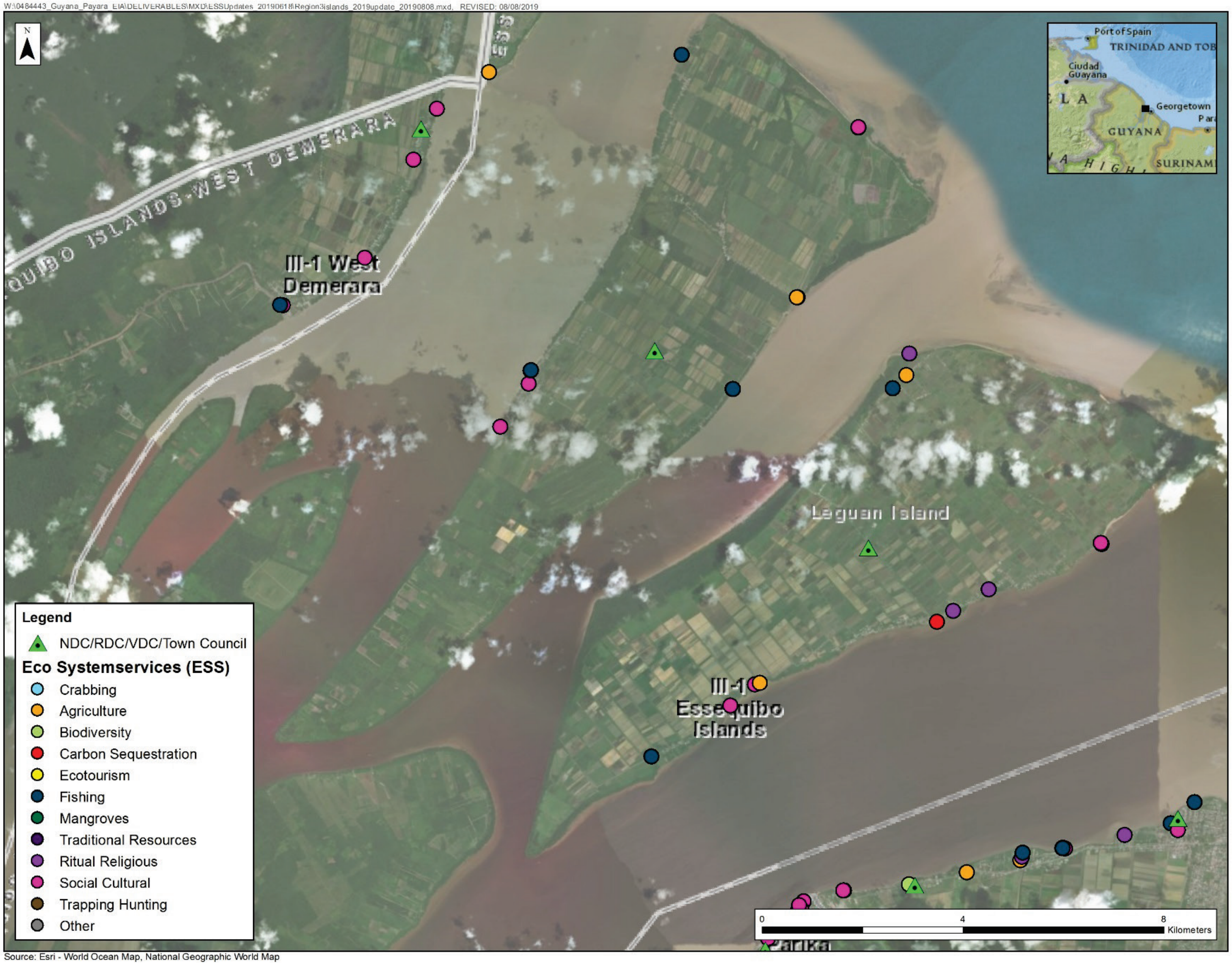


Figure 8.9-7: Region 3 Islands Identified Locations of Ecosystem Services

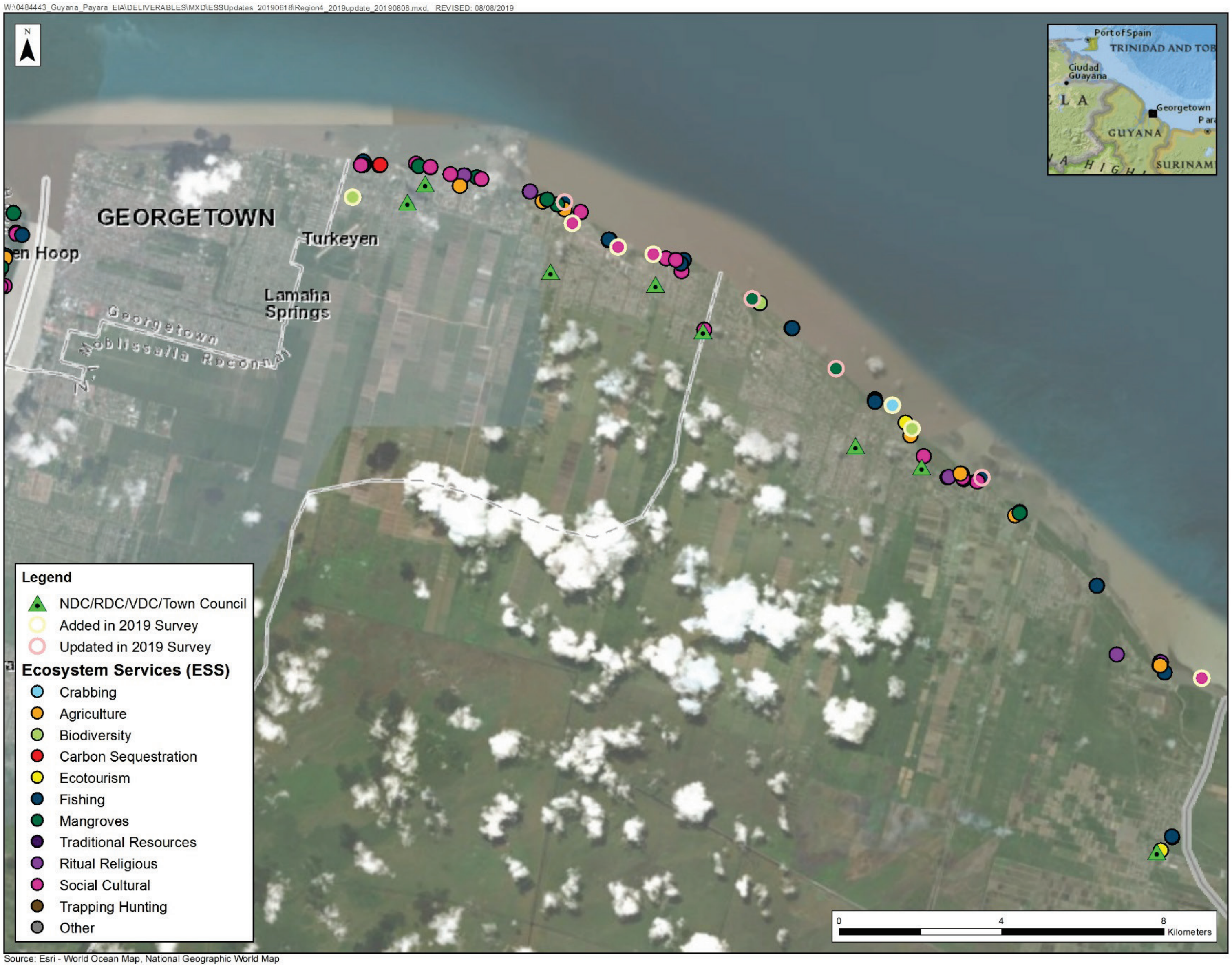


Figure 8.9-8: Region 4 Identified Locations of Ecosystem Services

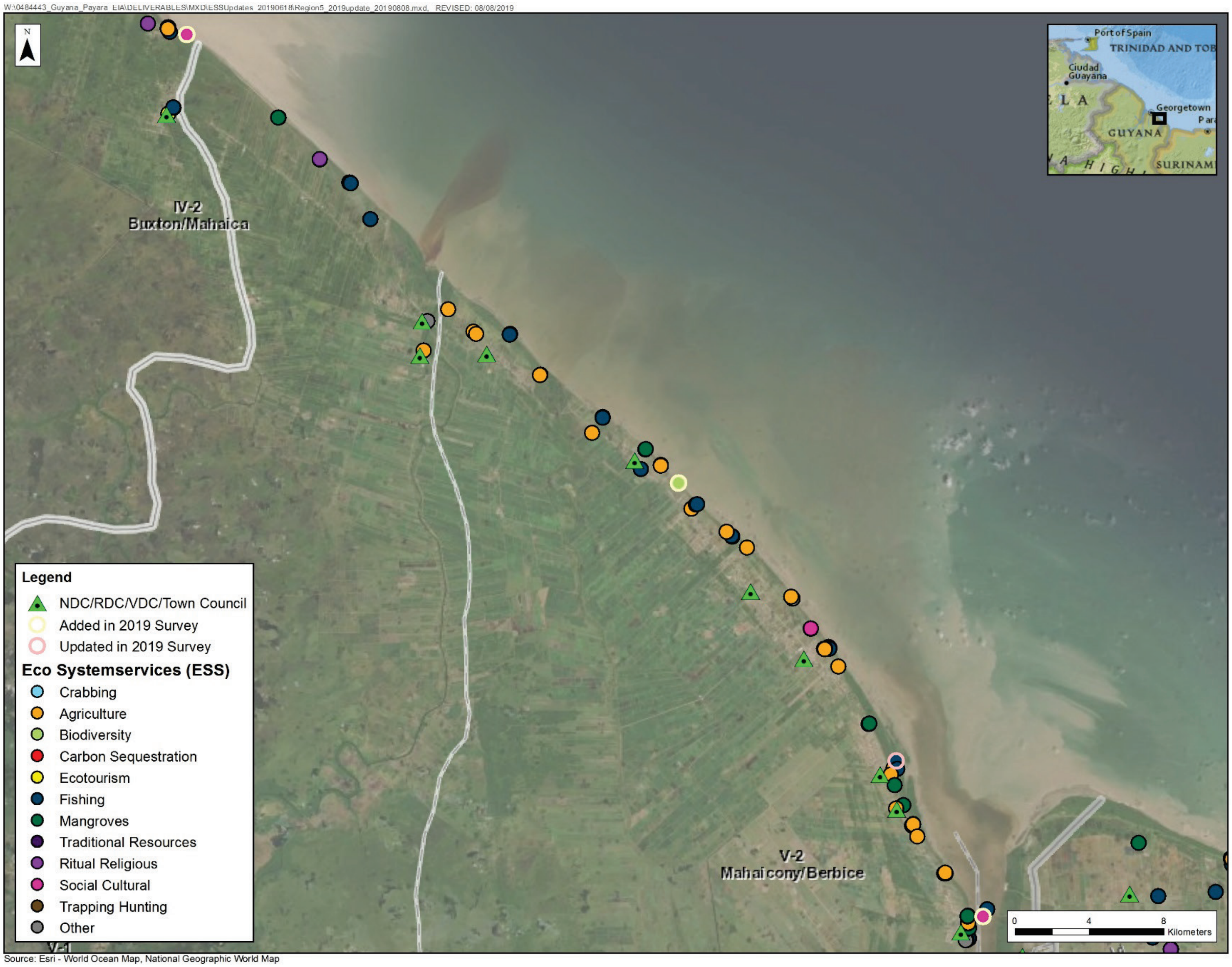


Figure 8.9-9: Region 5 Identified Locations of Ecosystem Services

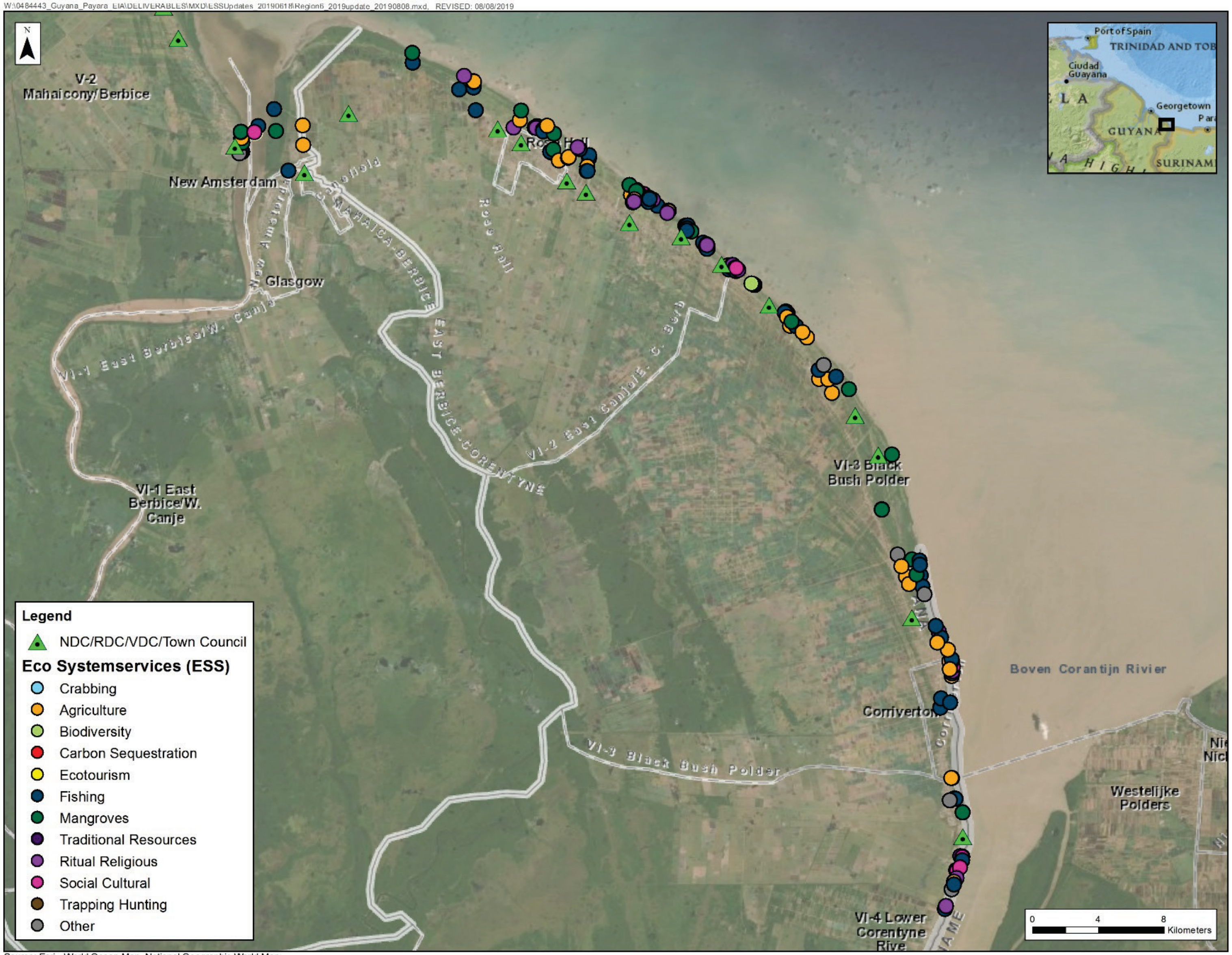


Figure 8.9-10: Region 6 Identified Locations of Ecosystem Services

Table 8.9-3: Highest Ecosystem Service Priority Ratings for each Region

Ecosystem Service Type	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
Provisioning Services						
Marine aquaculture and wild-caught fish & shellfish, including crab (food)	Critical	Critical	Critical	Critical	Critical	Critical
Cultivated crops	Critical	Critical	High	High	High	High
Livestock farming	Low	High	Medium	High	High	Critical
Food: wild plants and honey	Medium	NA	NA	Medium	Low	Low
Food: wild meat	High	Medium	Low	Medium	Medium	Medium
Biomass fuel	Low	NA	Medium	Low	NA	NA
Timber and wood products	Medium	NA	Low	Low	NA	NA
Non-wood fibers and resins	NA	NA	Low	NA	NA	NA
Traditional Resource Use/Traditional Medicine	High	NA	NA	NA	NA	NA
Freshwater for household use	Critical	NA	High	NA	NA	NA
Freshwater for irrigation use	NA	NA	Critical	NA	NA	NA
Aquatic transportation/ports	Critical	Critical	Critical	Critical	NA	NA
Social/Economic commercial activity	Critical	Medium	Critical	High	Critical	Critical
Social/Housing	High	NA	High	High	Low	High
Regulating Services						
Global climate regulation	NA	NA	NA	NA	NA	NA
Regulation of water timing and flows	NA	NA	NA	NA	NA	NA
Flood regulation	NA	NA	NA	NA	NA	NA
Erosion regulation	Critical	Critical	Critical	Critical	NA	NA
Shoreline protection/Mangroves/River defense	Critical	High	Medium	High	Medium	High
Pest regulation	NA	NA	NA	NA	NA	NA
Pollination	NA	NA	Medium	Medium	NA	NA
Disease regulation	NA	NA	NA	NA	NA	NA
Cultural Services						
Cultural, religious, or spiritual value	Medium	Medium	High	High	Critical	Critical
Aesthetic value of natural landscapes, historical landmarks	Low	Medium	Low	High	NA	NA
Tourism and recreation	High	High	Critical	Critical	Critical	Critical
Non-use value of biodiversity	NA	NA	Low	NA	NA	NA
Supporting Services						
Habitat provision, coastal protection	Critical	NA	Critical	Medium	NA	NA
Primary production, biodiversity	Critical	NA	Critical	NA	NA	NA
Nutrient cycling	NA	NA	NA	NA	NA	NA
Water cycling	NA	NA	NA	NA	NA	NA
Soil formation	NA	NA	NA	NA	NA	NA

NA = not applicable as not deemed present or valuable by beneficiaries or stakeholders during screening and scoping exercises

8.9.3. Impact Assessment—Ecosystem Services

Although the planned Project activities will have potential minor impacts on water quality, benthic communities, and marine wildlife, these potential impacts are not expected to significantly impact offshore ecosystem services. Specifically, the Project's planned offshore activities are not expected to impact the processes that regulate the physico-chemical attributes of the North Brazil Shelf Large Marine Ecosystem as a whole (e.g., water quality, currents, oceanographic conditions, bathymetry), nor are they expected to cause significant impacts on fishery production offshore Guyana.

The only potential impacts from planned Project activities in nearshore marine waters will be those related to an incremental increase in ship traffic in and out of Georgetown Harbour as ships transit between the shorebases and the PDA. This incremental increase is not expected to result in an impact on marine fauna that would lead to any significant impacts on the availability of marine fauna as an ecosystem service. Therefore, the Project's planned activities are not expected to impact ecosystem services provided by the nearshore marine ecosystem.

The planned Project activities will not involve any direct disturbance of coastal habitats and the Project's air emissions, discharges to water, and sound generation, all of which will occur approximately 207 kilometers (approximately 128 miles) northeast of the coastline of Georgetown, will not result in significant impacts on these habitats. Project use of the Guyana shorebases and onshore support facilities will have no impact on ecosystem services.

The Project's potential impacts on ecosystem services as a result of an unplanned event are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

8.9.4. Mitigation Measures—Ecosystem Services

As there are no potential impacts on ecosystem services as a result of planned Project activities, no mitigation measures are proposed.

8.10. INDIGENOUS PEOPLES

8.10.1. Administrative Framework—Indigenous Peoples

Table 8.10-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on indigenous peoples.

Table 8.10-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Indigenous Peoples

Title	Objective	Relevance to the Project
Legislation		
Amerindian Act (2006) Cap. 29:01.	Provides for the recognition and protection of the collective rights of Amerindian villages and communities, the granting of lands to Amerindian villages and communities, and the promotion of good governance with Amerindian villages and communities.	Within the broad context of protection of the collective rights of Amerindian villages, this could include the right of use of coastal resources for traditional and subsistence activities, which could be affected in the unlikely event of an oil spill from the Project.
International Agreements Signed/Acceded by Guyana		
United Nations Declaration on the Rights of Indigenous Peoples (2007)	A comprehensive statement addressing the rights of indigenous peoples. It emphasizes the rights of indigenous peoples to maintain and strengthen their own institutions, cultures, and traditions and to pursue their development in keeping with their own needs and aspirations. Further, it addresses both individual and collective rights, cultural rights and identity, rights to education, health, employment, and language, among others.	Aligning with these declarations commits Guyana to complying with the relevant provisions. As it regards the Project, these would include engagements with indigenous peoples and also taking necessary measures to ensure protection of the environment.
American Declaration on the Rights of Indigenous Peoples (Organisation of American States) (2016)	Offers specific protection for indigenous peoples in North America, Mexico, Central and South America, and the Caribbean. Affirms the right of self-determination; rights to education, health, self-government, culture, lands, territories, and natural resources; and it includes provisions that address the particular situation of indigenous peoples in the Americas, including protections indigenous women and children, and those living in voluntary isolation, among others.	Aligning with these declarations commits Guyana to complying with the relevant provisions. As it regards the Project, these would include engagements with indigenous peoples and also taking necessary measures to ensure protection of the environment.

8.10.2. Existing Conditions—Indigenous Peoples

Guyana's indigenous peoples, referred to as Amerindians (a term defined in the Amerindian Act to represent Guyana's First People), numbered 78,492 as of the 2012 census and their population is on the rise, with growth of 12.8 percent seen in the period 2002–2012 (BSG 2012). According to the 2012 census, Amerindians comprised 10.5 percent of the population and their numbers have nearly doubled since 1980 (see Table 8.10-2).

Table 8.10-2: Distribution of Population by Ethnic/Nationality Group (1980–2012)

Ethnicity Background	Population				Percentage			
	1980	1991	2002	2012	1980	1991	2002	2012
African/Black	234,094	233,465	227,062	218,483	30.8	32.3	30.2	29.3
Amerindian	40,343	46,722	68,675	78,492	5.3	6.5	9.1	10.5
Chinese	1,864	1,290	1,396	1,377	0.3	0.2	0.2	0.2
East Indian	394,417	351,939	326,277	297,493	51.9	48.6	43.4	39.8
Mixed	84,764	87,881	125,727	148,532	11.2	12.1	16.7	19.9
Portuguese	3,011	1,959	1,498	1,910	0.4	0.3	0.2	0.2
White	779	308	476	415	0.1	0.04	0.06	0.06
Other	294	107	112	253	0.04	0.01	0.01	0.03
Total	759,566	723,671	751,223	746,955	100	100	100	100

Source: BSG 2012

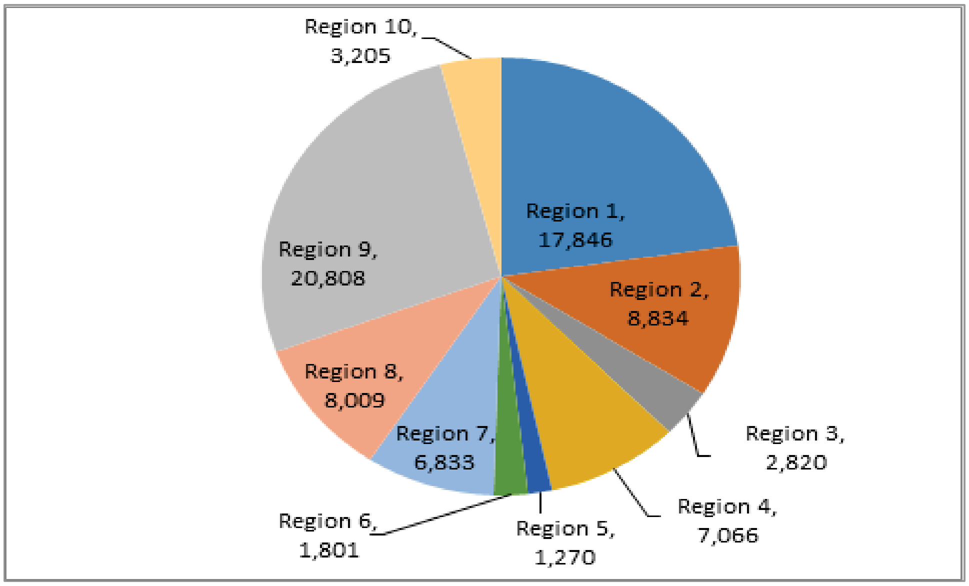
Amerindians are found in significant numbers in the Hinterland Regions. Amerindians make up 85.8 percent of the resident population in Region 9; 72.3 percent in Region 8; 64.6 percent in Region 1; and 37.2 percent in Region 7 (see Table 8.10-3).

Table 8.10-3: Percentage Distribution of Ethnic/Nationality Group by Region (2012)

Ethnic Background	Region										
	1	2	3	4	5	6	7	8	9	10	Total
African/Black	2.30	12.58	21.13	40.56	33.06	21.32	11.62	7.75	1.46	49.02	29.25
Amerindian	64.56	18.87	2.62	2.27	2.55	1.64	37.19	72.30	85.85	8.01	10.51
Chinese	0.05	0.09	0.18	0.24	0.09	0.16	0.14	0.08	0.04	0.32	0.18
East Indian	1.71	44.57	59.55	35.02	54.66	66.03	8.54	2.55	1.04	2.82	39.83
Mixed	31.17	23.60	16.38	21.45	9.51	10.69	40.89	16.59	11.17	39.63	19.88
Portuguese	0.17	0.22	0.08	0.37	0.08	0.07	1.21	0.69	0.30	0.10	0.26
White	0.04	0.07	0.03	0.06	0.03	0.05	0.05	0.05	0.12	0.08	0.06
Other	0.01	0.00	0.05	0.03	0.01	0.02	0.36	0.00	0.02	0.03	0.03
Total	100	100	100	100	100	100	100	100	100	100	100

Source: BSG 2012

According to Minority Rights Group International (2008), there are nine main Amerindian groups in Guyana, of which three are coastal: the Carib, Warrau, and Arawak tribes. Other groups tend to inhabit the country's Hinterland Regions. Many of the Amerindians in the coastal area have culturally integrated with the general population. They share many of the same livelihoods as the Afro- and Indo-Guyanese coastal populations; however, as a whole, the standard of living for the Amerindian population is lower than for the general population, particularly for those in remote areas where providing infrastructure and services is a challenge. The distribution of Amerindian population among the regions is shown on Figure 8.10-1.



Source: BSG 2012

Figure 8.10-1: Amerindian Population by Region, 2012

Region 1 and parts of Region 2 are not accessible by road. Amerindian communities in these areas are remote and are generally underserved by public infrastructure and services. These populations make use of a range of coastal resources for subsistence and livelihoods, including fishing and crabbing, as well as small-scale agriculture and hunting. Amerindian communities that are directly adjacent to the coast include Father's Beach and Almond Beach, which are untitled communities, as well as the titled community of Three Brothers along the Waini River, directly inland from Shell Beach. There are a few untitled communities in close proximity to the shore zone, including Imbotero and Smith's Creek. The principal titled indigenous communities located 5 to 10 kilometers (approximately 3 to 6 miles) inland from the coast include Santa Rosa, Waramuri, Manawarin, and Assakata in Region 1, and Wakapau, Mainstay/Whyaka, and Capoey in Region 2 (although these communities have limited interaction with the shore zones or associated coastal ecosystem) (ERM Personal Communication 20).

In the SBPA, fishing and crabbing occur at the westernmost end of Shell Beach, at the mouth of the Waini River. In this area, the Almond Beach community is engaged in coconut and other crops farming. Many communities from Regions 1 and 2, and inland from the coast, also venture to Shell Beach's easternmost coastline near the mouths of the Moruca and Pomeroon rivers to engage in these activities (ERM/EMC 2018). Also in this area, near Father's Beach, there are coconut plantations used for manufacturing oil and crop farming, and just northwest of this is a forested area where hunting, trapping, fishing, crabbing, crabwood seed harvesting, and lumbering occurs (PAC 2014). See Figure 8.10-2 for a map of these communities.

In the other regions, titled indigenous communities are located inland and not in proximity to the shore zone or coastal areas.

During the 2019 ecosystem services field validation efforts conducted in Region 1, stakeholders revealed that there has been an influx of migrants from Venezuela into some of the villages. These migrants have been fleeing economic hardship and have included returning Guyanese who had previously migrated to Venezuela, as well as Venezuelan nationals. The township of Mabaruma has reportedly had the greatest number of migrants, estimated to be around 1,000. However, residents claimed that thousands more passed through the community within the past year. Some indigenous communities have also reported to have had a significant amount of migrants present, including Imbotero, Smith's Creek, and Warapoka. Regional leadership acknowledged that the influx of persons from Venezuela is placing a strain on government resources in Region 1, especially social services (health, education, housing, etc.).

Given the importance of the Region 1 coastal communities in the unlikely event of an unmitigated oil spill from a well control event (see discussion in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events), basic socioeconomic and community health-related data at the village level are presented below for the 14 Amerindian communities depicted in Figure 8.10-2. This information was obtained during the April 2018 ecosystem services field work completed in Region 1 by the Consultants (ERM/EMC 2018). Where appropriate, it has been updated based on the ecosystem services field validation efforts completed in June 2019 in the same villages in Region 1(Appendix V, Interim Ecosystem Services Validation Data Summary).

Figure 8.10-2: Region 1 Amerindian Communities

8.10.2.1. Father's Beach Community

The community has approximately 23 people, declining rapidly from 47 in 2018 due to migration. There has been a continued steady decline in the population over the years from a peak of more than 300 persons (in the recent past) and it is currently comprised of persons from other communities such as Pomeroon River, Santa Rosa, and Haimokabra. The primary economic activity is sale of fish and crops, as well as a small boat building and repair facility that also sells fuel. The village provides rescue and repair services to stranded fisherfolk offshore. There is a school in the village, but it is not in use since there are only a few children who instead attend school at Waramuri. Although residents are Amerindian, the community is not a titled Amerindian community.

Access to the community is through one small canal, which makes access a challenge and entirely dependent upon tides. The community is surrounded by mangroves that protect it from the ocean. The land is comprised of mangroves, agriculture, and irrigation. In the past, the area had fertile coconut groves but some of these are now degraded due to the natural erosion cycles of mangrove growth, as well as burning practices in which community members have attempted to develop ditches for aquaculture use. The biodiversity in the area consists of jaguars, larger flocks of macaws, deer, agouti, wild ducks, and labba. Occasionally, deer, wild hog, iguanas, ibis, scarlet ibis, or heron are hunted for subsistence only. No hunting or trapping by outsiders is allowed.

Agriculture and fishing are the most important economic activities for the community, and a variety of crops are farmed for subsistence and sale, including vine crops, cassava, passion fruits, plantains, and other crops (pepper, tomatoes, okra, etc.). A renewed focus is on coconuts, with one family harvesting the 3-month crop in between fishing seasons and selling the coconuts in Charity where demand is high. The primary fishing areas include inland fishing along the coast behind the mangroves and coastal fishing with a focus at the mouth of the Pomeroon River and the canal entrance to Father's Beach. Coastal catch includes catfish, snouk, trout, banga, basha, snapper, mullet, catfish, curass, and butterfish. Fish caught inland include hassar, houri, sunfish, and yarrow. One family is engaged in boat building and repairs as well as fuel retailing.

Crabbing in mangroves along the beach area is also common, especially during the crab seasons, and residents from several villages, including as far as Pomeroon and Warapoka, come into Father's Beach to crab. Locals have complained that the amount of crabs burrowing has been causing damage to the dams, which are critical for flood prevention and drainage in the community. Other community members catch crab throughout the year for both subsistence and commercial purposes.

Source: ERM/EMC

Figure 8.10-3: Father's Beach Community

There are reportedly no longer any living cultural heritage sites important to the community and also reportedly no traditional religious practices undertaken in the community. They do use local resources such as red mangrove to make crafts and household items. Mangrove is currently the only source of hardwood and it is harvested inland to make poles for plantain trees. Buttonwood bark is used to make quake strings and shovel sticks. For recreational purposes, the communities use Gwennie Beach, Papaya Beach, and Bolton Area. The shells along the beach are used by residents for constructing building foundations, filling of yards, and placing around fruit trees to provide nutrients. Several plant species, including noni, are used for medicinal purposes.

A health hut is currently not in use, with community members traveling to Charity, Moruca, and Waramuri to receive healthcare services. Government health teams have not visited the community in years, and childbirth typically occurs at home because of the transportation constraints. There have been no recent reported malaria cases. Common cold, diarrhea, fever, and vomiting (typically contracted when outside the community) are most common, and community members use traditional medicine to heal. The primary water source is from rainwater harvesting and typically, during the dry season, the community will buy bottled drinking water from Charity.

8.10.2.2. Manawarin Village

The current population of the community is more than 2,000, increasing from 1,862 people in 2018, and the primary economic activity is commercial fishing as well as small-scale sale of fish. Access to the community is through the Manawarin River, a branch of the Moruka River. One primary school currently has 388 students enrolled and a nursery had 86 infants attending in 2018. Students in higher grades attend school at Santa Rosa Secondary. The village has its own village office, health center, multipurpose building, and playground. A major challenge in the community is lack of livelihoods and access to markets for commercial purposes. Another critical challenge is the intrusion of salt water into the community fishing grounds during the dry season.

The village is in close proximity to intact forest ecosystems with a high diversity of freshwater fishes, birds, and mammals. Wild hogs, tapir, labba, parrots, macaws, jaguars, panther, curry curry (a local name for scarlet ibis), powis, marudi, and river otters can be seen in the forests and sometimes in the savannas.

Agriculture is important for livelihoods, and virtually all families farm cassava for subsistence. The staple diet is cassava and fish, with flour and rice purchased from Charity. Approximately one-fourth of the population depends on fishing for their livelihoods and both freshwater and saltwater fishing are common. Within the freshwater areas, people fish for lukanani, patwa, houri, yarrow, and sunfish, among other species. Fishing in the ocean was more prevalent in the past, but is declining due to the cost of engines and boats required for the long journey.

Source: ERM/EMC

Figure 8.10-4: Manawarin Village

Most people from the village access the shoreline to catch crabs during the crab season. In addition, a few people catch crabs year round and bring them back to the village for sale. It is estimated that about one-fourth of the village is involved in hunting. Birds are often caught for sale and mammals are caught for subsistence.

One important living cultural heritage site called Rockstone is located up river, but there are reportedly no active traditional religious practices. Local resources, including palms and vines (ite, kufa, nibbi, and kufra), are used for making crafts and household items. Manicole palm was previously harvested and sold, but this is not currently common practice.

The village health clinic has two community health workers, but no doctor, nurse, or midwife. The clinic is commonly used for hypertension, diabetes, and post-natal and family planning. Health workers see approximately 40 people a day, mostly children for fever and cold symptoms. In an emergency, citizens rely on private transportation to Waramuri, Charity, or Kumaka. Medical supplies and medicines are in short supply and come from Kumaka, but the dates are reportedly normally close to expiration. Skin conditions are especially prevalent with babies. Water is not treated and gastroenteritis cases are common after the rainy season.

8.10.2.3. Haimokabra Village

The community is considered a satellite community of Waramuri and, as of 2018, had a population of approximately 600 people. The primary economic activity is sale of fish; however, at present, more than 100 people are employed in mining in the interior regions. There is one primary school which had 149 students in 2018; some students also attend school in Waramuri.

Agriculture is important to the community for livelihood and all households have farms and use higher lands not vulnerable to flooding for cultivating crops, specifically cassava. The staple diet is cassava and fish. Much of the village land consists of flooded savannas, which are burned as part of traditional burning practices in the dry season. The highland areas are forested and have some valuable species of hardwood used for construction in the village. The area also has a considerable number of fish and other wildlife. Trapping of parrots, toucans, and macaws is common for sale to traders and eventual resale in Charity.

Fishing is the main economic activity, with approximately half of the male population involved in the activity for both subsistence and commercial purposes. Fishing occurs out to approximately 8 kilometers (5 miles) on both sides of the Moruka River mouth in the ocean, by the use of hook and line and drift seine. Fishing trips range from daily to weekly and fisherfolk sometimes camp along the beach in the vicinity of Iron Punt, where they fish in the lagoon behind the beach. Fish are sold in the village, as well as other areas such as Waramuri and Kumaka. Freshwater fish are caught from streams within and surrounding the community. Crabs are caught seasonally by almost everyone in the village, as well as regularly by 10 to 12 people for sale at the weekly market. Lumbering is also prevalent, with about 20 chainsaws operating within the community. Each chainsaw operation employs about six people.

Source: ERM/EMC

Figure 8.10-5: Haimokabra Village

The village has more than 100 young men employed in various mines in the interior who work for about 3 months at a time. This influx of funds helps the village economy in general; however, villagers reported that it is common for many young men to return home alleging of not being paid by the mine for their labor.

There is an important cultural site in the form of a shell mound located within the community, and it is protected due to the low level of human traffic to the location. Mangroves along the shore are used to make fishing poles. Honey is collected from wild beehives along the coast in an opportunistic fashion.

The community has a solar-powered groundwater well that discharges into storage tanks from which gravity flow distributes the water to users. However, the system is not functioning properly, and community members lack the equipment to conduct a repair. A computer lab building was erected, but equipment has never been provided. Most people in the village have cellular phones, but few persons reportedly use them to access the internet.

The village has a health clinic with two community health workers but no doctor, nurse, or midwife. The health workers see an average of 20 people per day, with the most prevalent cases being flu/fever and hypertension. There are no laboratory facilities, and in the case of fevers, residents must pay for private transportation to Kumaka. Despite a high percentage of the population working in the mines, cases of malaria are low. A doctor based out of Waramuri visits some of the outpatients and pregnant mothers once a month. Due to a lack of electricity, equipment, and instruments, pregnant women are typically referred to Kumaka at 35 weeks.

8.10.2.4. Waramuri Village

The community has a current population of approximately 2,500 consisting of approximately 60 percent females. In 2018, the community had 308 households. The primary economic activity is sale of fish followed by mining in the interior. Some men also work on fishing vessels from Regions 2 and 3 on a rotation basis, with an average of two fishing trips per month. There is one primary school and a nursery school that in 2018 housed 406 students and 40 students, respectively.

Agriculture is important to the community for livelihood, and all families farm cassava for subsistence, with at least three farms growing at different levels of maturity. All households have farms and use land to cultivate crops. Coconut cultivation is increasing and coconuts are sold in Charity. Copra (dried meat or kernel of the coconut) is also harvested and sold.

Fishing is an important economic activity, with approximately 30 percent of the village involved. An average of three boats fish per week from the community along the coastline on both sides of the Moruka River mouth between Iron Punt and Cozier Canal. Saltwater fish (catfish, curass, gilbaker, snapper, basher, and highwater) are sold within the village as well as in neighboring communities. Freshwater fish (queriman, cufum, hassar, lukanani, houri, dari, patwa, yarrow) are caught in the lagoon behind the beach and in streams within and nearby the community. Crabs are caught seasonally by almost everyone in the village along both sides of the Moruca River between Corkwood and Cozier Canal, as well as regularly by a few persons for sale.

Source: ERM/EMC

Figure 8.10-6: Waramuri Village

The area has a considerable number of fish and birds, with few people involved in trapping wild animals (tapir, deer, iguana, wild ducks) near the beach for subsistence and commercial use. Honey is gathered from wild bees along the beach and medicinal plants, including noni, are collected from the beach as well as within the community. The ite palm (an indigenous type of palm) is recognized by the village as the tree of life. The palm provides tibisiri, food, roof material, fruit for drink making, other construction material, and the tacoma worm. Tibisiri is made from the fiber from the leaves of the palm and is used to make hammocks, thatch roof, furniture, baskets, and carpets. Tacoma worm, also known as the beetle larvae (*Rhynchophorus palmarum*), feeds on old ite trees that have fallen to the ground. These beetles are full of fat and are considered a delicacy and a good source of nutrients by the indigenous communities that consume them. Waramuri Village claims that it is the oldest Warrau village on the coastland. There are shell mounds, which are considered cultural heritage sites that are important for the community, but all traditional religious practices have reportedly ceased. The shell mounds are alleged to be more than 2,000 years old. The village intends for this site to be developed into a leading tourist attraction in the future as part of the village's plan to enhance ecotourism activities.

The village has a health center staffed with a doctor, nurse, midwife, community health worker, environmental health assistant, maid, and one boat hand. The most prevalent disease is hypertension, although other common ailments include gastroenteritis, flu/fever, sexually transmitted infections, and skin conditions. There are several clinics offered weekly, including maternal/child care, hypertension and diabetes. Alcohol consumption is banned in the community, so alcohol-related illnesses are not common.

The village has a playground that is used by villagers and neighboring communities. The playground was recently upgraded with support from EEPGL.

8.10.2.5. Santa Rosa Village

Santa Rosa is the largest indigenous community in the country, with a population of more than 10,500. Kumaka waterfront has become Santa Rosa's economic hub as well as an important area for neighboring villages and communities. There are three primary schools and two secondary schools in Santa Rosa and satellite villages. The secondary school in Santa Rosa cares for children for most of the Moruka Sub-District of Region 1, with dormitories for males, females, and teachers. The village houses the Region Administrative Office for the Moruka Sub-District, the Education Office, a police station, a District Hospital, and regional offices for the Ministry of Agriculture Mangrove Project and the Guyana Forestry Commission. The waterways provide the main form of transportation between the communities. The village also has an airstrip at Bimiche that was recently rehabilitated.

More than 500 people are employed in the mining and forestry sectors and remain away from the village for long periods at a time. About 100 people are employed in the village by the Guyana Geology and Mines Commission. Other government workers also constitute an important income earning group of about 50 additional people. The business sector in the community employs more than 200 people directly. The village has more than a dozen shopping centers that offer more than 100 products and employ from 3 to 10 people each. There are more than 20 nightspots that sell alcoholic beverages and food. A shopping mall is currently being constructed by the Village Council.

Many households have farms and use the lands to cultivate crops behind the airstrip. The families living on the bush islands use that land to farm and others have farmland further away on the highlands. Most of the land in the area consists of savannas that flood regularly and this land is therefore not used except for fishing and occasional hunting.

Fishing is important to the community for livelihood, with more than 100 fisherfolk involved in commercial and subsistence fishing in the sea along the coast from east of the Pomeroon River all the way to Waini Point, but mainly between the Pomeroon River and Iron Punt. These fishing trips can last up to a week, with most people making at least two trips per month to the sea. Inland freshwater fishing is also common in the streams throughout the community and in swamps behind the beach. In the dry season, when turtles are heading to the beach, there is usually a high presence of seaweed in the water that prevents many fisherfolk from setting their nets. Crabs are caught seasonally by almost everyone in the village, as well as regularly by about 20 people who sell them at the local market twice a week.

The area has many species of fish, mammals, turtles, iguanas, monkeys, and birds. Jaguars are found along the beach and within the village. No villagers are involved in legal trapping, as this activity was banned by the Village Council in 2016. Turtle meat is not openly sold, and offenders can be held accountable by the Village Council, which is strongly against such actions. Along the coast, muscovy (wild duck) eggs are harvested and iguana hunting occurs. There are some areas where timber and medicinal plants flourish and there are several smaller biodiversity important areas. Swamps located behind the beach serve as spawning grounds for fish species. Luri Creek and Baramani Lake are important areas where villagers conduct hunting of animals.

There is one living cultural/heritage site in the area that is far away and protected by its exclusive location, as well as a 200-year-old church that is considered a national heritage site. There is also a historical site called Lalancha along the Barabara River where there was a battle between the indigenous communities and the Venezuelans. Most traditional religious practices have reportedly ceased. Some villagers make use of medicinal plants such as noni, which grows abundantly along the coast and in the village. Manicole palm is harvested by villagers for their own use. Areas along the coast and the rivers are used for camping and picnicking.

There is one hospital in Santa Rosa called Kumaka District Hospital. As of 2018, the hospital treated approximately 1,000 outpatients per month, with the most prevalent diseases being gastroenteritis (due to poor water quality) and hypertension. Most causes of death are due to strokes and other diseases stemming from hypertension. There is one doctor and several nurses including a midwife. Teenage pregnancy is common, as are home deliveries, the latter due to lack of transportation and no ambulance service. Medical professionals claim there is a prostitution problem, as well as incidences of alcohol withdrawal syndrome.

Source: ERM/EMC

Figure 8.10-7: Santa Rosa

8.10.2.6. Assakata Village

The community has a population of 473 people, increasing from 345 in 2018 due to population growth not attributed to Venezuelan migration. There is one primary school that housed 95 students in 2018, with higher-grade students attending school in Santa Rosa or Mabaruma. The village has a health clinic, village office, primary school, sports ground, and communications by radio and cellphones. The primary economic activity is sale of fish, while mining in the interior is the main form of employment since there is no commercial economic activity within the community. Some of the men work on fishing vessels from Regions 2 and 3 and make two fishing trips per month for income.

Agriculture is important to the community for livelihood, and all families farm cassava for subsistence. Vegetables and other crops are also grown for food and some are sold to the hot-meals kitchen that serves the local school. Much of the village has land comprising flooded savannas, which are burned during the dry season. There is also a significant area of mangrove vegetation regrowth in the areas that were burned during the 1998 El Niño fire. The village has several waterways that are abundant with fish.

Luri Creek and Baramani Lake are important areas where villagers hunt animals for subsistence (labba, agouti, deer, tapir), but there is no hunting or trapping of illegal species. Birds, including powis and ducks, nest along the Baramani Lake and eggs are collected. There is also a high prevalence of flamingos using the area behind the beach. Within the community, there are three different types of river turtles (Jumbie Axe [scorpion mud turtle], Stink Turtle, and Red Head [labaria turtle]).

Most families visit the coastal area/beach once a month (mainly through Luri Creek to the Iron Punt area) for fishing, hunting, and gathering. Commonly caught fish includes queriman, snook, and curass. In the swamp behind the beach, patwa, houri, and cufum are commonly caught. Crabs are caught seasonally by almost everyone in the village, as well as regularly by a few persons for sale.

While firewood is used on a daily basis by some villagers, many people cook with gas stoves. Some people use noni and other herbal medicines for medicinal purposes. These are collected during trips to the beach. Most men will harvest manicole palm seasonally.

There is a lake within the community that has several traditional stories attributed to it and that could serve as a tourist attraction if infrastructure was available. There are two shell mounds within the community (a large one and a smaller one). The community is currently developing an ecotourism plan and intending to seek funding from the government or private investment to build their ecotourism potential. In addition, according to data obtained from the National Trust of Guyana, there was a site for preparing and sharpening tools and implements in the village (EMC Personal Communication 6).

Source: ERM/EMC

Figure 8.10-8: Assakata Village

The village has a health center staffed with one community health worker. The most prevalent illnesses are cold/flu, hypertension, and diarrhea. Approximately 35 patients are seen daily during outpatient services and many are referred to the Kumaka Hospital in Santa Rosa. The community has one boat that assists in cases of medical emergencies, but it is not dedicated to the health facility. There are few cases of malaria but this is likely attributed to the lack of malaria testing equipment and supplies, indicating a possibility that some infected people may go undiagnosed/untreated.

8.10.2.7. Warapoka Village

The population of Warapoka is approximately 650 people, increasing from 590 in 2018, with more males than females. There were 87 households within the village in 2018. In addition, there are currently approximately 80 migrants from Venezuela who have joined the community in the past year. There is one primary school that houses 182 students and a nursery with 34 infants. Students in higher grades attend school in Santa Rosa or Mabaruma. The village has a health clinic, village office, and a tourism center/lodge that can house six tourists.

Ecotourism is becoming an important feature of the village economy, with tourist arrivals and activities increasing, especially Guyanese tourists. The caves, petroglyphs, shell mounds, harpy eagle nesting sites, and other attractions within the community serve as attractions for tourists. A guest house consisting of six rooms houses visitors during their stay. Sport fishing in Luri Creek was recently added to the tourism package. Twenty people are currently employed directly in the tourism operation, increasing from 10 in 2018. The river serves as the main source of water for the community. The primary economic activity is sale of fish, with government workers, hunting/trapping, and tourism as other income generators within the community; fishing in other regions and mining in the interior are also prevalent.

All households live in close proximity to the village center and all have farms and use the highlands close to the forest to cultivate crops, specifically cassava. Some people farm to supply hot meals for the school and the tourism center when tourists are visiting the village. Most men are involved in fishing, particularly along the beach in the Iron Punt area, which is accessed through Luri Creek. About 20 people fish in this area every 2 weeks and catch queriman, snook, basha, cufum, and catfish. Crabs are caught seasonally by almost everyone in the village, as well as regularly by a few people for sale. Shrimp is also caught in the rivers within the community.

Source: ERM/EMC

Figure 8.10-9: Warapoka Village

The village has flooded savannas that have large parts burned in the dry season. Many people make use of the manicole palms harvesting for sale, with about 80 persons involved in this activity. There is also a significant area of mangrove vegetation regrowth in the areas that were burned during the 1998 El Niño fire, which allows for an abundance of fish and birds, with many people involved in trapping wildlife for sale. People come to the village to purchase wildlife including snakes, parrots, macaws, and river turtles (red neck, side neck, jumbie head [scorpion mud turtle], and black turtle). In terms of other biodiversity, manatees are also observed in Luri and Muribu creeks and the village has two harpy eagle nesting sites, with one currently active. Luri Creek is very important since it serves as an important food source due to the presence of many species. Some community members gather honey from wild bees at the beach and one family has a professional beekeeping business.

There are many marine species that can be found in the swamp behind the beach at Iron Punt. Wildlife access the area during the high tide when ocean water flows over the low beach in this area. Hunting of iguanas, birds, and wild ducks is conducted on the beach and duck eggs are collected. Within the village, bird eggs are collected seasonally (blue tiger bird and qak). Marine turtles killed by jaguars are sometimes observed on the beach.

Close to its village office, the village has a cultural site, which was used by the previous generations of Warraus to make and sharpen tools. There are also caves and petroglyphs within the community, and three large shell mounds (as a well as a few smaller ones) within the reservation. In addition, according to the National Trust of Guyana, ceramics of cultural value were located in the village (EMC Personal Communication 6). Medicinal plants including noni are collected from the beach and mangrove bark is also used for medicinal purposes.

There is a health center with one community health worker. The most prevalent illnesses are cold/fever, diarrhea, and vomiting. There are on average 10 patients seen daily, with severe cases being referred to Moruca Hospital or Kumaka Hospital in Santa Rosa. There have been a few reported cases of malaria in the recent past. There are no immunization supplies and medications are limited. All pregnancies that are higher-risk are referred to other facilities at 37 weeks. Villagers must rely on private transportation for emergencies.

8.10.2.8. Three Brothers Village

The community has a population of 120 people living in three satellite villages (Lower Waini, St. Johns, and Kachicamo) along a 45-mile stretch of the Waini River. The population has declined from 310 in 2018 due to villagers leaving for other areas with better infrastructure and opportunities. There are two primary schools, one at St. Johns that houses 36 students and one at Kachicamo that houses 35 students (as of 2018). Students in higher grades attend school at Mabaruma or Santa Rosa.

Source: ERM/EMC

Figure 8.10-10: Three Brothers Village

The primary economic activity is sale of fish followed by agriculture, government work, and commercial activities such as fuel sales. More than 100 men work on fishing vessels, making at least one trip per month that can last for 7 days. All households have farms that need to be bolstered by earth to protect against floods. Agriculture is important to the community for livelihood, and all families farm cassava for subsistence along with coconuts that can be sold for water or harvested for copra. Two large farms exist in the area with boats from Trinidad, Venezuela, and Suriname visiting to buy ginger and coconuts grown on the farms. Approximately 90 percent of the village are engaged in the harvesting of manicole, which is done throughout the year.

Fishing is conducted mainly in the rivers, including Luri Creek and the lagoon, with a variety of species caught, including basher, queriman, morocut, curass, cuffum, lou lou, dew fish, and catfish. Beach fishing is common through Luri Creek from May to July, and at Waini Point during the dry season for saltwater species. Crabs are caught seasonally by almost everyone in the village, as well as regularly by a few people for sale. People from other areas come to the village to catch crabs as well. Some villagers are involved in the fuel sales business and some have shops supplying household items.

Much of the village is covered by mangroves that are used for construction, firewood, and planting materials. All abandoned areas are quickly reclaimed by the mangrove forests, as the crabs tend to break up dams and the areas subsequently flood rapidly. Numerous mammals are seen in the area, although no villagers are reportedly involved in hunting/trapping. Wild ducks and other birds are hunted for food. Iguanas and land turtles are used for subsistence or sometimes sold for commercial purposes. River dolphins were prevalent in the past but have not been sighted recently, which many villagers attribute to an increase in speed boats operating within the area and fuel spills in waterways. Both the neotropical otter and giant otter are found within the area, as are harpy eagle nesting sites. There is also a high presence of jaguars that kill domestic dogs and livestock.

This village has no protected sites and all traditional religious practices have reportedly ceased. Mangroves are used for firewood, building materials (red mangrove), fishing poles, and plantain poles. Honey is collected from wild bees throughout the village by residents. The main area used for recreational purposes is Waini Beach, where villagers camp, picnic, and spend holidays, including Easter. There are villagers involved in manufacturing crab oil, and a crab oil press is located within the village. Crab oil is important to the community, and has a number of beneficial uses. Medicinal plants including noni are collected from the beach.

There is a health center with a community health worker. The most prevalent illness is related to respiratory distress, mostly in school children, as well as diarrhea in children and adults from a lack of clean water. There are reported cases of malaria from villagers when they return from the mining areas. All childbirth deliveries are referred to the regional hospital in Mabaruma.

8.10.2.9. Mabaruma Town

The town of Mabaruma has a population of approximately 8,000 people comprising six communities. There are currently reportedly about 1,000 migrants from Venezuela within the community, but many more are alleged to pass through on a daily basis. The primary economic activity is business/commerce, as this is the key administrative and business center of the region. Fishing and its related services is next in importance, followed by agriculture and government workers. There are six nursery schools, eight primary schools, and two secondary schools within the new town council. The town has a hospital, a police station, a magistrate’s court, a military base, a Coast Guard base, regional administration offices, and numerous government offices.

Agriculture is important to the community for livelihoods and many families, particularly in the outlying areas, farm cassava for subsistence and cash crops for sale or daily use. Some communities are involved in fishing, including Waicaribe, Koriabo, Smith’s Creek, and Aruka Mouth. Crab are caught daily for sale at Kumaka and to hucksters working on the ferry to Georgetown. Blue crabs are found year-round but red crabs are seasonal. Some villagers work in beekeeping, which is facilitated by a Community Development Project. The major land use in the area is housing/business or administrative services, with numerous wharfs and boat landings in the rivers. Some large farms are still functional, with others converted to grazing for the over 300 head of cattle in the township. Community members are also involved in the harvesting of manicole palm, especially where there are manicole groves.

The villages have more than 500 young men employed in various mines who work for between 3 and 6 months per year before returning home. Many miners, traders, and sex workers pass through the area, adding to commercial activity in the town.

The area has a variety of fish species, as well as mammals and birds with a few people involved in trapping and one major trader operating at the Kumaka Wharf. Most of the fish and meat are imported from other areas, with many small businesses now producing chickens. Trapping and hunting are conducted mainly along the riverbanks, and iguanas, labba, agouti, and wild ducks are the main animals hunted. Many bird species are also trapped, especially toucans, macaws, and parrots. It is estimated that there are 100 trappers within the area and three traders based at Kumaka. Sting rays are observed up river and previously dolphins were observed up to Morawhanna but are reportedly no longer sighted.

The town has a few shell mounds, tourist attractions, and a newly constructed park. All traditional religious practices have reportedly ceased, with the majority of people being Christians, with a few Hindus and Muslims. Medicinal plants are harvested from the beach area and mangroves are used by people living in swampy areas for construction and building materials. Mangrove barks are also harvested for use in tanning. The township has three sawmills that provide dress lumber to the town and nearby communities. The owners have timber concessions and also purchase timber from the Amerindian communities upon order. There is a current boost in the building sector that has been good for the three sawmills.

Source: ERM/EMC

Figure 8.10-11: Mabaruma Town

The township has embraced the Green State Development Strategy and with support from the central government has built a "Green Park" at Hosororo and planted more than 1,000 trees in the town. It also has a solar farm that generates power for the electric grid. There are plans to install a wind farm as well to provide power for the residents.

There is a regional hospital that has two doctors, five staff nurses, four nursing assistants, four midwives, and two additional midwives dedicated to the maternal and child health clinic. The most prevalent illnesses are hypertension, diabetes, and acute respiratory infections. Despite being the most frequented hospital in the region, there is often a shortage of medication and anesthetics, so operations are uncommon.

8.10.2.10. Aruka Mouth Village

The community has a population of approximately 300 people, increasing from 180 in 2018, with an approximately equal male/female ratio. The primary economic activity is commerce, with many persons trading in fuel, household items, fresh/salted fish, and crabs. The community is considered a part of the Mabaruma Town Council. There is one primary school that housed 48 students in 2018 and higher grades attend school at Mabaruma or Hosororo.

Many people have shops and trade in fuel, but 80 percent of the population is focused on fishing and manicole palm harvesting. Fishing is done both in the ocean and rivers in vicinity of the community. Many men work on fishing vessels, catching fish for the weekly markets at Kumaka and also catching crabs. Shrimp is caught during certain periods. Crabs are prevalent during the crab season when all households contribute to crabbing, while five households specifically supply the twice-a-week market at Kumaka. Some households have farms and use the lands to cultivate crops (when there is no flooding) for subsistence and sale at the local market. Community members claim that most of the aquatic mammals have moved away due to increased fuel in the water. A few households are involved in the harvesting of manicole palms.

There are no cultural sites and traditional religious practices have reportedly ceased. Some medicinal plants are collected from within the community. Mangroves are utilized by persons living in swampy areas as posts for construction and for building foundations and firewood. Some people utilize the Kissing Rocks and the beach for recreational purposes.

The community does not have a health facility and residents must go to the Mabaruma Regional Hospital.

Source: ERM/EMC

Figure 8.10-12: Aruka Mouth Village

8.10.2.11. Morawhanna Village

The community has approximately 100 people, increasing from 85 in 2018, and consists mainly of mixed ethnicity. The primary economic activity is fishing by two large boats and about a dozen small boats. There is one primary school shared with Smith's Creek that has 88 children. Students in higher grades attend school in Mabaruma. The area has a major wharf, Guyana Revenue Authority outstation, Coast Guard base, police outstation, and a teachers' accommodation.

There has been an increase in economic activities within the past few months due to the fuel trade, with boats bringing fuel from Venezuela and selling to local Guyanese dealers. An ice plant is now operational and many fishing vessels visit to purchase ice. Locals are capitalizing on the increase in activities by selling of food and beverages to persons engaged in these activities.

Fishing is the major economic activity in the village, with boats from Venezuela visiting the port to purchase fresh fish. Commercial activities are important for livelihoods with food purchased from Mabaruma or at the many local shops. Ocean fishing typically includes two to three trips per month and fish caught includes banga, gilbaker, curass, trout, snapper, snook, etc. There are two fishing boats from the community and some villagers work on other boats and at the fishing base camp at Waini Mouth. Approximately 15 people continuously conduct crabbing for sale at the Kumaka market and to hucksters on the ferry to Georgetown.

There are no household farms in the area, as flooding is common due to high tides and lack of mangroves and dams. Some persons use traditional plants (noni and fergosa) for medicinal purposes. The area has many species of fish and birds that roost nearby in a few locations. Dolphins used to be sighted in the past but have not been seen recently.

There are no documented cultural or heritage sites in the community despite being the oldest settlement in the area. Traditional religious practices have reportedly ceased. Mangroves are used by people for construction and for building foundation and for firewood. Barks are also harvested for use in tanning. The beach at Waini Point is used for recreational purposes, especially at Easter.

There is a health center but it is not operational, although repairs to the building are underway. All health matters are referred to Mabaruma Regional Hospital and Hosororo.

Source: ERM/EMC

Figure 8.10-13: Morawhanna Village

8.10.2.12. Smith's Creek Village

The community has 248 people, increasing from 208 in 2018. The residents are mainly of Warrau descent, with more females than males (60 percent and 40 percent, respectively). There are some Venezuelan migrants within the community, with as many as 80 being present at one time. The primary economic activity is sale of fish followed by manicole palm harvesting and farming. The community is considered part of the Mabaruma Town Council. There is no primary school in the village and in 2018 there were 36 children who attended school at Morawhanna. Students in higher grades attend school at Mabaruma and Hosororo.

Fishing is important to the community for livelihoods, with three large boats and 15 small boats fishing on an average of two times per month. Large boat trips are up to 10 days while smaller boats are out 2 to 3 days. Fresh fish is sold at Kumaka market and to Venezuelan trawlers. Typical saltwater species caught include snapper, trout, queriman, curass, gillbacker, and banga. Freshwater fishing is also conducted in the rivers and species caught include curass, gillbacker, and basher. Fish camps by small boats are sometimes set up at the Waini Mouth. Three households have farms and use the lands to cultivate crops where the land is high enough to not flood. The village is easily flooded and thus farmers are discouraged from farming. All community members conduct crabbing during the crab seasons and other persons catch crab year round. A crab meat processing facility is currently being established. About 10 to 15 households are engaged in harvesting manicole. A family or crew can harvest 1,500 sticks of manicole palms per trip, making one trip per month.

The area has many species of birds, and curry curry (scarlet ibis) and gaulins (cattle egrets) roost nearby in a few locations. There are also ducks at the creek head and one villager is involved in trapping in the outlying areas such as Macaw Point and Crab Dog Area. One person is involved in hunting and usually hunts labba, deer, and turtles.

There are no cultural heritage sites in the area and traditional religious practices have reportedly ceased. Medicinal plants including noni and mangroves are collected from the beach. Mangroves are used by persons for construction and for building foundations, firewood, fishing poles, and medicinal uses.

There is no health facility and all health matters are referred to Mabaruma Regional Hospital, although the residents would more easily access the health clinic in Morawhanna Village if it was operational.

Source: ERM/EMC

Figure 8.10-14: Smith's Creek Village

8.10.2.13. Imbotero Village

The community has 353 persons, increasing from 200 in 2018, and consisting mainly of Warrau descent. There are currently 153 Venezuelan migrants of Warrau descent within the community who have joined in the past year. They were given temporary status to live and use the village resources and are being supported by the Government of Guyana through the Civil Defence Commission. The Warraus from Venezuela bring hammocks, dried fish, craft, and household items for sale in the village and at Kumaka.

The primary economic activity is fishing, with manicole palm harvesting in the dry season and farming also important. There is one primary school in the village housing 53 students in 2018. Students in higher grades attend school at Mabaruma and Hosororo. There is a police outpost that serves as a checkpoint since the village is located at the border with Venezuela. The village is facing health challenges due to a scarcity in drinking water and proper toilet facilities.

Fishing is important to the community for livelihoods, with all men and some women involved in fishing for commercial purposes for sale at Kumaka. Sometimes people come to the community to purchase fresh fish, including morocut, curass, gilbaker, houri, yarrow, patwa, and hassar.

Some families/fishing crews harvest manicole palms every month for sale and almost all people conduct crabbing during the crab seasons. Twenty households have farms and use the lands not vulnerable to flooding to cultivate crops. The village is easily flooded, and the dams are consistently destroyed by crabs. Some villagers are involved in trapping but most of the activity is opportunistic during fishing trips to outlying areas such as Macaw Point or Lion Creek. There are numerous jaguars in the area, which have eaten over 30 village hunting dogs in recent months. Land and river turtles are caught by persons for food and sold at Kumaka. Other animals hunted include iguanas, deer, wild hogs, agouti, and labba.

There are no cultural heritage sites in the area and traditional religious practices have reportedly ceased. People use medicinal plants as the village has no health worker. These medicinal plants are collected from the coast and within the community and include mangrove, noni, sweet broom, and wild tobacco. Mangroves are used by persons for various purposes.

There is no health facility and all health matters are referred to Mabaruma or dealt with by using local medicine from herbs. There has been a recent trend of death in children attributed to lack of clean water and sanitary facilities.

Source: ERM/EMC

Figure 8.10-15: Imbotero

8.10.2.14. Almond Beach

This community is located within the SBPA. The community has 51 people, with many having migrated away due to the erosion of the beach areas. There are more males than females. The primary economic activity is fishing, with all males involved and using three large boats and three small boats. Farming is the next important activity with staples such as cassava being the main food crop and coconuts planted for sale. Copra and coconuts are sold at Kumaka. Miles of coconut farm were washed away in the past 5 years due to erosion with farmers having since relocated away from the area. There is one primary school in the village housing eight students. Students in higher grades attend school at Mabaruma or Hosororo. The Protected Areas Commission has three buildings in the village to house its workers and other personnel.

Fishing is important to the community for livelihoods, with all men involved in fishing for commercial purposes and household consumption. There are three main families involved in fishing, which is primarily done between Waini Point and Tiger Beach using hook and lines and short nets. Fishing trips are 2 weeks long and usually there are two trips per month using the three small boats. Most of the fish caught are sold at Kumaka. During the rainy seasons, freshwater fish are caught in the swamp behind the beach. Some people catch crabs for the Kumaka market days year-round.

All households have farms and use the lands to cultivate crops where the land is safe from erosion. Farming is conducted mainly during the wet season due to irrigation with cash crops (pumpkin, watermelon, red beans, bora, okra) and cassava being planted. Excess crops are sold at Kumaka. Coconuts are also harvested and sold. Seven persons are employed seasonally (February to July) with the Protected Areas Commission as rangers, and one person is employed full time as the caretaker.

The area is also used by the Protected Areas Commission for its base and for tourism activities. Tourists used to visit the area but this is currently closed since the buildings that used to support this activity are being relocated due to erosion. However, local visitors from surrounding areas still frequent the beach. Waini Point is now a main stopping point for boats, including fisherfolk, fuel traders, and boat repairs. The area has many species of fish, mammals, turtles, iguanas, and birds. No villagers are involved in trapping, but wild animals are hunted for food, including labba, deer, iguanas, agouti, and wild ducks (muscovy). There are numerous jaguars in the area that hunt turtles. Harpy eagles are sometimes sighted within the area and armadillos are also sometimes observed.

Source: ERM/EMC

Figure 8.10-16: Almond Beach

Mangroves (mature trees) are decreasing along the beach due to erosion, but new plants are growing in the lagoon. Previously, burning was conducted to keep the farming areas clear, but this practice has been reduced due to the protected area status. Families used to participate in livestock rearing, including pigs, cows, and goats but there are no livestock at the moment, other than poultry.

There are no documented cultural heritage sites in the area and traditional religious practices have reportedly ceased. Persons make use of medicinal plants, with noni growing abundantly on the beach. Other plants used include red mangrove, buttercup vine, periwinkle flowers, and sweet broom. Some species are used for building materials including the black mangrove, white mangrove, and almond nut tree. Black and red mangroves are also used for fishing poles. Drift wood is used for firewood. Honey is collected occasionally from wild beehives.

There is a health center building but no staff. All health matters are referred to Mabaruma or people take local medicine from herbs.

8.10.3. Impact Assessment—Indigenous Peoples

Planned Project activities will not impact indigenous peoples (typically referred to as Amerindians in Guyana). The Project will not involve any direct disturbance of any indigenous communities, or coastal habitats upon which they rely, and the Project's air emissions, discharges to water, and sound generation, all of which will occur approximately 207 kilometers (approximately 128 miles) northeast of the coastline of Georgetown, will not significantly impact their communities or the habitats on which they rely. Project use of the Guyana shorebases and onshore support facilities in Georgetown will have no impact on indigenous peoples, as these facilities are well removed from any traditional indigenous communities.

The Project's potential impacts on indigenous peoples as a result of an unplanned event, are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events

8.10.4. Mitigation Measures—Indigenous Peoples

As there are no potential impacts on indigenous peoples as a result of planned Project activities, no mitigation measures are proposed. Table 8.10-4 summarizes the monitoring measures relevant to this receptor.

Table 8.10-4: List of Monitoring Measures

Monitoring Measures
Monitor frequency of engagement with stakeholders, including fisherfolk, coastal communities, vulnerable groups and Indigenous populations.

9. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM UNPLANNED EVENTS

9.1. INTRODUCTION

An unplanned event is defined as an event that is not planned to occur as part of the Project (e.g., accidents), but that has the potential to occur. Since such events are not planned, they are evaluated in a different manner from planned events, specifically by evaluating the consequence of a realistic scenario for an unplanned event and taking into consideration the likelihood that the event could occur. Three levels of likelihood are used: unlikely, possible, and likely, as defined in Table 9.1-1.

Table 9.1-1: Levels of Likelihood for an Unplanned Event Impact Assessment

Likelihood	Definition
Unlikely	Considered a rare event, and there is a small likelihood that an event could occur.
Possible	The event has a reasonable chance to occur at some time during normal operating conditions.
Likely	The event is expected to occur during the life of the facility.

As described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, a risk matrix using the likelihood and consequence/severity of the event is used to evaluate the potential significance of unplanned events. The consequence/severity of the unplanned event is measured in terms of the importance/vulnerability/sensitivity of the resource/receptor and the magnitude of the impact (Table 9.1-2).

Table 9.1-2: Risk Rating Matrix for Unplanned Events

		Consequence/Severity		
		Low	Medium	High
Likelihood	Unlikely	Minor	Minor	Moderate
	Possible	Minor	Moderate	Major
	Likely	Moderate	Major	Major

For the purposes of the EIA, the following unplanned events are considered as having the potential to occur during the Project life (at least 20 years), should a combination of standard and Project-specific safety controls fail concurrently:

- Hydrocarbon spill (potentially resulting from any of several different unplanned events);
- Marine vessel collision (focused on potential physical damage to other vessels or structures, and/or injuries);
- Offshore discharge of untreated wastewater from the Floating Production, Storage, and Offloading (FPSO) vessel; and
- Onshore vehicular accident.

These potential unplanned events are described in more detail below. There are other minor unplanned events (e.g., dropped objects, small spills on deck that do not enter the ocean) that have a credible potential to occur, but which would not significantly impact any resources/ receptors considered in this EIA. These other unplanned events would occur on the drill ships, installation vessels, supply vessels, or the FPSO, and their impacts would tend to be limited to Project employees and contractors (e.g., a variety of accidents that could result in worker injury, but no measurable impact on natural resources or the public). These events are addressed primarily through EEPGL's and its contractors' health and safety policies and procedures, which are discussed in Chapter 2, Description of the Project; Chapter 11, Environmental and Socioeconomic Management Plan Framework; and the Project's Environmental and Socioeconomic Management Plan (ESMP), but are otherwise beyond the scope of this EIA.

The Consultants have performed the impact assessment for unplanned events on the basis that the Project will use existing shorebases located in Georgetown, which are not dedicated to the Project. Should any new or expanded shorebases or onshore support facilities be used, the construction/expansion and any required dredging, as well as the associated permitting, of such facilities, would be the responsibility of the owner/operator, and such work scope would not be included in the scope of this EIA.

9.1.1. Hydrocarbon Spill

Producing, processing, storing, and offloading crude oil are core Project activities. Additionally, the Project will use marine vessels, aircraft, and processing equipment that use petroleum products for fuel and lubrication. There are multiple layers of control in place with respect to these activities; however, if multiple controls fail, there is the potential for a hydrocarbon oil spill to occur. EEPGL categorizes oil spills into three tiers:

- Tier I—Spill is small, the source of spill is under control, and response would be managed by EEPGL and its contractors using local resources;
- Tier II—Spill is moderate, the source can be quickly brought under control, local response equipment immediately available, and broader response would be managed in a coordinated manner using regional resources as needed; and
- Tier III—Spill is large and/or the source of the spill is not under control, and response would be managed in a coordinated manner with regional and internationally sourced resources.

Hydrocarbons that could potentially be released include crude oil, marine diesel, fuel oil, aviation fuel, lubricating oil, and non-aqueous drilling fluid (NADF). Releases of hydrocarbons could result from a number of different unplanned events. Discussions of the unplanned events considered are provided below.

9.1.1.1. Helicopter Ditching

The Project will involve the use of helicopters to support drilling, installation, production operations, and decommissioning activities. It is estimated that during development drilling and FPSO/Subsea Umbilicals, Risers, and Flowlines (SURF) installation, flights may increase at peak to a total of approximately 45 to 55 round-trip flights per week. During FPSO/SURF production operations, an estimated maximum of 30 to 45 round-trip flights per week will be necessary to support FPSO/SURF production operations and continued development-drilling activities. Flights during the decommissioning stage would likely be similar to those during the FPSO/SURF installation stage.

Although aviation accidents are rare events, there is the potential for a helicopter to ditch at sea. A ditching incident could be the result of a number of factors, which may potentially include loss of power, severe weather, or bird strike. Worker safety-related aspects are addressed primarily through EEPGL's and its contractors' health and safety policies and procedures, and these are not otherwise addressed in this EIA. However, a ditching could potentially result in a spill of aviation fuel or lube oils from the helicopter and related potential localized environmental impacts.

9.1.1.2. FPSO or Drill Ship Fire

Although an **Unlikely** event, there are a number of potential scenarios that could lead to a fire event on the FPSO or a drill ship (e.g., inadvertent ignition of oily rags or related materials, electrical panel fault, etc.). To reduce the possibility and consequence of a fire, EEPGL or the drill ship operator will implement a series of fire prevention controls (design-based and operations) in alignment with Good International Oilfield Practice. There are multiple automated safety features designed into the FPSO and drill ships to minimize the risk of any fire (e.g., fire detection, automated shut-off valves, alarms, deluge system, fire protection) as well as trained operations and maintenance crew. Additionally, the FPSO and drill ships will have a robust emergency response plan to direct activities in the event of such a fire. Any fire would likely be quickly detected and extinguished, via either an automated and/or manual system. Further escalation of a fire event would be a rare event.

The firewater used in a response would likely be captured within the deck open-drain system, but some could potentially wash over the deck to the sea. While these measures would significantly reduce the potential for a fire to occur in the first place, operational procedure and engineering design systems would further limit the potential for a release of hydrocarbon-containing firewater overboard during response. The possible washover of firewater from the FPSO or drill ship deck to the sea could result in the discharge of relatively minor amounts of hydrocarbons, with the potential for related, localized environmental impacts.

9.1.1.3. Offshore Collision between FPSO and Offloading Tanker

During offloading of crude oil from the FPSO to a conventional tanker, the offloading tanker must approach at a controlled, safe speed to about 120 meters (approximately 390 feet) of the FPSO. To minimize the risk of collision during the approach to the FPSO and during offloading, EEPGL will use a Mooring Master on the offloading tanker. The Mooring Master will guide the offloading tanker to the FPSO for offloading, remain on board during offloading, and then guide the offloading tanker away from the FPSO after offloading. Up to three assistance tugs will help position the offloading tanker during the approach to the FPSO to maintain a safe separation distance. During offloading, the tanker will be connected to the FPSO via a hawser (a taut line) and the tugs will be connected to the tanker via hawser lines to help ensure the offloading tanker maintains a safe distance from the FPSO at all times (see Figure 2.9-1).

Offloading will only occur when weather and sea conditions allow for safe operations. If the environmental conditions prior to the tanker approaching the FPSO are not suitable, the tanker will stand by at a safe distance away until conditions are within acceptable limits. If unexpected adverse weather (e.g., a squall) occurs during offloading, the offloading operations will be stopped and the tanker disconnected and moved away from the FPSO until conditions are within approved, safe limits. With these precautions, the potential for a collision between the FPSO and the offloading tanker is considered **Unlikely**. In the unlikely event of a collision during the tanker approach to or departure from the FPSO, the risk of a cargo tank breach on either vessel is greatly reduced by the design of the FPSO (double-hull protected on sides) and the tankers (double-hulled), and the fact that the FPSO is stationary and the offloading tanker would be travelling at a very slow maneuvering speed (assisted/pulled back by tugs). Therefore, there is not expected to be sufficient collision energy to breach the hulls, and a spill scenario from a tank breach was therefore not considered in relation to this unplanned event.

9.1.1.4. Nearshore Collision between a Project Supply Vessel and another (Third-Party) Vessel or Structure, or Grounding

There are a variety of Project vessels that will supply and support drilling, installation, and production operations activities. These vessels will transit between the Guyana shorebases and the Project Development Area (PDA). There is a potential for collisions between these vessels and other third-party vessels/structures in the Georgetown Harbour/Demerara River area or for the nearshore grounding of a vessel. Such an incident may result from navigation error or a temporary loss of power that affects the ability of a vessel to steer. Fuel oil or lubricating oil spills resulting from an event could potentially cause environmental impacts.

A number of controls will be implemented to prevent these types of vessel incidents from occurring. EEPGL has comprehensive contractor selection guidelines to ensure contractors are qualified and have robust safety, health, and environmental management systems. EEPGL will provide active oversight over its contractors to verify they are complying with its requirements. Contractors are required to regularly inspect their vessels, which addresses marine safety and maintenance considerations and reduces the risk of a vessel losing power or steering capability. In addition, vessels operating within the Georgetown Harbour or other coastal areas will be required to adhere to speed restrictions and navigation aids.

9.1.1.5. Other Shorebase-Related Events

Spills of hydrocarbons at the shorebases could also occur from the following initial unplanned events:

- Partial loss of onshore diesel storage tank contents; and
- Hose failure, mechanical failure, or human error during bunkering operations, resulting in a release of fuel to the water.

9.1.1.6. Offshore Collision between Project Vessels or between a Project Vessel and another (Third-Party) Vessel

Other vessel collisions (e.g., collisions between drill ships, installation vessels, or the FPSO and other vessels) are not considered reasonably foreseeable scenarios given the following safety measures that will be put in place:

- The Maritime Administration Department (MARAD) will issue notices to mariners concerning safety at sea and the location of the drill ships, installation vessels, and the FPSO. EEPGL will also communicate major Project vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners. Through a stakeholder engagement process, EEPGL will communicate Project activities, where possible, to those individuals to aid them in avoiding Project vessels. Marine safety exclusion zones with a 500-meter (approximately 1,640-foot) radius will be established around the drill ships during drilling operations and around drill centers during well workovers, in accordance with industry standards and practices. No unauthorized vessels will be allowed to enter these marine safety exclusion zones. Similar marine safety exclusion zones will be established for the major installation vessels.
- A marine safety exclusion zone of 2 nautical miles will be established around the FPSO. No unauthorized vessels will be allowed to enter this marine safety exclusion zone during offloading.
- EEPGL will use what is known as a Simultaneous Operations procedure to safely manage Project marine vessels that are performing work in the same vicinity of each other, which will include considerations to avoid vessel collisions.
- Marine vessels will have industry-proven station-keeping systems (e.g., FPSO mooring system, dynamic position systems on drill ships) to maintain station in the offshore environment.

9.1.1.7. Drilling-Related Spills

Spills of hydrocarbons during drilling could occur from the following unplanned events:

- A failure in containment or breach of fuel storage tank on a drill ship, resulting in a release of fuel;
- A spill of NADF due to a loss of riser contents resulting from an emergency disconnect between the riser and Lower Marine Riser Package connected to the drill ship and the blowout preventer (BOP) (e.g., due to dynamic positioning (DP) station keeping failure);
- A limited well control event with loss of containment (e.g., if the well becomes unbalanced during the drilling process and begins flowing) that is contained within a relatively short period of time (i.e., within a matter of minutes or hours); and
- A larger well control event with loss of containment where a release continues for a longer (i.e., up to a multi-day) period of time while activities are undertaken to bring the well under control.

9.1.1.8. Production-Related Spills

Spills of hydrocarbons during FPSO production operations could occur from the following unplanned events:

- A failure in containment on the FPSO topsides, resulting in a release of crude oil to the deck and/or sea;
- A failure in containment or breach of fuel or chemical storage tank on the deck of the FPSO, resulting in a release of fuel to the deck and/or sea; and
- A failure of an offloading hose during offloading from the FPSO to a conventional offloading tanker, resulting in a release of crude oil into the sea.

9.1.1.9. Summary of Spill Scenarios Considered

Based on the considerations of unplanned events discussed above, a range of potential spill scenarios were considered for the purpose of the EIA. The scenarios considered provide a representation of the different spill volumes, hydrocarbon types, and locations of spills that could reasonably be expected to occur in this type of project. These include the following:

- Spills of fuel at the Guyana shorebases (Georgetown area) into the Demerara River, or at other locations near the coast, which could result from:
  - An onshore spill from fuel storage at a shorebase facility (Scenario 1);
  - An on-water spill of fuel (e.g., during bunkering of a supply vessel; Scenarios 2 and 3); and
  - An on-water spill of fuel resulting from nearshore collision of a supply vessel with another third party vessel or structure or from grounding of a supply vessel (Scenario 4).
- Spills of fuel offshore, which could result from:
  - Releases of marine diesel from a supply vessel (e.g., due to human error or equipment failure; Scenario 5);
  - Releases of marine diesel from a drill ship or the FPSO (e.g., due to human error or equipment failure; Scenarios 6 and 7);
  - Helicopter ditching into the ocean during transit between the shore and the FPSO or drill ships and resultant loss of fuel to the ocean (Scenario 8); and
  - A minor FPSO or drill ship deck fire and resultant loss of hydrocarbons along with firewater that washes overboard during firefighting (Scenario 9).
- Spills of crude oil during production operations, which could result from:
  - Releases of crude oil from the FPSO topsides (e.g., due to failure of topsides equipment; Scenario 10); and
  - Releases of crude oil during offloading (e.g., resulting from failure of offloading hose during offloading from FPSO to tanker; Scenario 12).

- Spills during development drilling operations, which could result from:
  - Spills of crude oil as a result of loss of well control with loss of containment (Scenarios 11, 13, and 14); and
  - Spills of NADF (e.g., as a result of loss of riser contents after emergency disconnect due to DP station keeping failure; Scenario 15).

Scenario 13 represents a loss-of-well-control scenario, with an estimated discharge rate of 20,000 barrels of oil per day (BOPD); this scenario was developed by EEPGL based on its worldwide experience conducting similar analyses.

In response to a request from the Guyana Department of Energy regarding the Liza Phase 2 Project Development Plan, EEPGL commissioned a third party (Gemini Solutions; GSI) to develop supplementary loss-of-well-control discharge scenarios. Specifically, GSI was commissioned to develop worst-case discharge (WCD) calculations for the reservoirs to be developed as part of the Project in accordance with the U.S. Bureau of Safety and Environmental Enforcement's (BSEE's) guidelines published in the U.S. Department of Interior BSEE Worst Case Discharge Analysis (Volume I, February 2016). As stated in the BSEE guidelines document, although WCD modeling results "present an extremely dire representation of the potential for contact between the discharged oil and the environment, they do provide a working baseline of datum that will be useful for further analysis" (BSEE 2016).

The U.S. Bureau of Ocean Energy Management (BOEM) defines the WCD as the single highest daily flow rate of liquid hydrocarbon during an uncontrolled wellbore flow event (i.e., the average daily flow rate on the day that the highest rate occurs, under worst-case conditions). The WCD values represent an open well condition in which *no flow restrictions or well control technologies* such as blow out preventers are in operation. The WCD is neither the total volume spilled over the duration of the event, nor the maximum possible flow rate that would result from high-side reservoir parameters. It is a single value for the expected flow rate calculated under worst-case wellbore conditions using expected reservoir properties. The main purpose of a WCD calculation is to support oil spill response planning. The duration of the WCD release is typically 30 days unless shutting in the well with a capping stack or other technology is expected to occur earlier. GSI is the predominant vendor for WCD calculations provided to BSEE in the Gulf of Mexico region.

EEPGL provided GSI with technical information on six targeted Project reservoirs, and GSI incorporated the information into its WCD simulation program and calculated six reservoir-specific WCDs ranging from 25,151 to 202,192 BOPD. In consultation with EEPGL's oil spill modeling contractor (RPS), EEPGL identified two WCD scenarios to characterize a potential Project well-control scenario with loss of containment. These two scenarios were selected in order to characterize uncontrolled wellbore flows for Project reservoirs with varying characteristics.

EEPGL contracted RPS to model two WCD scenarios for the Project. The 20,000 BPD loss-of-well-control scenario is very close to the lowest of the calculated WCD rates (and therefore would be expected to produce similar modeling results), so this scenario was modeled as the

"Most Credible WCD." Additionally, the highest of the calculated WCD rates was modeled as the "Maximum WCD." Although modeling of the Maximum WCD scenario supports oil spill response planning, the scenario represents an operational condition, which is highly unlikely to be encountered during drilling operations. In a more representative scenario, apart from BOPs on the wellhead, there would be drill string, tubing, and/or other equipment that would be in the wellbore during a well control event, which would partially constrain and restrict flow from the reservoir.

In summary, the following WCDs were selected for modeling of a potential Project loss-of-well-control scenario:

- Most Credible WCD—20,000 BOPD for 30 days (Scenario 13)
- Maximum WCD—202,192 BOPD for 30 days (Scenario 14)

The results of the Maximum WCD serve as the WCD calculation for a well-control scenario with loss of containment in alignment with the United States' Gulf of Mexico practice.

These are summarized, together with reasonable assumptions for associated spill volumes, in Table 9.1-3. The representative spill volumes were developed based on industry experience (i.e., what spill volumes have been known to occur) and to correspond to the three tiers of response that would be employed.

Table 9.1-3: Hydrocarbon Spill Scenarios Considered for Impact Assessment

#	Tier	Location	Possible Scenario	Potential Impact [a]
1	I	Shorebase	Onshore spill of less than 10 bbl (e.g., partial loss of diesel storage tank contents)	Contained onshore; no shoreline impact likely
2	II	Shorebase	On-water spill of less than 100 bbl (e.g., shore to vessel bunkering spill)	Diesel enters Demerara River estuary; possible minor shoreline impact
3	II	Supply vessel at shorebase	On-water release of less than 500 bbl of diesel (e.g., shore to vessel bunkering)	Diesel enters Demerara River estuary; possible shoreline impact
4	II	Supply vessel at shorebase or nearshore	On-water spill of less than 100 bbl (e.g., resulting from grounding or collision with a non-Project vessel or structure)	Diesel enters Demerara River estuary or nearshore waters; possible minor shoreline impact
5	I	Supply vessel offshore	Offshore spill of less than 50 bbl of fuel	Hydrocarbons enter water, creating sheen on the water surface; no shoreline impact likely
6	I	Drill ship or FPSO offshore	Offshore spill of less than 50 bbl of fuel (e.g., leak or release due to human error or failure of equipment)	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely
7	II	Drill ship or FPSO offshore	Offshore spill of less than 250 bbl of fuel (e.g., leak or release due to human error or failure of equipment)	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely

#	Tier	Location	Possible Scenario	Potential Impact [a]
8	I	Helicopter offshore	Offshore spill of less than 50 bbl of fuel resulting from helicopter ditching and resultant release of fuel tank contents	Enters offshore Atlantic Ocean; no shoreline impact likely
9	I	FPSO offshore	Offshore spill of less than 50 bbl of fuel resulting from discharge of hydrocarbons along with washover of firewater	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely
10	I	FPSO offshore	Offshore spill of less than 50 bbl of crude oil from FPSO topsides (e.g., leak or release due to human error or failure of equipment)	Contained on deck of vessel or enters offshore Atlantic Ocean; possible shoreline impact
11	II	Drill ship/well offshore	Well-control release of less than 250 bbl (e.g., well becomes unbalanced during the drilling process and begins flowing at a low rate prior to containment)	Hydrocarbons enter Atlantic Ocean; no shoreline impact likely
12	II	FPSO, offloading tanker offshore	Offshore release of 2,500 bbl of oil (e.g., failure of offloading hose during offloading from FPSO to tanker)	Oil enters Atlantic Ocean; possible shoreline impact
13	III	Drill ship/well offshore	Offshore release of oil from well control event (30 day duration at 20,000 BOPD) (Most Credible WCD)	Oil enters Atlantic Ocean; possible shoreline impact
14	III	Drill ship/well offshore	Offshore release of oil from well control event (30 day duration at initial rate of 202,192 BOPD) (Maximum WCD)	Oil enters Atlantic Ocean; possible shoreline impact
15	II	Drill ship/well offshore	Offshore release of up to 2,200 bbl of NADF due to loss of riser contents after emergency disconnect due to DP station keeping failure	NADF enters water near the seafloor; no shoreline impact likely

bbl = barrels
[a] Potential impact is based on modeling of an **unmitigated** spill scenario (see Oil Spill Response Plan in Volume III for further discussion of Scenarios other than 12 and 13).

Oil spill modeling for this EIA focused on higher-volume releases (Scenarios 11–14) in which an active response is anticipated. Oil spill modeling serves several purposes: (1) it indicates where the spilled oil is located; (2) it predicts where the oil is going, e.g., trajectory; (3) it provides information on when the oil will get there, e.g., timing; and (4) it predicts whether it will be in recoverable quantities, e.g., fate and mass balance.

Hydrocarbon releases of less than 100 barrels (bbl) (Scenarios 1, 2, 4, 5, 6, 8, 9, and 10) would be expected to be quickly brought under control, and would be managed with locally available spill control equipment. Several of the scenarios (7, 9, and 10) are contained on the deck of the vessel and are not expected to enter the ocean, so were not modeled. The diesel fuel releases into the Demerara River represent a release of non-persistent fuel material and were not modeled.

These releases are known to be transient with a short duration in this river environment. These spills of diesel would not represent an active response beyond possible diversion booming, depending upon season and species of animals in the area. The focus of Scenario 8 would be the safety, rescue, and recovery of the helicopter crew. The helicopter fuel volume is quite small and this is not a hydrocarbon that is persistent in the environment. Considering the known transient nature of this fuel in the environment, no modeling was performed and no spill response is anticipated. A temporary, visible sheen on the water surface may occur, water quality would be temporarily impaired in a localized area, and sensitive receptors (e.g., plankton and possibly some seabirds or shorebirds) may be locally affected. However, there is not considered to be potential for any long-term or ecosystem-level impacts on ecologically important or protected species. These spills are, therefore, not considered further in the assessment of risks from potential hydrocarbon spills.

A hydrocarbon release under Scenario 15 would involve a spill of up to approximately 2,200 bbl of NADF into the ocean near the seafloor. Under this scenario, the spill would be limited to the capacity of the drilling riser. The potential impacts of a release of this nature would primarily occur at or near the seabed, and may include localized smothering and toxicity that would affect benthic species, although this disturbance would occur in the same area where disturbance from drilling and cuttings discharges have already occurred. Any dispersion of the NADF would also result in localized impacts on water quality and sensitive planktonic or fish species. Other than a localized area where the material has deposited, any water quality or other effects would be short-term, as the product would disperse within the water column and be carried away by currents.

A hydrocarbon release under Scenario 3 would involve a spill of approximately 500 bbl of diesel into an adjacent river or water body where a shorebase is located. Due to the rapid natural dispersion and evaporation of diesel, combined with dilution by water movement and tidal exchange, impacts would be limited in duration and would reduce with distance from the spill site.

Hydrocarbon releases under Scenario 11 (minor well control release during drilling), Scenario 12 (release during offloading from FPSO to tanker), and 13 and 14 (a larger well control incident) would all involve a crude oil spill in the PDA, requiring the implementation of both local and regional response resources as well as Oil Spill Response Limited's (OSRL) global oil spill technical response teams and equipment. Oil spill modeling for the larger release scenarios (Scenarios 12 to 14) and coastal sensitivity mapping have been conducted to identify and characterize the resources/receptors with the potential to be exposed to spilled oil from these types of events. An overview of the modeling approach and results for Scenarios 12 to 14 are provided in Section 9.1.4, Oil Spill Modeling Overview, and Section 9.1.5, Oil Spill Modeling Results. The potential risks associated with the smaller volume offshore oil spills are encompassed within the modeling.

It should be noted, however, that a hydrocarbon spill is considered highly unlikely primarily because of controls EEPGL and its contractors put in place to prevent a spill from occurring. Section 2.13, Embedded Controls, provides a description of the embedded controls related to spill prevention; further detail is provided in Section 9.1.7, Oil Spill Prevention, Control, and Emergency Response Measures.

Despite the unlikely probability of an oil spill, the impact assessment considers potential impacts associated with Scenario 3, the largest of the nearshore spill scenarios—referred to in the resource-specific assessments as a "coastal oil spill"; Scenarios 13 and 14—referred to in the resource-specific assessments as a "marine oil spill"; and Scenario 15—referred to in the resource-specific assessments as an "NADF release."

9.1.2. Factors Impacting Severity of Hydrocarbon Spills

Several factors impact the severity of hydrocarbon spills and the options for, and effectiveness of, a range of spill response measures. These factors include the hydrocarbon properties, volume and location of the spill, metocean conditions, and seasonal factors impacting the presence of wildlife (Dicks 1998).

Hydrocarbon products vary widely in their physical and chemical properties, as well as their potential impacts on marine organisms (Figure 9.1-1). Heavy oils have the potential to cause more significant and longer-term impacts, as they may persist along shorelines and cause smothering of intertidal plants and coral reef habitats. In contrast, light oils tend to be more toxic, but dissipate much more quickly through evaporation and dispersion, so they are generally less impactful overall and their potential toxic impacts are likely to be localized and short-lived (ITOPF 2014; Dicks 1998).

Source: ITOPF 2014

Figure 9.1-1: Typical Impacts on Marine Organisms across a Range of Oil Classes

The oil that will be produced from the Payara field is categorized as a "medium crude" oil with a specific gravity less than that of water. For a release near the top of the water column, the majority of this oil would rise quickly to the water surface. For a release near the seabed, the oil would rise, and the plume containing the oil droplets and gas bubbles would entrain seawater as it moves upwards. In the PDA, the water depth is sufficient to cause these plumes to terminate (i.e., "trap") within the water column. Once the plume traps, the oil droplets would rise only through buoyancy until they reach the surface or dissolve, with the rise rate of the oil droplets varying depending on the droplet size (i.e., with larger droplets rising faster than small) (RPS 2019). As a result, the potential for persistent slicks, shoreline impacts, and smothering is reduced relative to heavy crude or heavy fuel oil products.

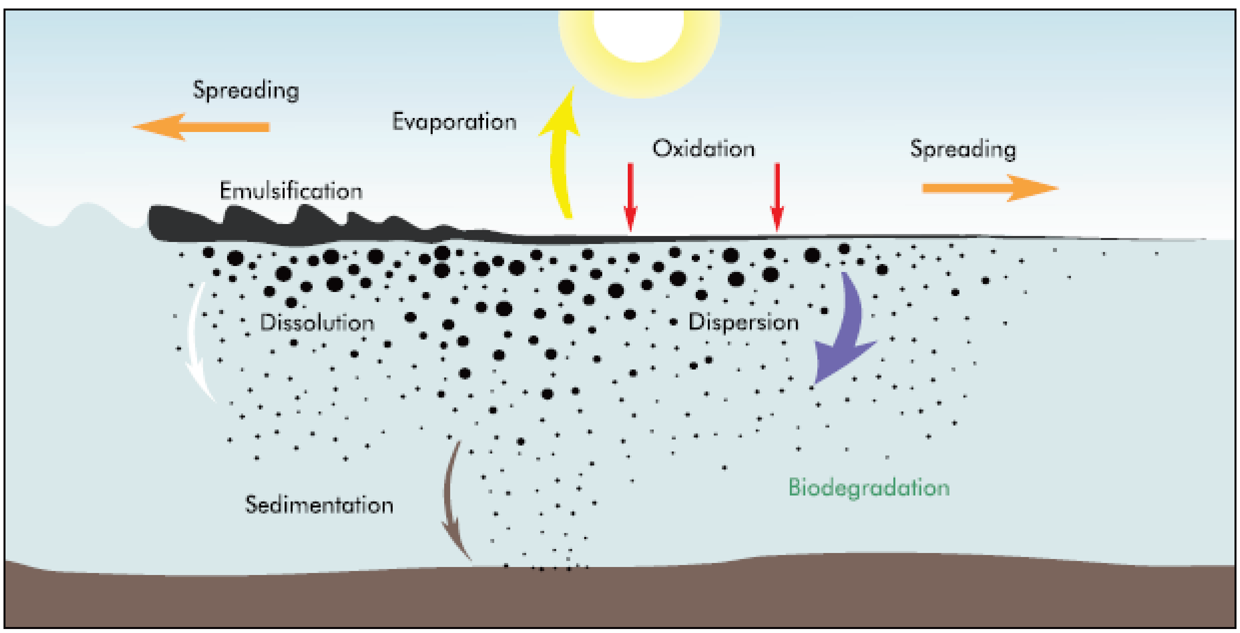
The Project will use low-toxicity NADF in its drilling operations, which is denser than the medium crude oil in the Payara field and contains specific weighting materials used during the drilling process. As such, the NADF would tend to remain near the seafloor if released from the bottom of the riser (e.g., during an emergency disconnect scenario).

The loss-of-well-control events considered for the purpose of this EIA would occur in the ocean approximately 207 kilometers (approximately 128 miles) northeast of the coastline of Georgetown. The open waters of the ocean, and associated pelagic and seabed communities, are typically more resilient to spills than shoreline environments (Dicks 1998).

Climate and weather can also impact the behavior of an oil spill. For example, oils become more viscous (i.e., flow less readily) at lower sea surface and air temperatures. In this case, the surface waters in the Project Area of Influence (AOI) are relatively warm, typically ranging from 24 to 30 degrees Celsius (°C), which would result in the oil remaining fluid, enhance evaporation of the lighter fractions (as discussed below), and improve spill response options such as dispersant application and *in situ* burning.

9.1.3. Weathering Process

As soon as hydrocarbons are introduced into the ocean, advection and spreading begin immediately and result in a rapid increase in the area of exposure of the hydrocarbons to subsequent "weathering" processes (Figure 9.1-2). These processes include evaporation, dissolution, vertical dispersion, emulsification, and sedimentation. All of these processes are influenced by the specific composition of the introduced hydrocarbon. In addition, some components are degraded by photochemical oxidation induced by sunlight.



Source: ITOPF 2013

Figure 9.1-2: Weathering Processes Acting on Hydrocarbons in an Ocean Environment

These processes may result in vaporized hydrocarbon fractions and reaction products in the atmosphere, slicks and tar lumps on the surface of the ocean, dissolved and particulate hydrocarbon materials in the water column, and similar components in the sediments. While physical and chemical weathering processes are occurring, biological processes, including degradation of the hydrocarbons by microorganisms to carbon dioxide or organic components in intermediate oxidation stages and uptake by larger organisms and subsequent metabolism, storage, or discharge, can also act on the hydrocarbons.

Although some of these processes (e.g., photochemical oxidation, evaporation) would not occur at the depths at which an NADF release could occur, the NADF would be subject to biological degradation. Biological degradation proceeds more slowly under anoxic conditions than under well-oxygenated conditions, so biological degradation would tend to occur most rapidly where the NADF is thinly distributed over a wide area of seafloor rather than in thicker clumps over a small area.

9.1.4. Oil Spill Modeling Overview

Oil spill models have been in use for more than 30 years to support the development of oil spill response planning. Trajectory and fate models simulate oil transport and predict the changes the oil undergoes (i.e., its fate) as it interacts with water, air, and land. The models simulate spill events based on a characterization of the wind and hydrodynamic (marine currents) forces that influence oil transport. The model uses current data directly as surface oil moves with the speed and direction of the current. Wind data affect oil slicks at a range of 1 to 5 percent, and the SIMAP Model (RPS 2018b) was set with the wind drift estimated as 3.5 percent of wind speed. The model combines the magnitude and direction of the wind and current data inputs. The resulting predictions from the models can be used to quantify the potential consequences of a spill, which can then be used to guide response planning and prioritize response asset deployment. There are two principal modes in which oil spill models can be used:

1. **Stochastic** (statistical) mode, which examines *many potential releases* from the same point using the full range of historical data for wind and currents; and
2. **Deterministic** mode, which examines a *single potential release* using specific historical wind and hydrodynamic data selected from a range of historical data, or using forecasted wind and hydrodynamic data for an ongoing or future event.

Extreme weather events typically are considered qualitatively in oil spill modeling. The PDA is not in a seismically active area, so seismic events such as tsunamis did not factor into oil spill modeling. The Project infrastructure is designed to withstand other potential extreme events (e.g., squalls); in fact, these extreme events have little to no effect on the wells, which are located approximately 1,900 to 2,100 meters (6,234 to 6,890 feet) below the ocean surface. In any case, weather forecasts would provide advance notice of these events and would enable EEPGL to take appropriate operational precautions to reduce the chance of an oil spill under such conditions. Accordingly, the oil spill modeling conducted for the purpose of this EIA was based on historical environmental (wind, wave, and current) and hydrodynamic data.

A typical approach to using oil spill models in oil spill response planning is to first apply the stochastic mode to determine the most likely trajectory for the spill scenarios of interest. The stochastic approach captures variability in the trajectory by simulating hundreds of individual spills (i.e., under different environmental [wind, wave, and current] and hydrodynamic conditions) and generating a map that is a composite of all of the predicted trajectories, thus providing a *probability footprint* showing the most likely path for a given spill scenario. Spill scenarios are typically modeled in stochastic mode to estimate probability that a specific area would be impacted by the spill and timing of arrival of the spill at a particular area for each season or wind regime in the region.

Each stochastic model run results in a map showing the probability of a specified thickness of oil on the sea surface across the study area, and the minimum time of oil arrival across the study area. Examples of stochastic maps are shown in Section 9.1.5, Oil Spill Modeling Results.

The specified thickness threshold on which the probabilities are based is chosen based on the purpose of the modeling or the types of impacts being considered, including ecological and socioeconomic impacts. Modeling is then used to determine the probability that oil would be present at a location in a thickness at or exceeding the designated threshold. For example, a surface slick thickness threshold can be based on the minimum thickness that can be mechanically recovered or on the minimum thickness that is thought to cause ecological or socioeconomic impacts. When applied in this way, a trajectory and fate model can quantify the likelihood of specific spill consequences, which is supportive of spill response planning and preparedness and environmental impact analysis.

Surface oil thickness thresholds are typically expressed in units of mass per unit area (e.g., grams per square meter [g/m^2]). Table 9.1-4 summarizes the range of thicknesses relative to their appearance on water.

Table 9.1-4: Oil Thicknesses (g/m^2) and Appearance on Water

Code	Description	Layer Thickness Interval (g/m^2)	Liters per Square Kilometer
1	Sheen	0.04–0.3	40–300
2	Rainbow	0.3–5.0	400–5,000
3	Metallic	5.0–50	5,000–50,000
4	Discontinuous True Oil Color	50–200	50,000–200,000
5	Continuous True Oil Color	200 +	200,000 +

Source: Bonn Agreement 2007

For the purpose of this EIA and oil spill response planning, a threshold of 1.0 g/m^2 has been used for the modeling of spills. This represents an oil thickness where ecological effects on very sensitive species may potentially occur and select spill response and recovery methods could be applied in suitable circumstances (e.g., wind and sea state).

Oil spill modeling in the deterministic mode is used to predict where spilled oil from a single release would go and how quickly it would arrive at given locations. The trajectory of the spill is determined by the specific modeled wind and hydrodynamic conditions. The model predicts the spill pathway by calculating the movement of the oil for individual short increments of time over the spill's duration, which cumulatively results in what is known as the *spill trajectory*. Knowing the distance traveled by the oil over a period of time also provides a prediction of the time of travel for the spill to reach specific areas. Consequences from the spill are determined by running the model within a geospatial framework so that interactions between the oil and elements of the environment (e.g., habitats) can be considered. Given an adequate definition of currents, winds, and the environment, a deterministic model can provide comprehensive predictions of the trajectory, fate, and effects of the oil.

Oil spill trajectory and fate models provide a quantifiable and consistent means to quantify spill consequences. A trajectory and fate model can also simulate the effects of spill response activities such as mechanical recovery, dispersant application, and *in situ* burning. Model simulations with and without spill mitigation measures are used to calculate the effectiveness of different response strategies and equipment and can be used to help validate and improve spill response plans and contribute to a Net Environmental Benefit Analysis (NEBA) process. The NEBA process examines the benefit of using various spill response technologies against the effect of the oil spill itself prior to deploying the preferred technologies in a spill event.

Once individual spill events have been defined based on the selected criteria, a deterministic map for each event, showing the predicted trajectory and fate of the spilled oil, is generated. These deterministic maps can be generated for a range of spill scenarios and included in an Oil Spill Response Plan (OSRP) for use in planning responses to different scenarios. Examples of deterministic maps are shown in Section 9.1.5, Oil Spill Modeling Results.

9.1.5. Oil Spill Modeling Results

From the list of oil spill scenarios described in Section 9.1.1, Hydrocarbon Spill, oil spill modeling results are presented in this section for Scenarios 12 to 14 (the marine oil spill scenarios with the largest release volumes). Modeling results for additional (smaller release volume) scenarios are included in the OSRP. Scenario 12 is a 2,500 bbl surface spill associated with FPSO offloading to a conventional tanker. Scenarios 13 and 14 are 30-day loss-of-well-control events, with oil released to the ocean from near the seafloor at rates of 20,000 barrels per day (bpd) for the Most Credible WCD and 202,192 bpd (initial release rate) for the Maximum WCD.

The initial deterministic model runs for each scenario predict potential impacts in the absence of spill response measures, a baseline that response activities may be measured against. Subsequently, additional deterministic model runs were conducted with implementation of response measures, which significantly reduces the severity and extent of a spill and its impacts, as demonstrated by the modeling.

Spills originating near the seafloor were simulated using the OILMAP Deep model (RPS 2018a) to predict the discharge plume geometry, droplet size distribution discharged into the water column, and fate of the oil plume. The SIMAP model system (RPS 2018b) was used to predict the probability of oil reaching the 1 g/m^2 thickness on the sea surface across the study area, taking into account the weathering profile of the oil (which would result in a proportion of the oil evaporating or dispersing into the water column). Spills were simulated taking into consideration the quantity of oil released, the type of oil and its characteristics (e.g., density), historical seasonal wind and current patterns, and water depth, among other factors.

For each of these scenarios, modeling was performed for the Jun−Nov season, as well as the Dec−May season. The results are described below, including modeling under stochastic, deterministic (i.e., unmitigated), and deterministic-with-response (i.e., mitigated) modes.

9.1.5.1. Scenario 12—FPSO Release of 2,500 bbl of Crude Oil

Figure 9.1-3a shows a stochastic map for sea surface oiling (without mitigation by response activities) resulting from Scenario 12 (a 2,500 bbl surface spill originating from the FPSO location) in the Jun−Nov season. The top panel shows the probability of sea surface oiling above a minimum thickness of 1.0 g/m^2, and the bottom panel shows the minimum amount of time for sea surface oiling above a minimum thickness of 1.0 g/m^2. Figure 9.1-3b shows the same stochastic map, zoomed in.

Figures 9.1-4a and 9.1-4b show the stochastic maps for sea surface oiling (without mitigation by response activities) resulting from Scenario 12 in the Dec−May season.

Figure 9.1-5a shows a deterministic map (without mitigation by response activities) resulting from Scenario 12 in the Jun−Nov season. The dark blue area shows the “swept area,” which is the aggregated area across which modeling predicts the unmitigated oil spill will have traveled by the end of the 10-day modeling simulation. The black areas show the oil predicted to be remaining on the surface above a minimum thickness of 1.0 g/m^2 at the end of the 10-day modeling simulation. The red areas show the oil predicted to have made shoreline contact above a minimum thickness of 1.0 g/m^2 at the end of the 10-day modeling simulation. Figure 9.1-5b shows the same deterministic map zoomed in on the Guyanese coast.

Figures 9.1-6a and 9.1-6b show the deterministic maps (without mitigation by response activities) resulting from Scenario 12 in the Dec−May season.

Figures 9.1-7a and 9.1-7b show the deterministic maps (with mitigation by response activities) resulting from Scenario 12 in the Jun−Nov season. Figures 9.1-8a and 9.1-8b shows the deterministic maps (with mitigation by response activities) resulting from Scenario 12 in the Dec−May season. As shown by the modeling results, with the application of spill response measures, the modeling predicts a significantly reduced extent of surface movement of the spill and no impacts on any coastlines.

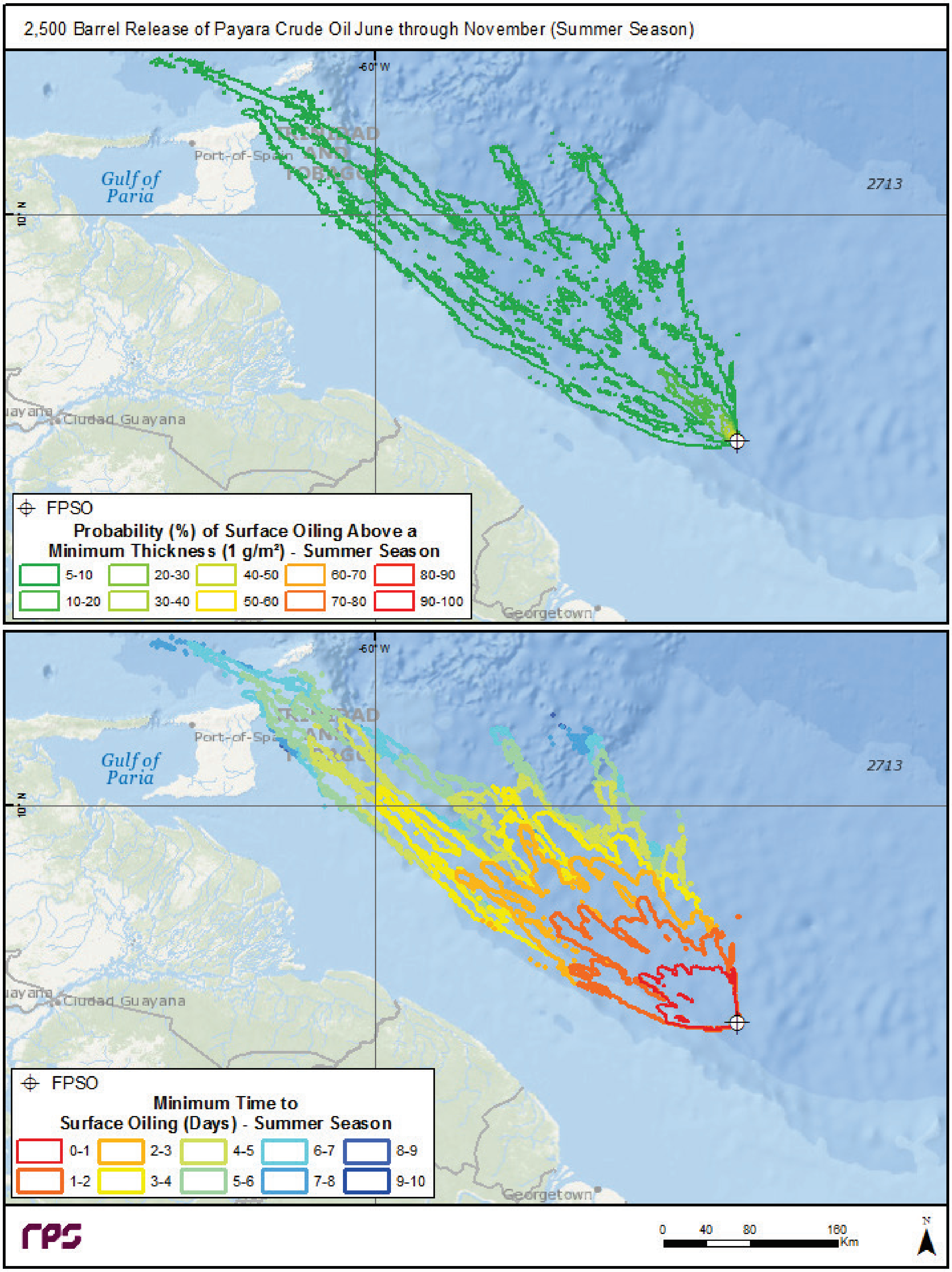


Figure 9.1-3a: Stochastic Map for Scenario 12—Predicted Surface Oiling and Timing from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Jun–Nov)

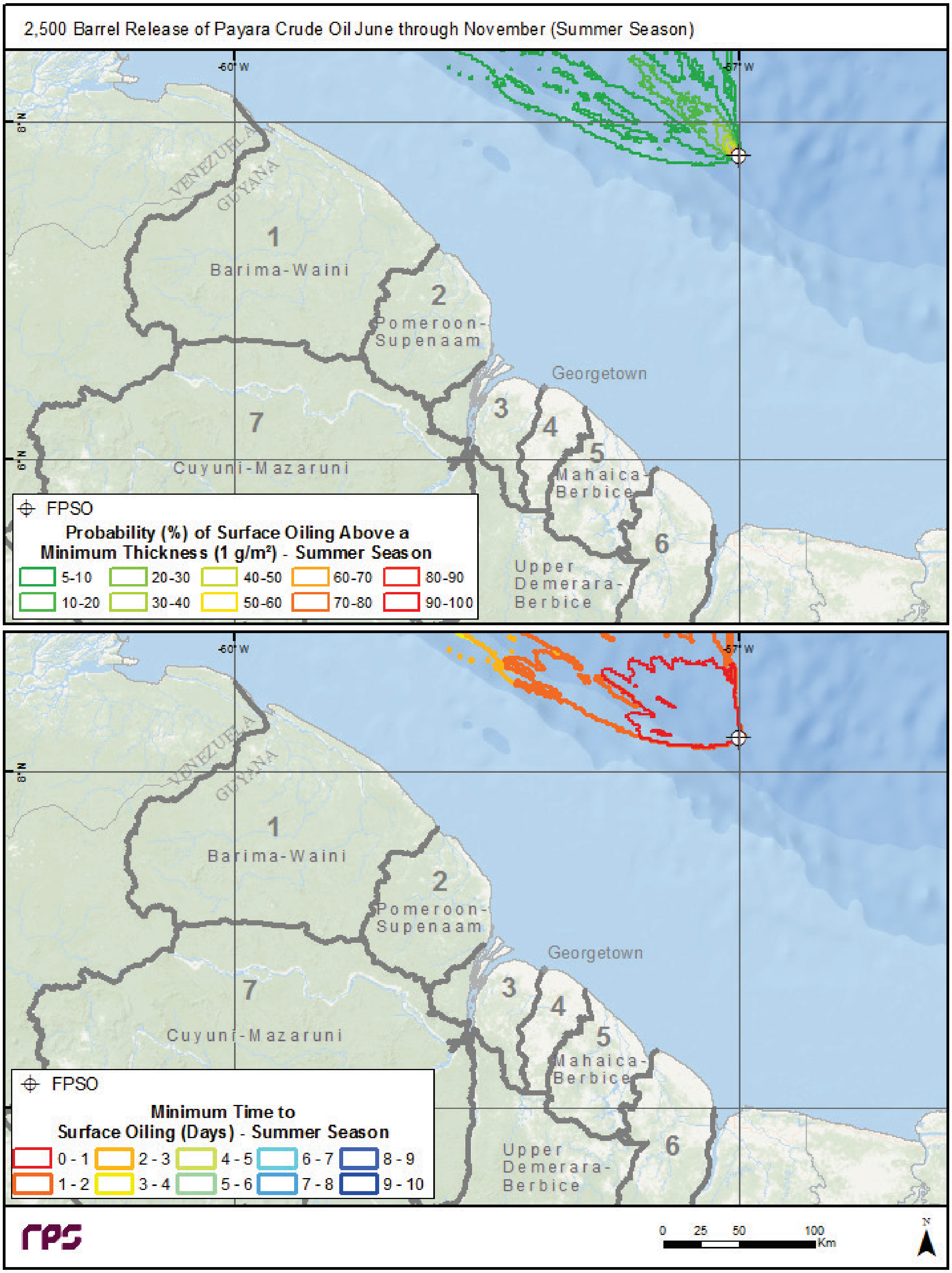


Figure 9.1-3b: (Zoomed In) Stochastic Map for Scenario 12—Predicted Surface Oiling and Timing from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Jun–Nov)

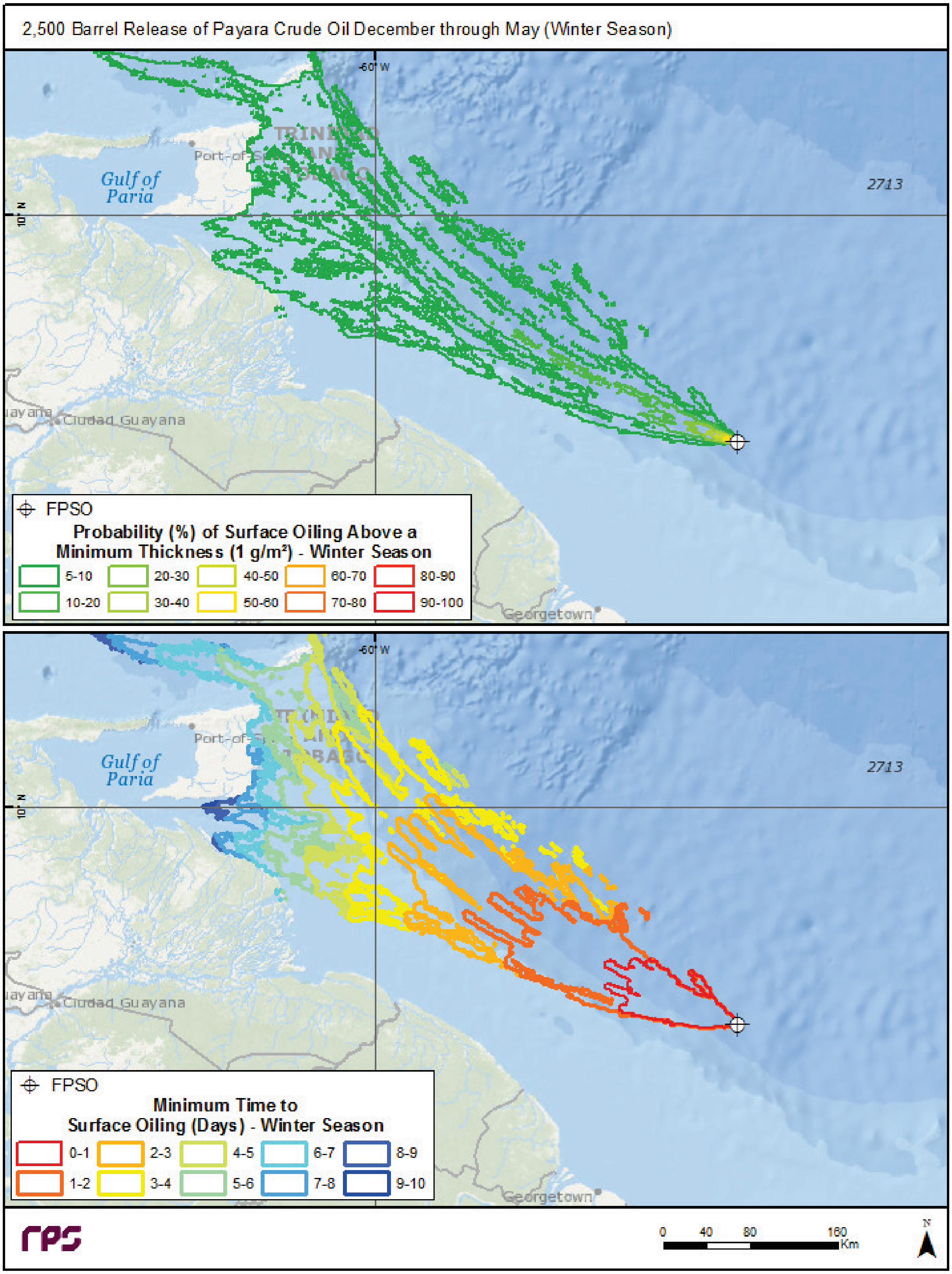


Figure 9.1-4a: Stochastic Map for Scenario 12—Predicted Surface Oiling and Timing from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Dec–May)

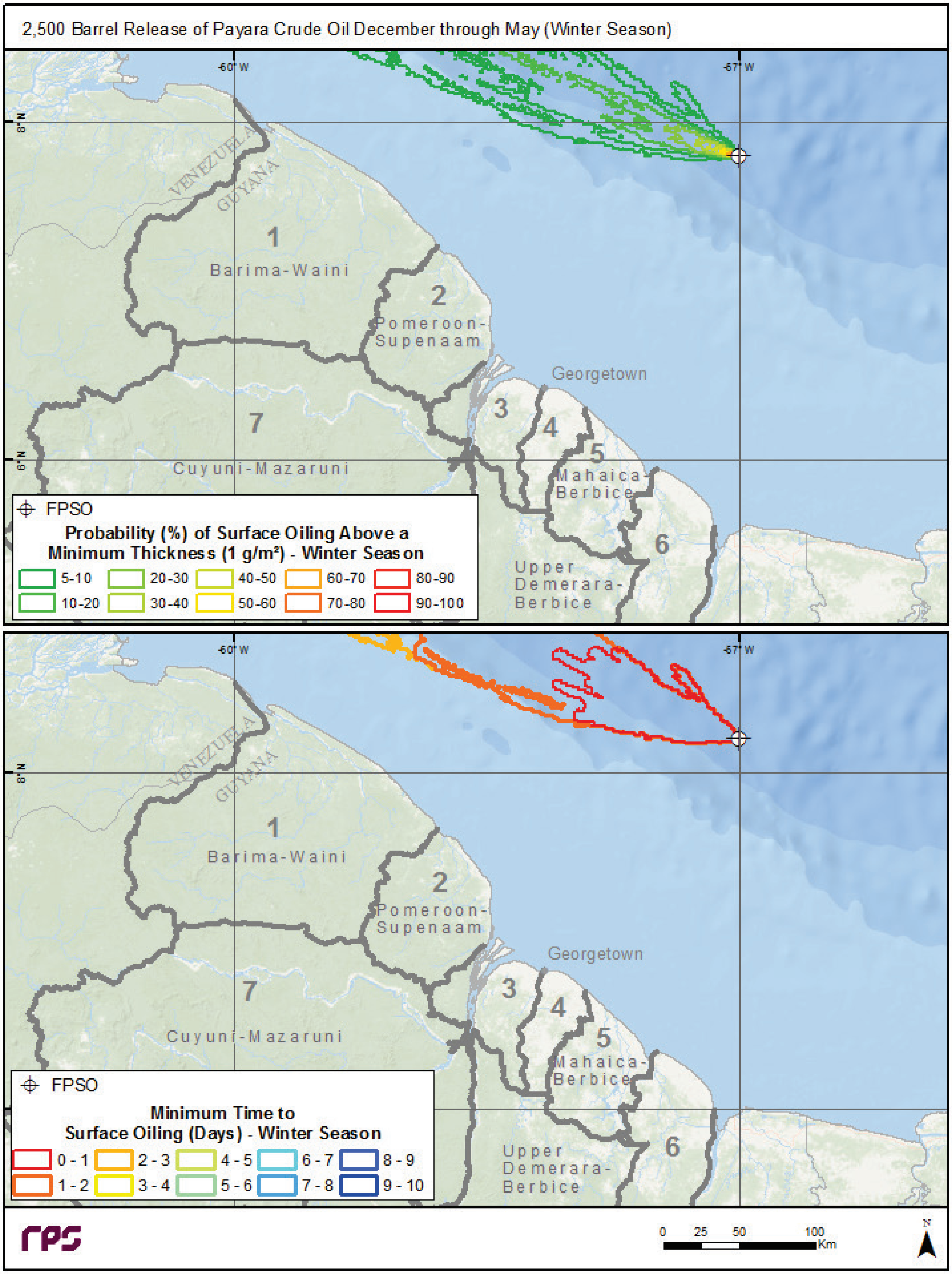


Figure 9.1-4b: (Zoomed In) Stochastic Map for Scenario 12—Predicted Surface Oiling and Timing from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Dec–May)

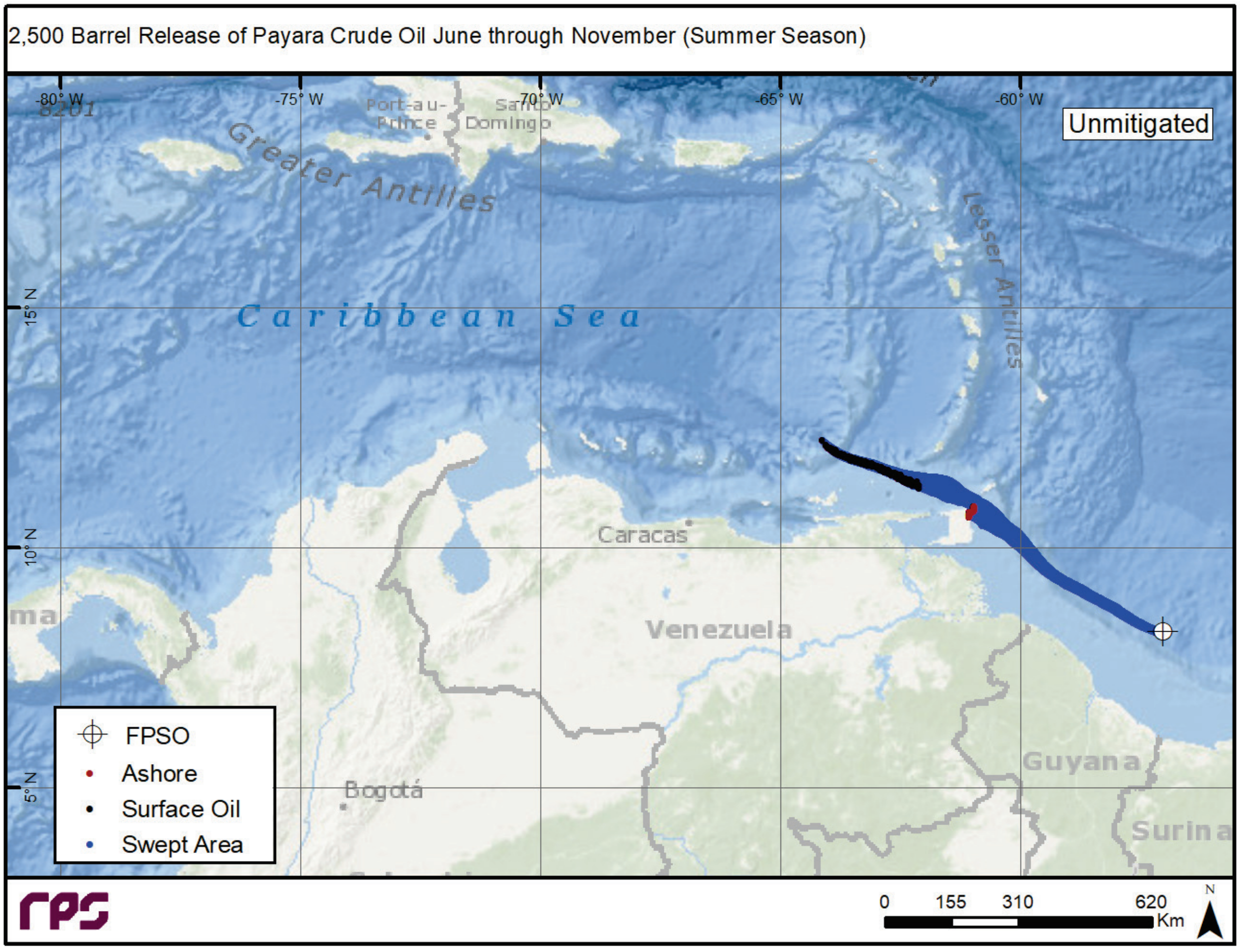


Figure 9.1-5a: Deterministic Map for Scenario 12—Predicted Transport after 10 Days from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Jun–Nov)

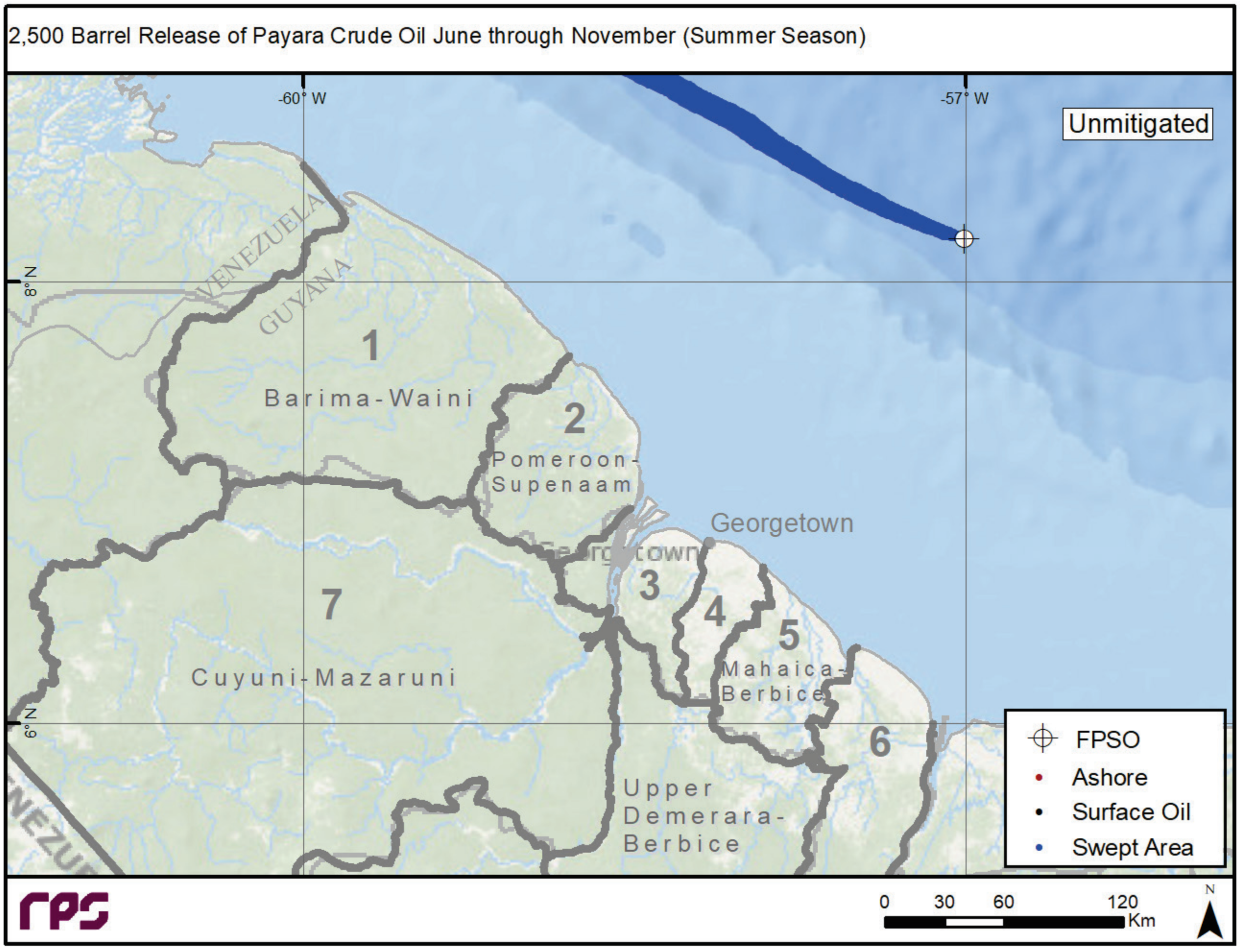


Figure 9.1-5b: (Zoomed in) Deterministic Map for Scenario 12—Predicted Transport after 10 Days from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Jun–Nov)

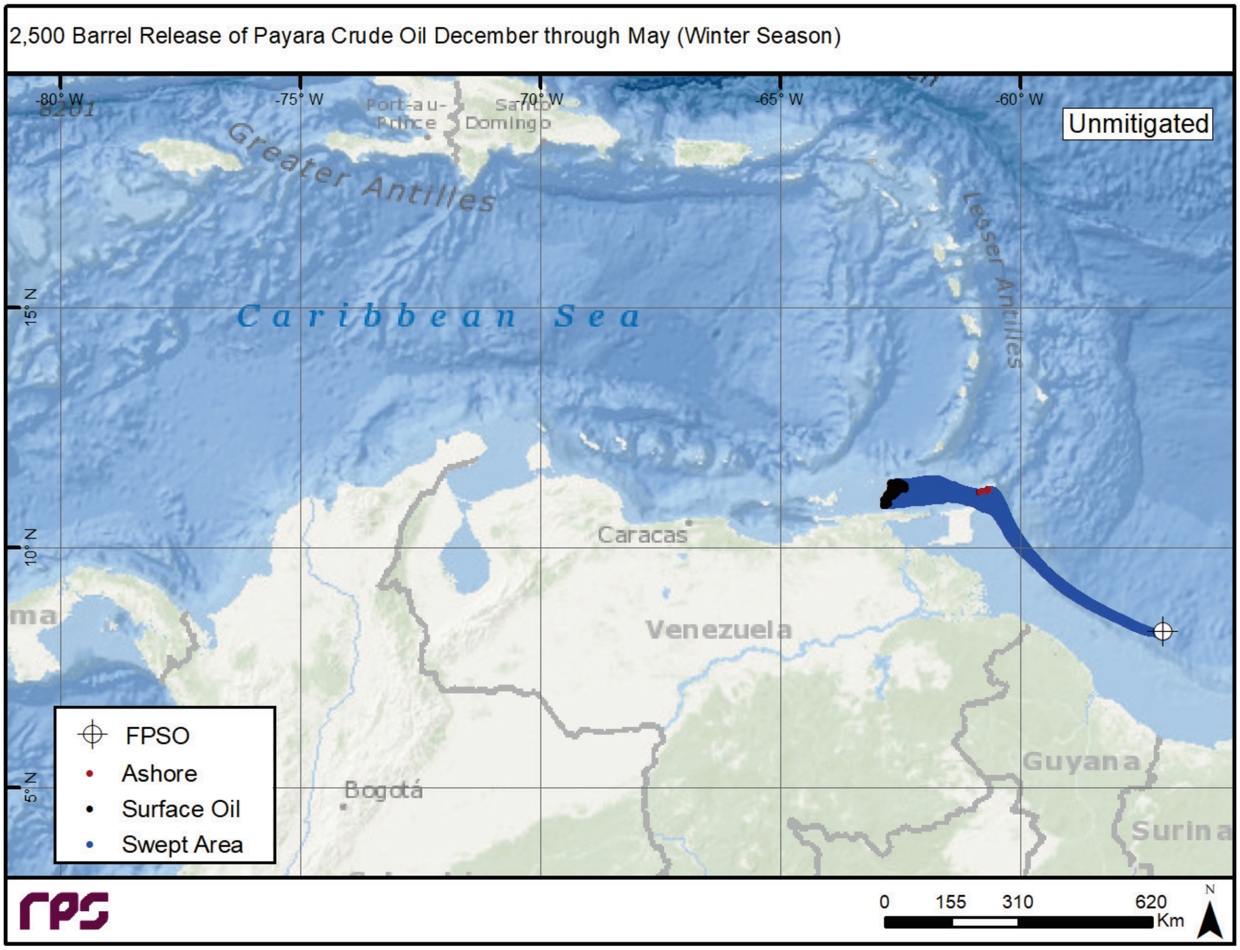


Figure 9.1-6a: Deterministic Map for Scenario 12—Predicted Transport after 10 Days from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Dec–May)

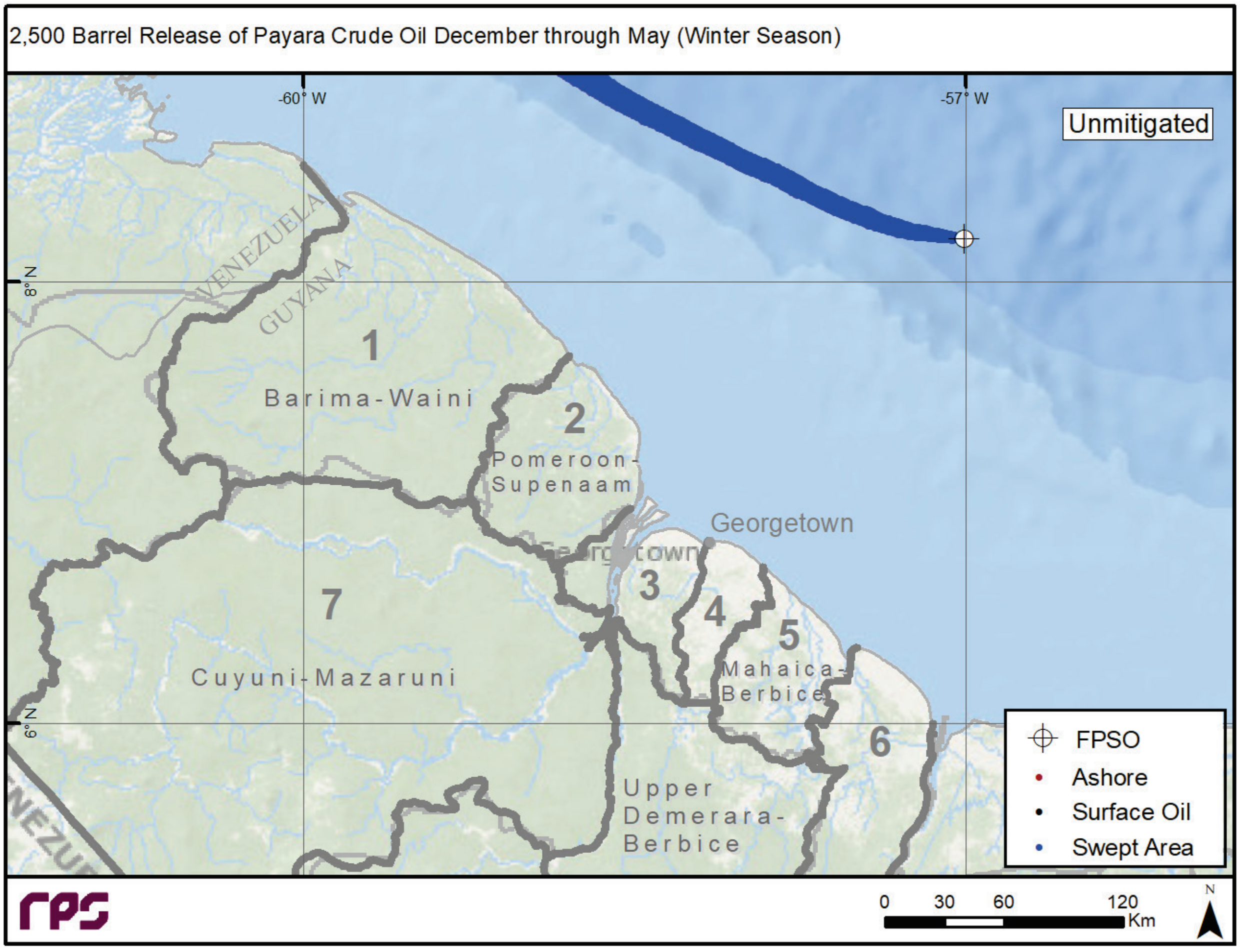


Figure 9.1-6b: (Zoomed in) Deterministic Map for Scenario 12—Predicted Transport after 10 Days from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Dec–May)

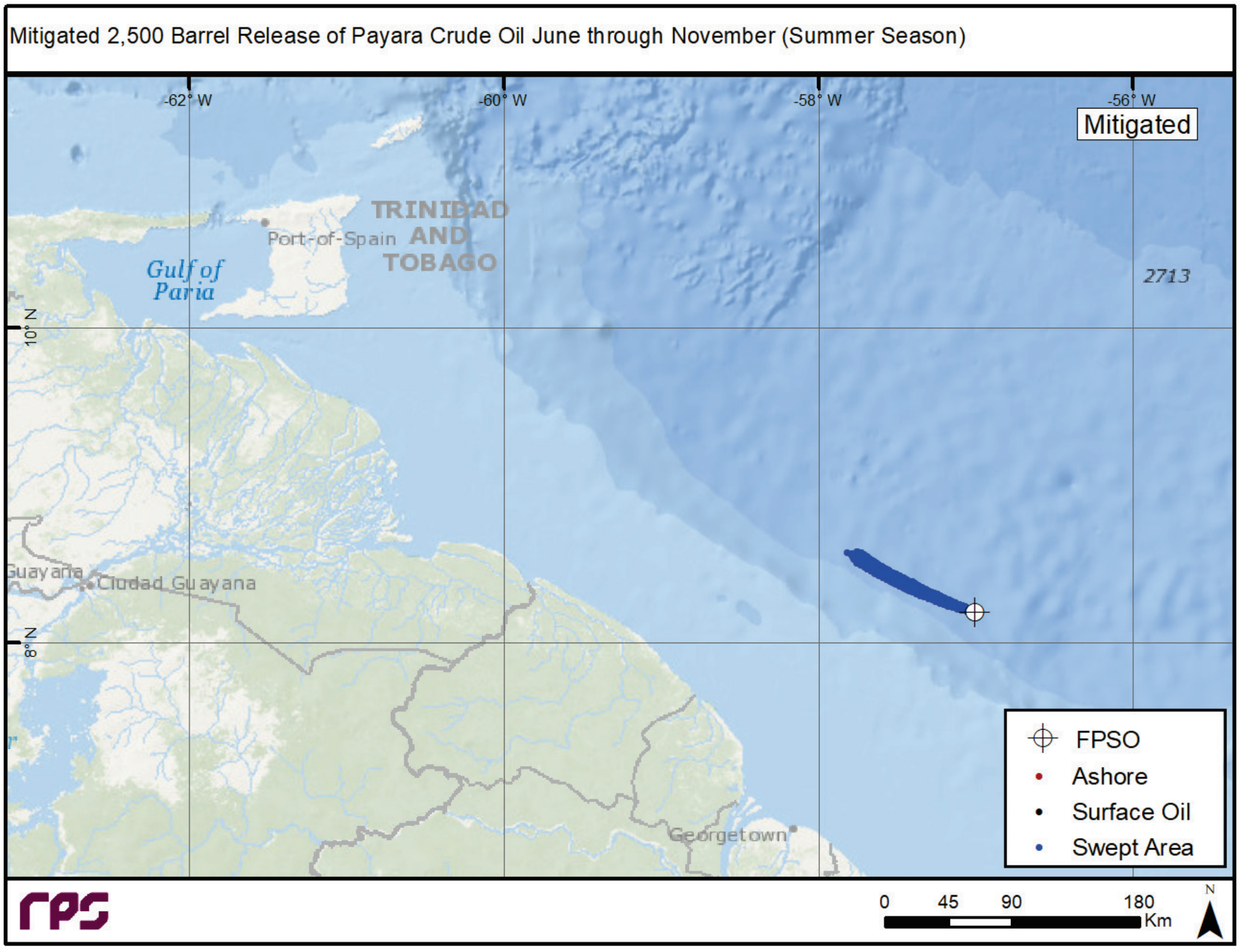


Figure 9.1-7a: Deterministic Map for Scenario 12—Predicted Transport after 10 Days from a Mitigated 2,500-Barrel Surface Release of Crude Oil (Jun–Nov)

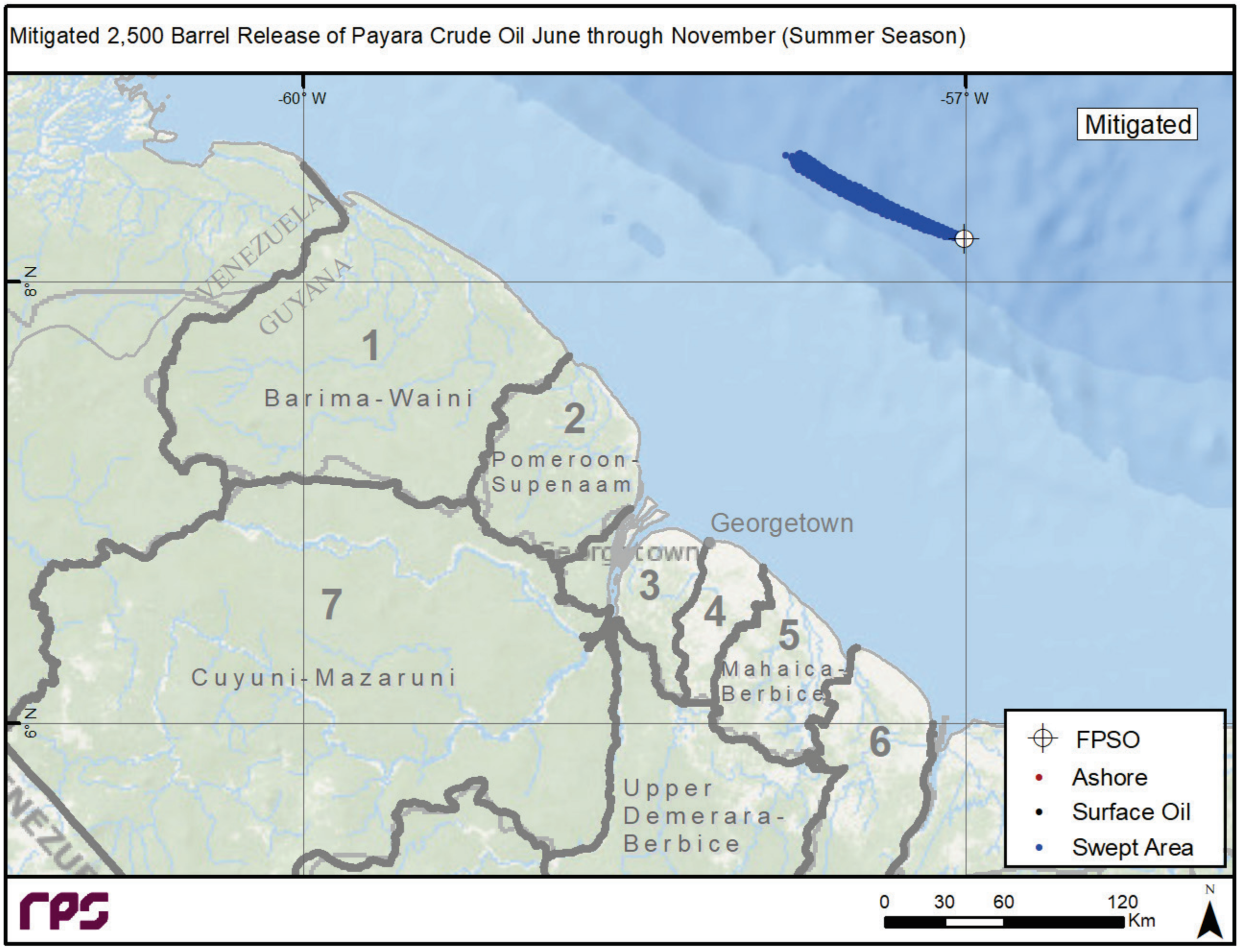


Figure 9.1-7b: (Zoomed In) Deterministic Map for Scenario 12—Predicted Transport after 10 Days from a Mitigated 2,500-Barrel Surface Release of Crude Oil (Jun–Nov)

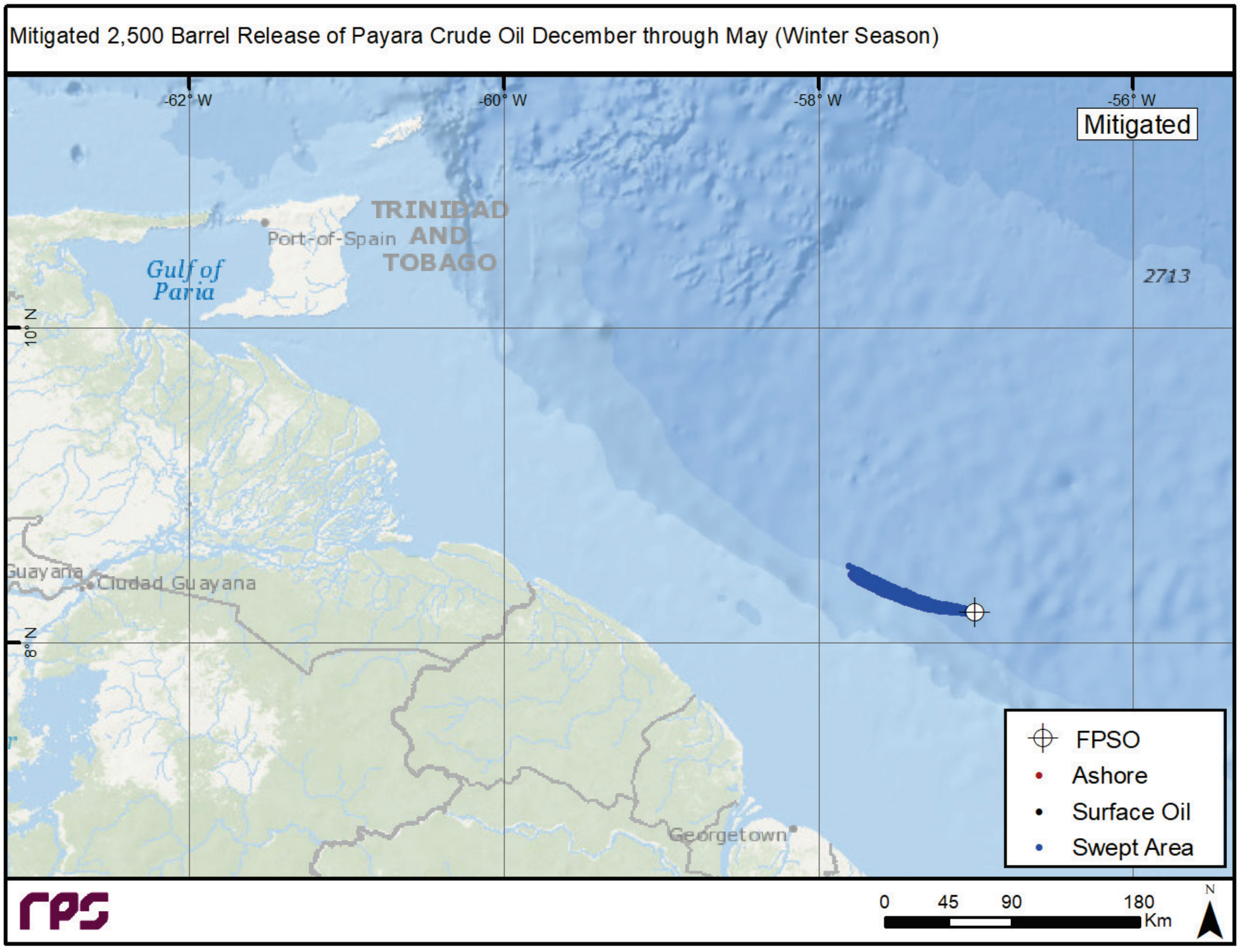


Figure 9.1-8a: Deterministic Map for Scenario 12—Predicted Transport after 10 Days from a Mitigated 2,500-Barrel Surface Release of Crude Oil (Dec–May)

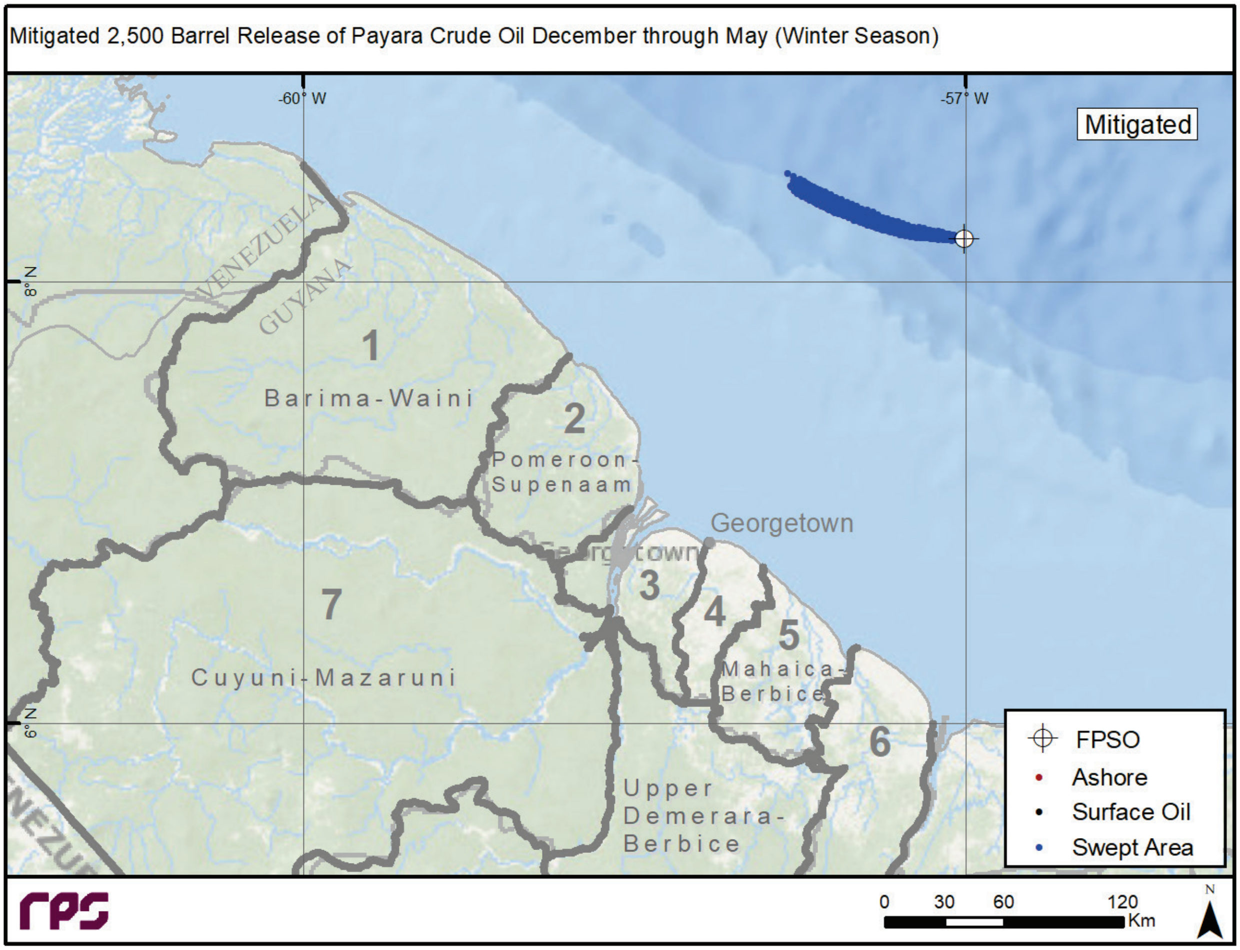


Figure 9.1-8b: (Zoomed In) Deterministic Map for Scenario 12—Predicted Transport after 10 Days from a Mitigated 2,500-Barrel Surface Release of Crude Oil (Dec–May)

9.1.5.2. Scenario 13—Loss of Well Control Resulting in 30-Day Subsea Release of Crude Oil at 20,000 BPD (Most Credible WCD)

Figure 9.1-9a shows a stochastic map for sea surface oiling (without mitigation by response activities) resulting from Scenario 13 (a loss-of-well-control event that results in a 20,000 BPD subsea release lasting for 30 days) in the Jun–Nov season. The top panel shows the probability of sea surface oiling above a minimum thickness of 1.0 g/m^2, and the bottom panel shows the minimum amount of time for sea surface oiling above a minimum thickness of 1.0 g/m^2. Figure 9.1-9b shows the same stochastic map, zoomed in on the Guyanese coast.

Figures 9.1-10a and 9.1-10b show the stochastic maps for sea surface oiling (without mitigation by response activities) resulting from Scenario 13 in the Dec–May season.

Figure 9.1-11a shows a deterministic map (without mitigation by response activities) resulting from Scenario 13 in the Jun–Nov season. The dark blue area shows the "swept area," which is the aggregated area across which modeling predicts the unmitigated oil spill will have traveled by the end of the 45-day modeling simulation. The black areas show the oil predicted to be remaining on the surface at the end of the 45-day modeling simulation. The red areas show the oil predicted to have made shoreline contact at the end of the 45-day modeling simulation, all based on the minimum thickness threshold. Figure 9.1-11b shows the same deterministic map zoomed in on the Guyanese coast.

Figures 9.1-12a and 9.1-12b show the deterministic maps (without mitigation by response activities) resulting from Scenario 13 in the Dec–May season.

Figures 9.1-13a and 9.1-13b show the deterministic maps (with mitigation by response activities) resulting from Scenario 13 in the Jun–Nov season. Figures 9.1-14a and 9.1-14b show the deterministic maps (with mitigation by response activities) resulting from Scenario 13 in the Dec–May season. As shown by the modeling results, on the basis the release has been stopped within a period of 9 days, and with the application of spill response measures, the modeling predicts a significantly reduced extent of surface movement of the spill and no impacts on the Guyana coastline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

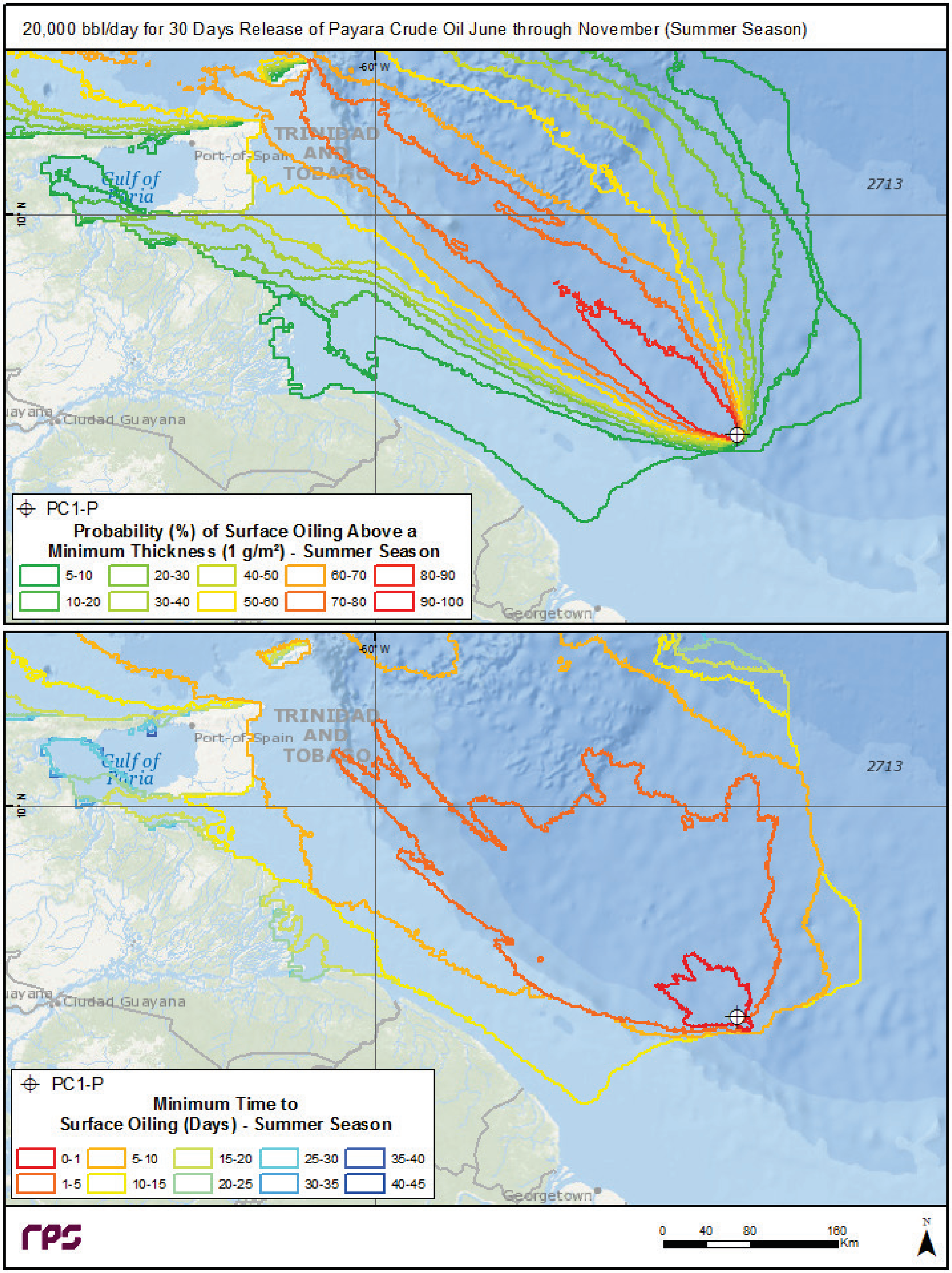


Figure 9.1-9a: Stochastic Map for Scenario 13—Predicted Surface Oiling and Timing from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

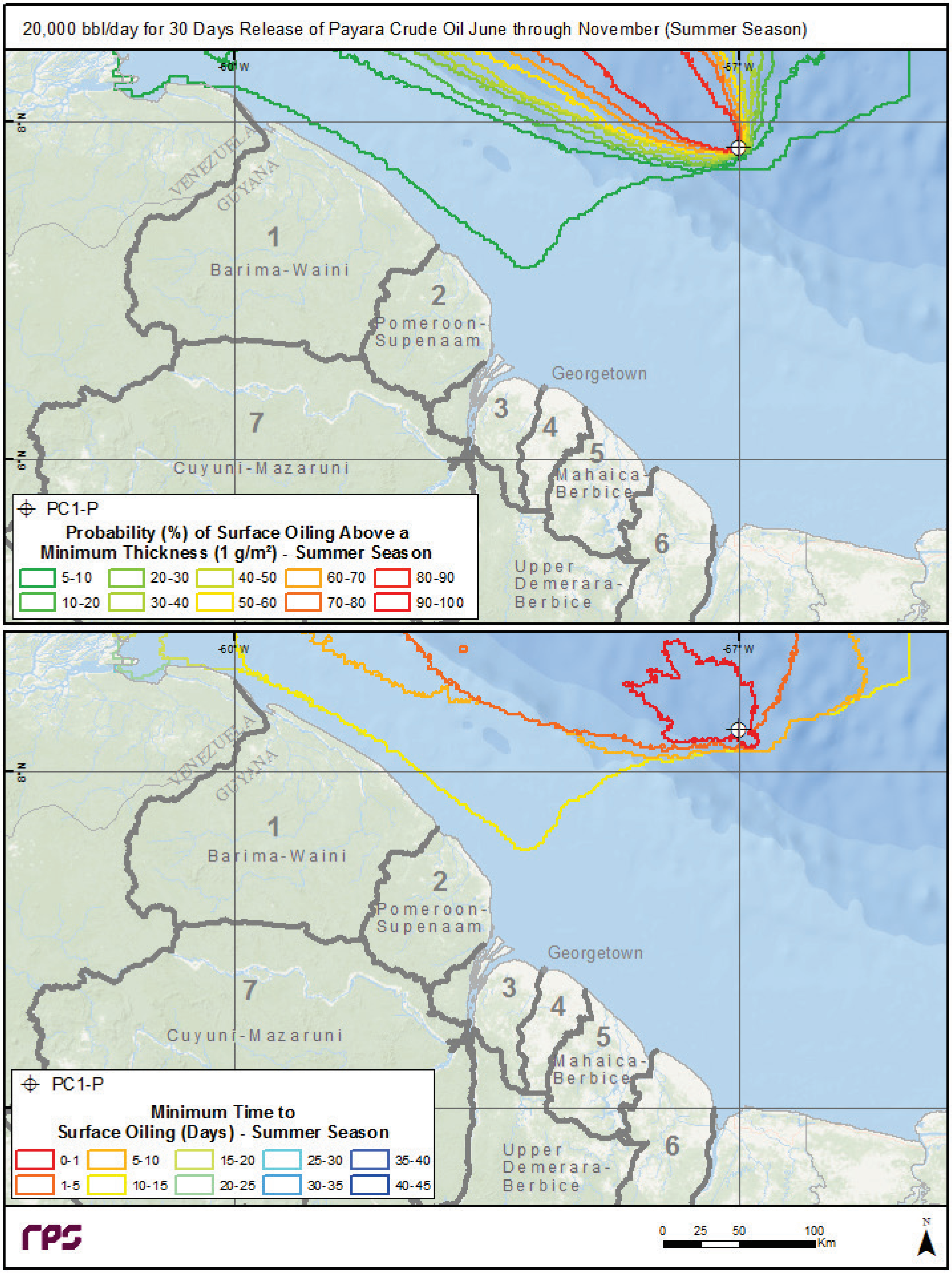


Figure 9.1-9b: (Zoomed In) Stochastic Map for Scenario 13—Predicted Surface Oiling and Timing from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

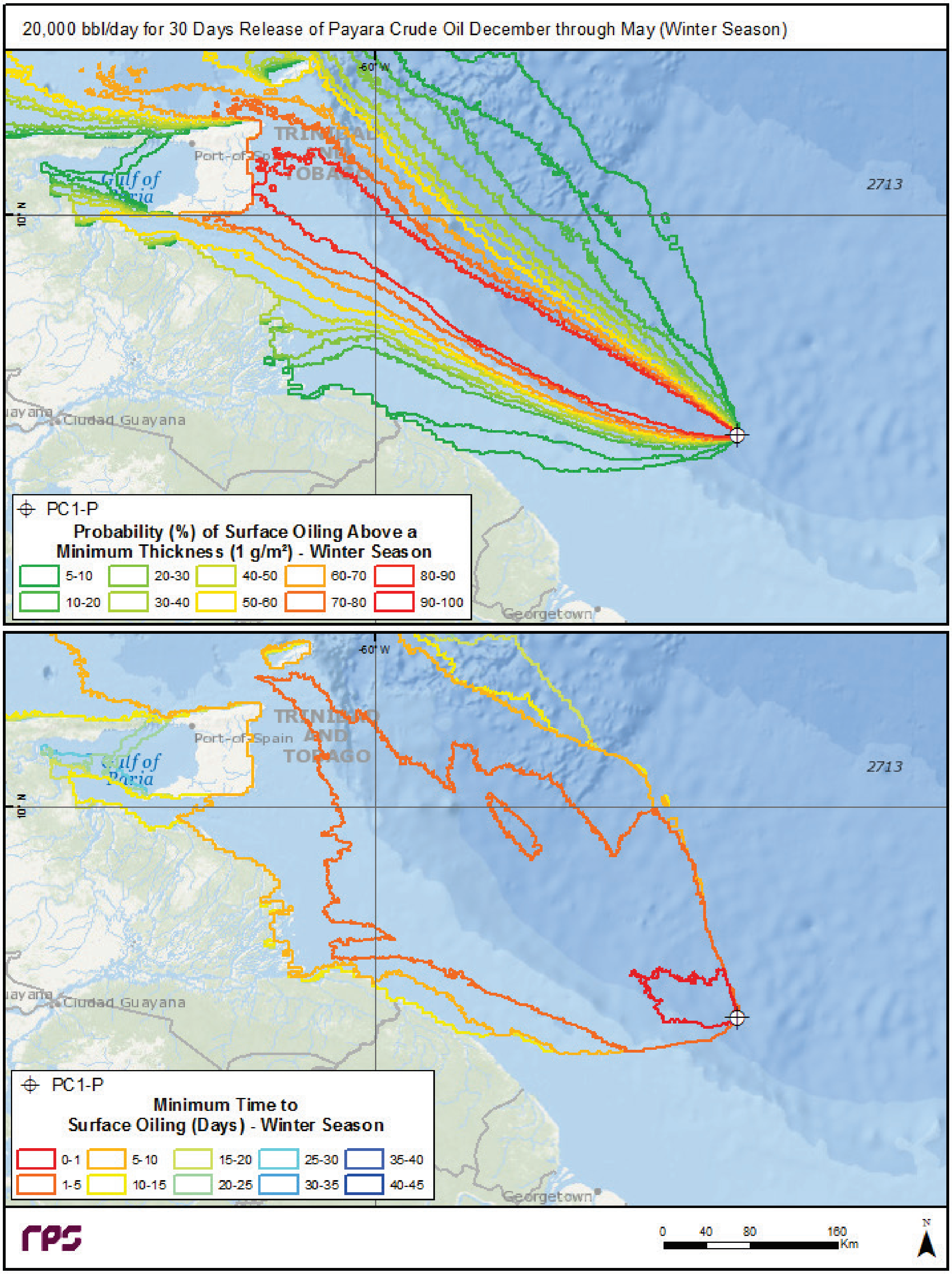


Figure 9.1-10a: Stochastic Map for Scenario 13—Predicted Surface Oiling and Timing from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Dec–May)

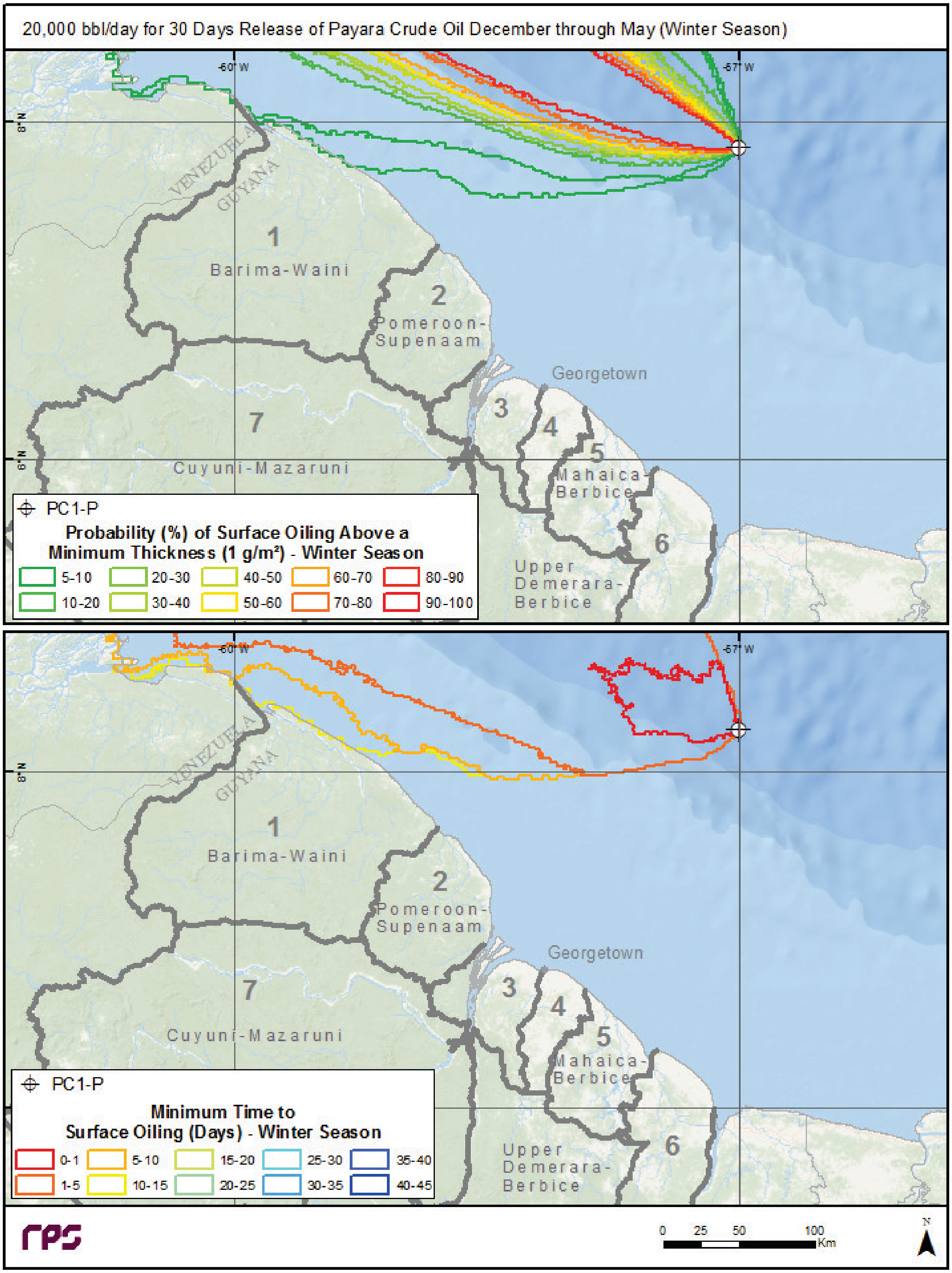


Figure 9.1-10b: (Zoomed In) Stochastic Map for Scenario 13—Predicted Surface Oiling and Timing from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Dec–May)

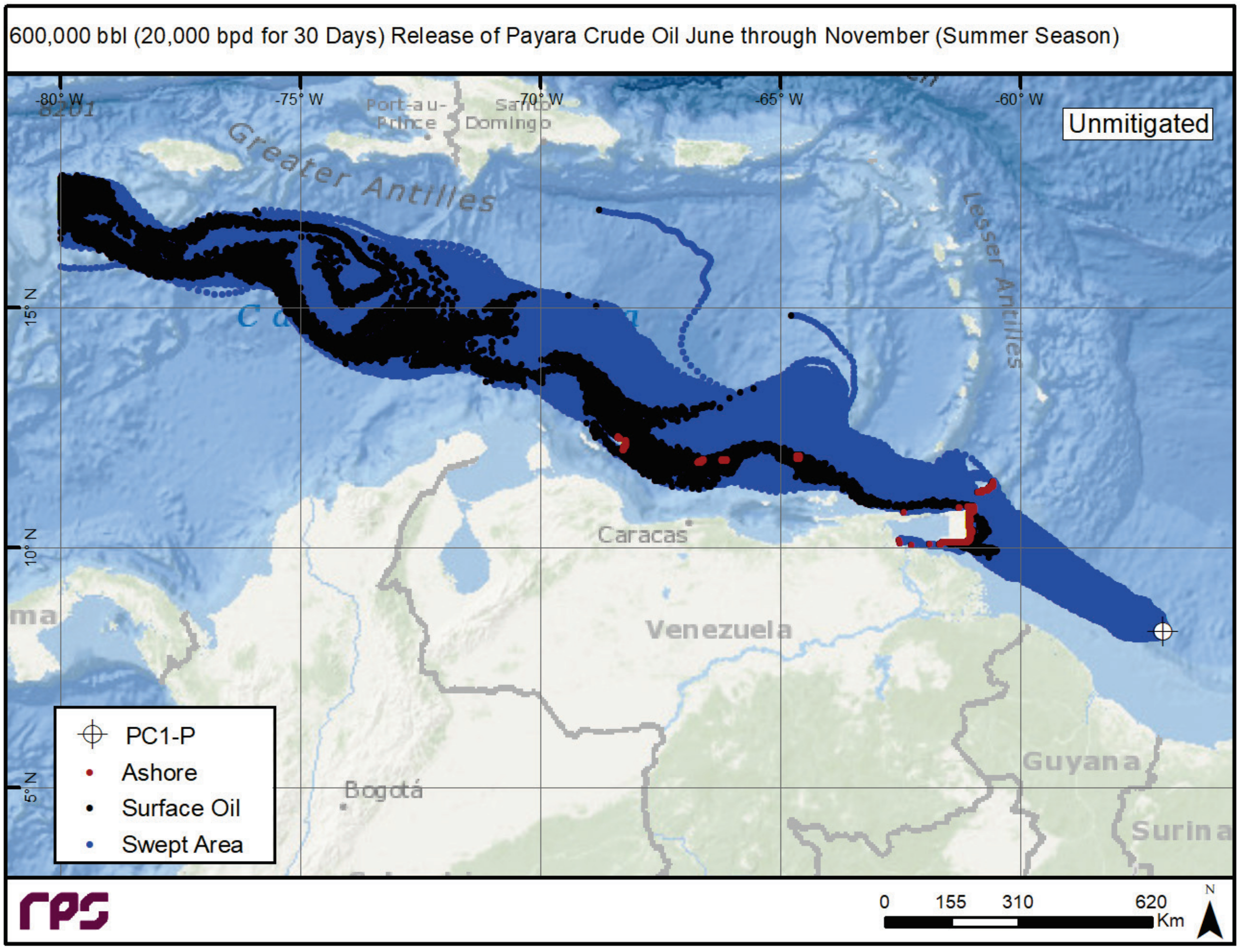


Figure 9.1-11a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

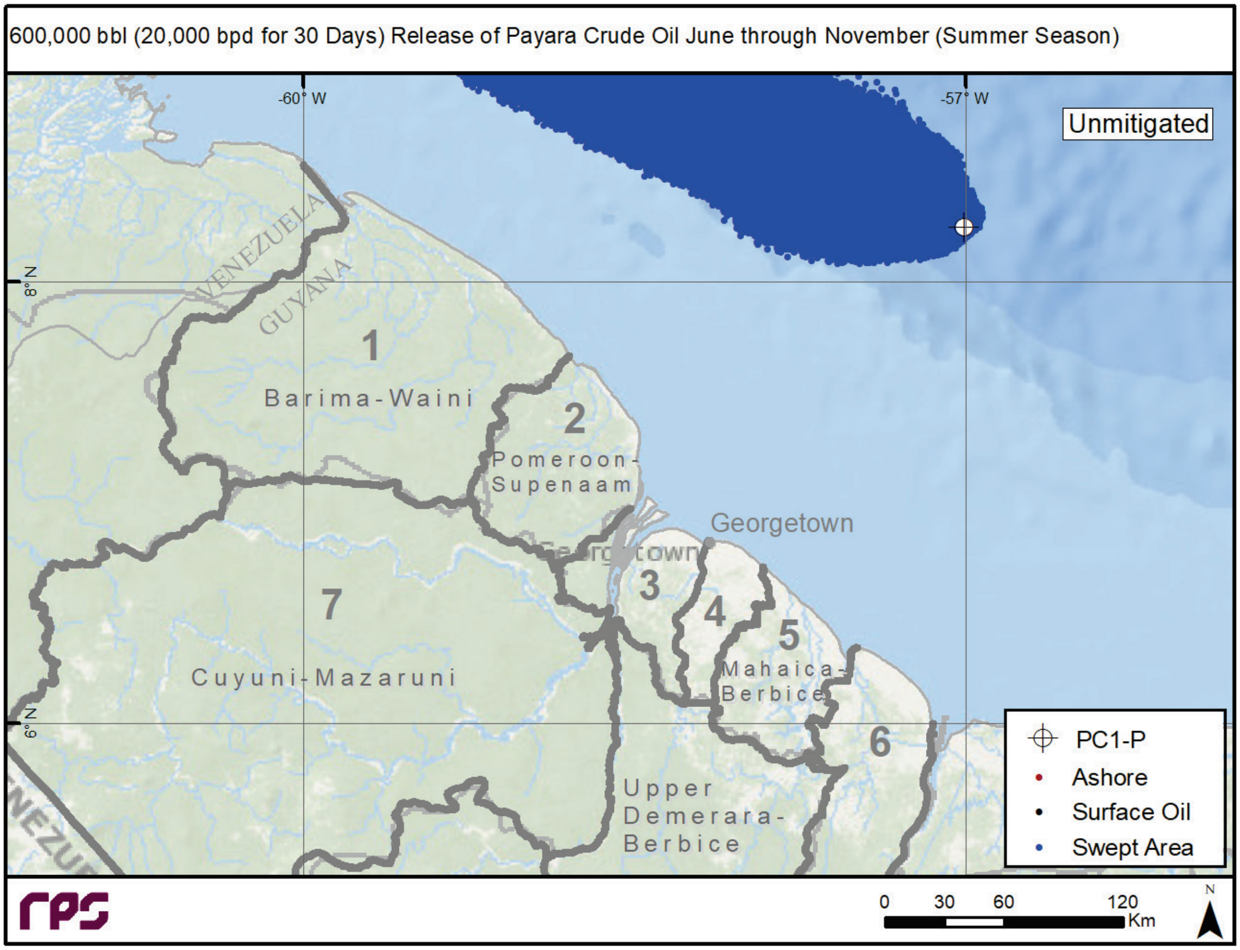


Figure 9.1-11b: (Zoomed In) Deterministic Map for Scenario 13—Predicted Transport after 45 days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

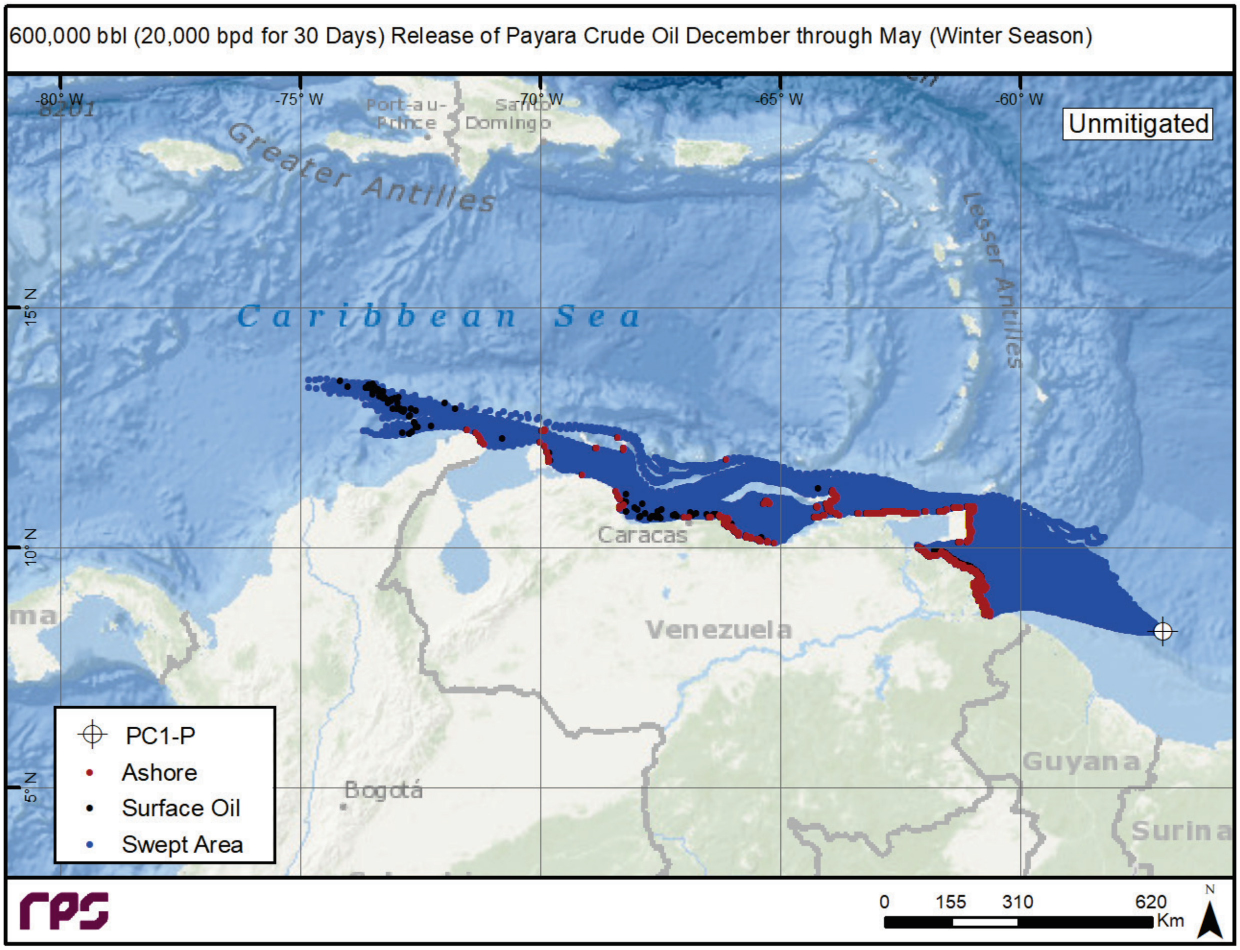


Figure 9.1-12a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Dec–May)

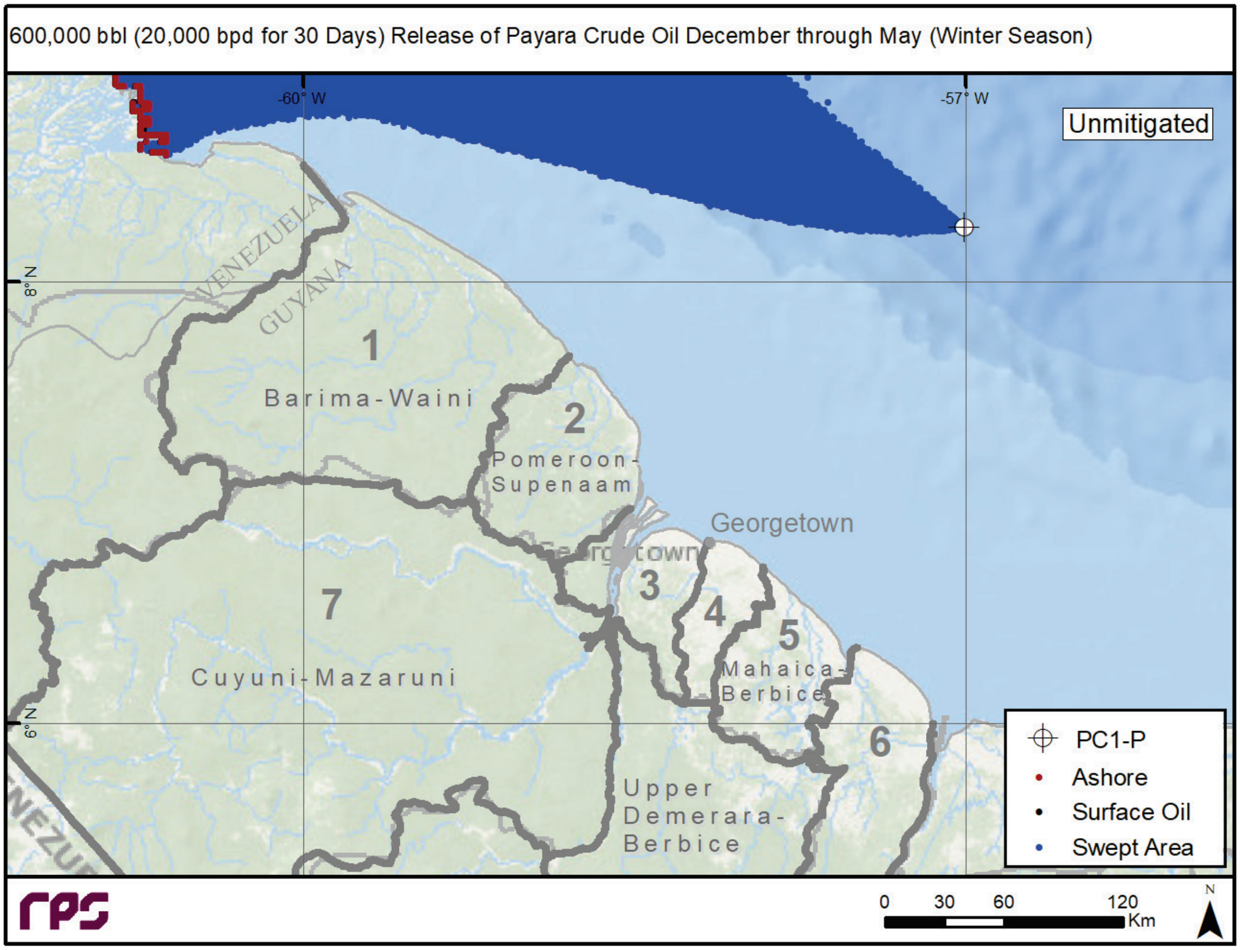


Figure 9.1-12b: (Zoomed In) Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Dec–May)

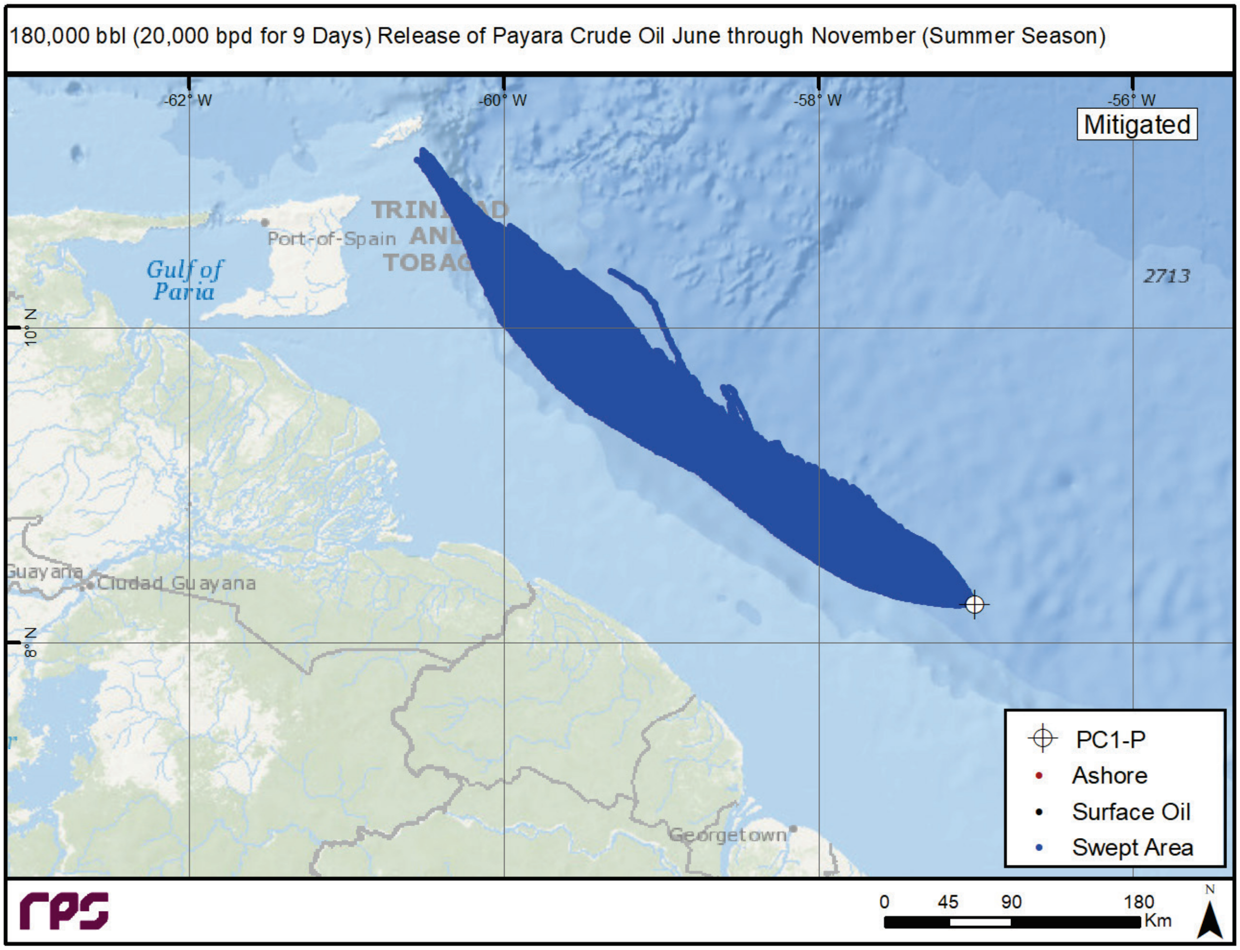


Figure 9.1-13a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from a Mitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil—Capped After 9 Days (Jun–Nov)

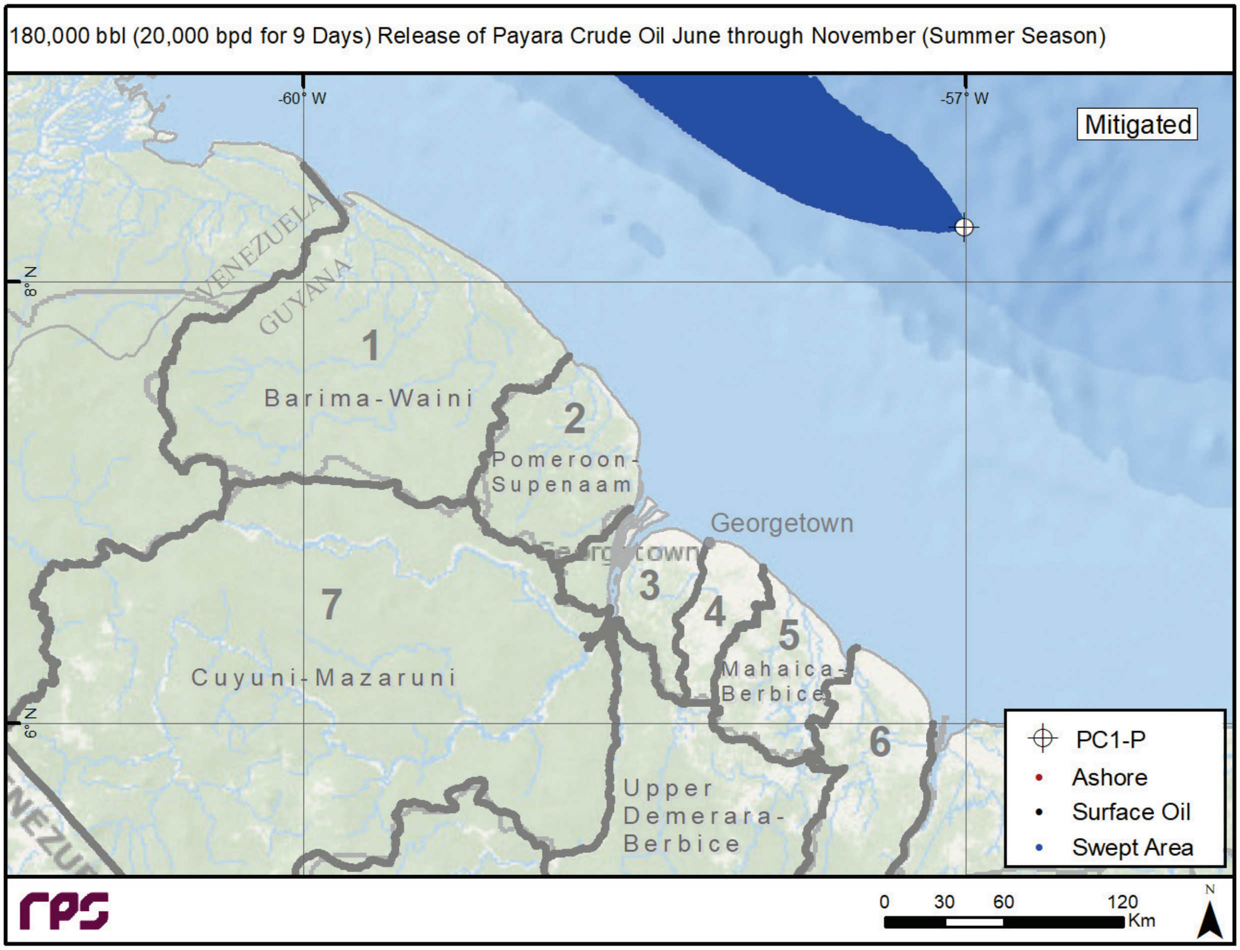


Figure 9.1-13b: (Zoomed In) Deterministic Map for Scenario 13—Predicted Transport after 45 Days from a Mitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil—Capped After 9 Days (Jun–Nov)

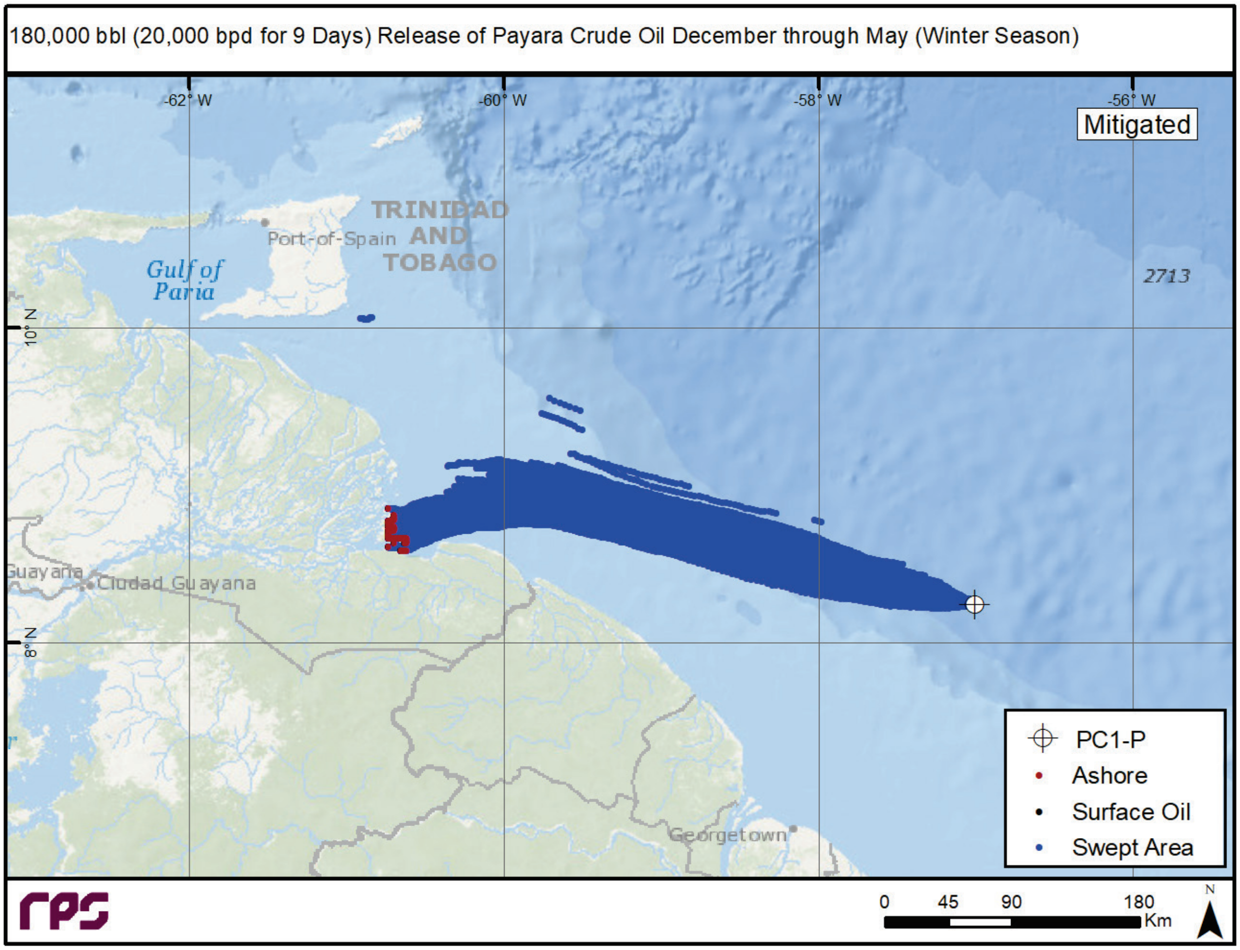


Figure 9.1-14a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from a Mitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil—Capped After 9 Days (Dec–May)

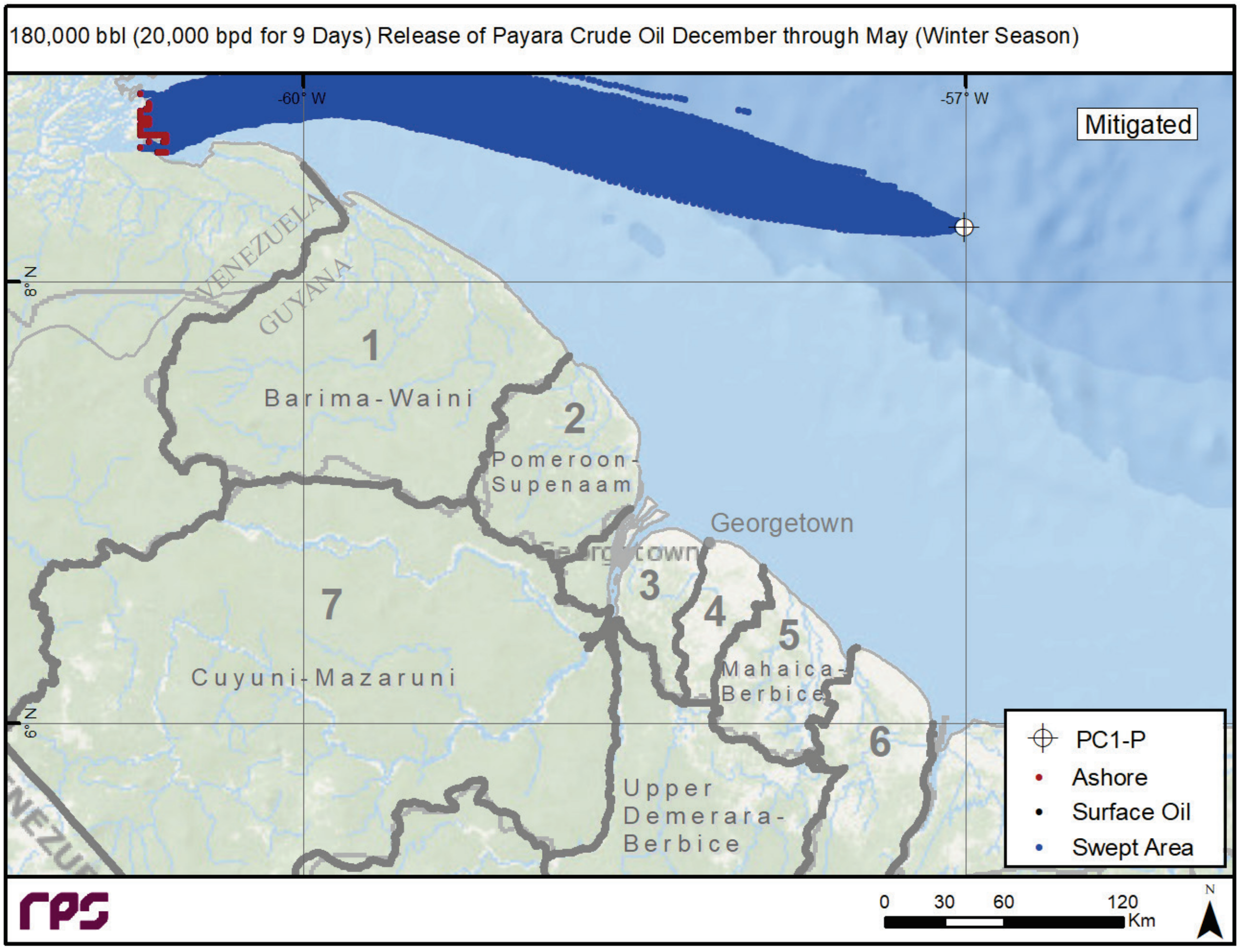


Figure 9.1-14b: (Zoomed In) Deterministic Map for Scenario 13—Predicted Transport after 45 Days from a Mitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil—Capped After 9 Days (Dec–May)

9.1.5.3. Scenario 14—Loss-of-Well-Control Resulting in 30-Day Subsea Release of Crude Oil at 202,192 BPD (Maximum WCD)

Figure 9.1-15a shows a stochastic map for sea surface oiling (without mitigation by response activities) resulting from Scenario 14 (a loss-of-well-control event that results in a 202,192 BPD subsea release lasting for 30 days) in the Jun–Nov season. The top panel shows the probability of sea surface oiling above a minimum thickness of 1.0 g/m^2, and the bottom panel shows the minimum amount of time for sea surface oiling above a minimum thickness of 1.0 g/m^2. Figure 9.1-15b shows the same stochastic map, zoomed in on the Guyanese coast.

Figures 9.1-16a and 9.1-16b show the stochastic maps for sea surface oiling (without mitigation by response activities) resulting from Scenario 14 in the Dec–May season.

Figure 9.1-17a shows a deterministic map (without mitigation by response activities) resulting from Scenario 14 in the Jun–Nov season. The dark blue area shows the "swept area," which is the aggregated area across which modeling predicts the oil spill will have traveled by the end of the 54-day modeling simulation. The black areas show the oil predicted to be remaining on the surface at the end of the 54-day modeling simulation. The red areas show the oil predicted to have made shoreline contact at the end of the 54-day modeling simulation, all based on the minimum thickness threshold. Figure 9.1-17b shows the same deterministic map zoomed in on the Guyanese coast.

Figures 9.1-18a and 9.1-18b show the deterministic maps (without mitigation by response activities) resulting from Scenario 14 in the Dec–May season.

Figures 9.1-19a and 9.1-19b show the deterministic maps (with mitigation by response activities) resulting from Scenario 14 in the Jun–Nov season. Figures 9.1-20a and 9.1-20b show the deterministic maps (with mitigation by response activities) resulting from Scenario 14 in the Dec–May season. As shown by the modeling results, on the basis the release has been stopped within a period of 9 days, and with the application of spill response measures, the modeling predicts a significantly reduced extent of surface movement of the spill and no impacts on any Guyana coastlines. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

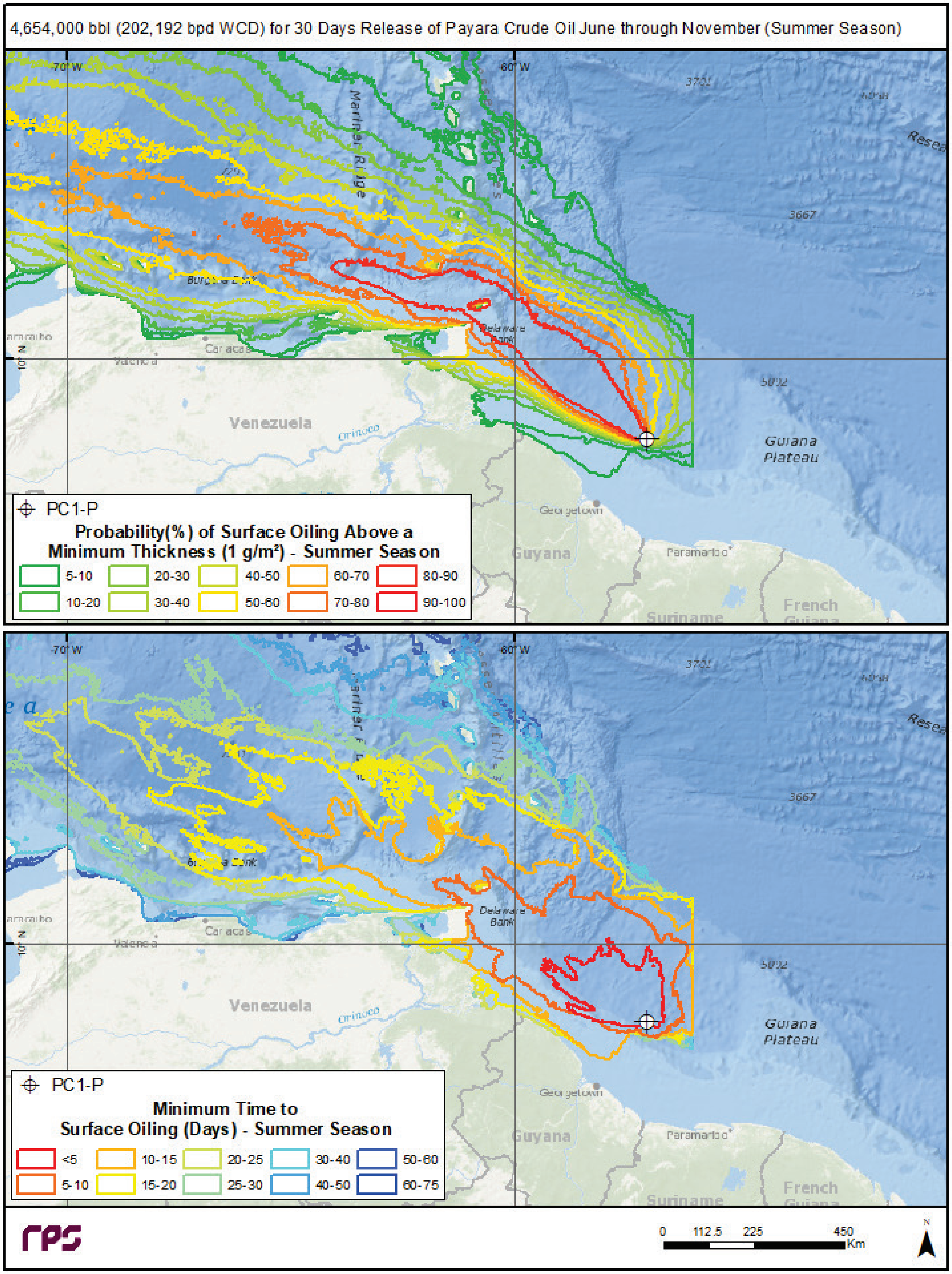


Figure 9.1-15a: Stochastic Map for Scenario 14—Predicted Surface Oiling and Timing from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

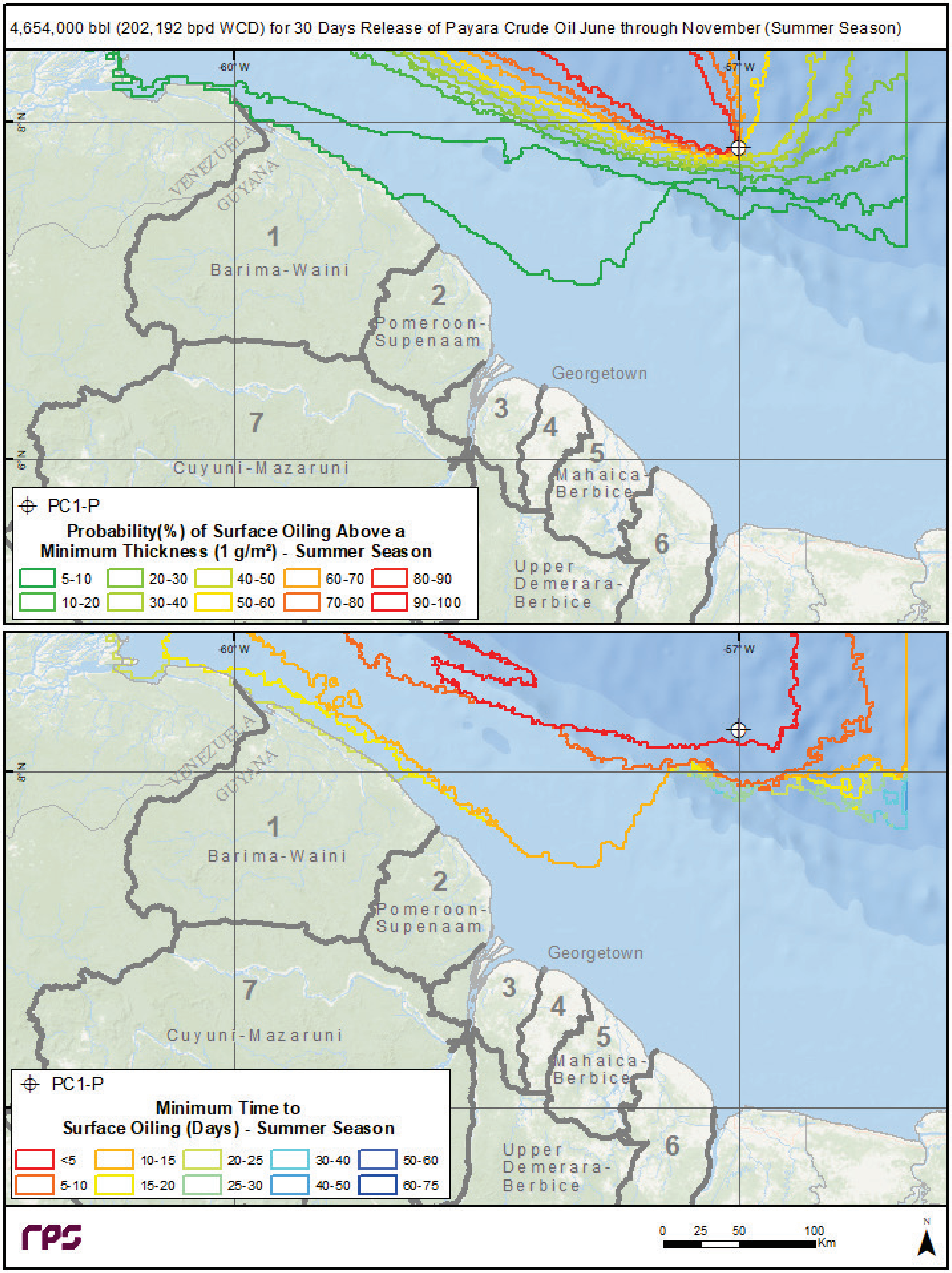


Figure 9.1-15b: (Zoomed In) Stochastic Map for Scenario 14—Predicted Surface Oiling and Timing from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

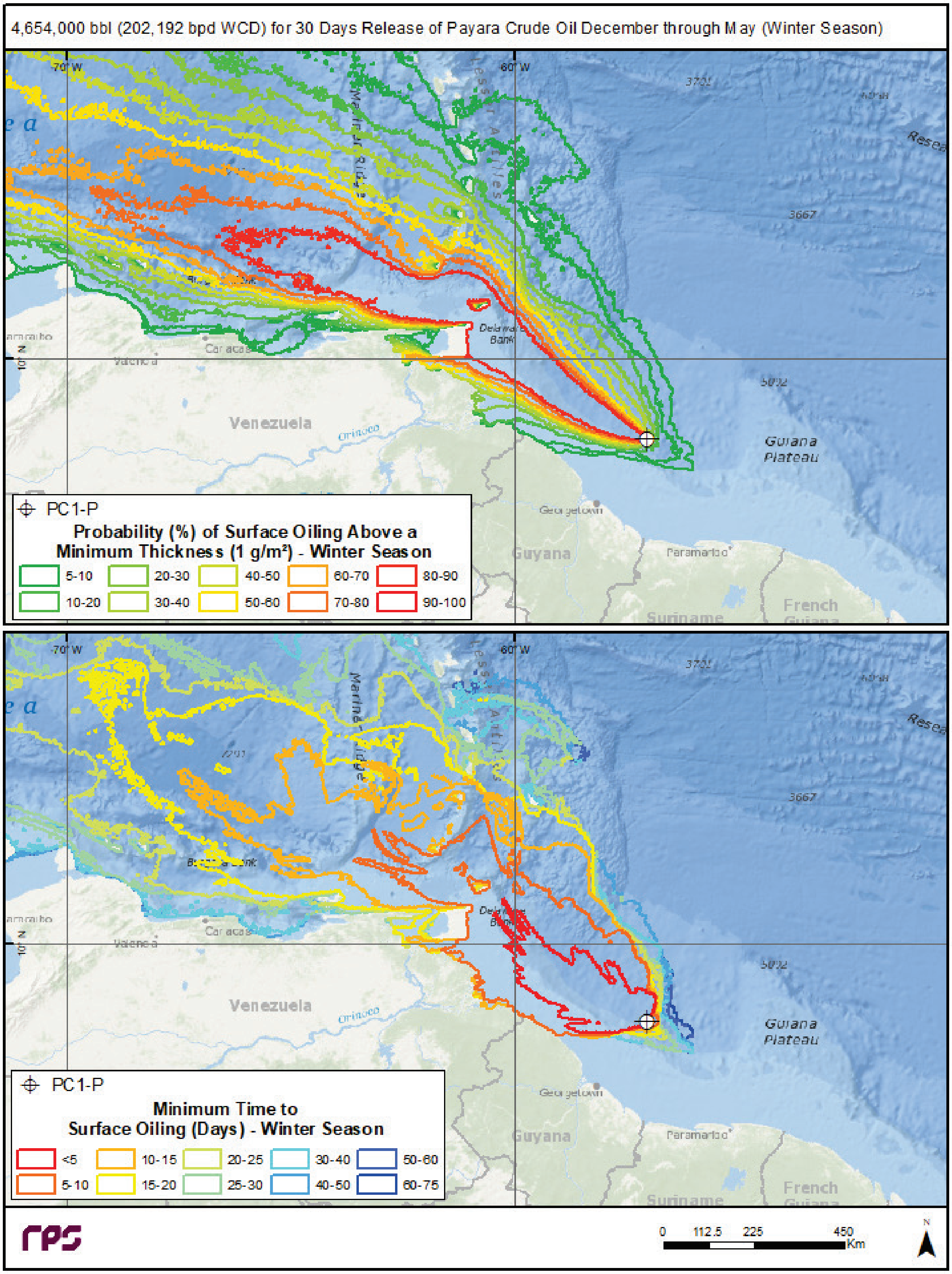


Figure 9.1-16a: Stochastic Map for Scenario 14—Predicted Surface Oiling and Timing from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Dec–May)

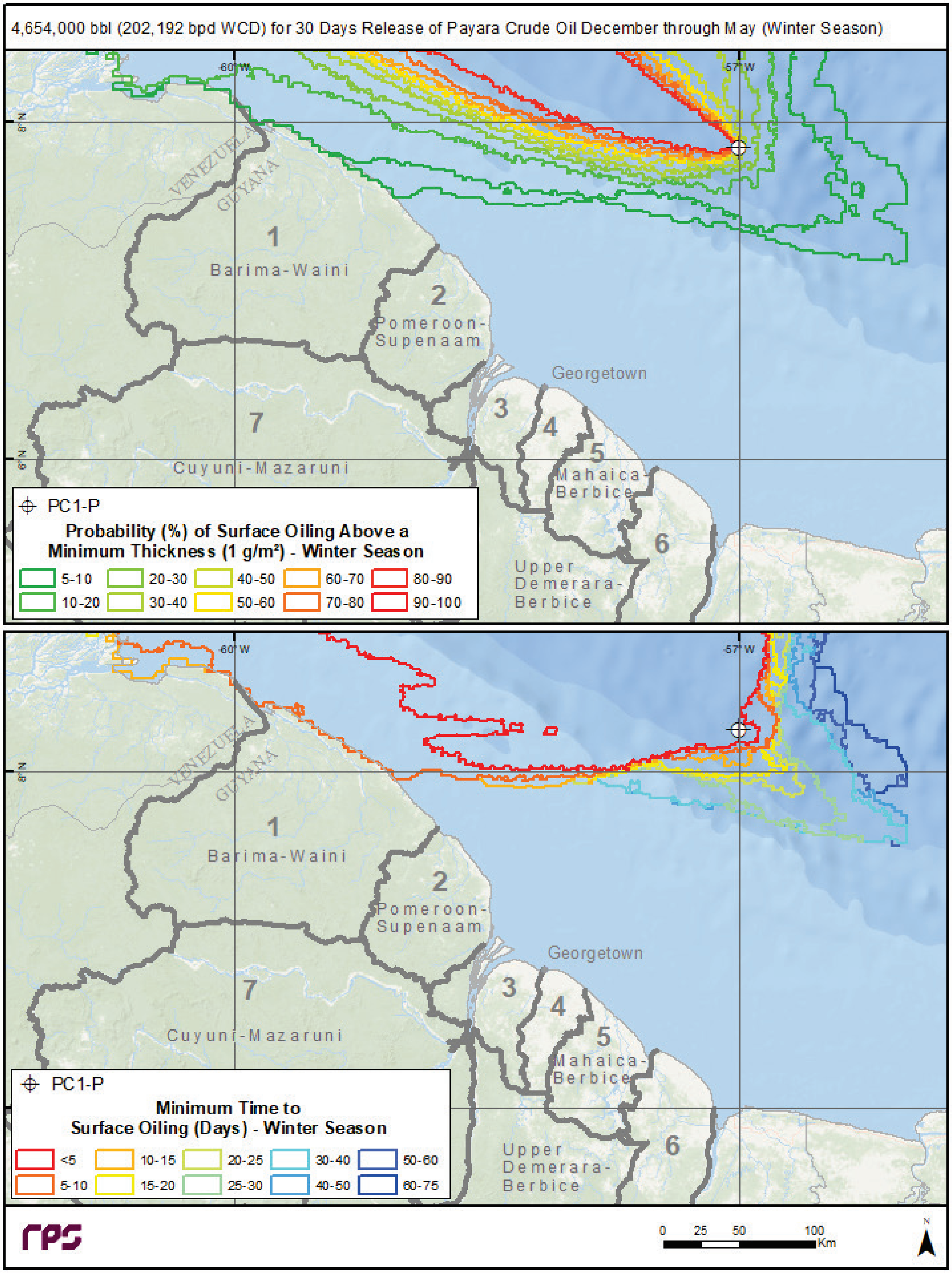


Figure 9.1-16b: (Zoomed In) Stochastic Map for Scenario 14—Predicted Surface Oiling and Timing from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Dec–May)

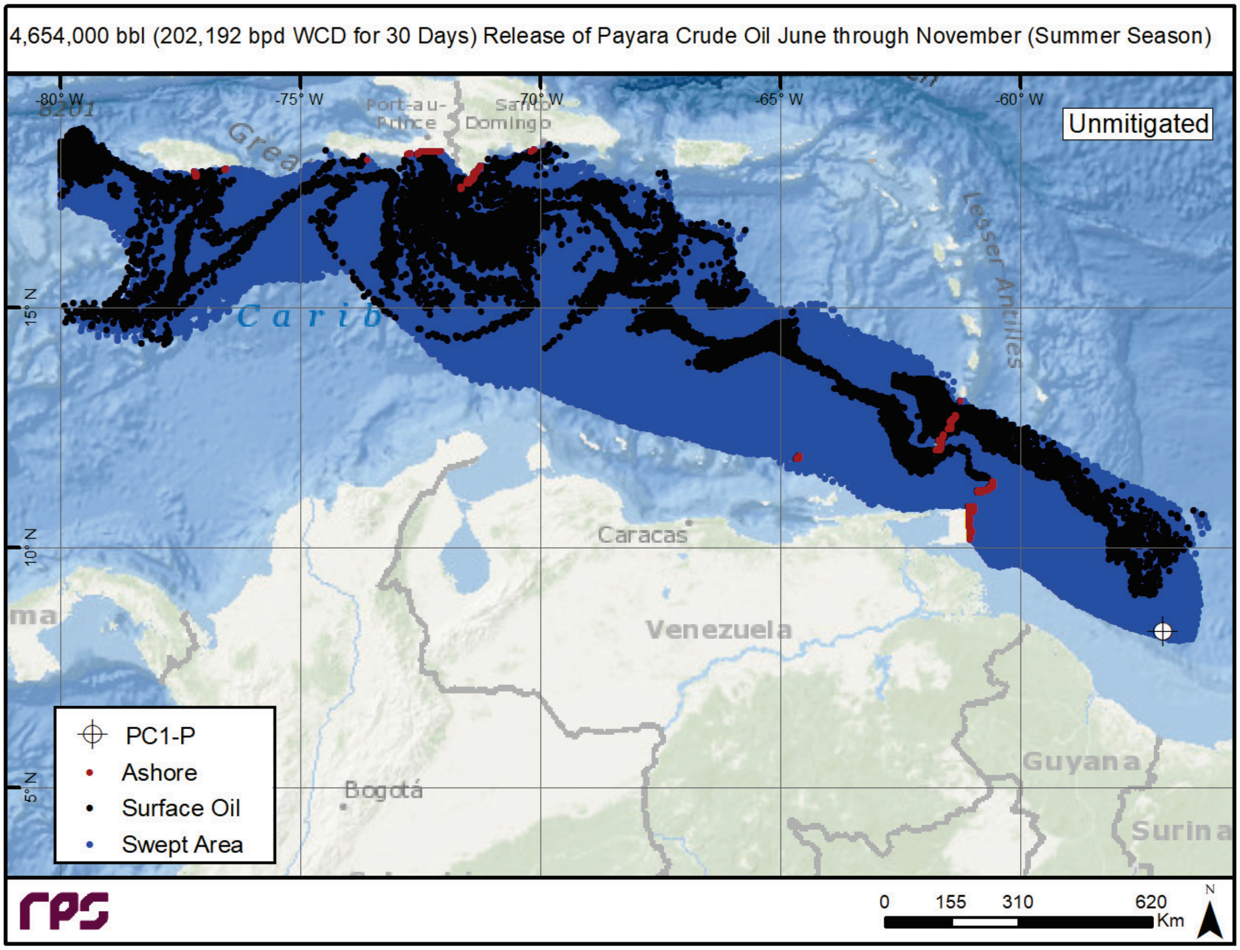


Figure 9.1-17a: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

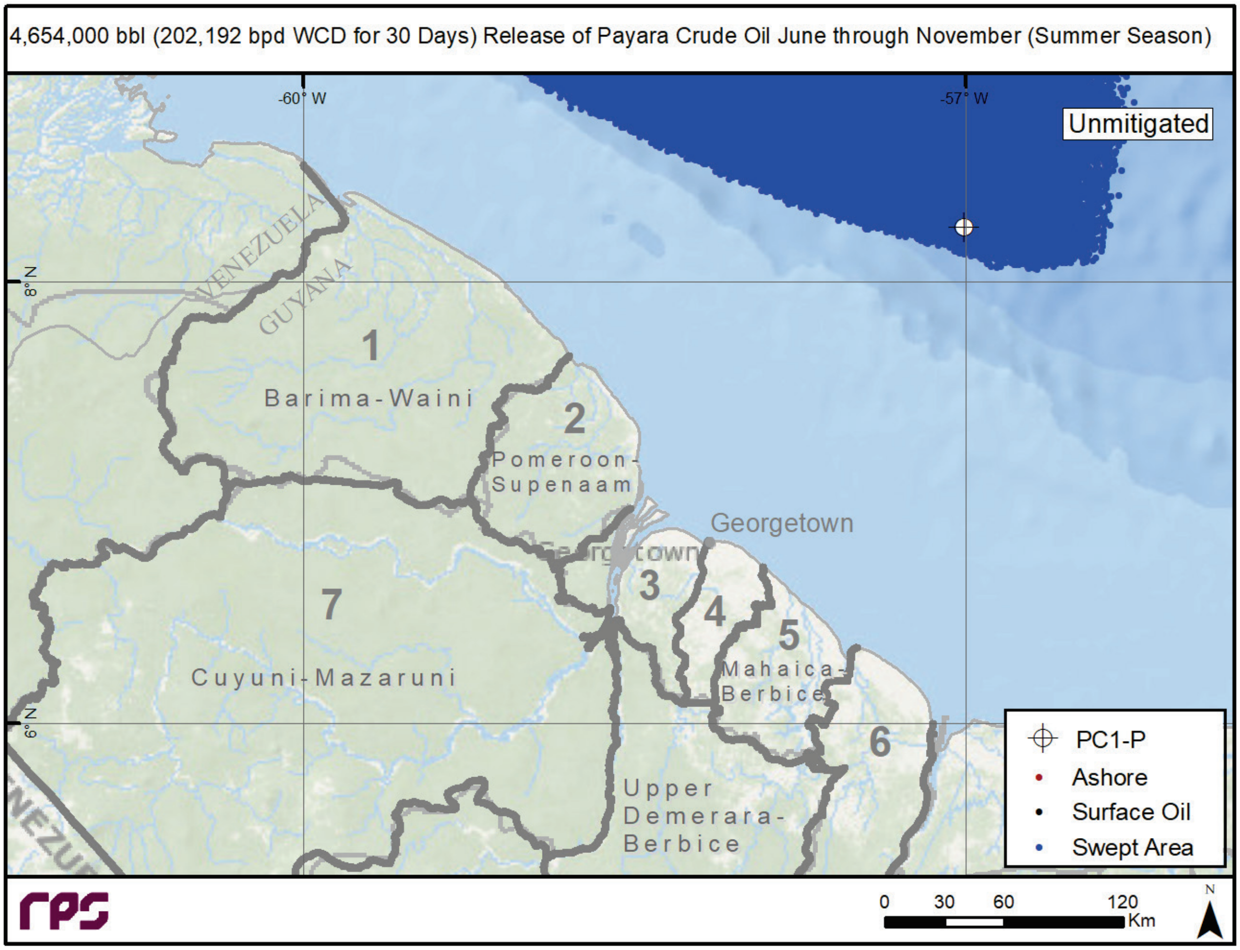


Figure 9.1-17b: (Zoomed In) Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

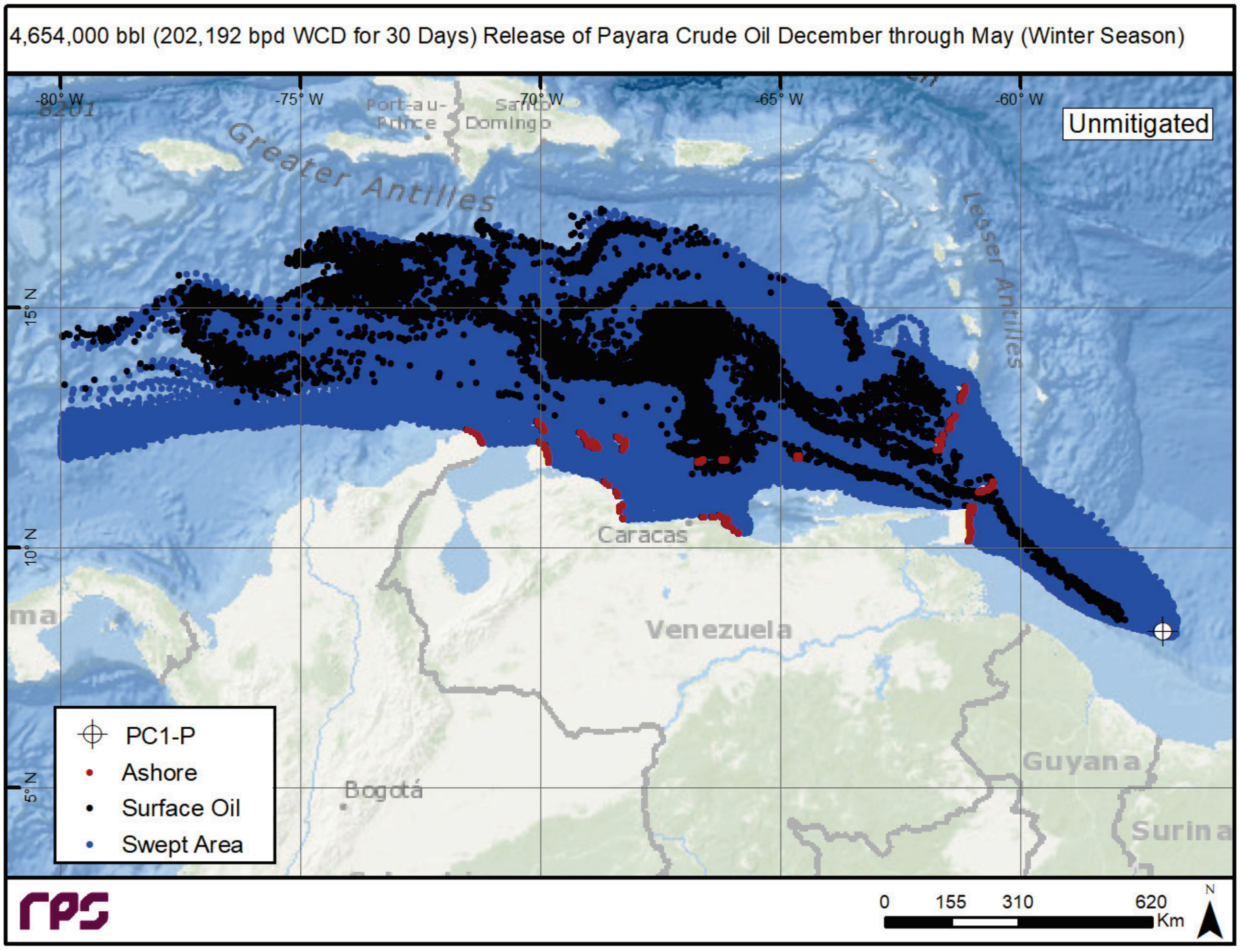


Figure 9.1-18a: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Dec–May)

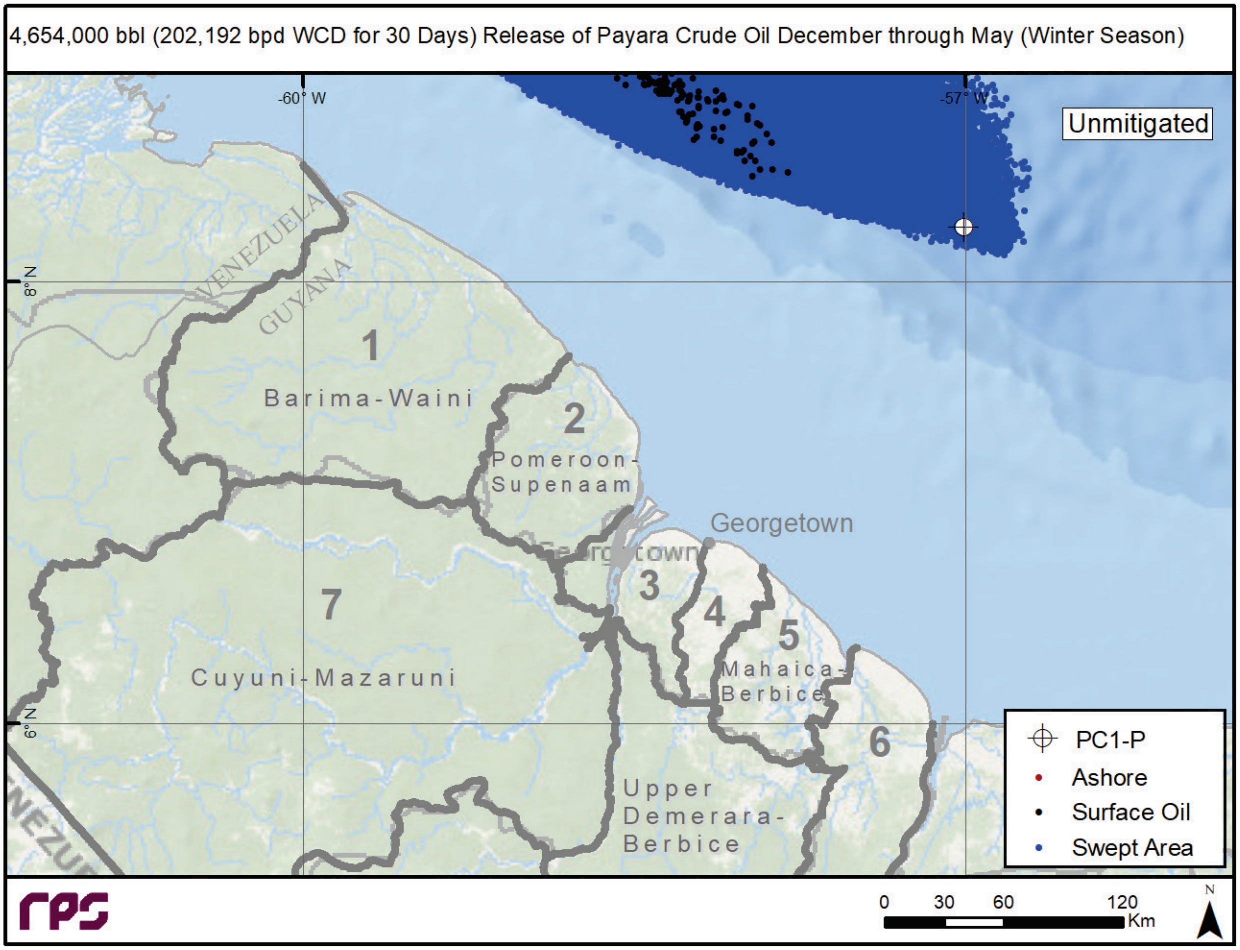


Figure 9.1-18b: (Zoomed In) Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Dec–May)

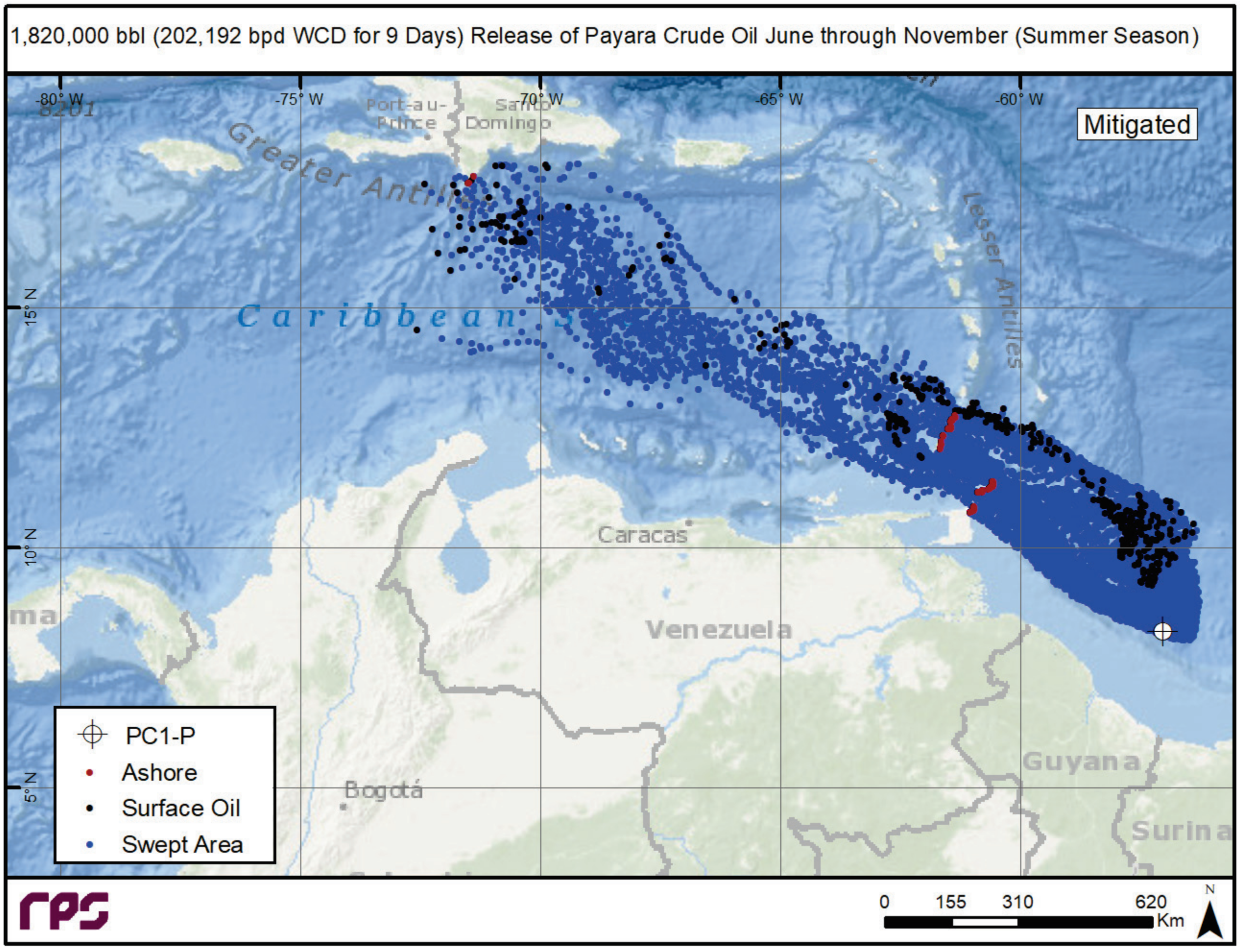


Figure 9.1-19a: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from a Mitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil—Capped After 9 Days (Jun–Nov)

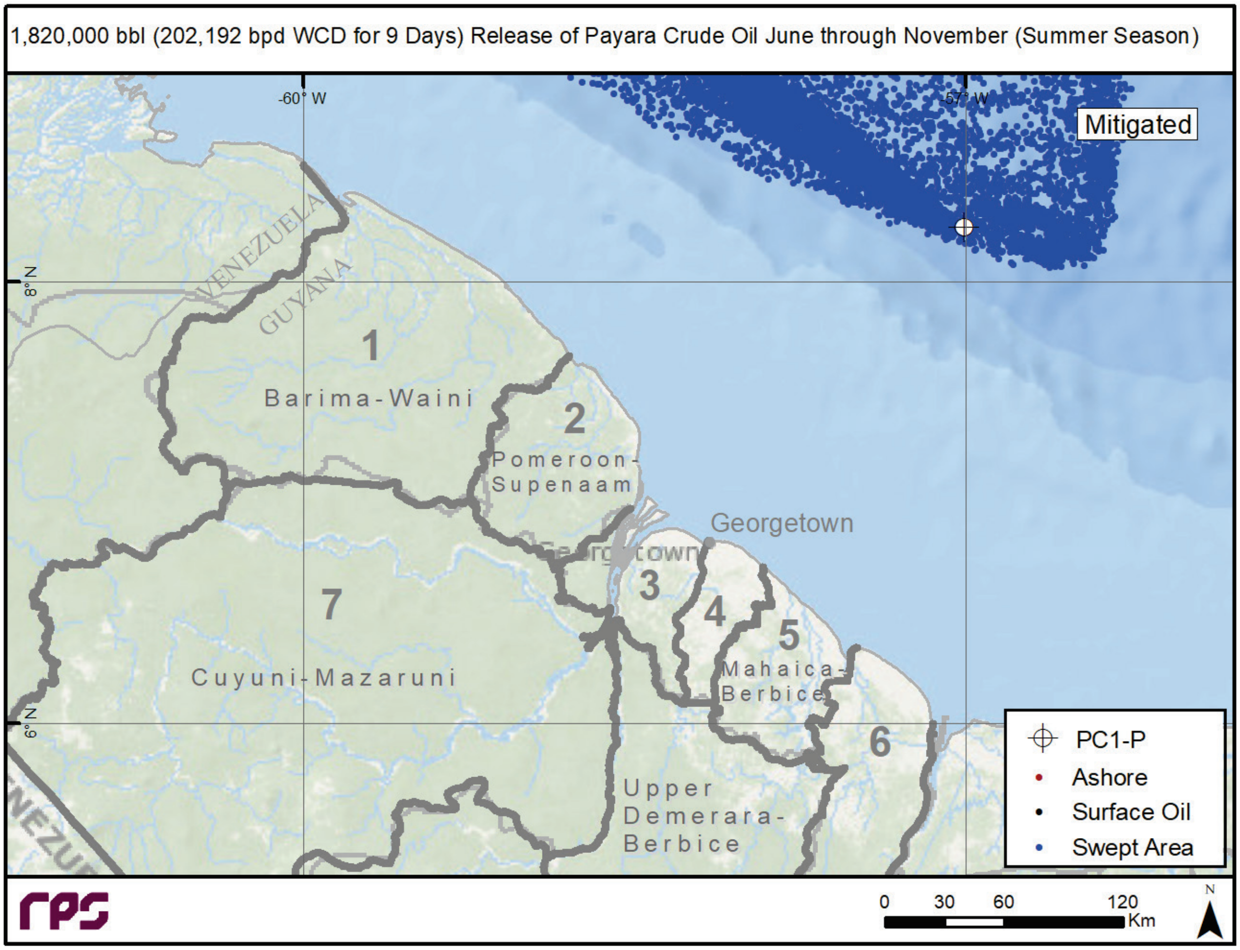


Figure 9.1-19b: (Zoomed In) Deterministic Map for Scenario 14—Predicted Transport after 54 Days from a Mitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil—Capped After 9 Days (Jun–Nov)

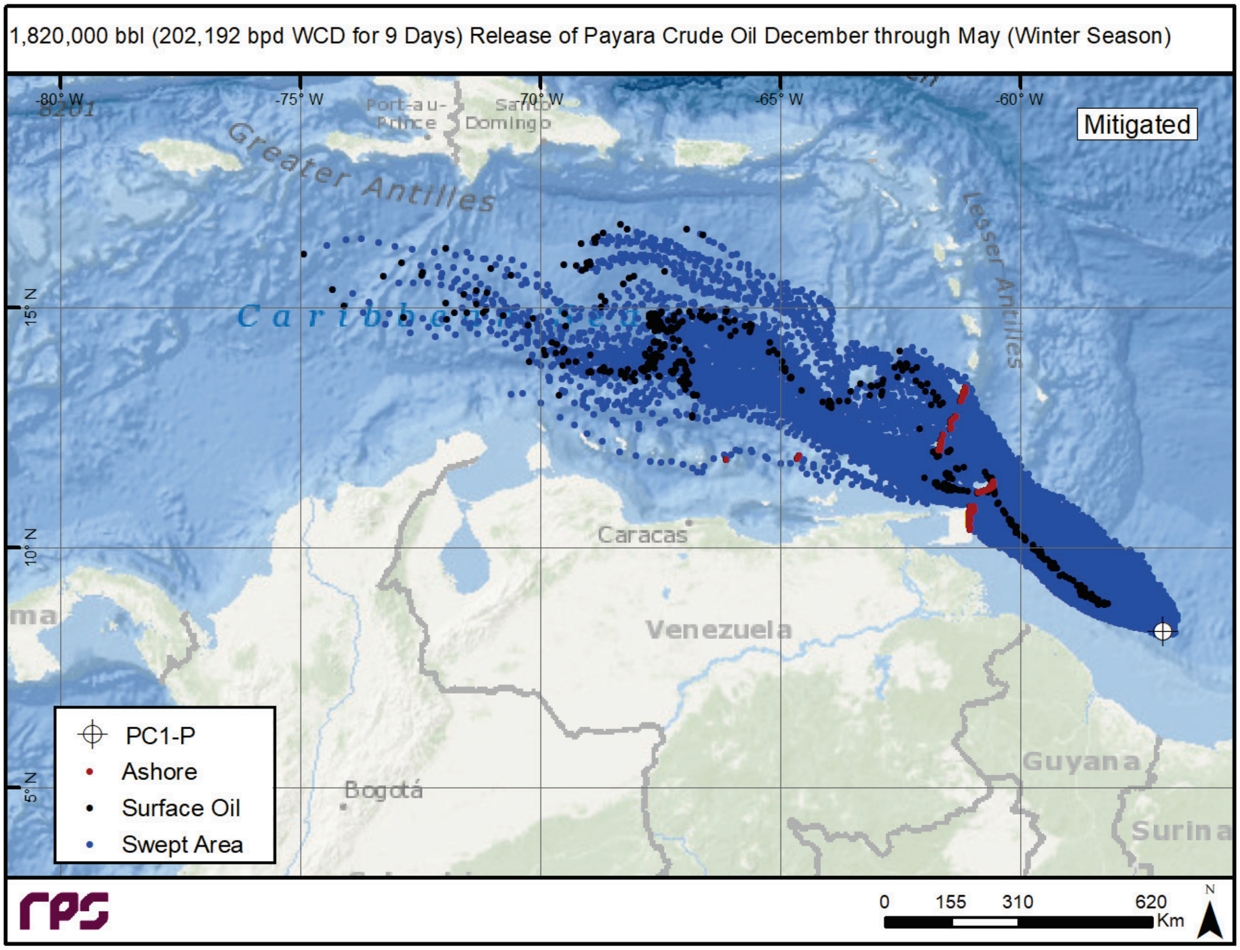


Figure 9.1-20a: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from a Mitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil—Capped After 9 Days (Dec–May)

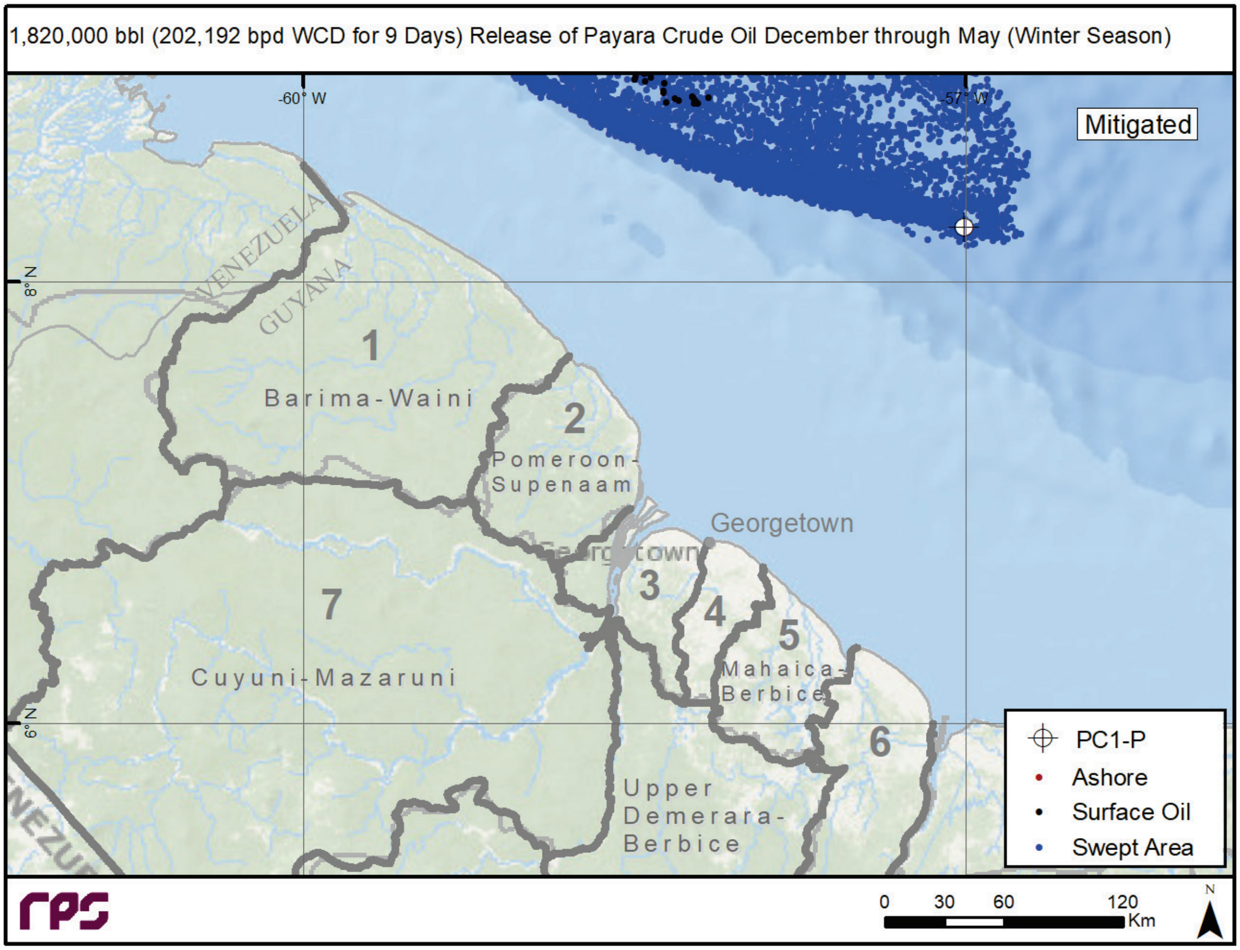


Figure 9.1-20b: (Zoomed In) Deterministic Map for Scenario 14—Predicted Transport after 54 Days from a Mitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil—Capped After 9 Days (Dec–May)

9.1.6. Coastal Sensitivity Mapping

Coastal sensitivity mapping was completed for the coastal areas identified in the oil spill modeling as having the potential to be contacted by hydrocarbons as a result of any of the deterministic modeling of unmitigated marine oil spill scenarios. The coastal sensitivity mapping consisted of initial desktop-based research, followed by field verification in specific areas (Regions 1‒6 in Guyana,[1] and Trinidad and Tobago). The mapping included characterization of the following resources:

- Environmental—protected areas, mangroves, shoreline types, seagrass beds, coral reefs, important coastal fish habitats, important coastal bird habitats, and other sensitive habitats; and
- Socioeconomic—coastal and/or indigenous peoples communities (e.g., locations, demographics, and socioeconomic characteristics), ecosystem services (type, beneficiaries, value of services to beneficiaries, habitats, and resources), shoreline- and coastal-dependent commercial and artisanal activities (e.g., fishing, foraging, hunting, agriculture and grazing, and transportation), industrial activities and infrastructure (e.g., water intake facilities, ports), and traditional and cultural practices.

This information will enable EEPGL to prioritize the mobilization of emergency response resources (manpower and equipment) to those areas most sensitive to a spill.

The coastal sensitivity maps are provided in Appendix P. Maps are provided for each country (or portion of a country) where deterministic modeling of an unmitigated loss-of-well-control event for at least one of the two WCD scenarios (either season) predicted shoreline oiling[2].

To aid in comparing the results of oil spill modeling to coastal sensitivity data, the following figures show the results of deterministic modeling of an unmitigated loss of well control for both WCD scenarios (both seasons), each overlaid with the relevant coastal sensitivity map "tiles" included in Appendix P:

- Guyana: Figures 9.1-21a through 9.1-21b
- Trinidad and Tobago: Figures 9.1-22a through 9.1-22b
- Venezuela: Figures 9.1-23a through 9.1-23b
- Grenada: Figures 9.1-24a through 9.1-24b
- St. Vincent and The Grenadines: Figures 9.1-25a through 9.1-25b
- Bonaire: Figures 9.1-26a through 9.1-26b
- Curacao: Figures 9.1-27a through 9.1-27b
- Aruba: Figures 9.1-28a through 9.1-28b
- Dominican Republic: Figures 9.1-29a through 9.1-29b

[1] Although oil spill modeling indicates Region 1 is the only Guyanese region with the potential to have a coastline impacted by an unmitigated subsea release from a loss-of-well-control event, coastal sensitivity data were collected for Regions 1–6 as part of Liza Phase 1 post permit studies.

[2] None of the modeling predicted shoreline oiling of Barbados from an unmitigated loss-of-well-control event, but coastal sensitivity maps were prepared since it is in close proximity to other countries with predicted shoreline oiling.

- Haiti: Figures 9.1-30a through 9.1-30b
- Jamaica: Figures 9.1-31a through 9.1-31b
- Colombia: Figures 9.1-32a through 9.1-32b

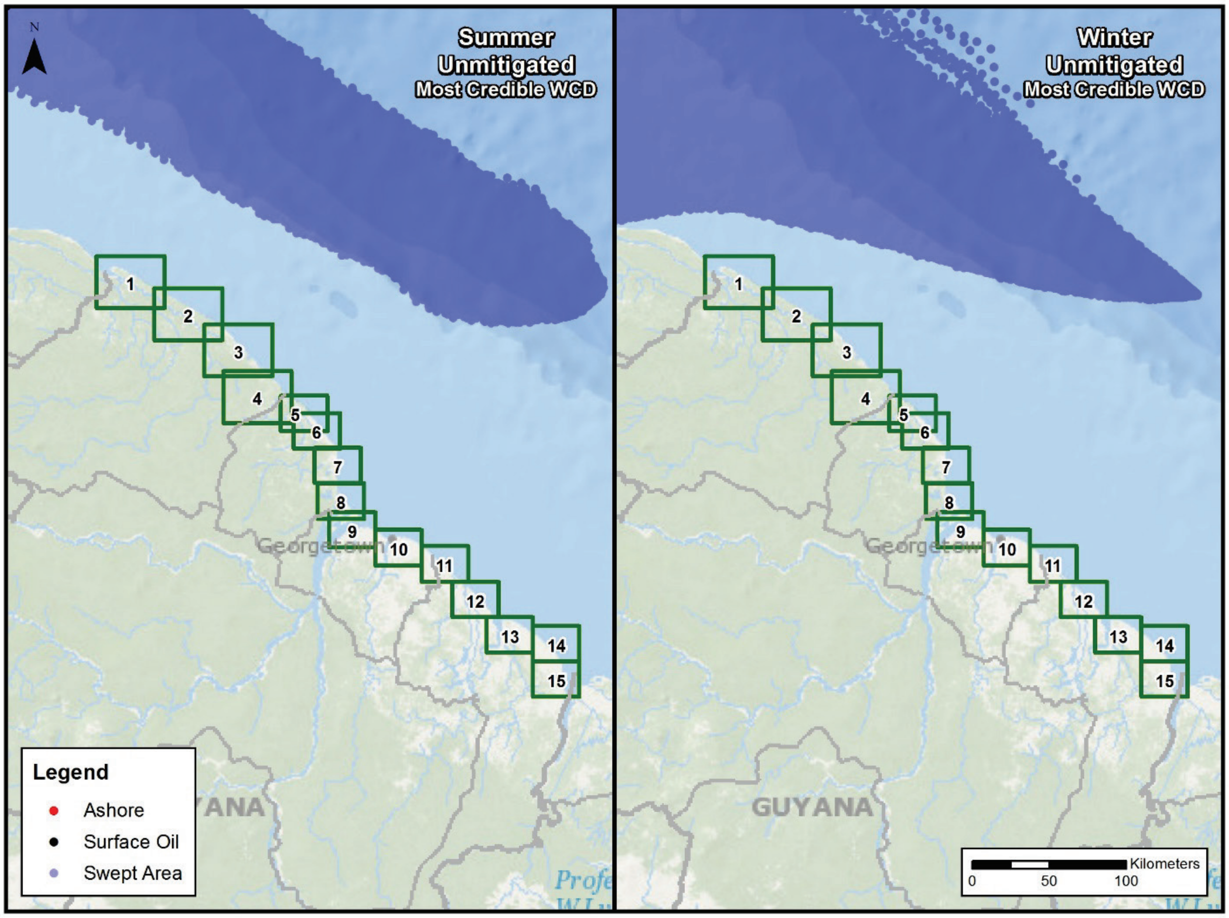


Figure 9.1-21a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Guyana

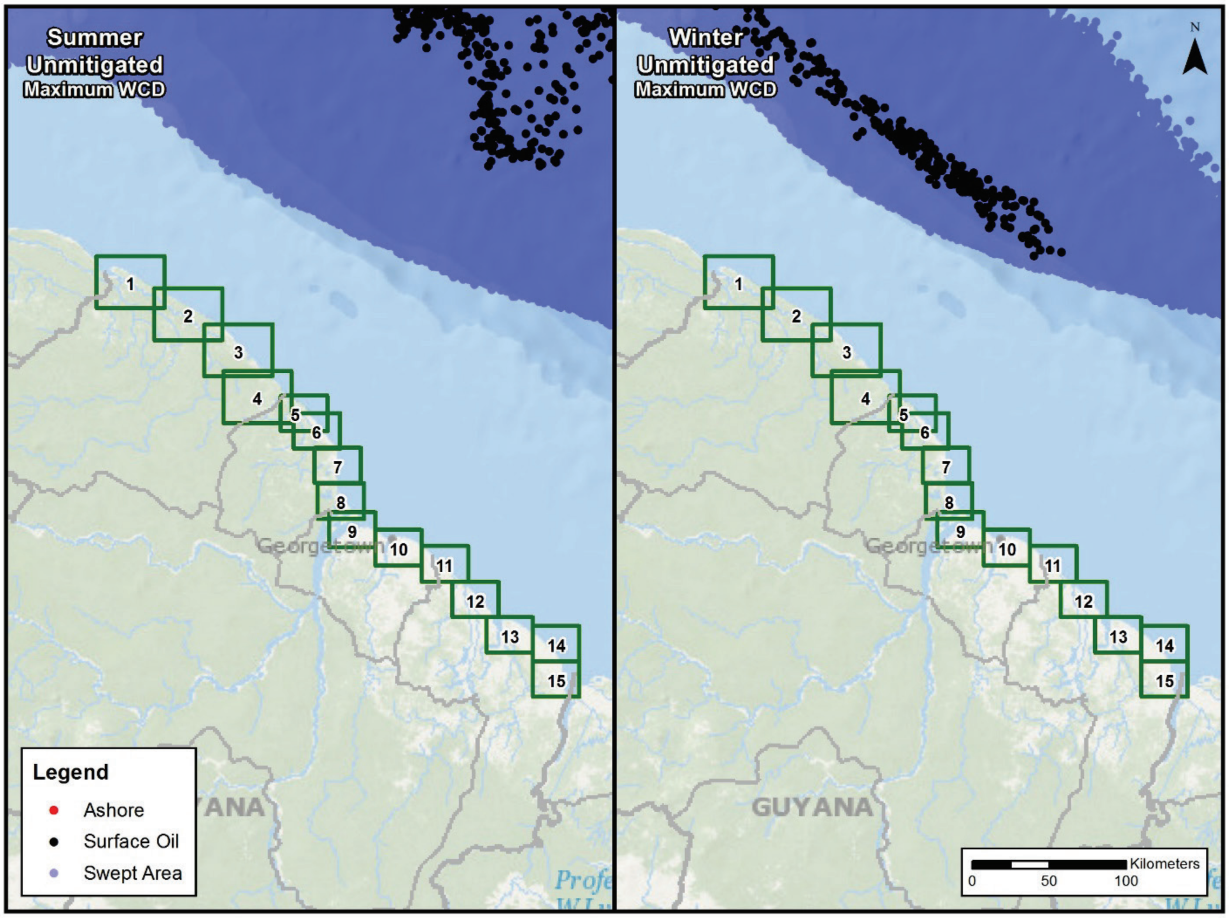


Figure 9.1-21b: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Guyana

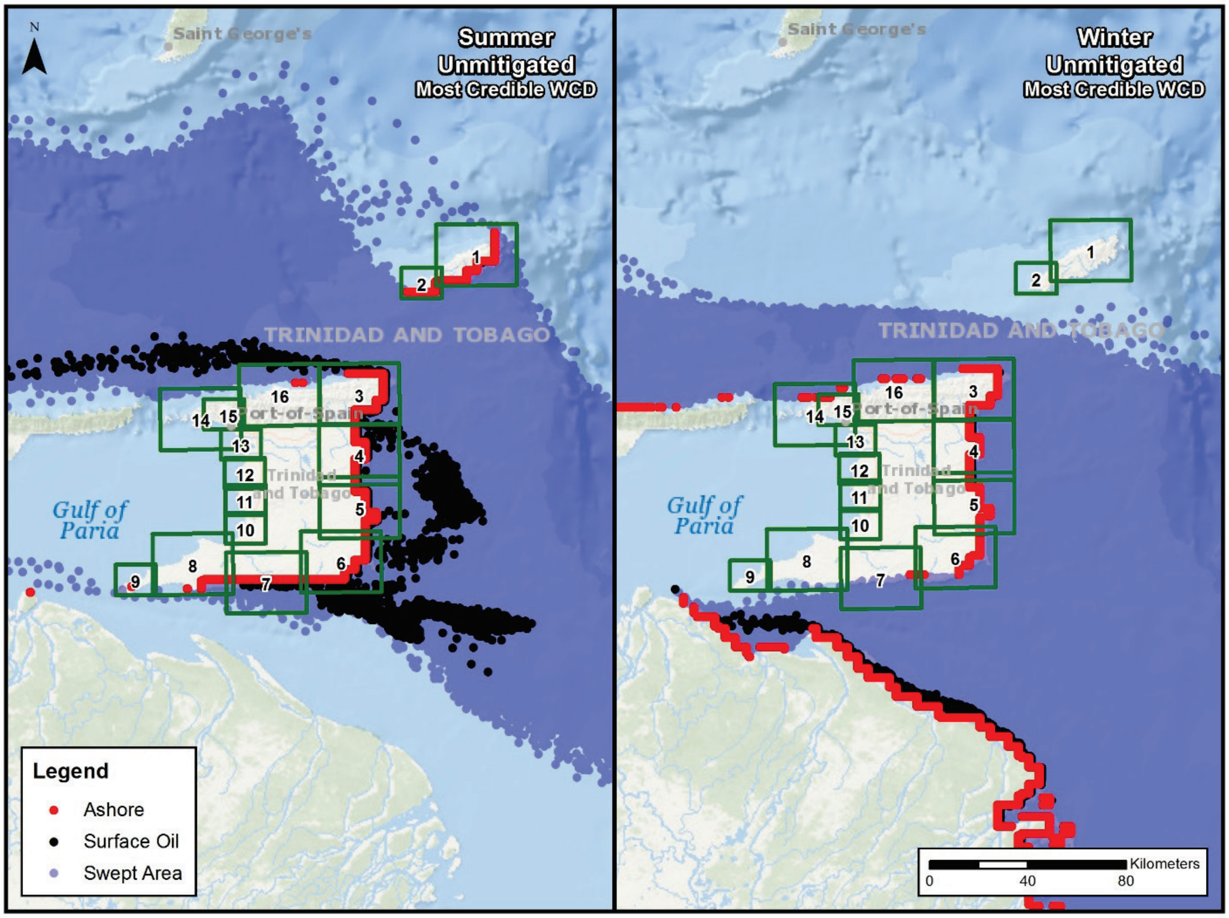


Figure 9.1-22a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Trinidad and Tobago

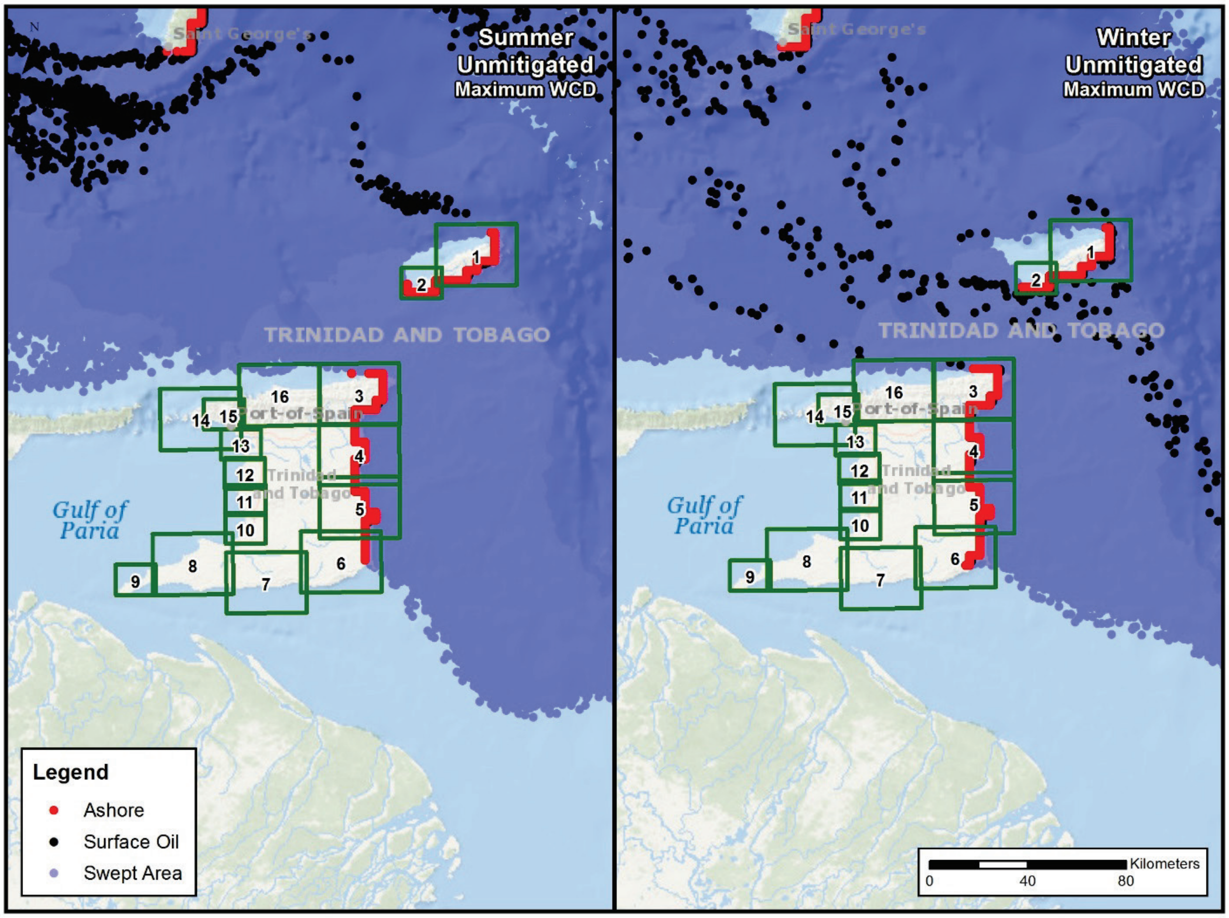


Figure 9.1-22b: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Trinidad and Tobago

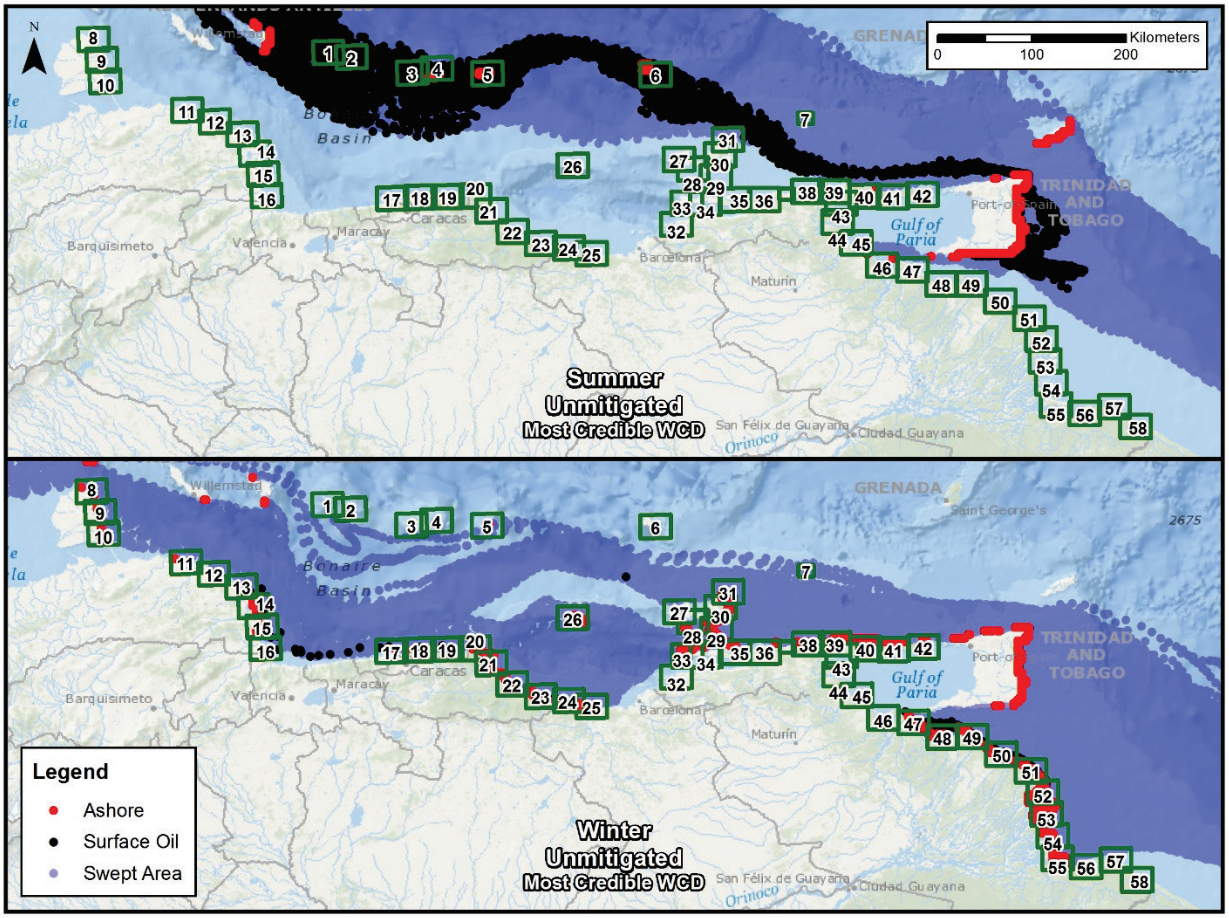


Figure 9.1-23a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Venezuela

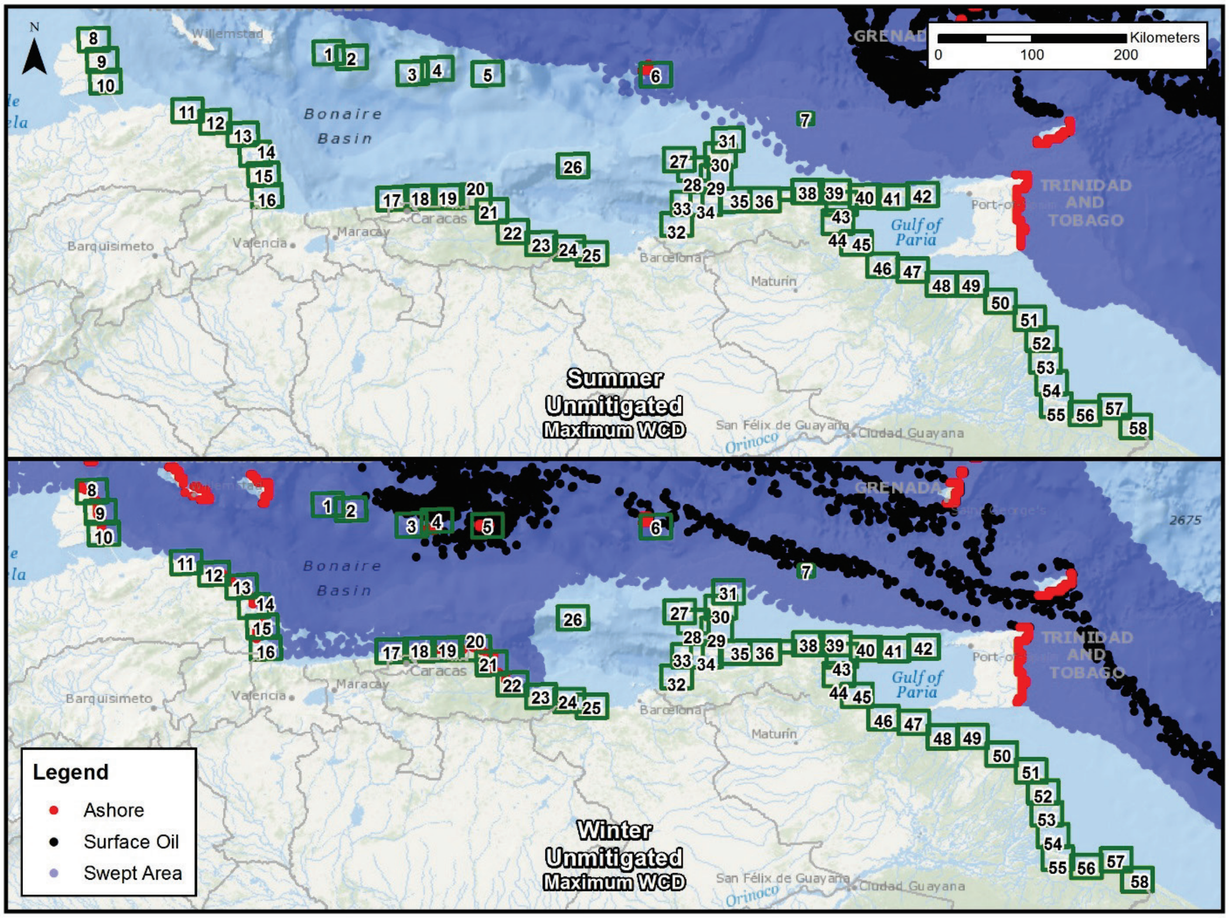


Figure 9.1-23b: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Venezuela

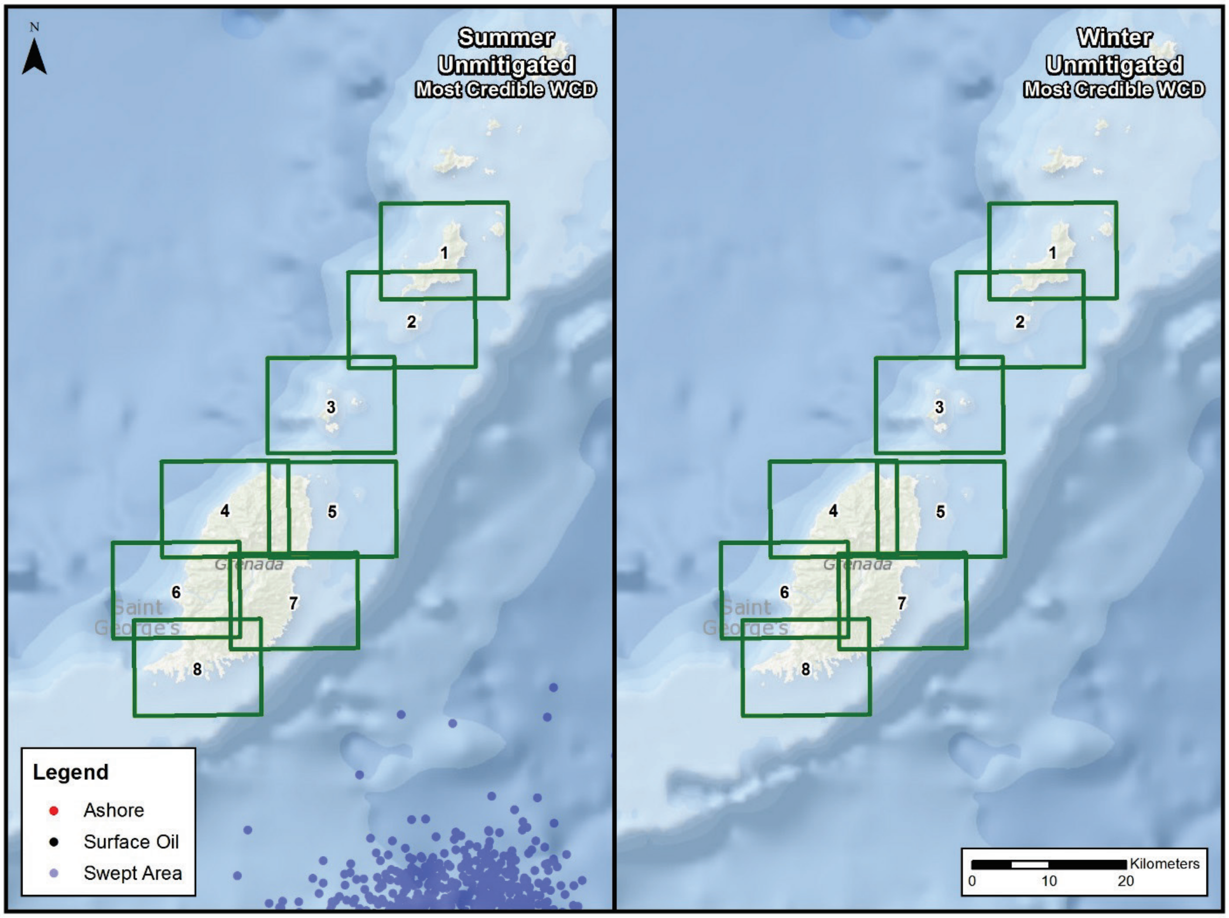


Figure 9.1-24a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Grenada

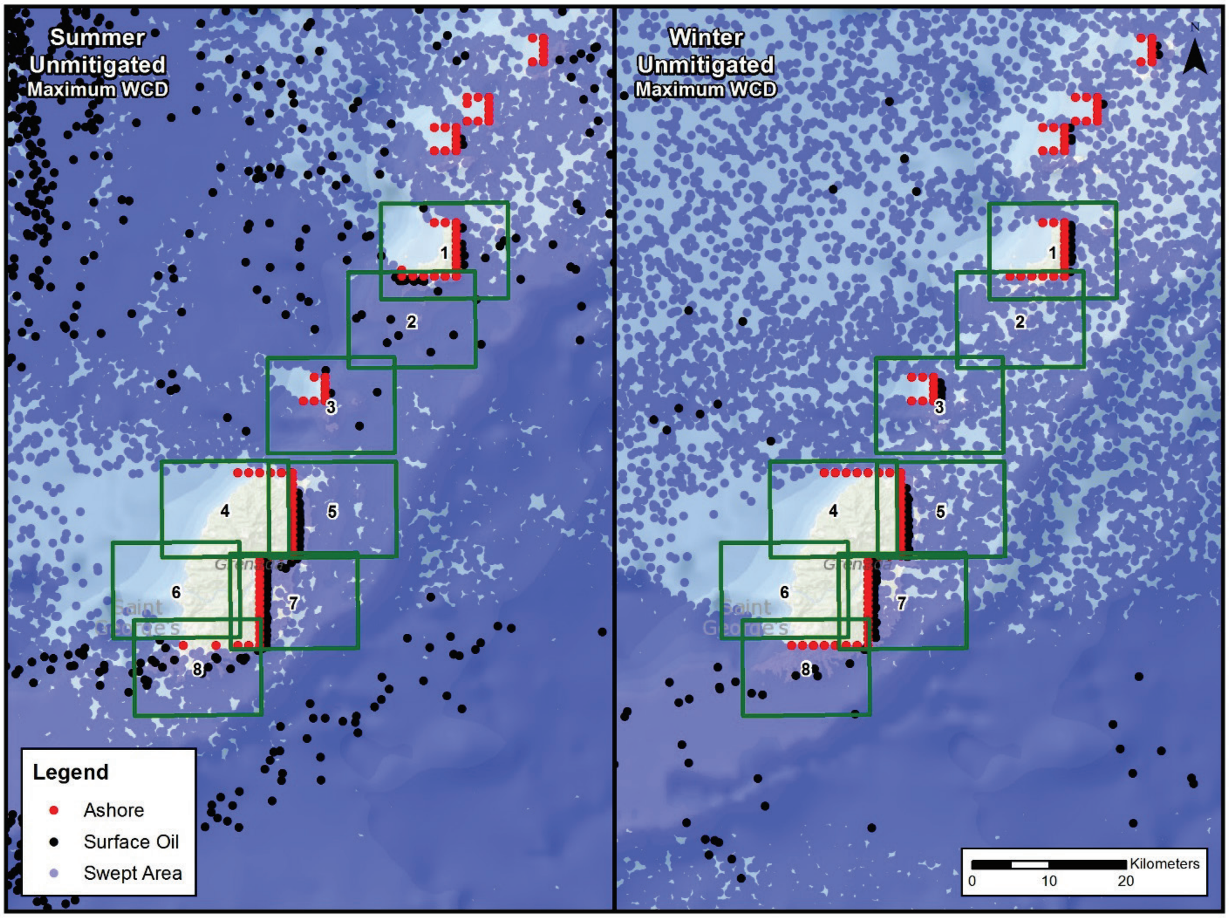


Figure 9.1-24b: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Grenada

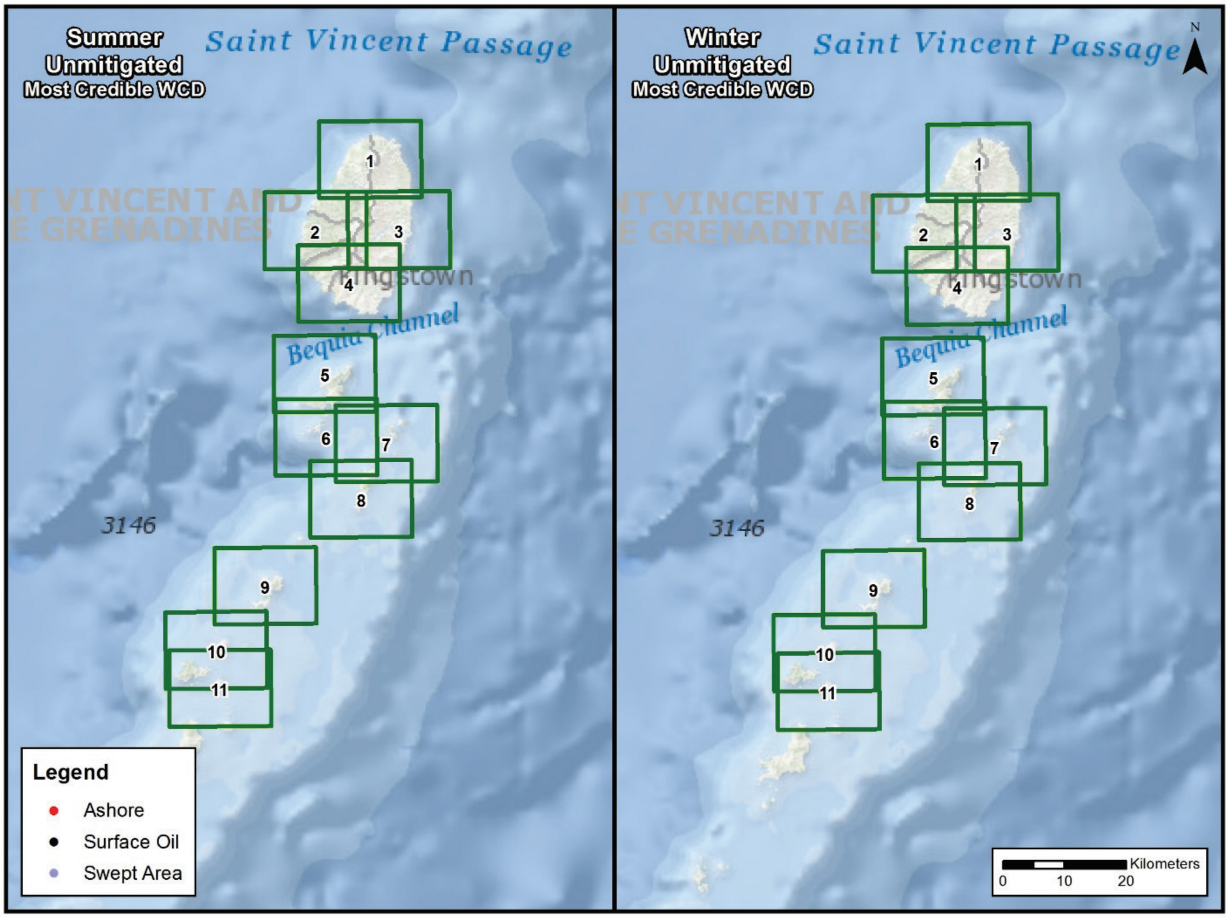


Figure 9.1-25a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for St. Vincent and The Grenadines

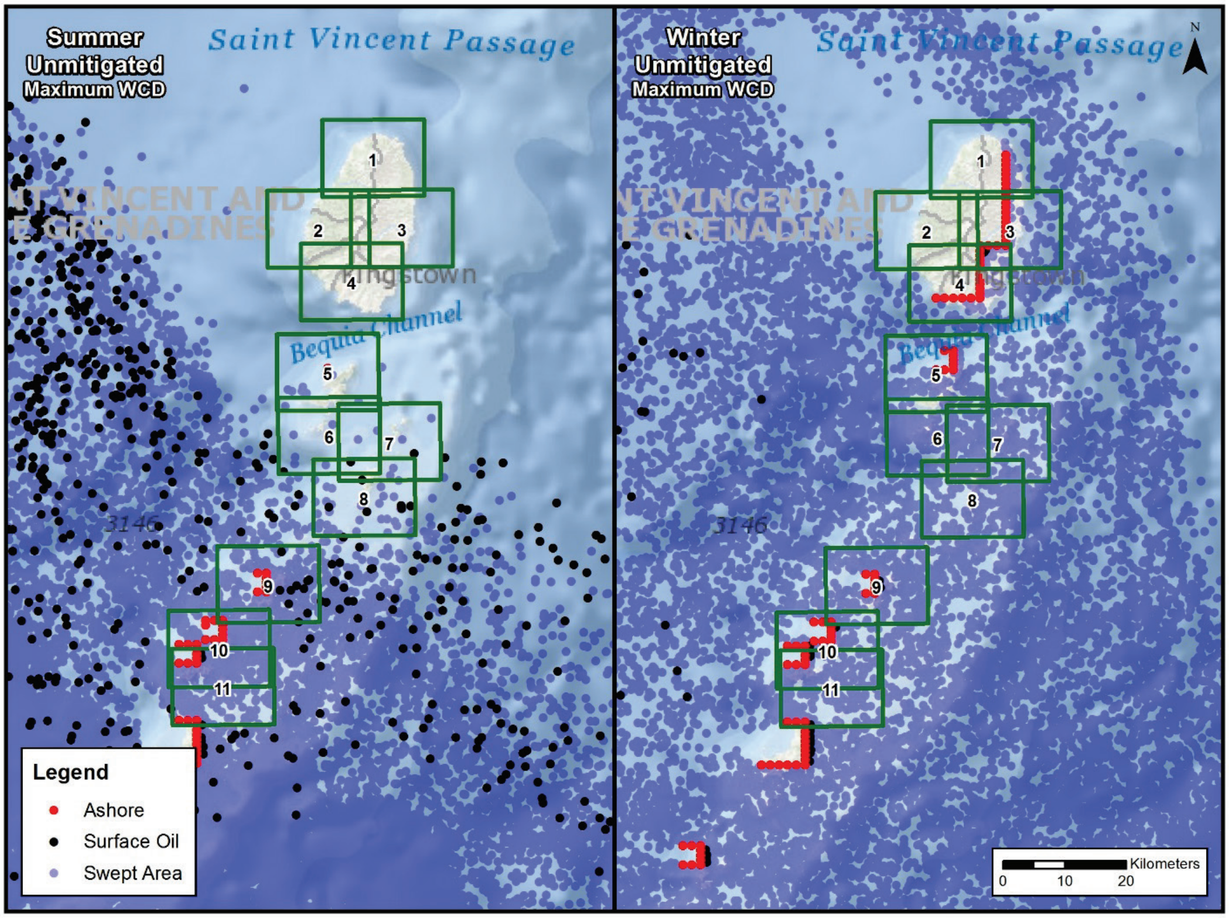


Figure 9.1-25b: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for St. Vincent and The Grenadines

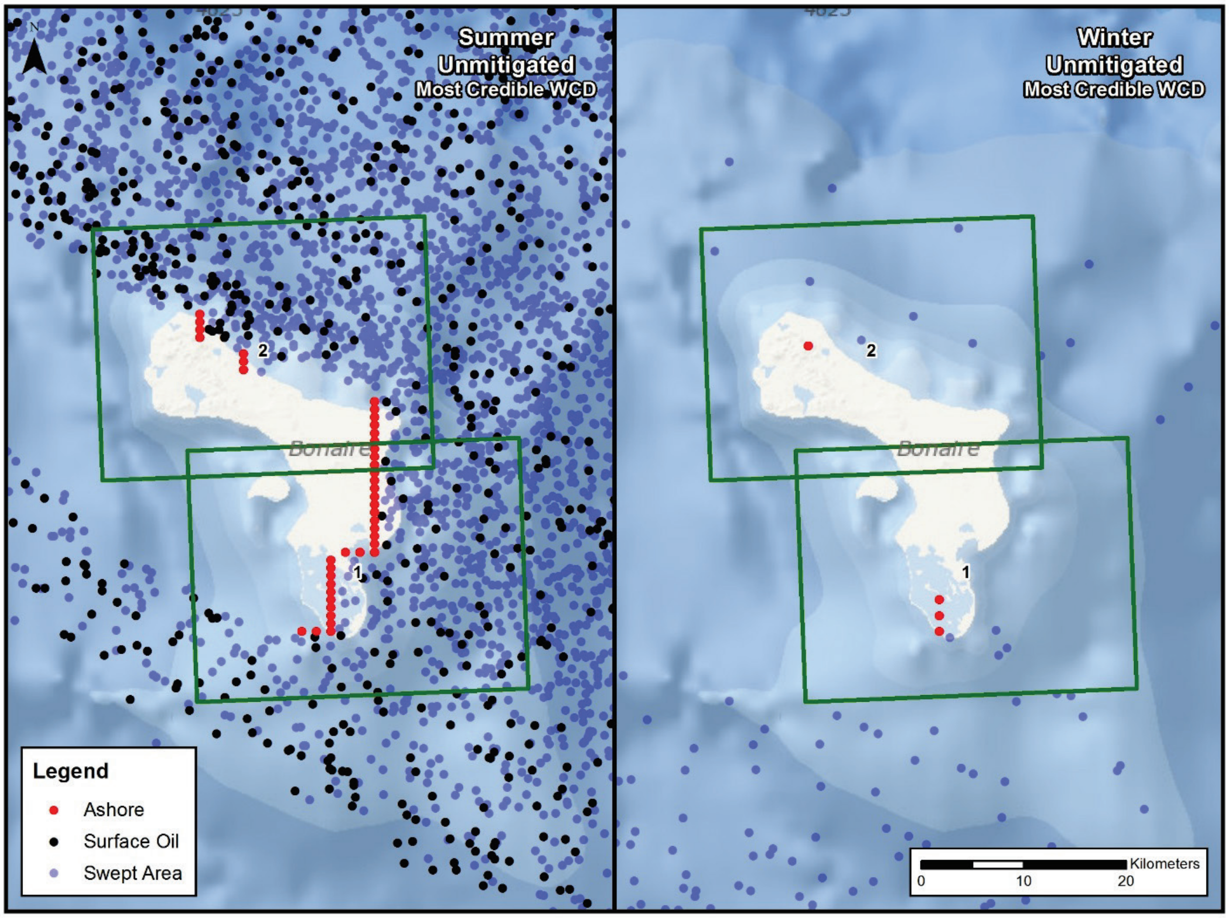


Figure 9.1-26a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Bonaire

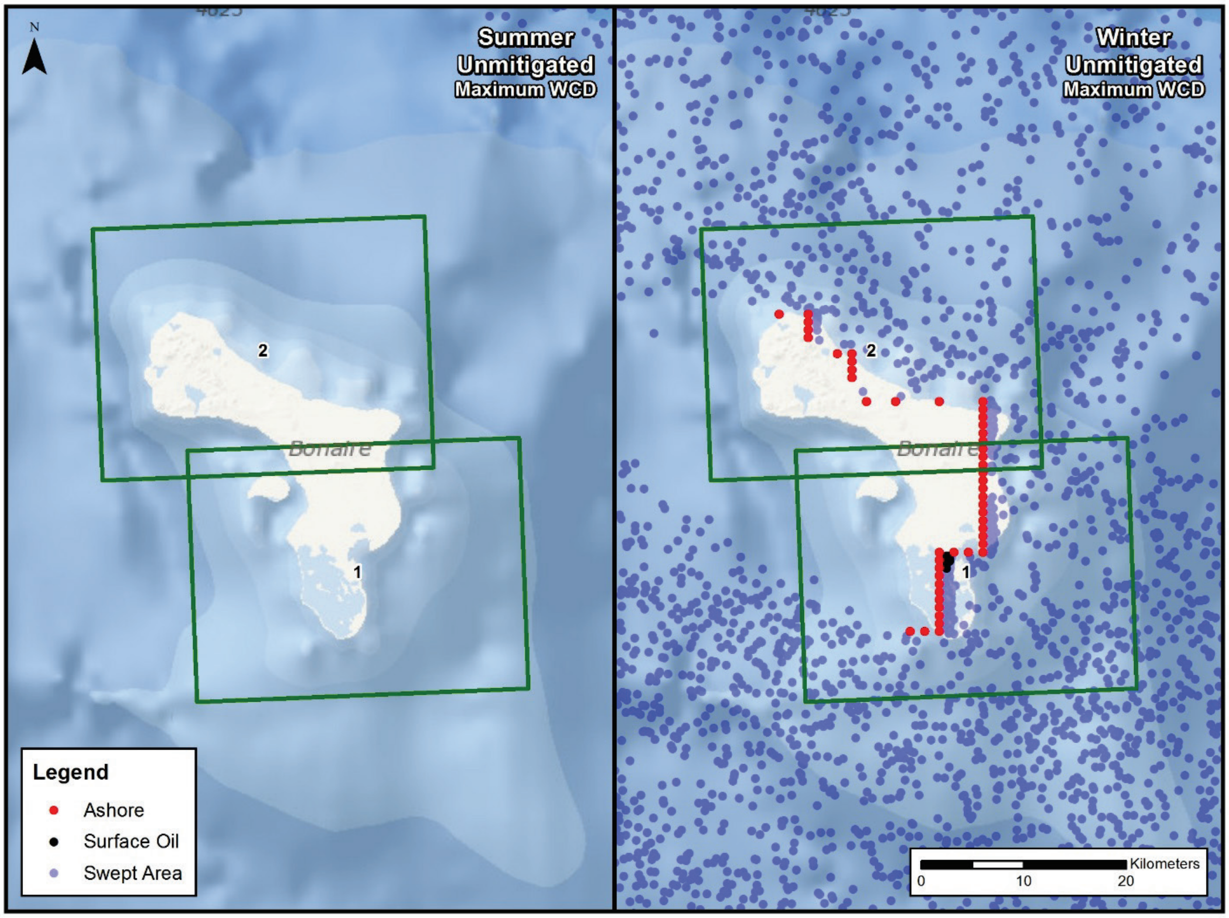


Figure 9.1-26b: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Bonaire

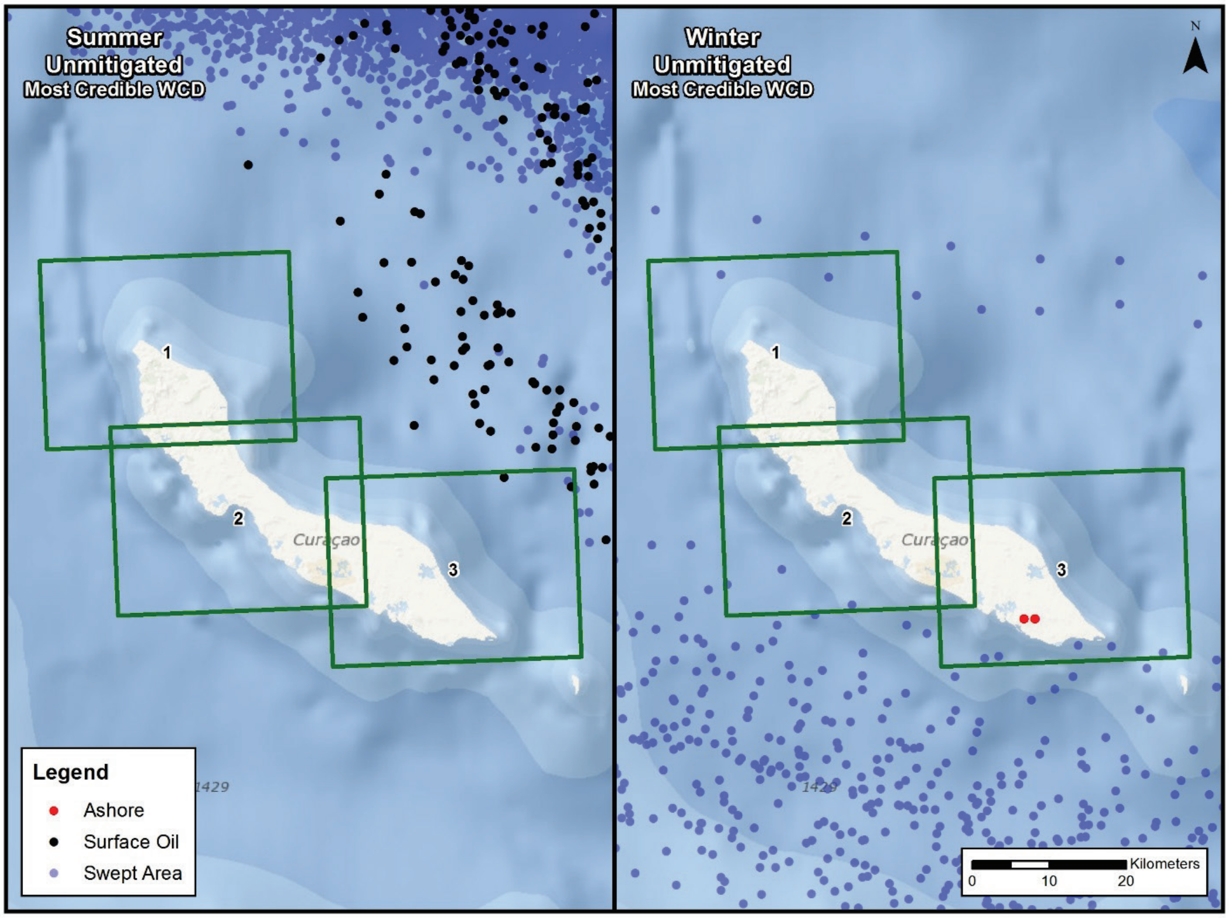


Figure 9.1-27a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Curacao

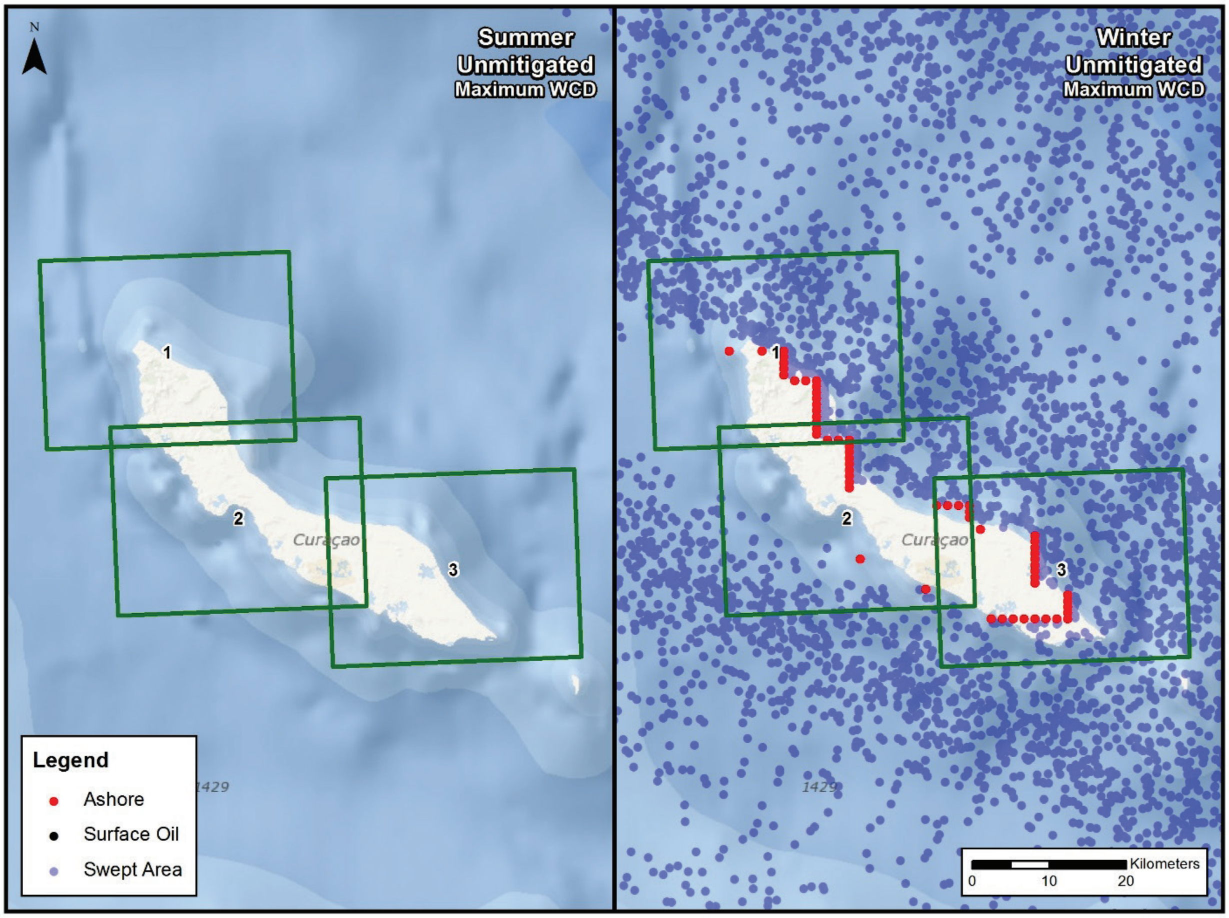


Figure 9.1-27b: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Curacao

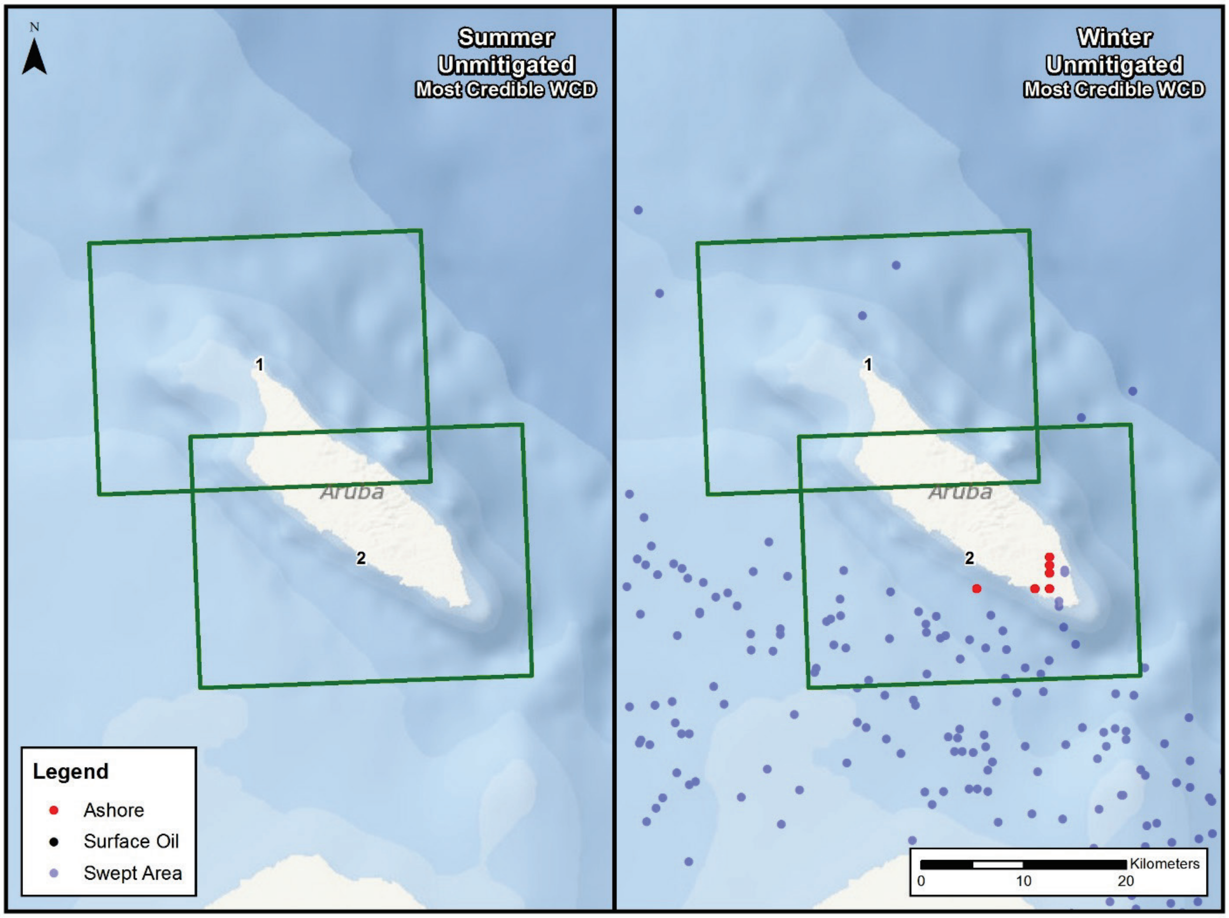


Figure 9.1-28a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Aruba

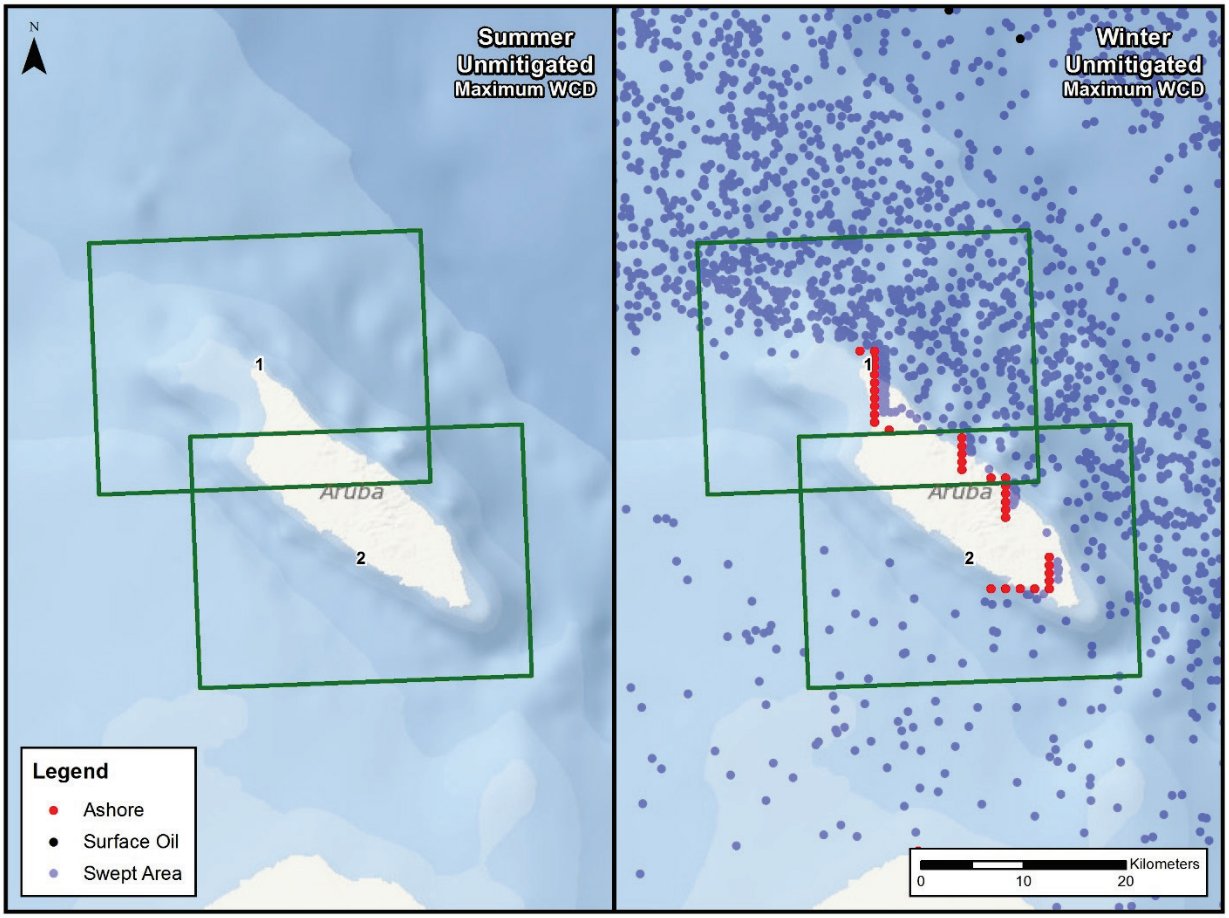


Figure 9.1-28b: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Aruba

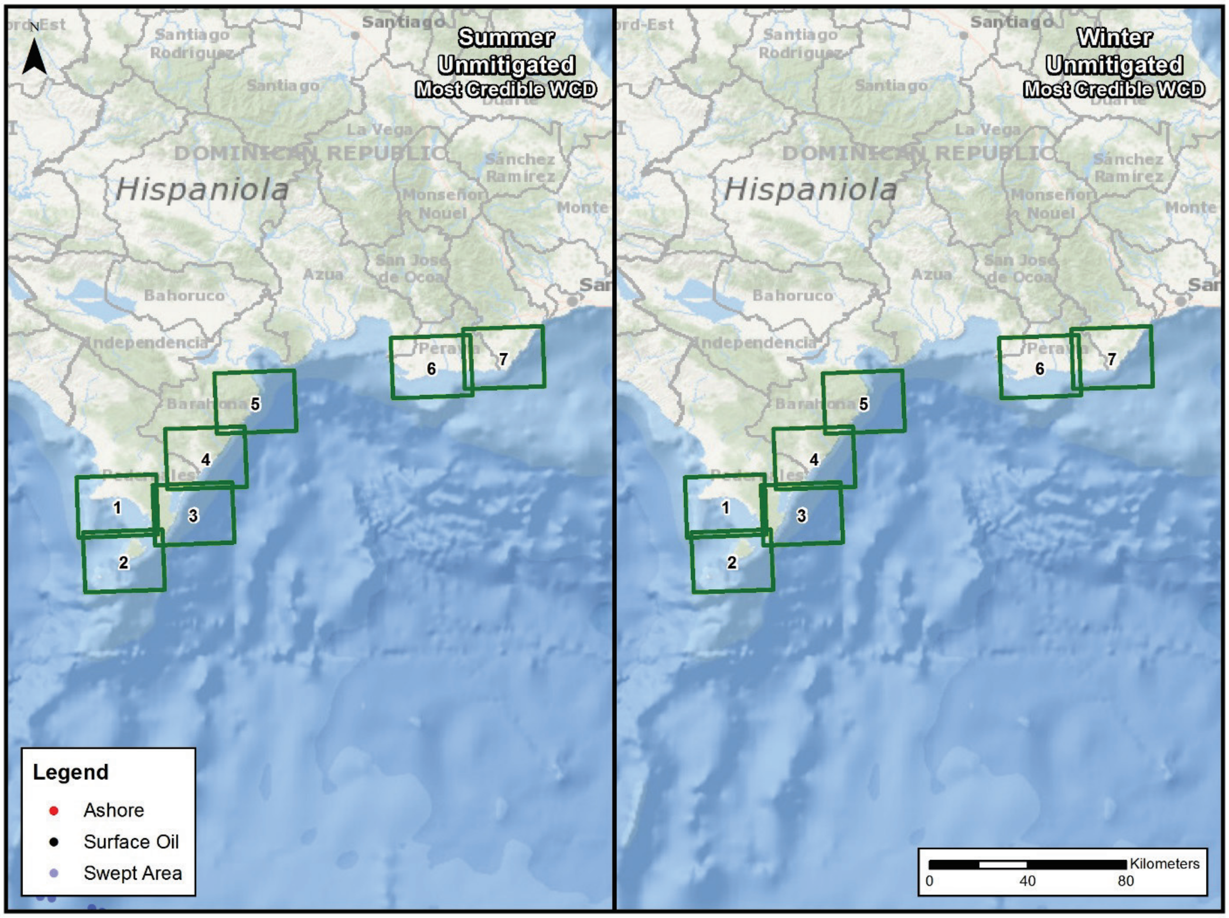


Figure 9.1-29a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Dominican Republic

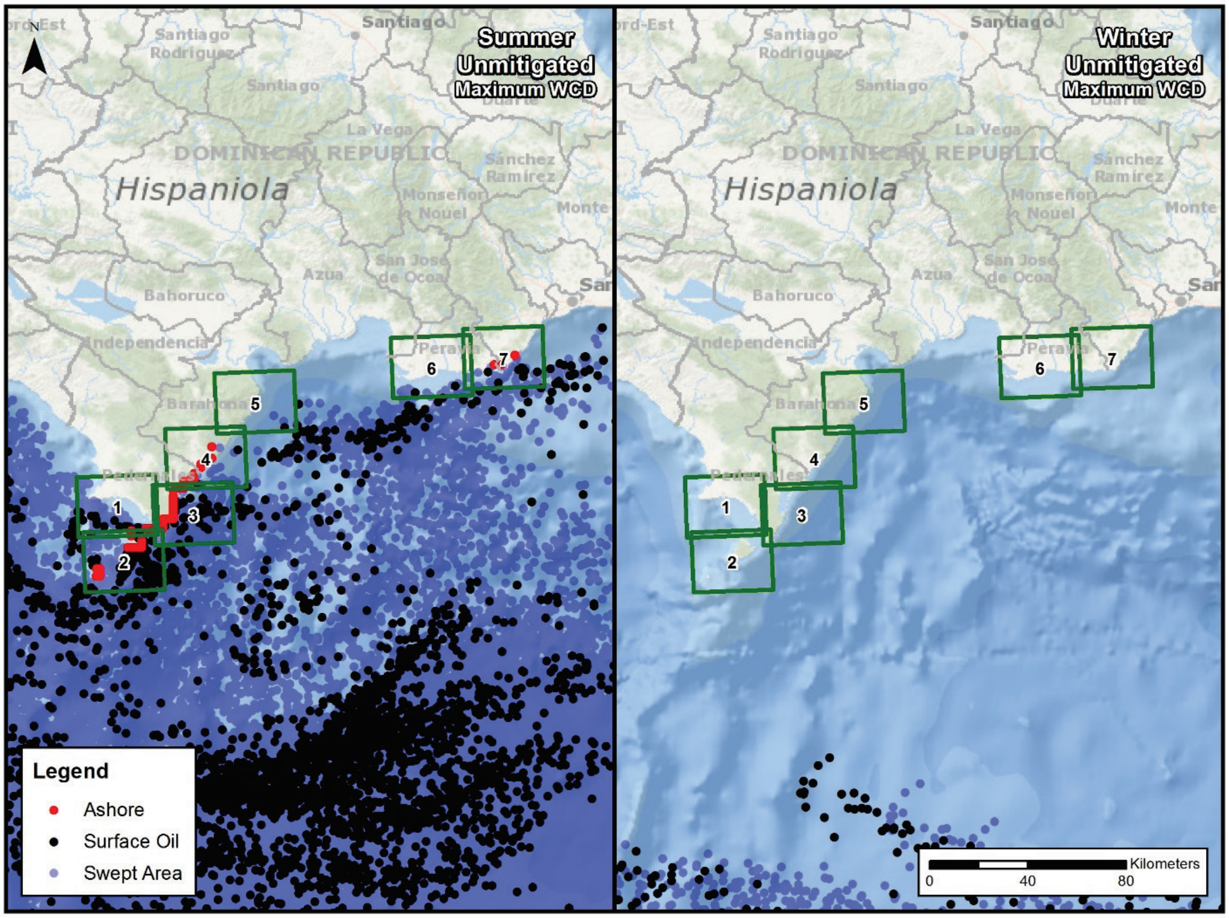


Figure 9.1-29b: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Dominican Republic

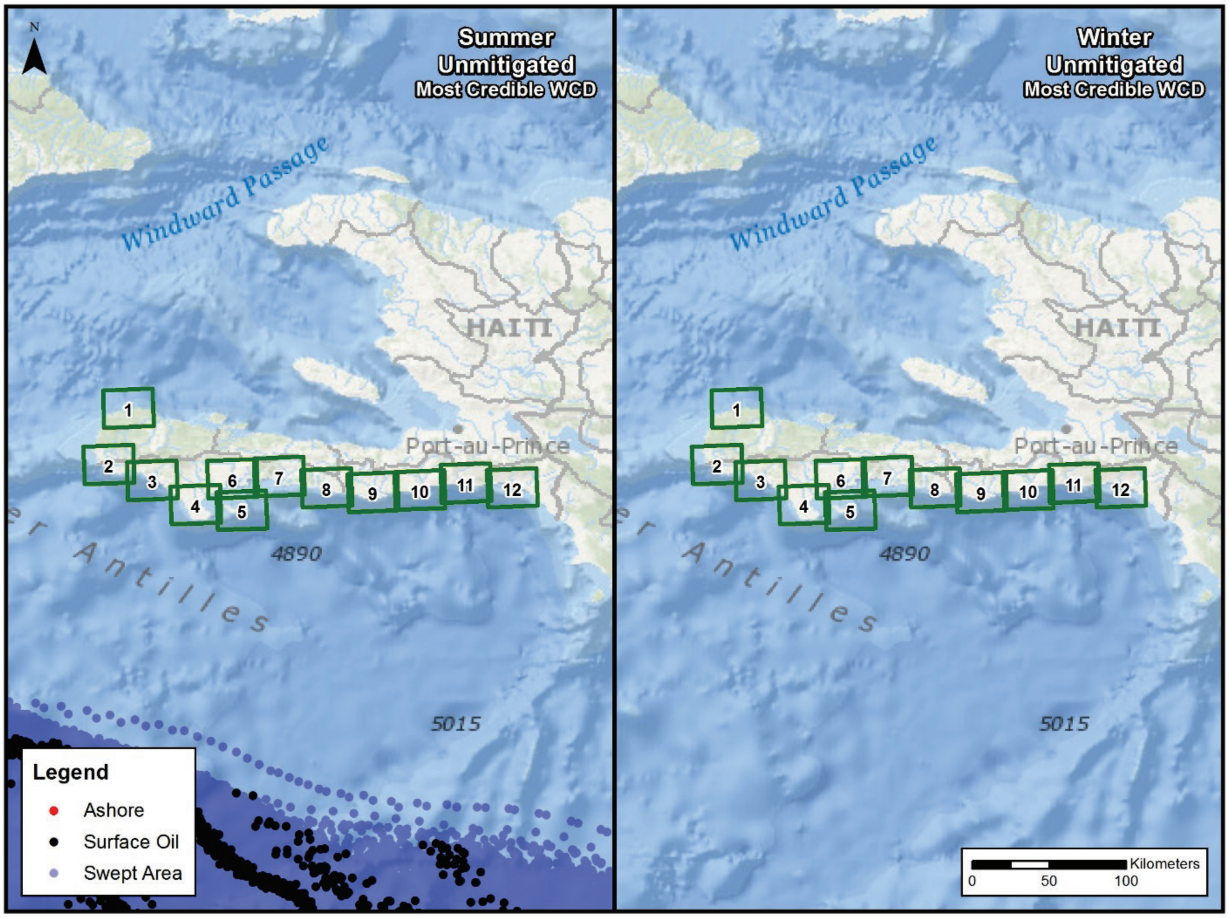


Figure 9.1-30a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Haiti

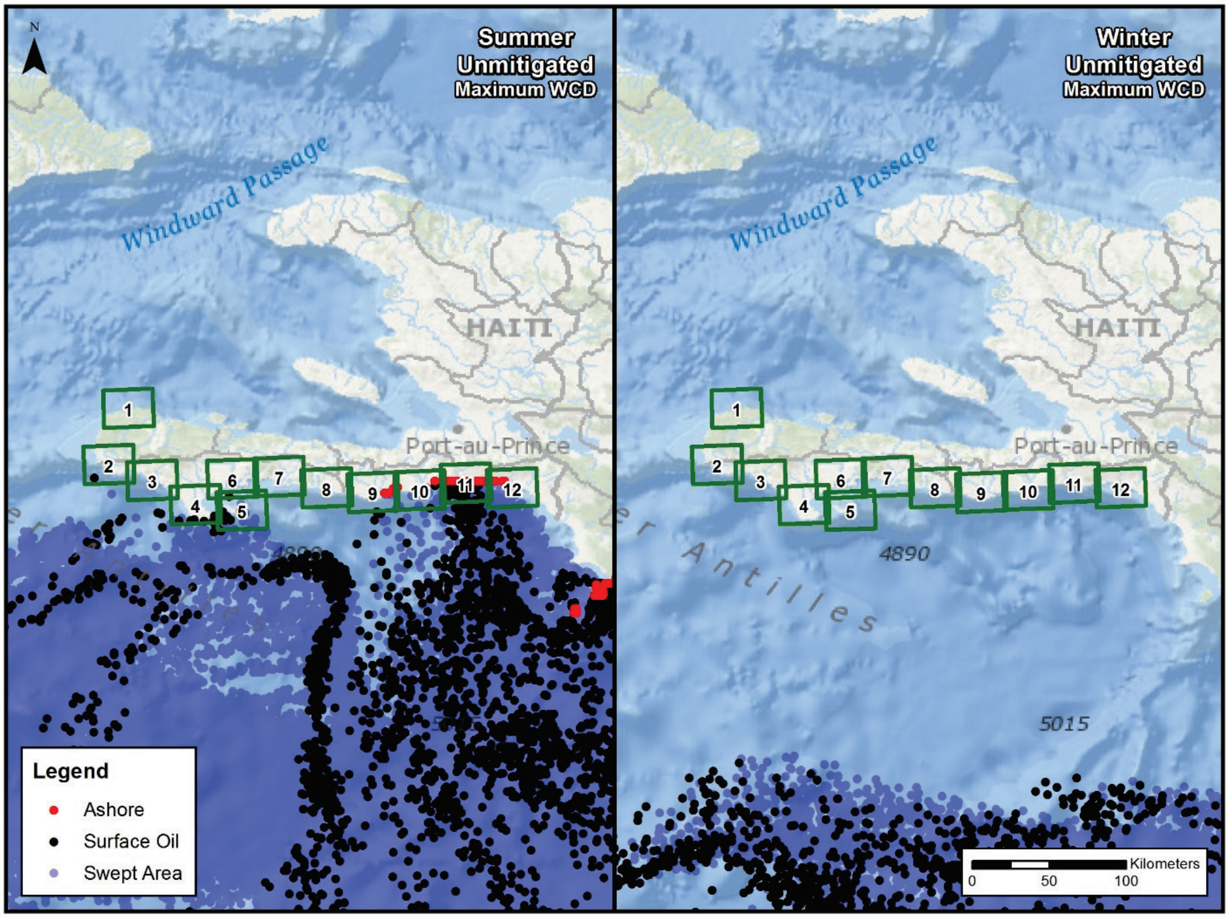


Figure 9.1-30b: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Haiti

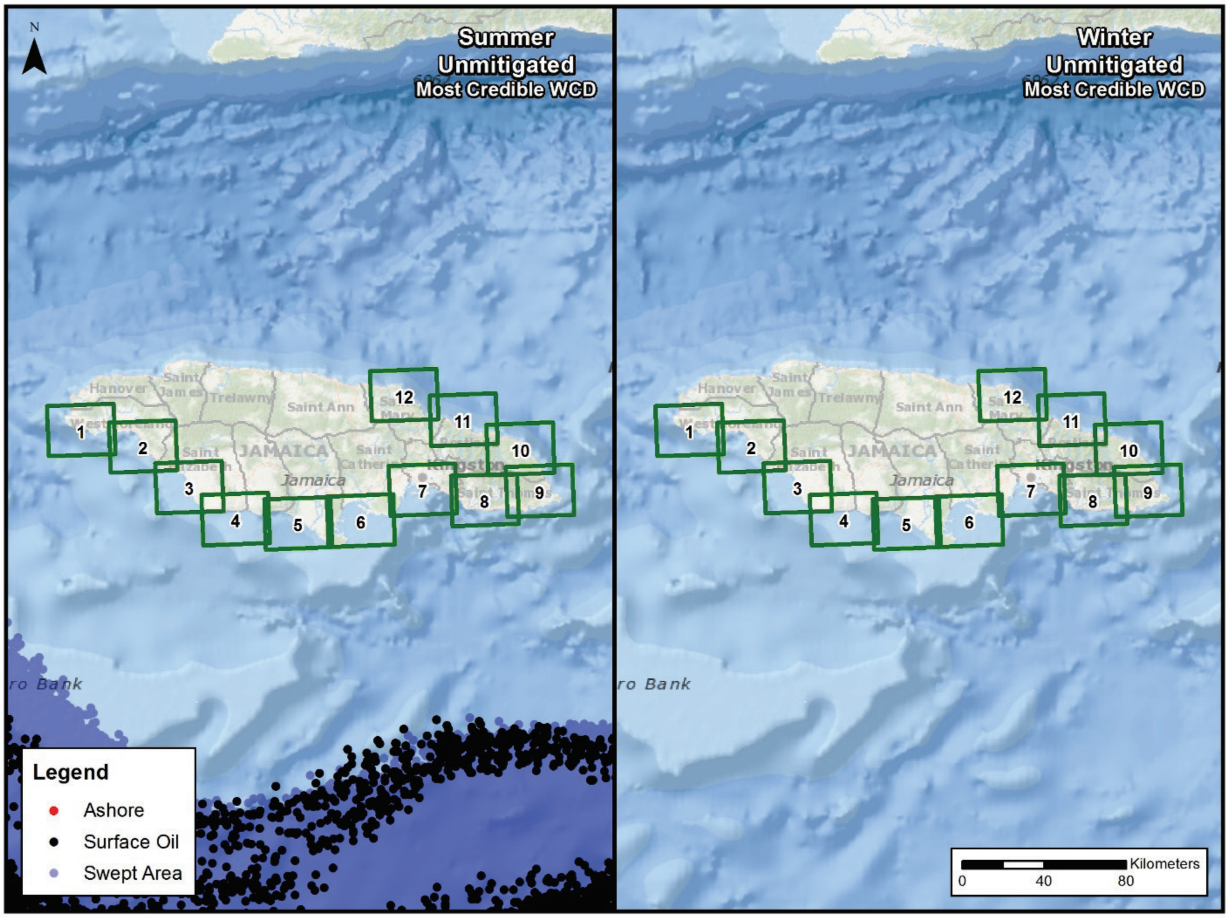


Figure 9.1-31a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Jamaica

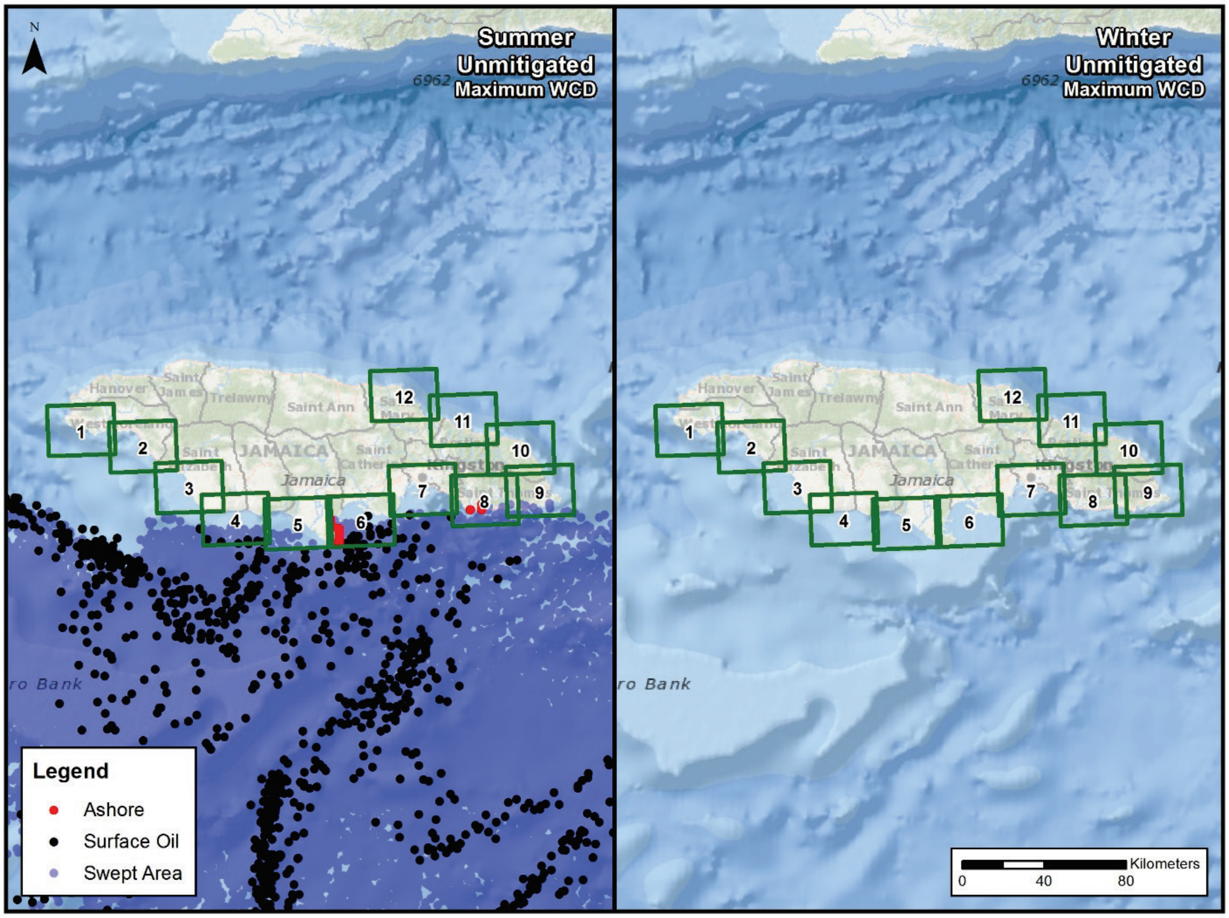


Figure 9.1-31b: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Jamaica

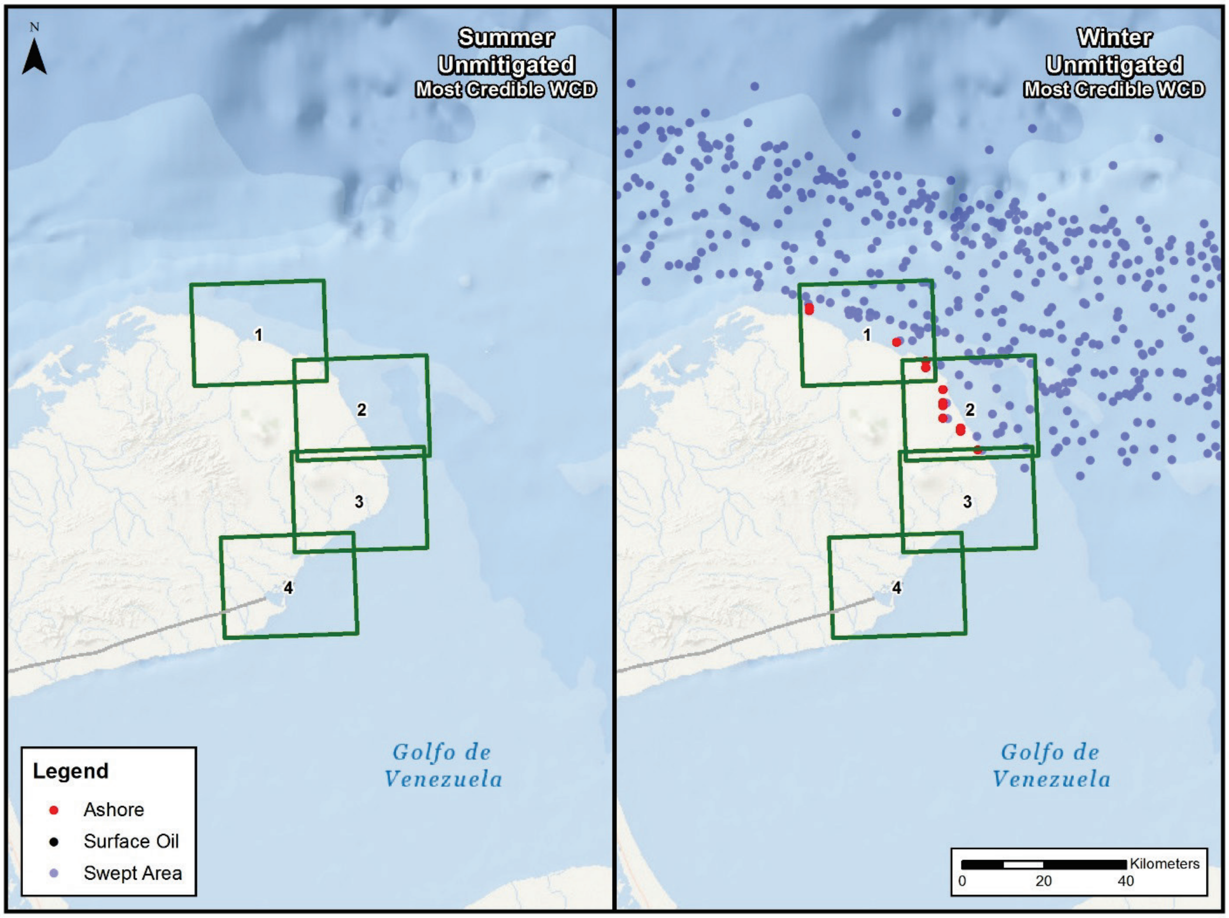


Figure 9.1-32a: Deterministic Map for Scenario 13—Predicted Transport after 45 Days from an Unmitigated 20,000-BPD Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Colombia

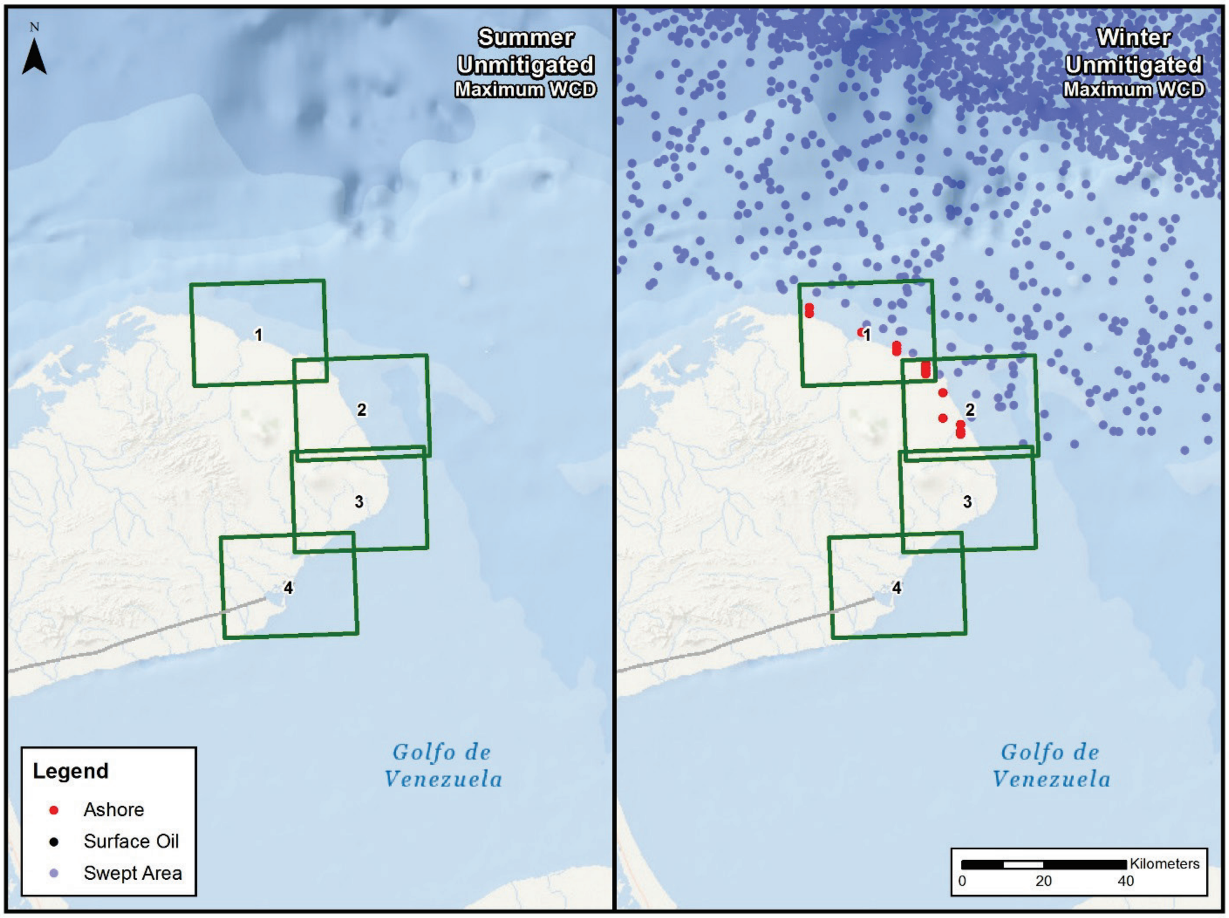


Figure 9.1-32b: Deterministic Map for Scenario 14—Predicted Transport after 54 Days from an Unmitigated 202,192-BPD Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Colombia

9.1.7. Oil Spill Prevention, Control, and Emergency Response Measures

Regarding spill prevention controls associated with Scenarios 13 to 15 (loss-of-well-control release), EEPGL's well-control philosophy is focused on spill prevention using safety and risk management systems, management of change procedures, global standards, and trained, experienced personnel. EEPGL has a robust management system (Operations Integrity Management System [OIMS]; see Chapter 2, Description of the Project) that emphasizes attention to safety, well control, and environmental protection. Measures to avoid a loss of well control include:

- Proper preparation for wells (well design, well control equipment inspection and testing);
- Automatic detecting of any excess pressure entering the well during drilling;
- Use of physical barriers including automatic BOPs;
- Personnel training and proficiency drills for well control; and
- Use of drilling fluids to control pressures within the well.

Chapter 2 provides additional information related to well control measures.

Regarding spill prevention controls associated with Scenario 12 (FPSO offloading spill), the measures to avoid a spill associated with FPSO offloading include:

- FPSO and tanker collision avoidance controls (as described in Section 9.1.1.3, Offshore Collision between FPSO and Offloading Tanker);
- Use of a certified engineered floating hose system;
- Floating hose damage protection controls;
- Use of emergency disconnect controls on the floating hose system;
- Use of load monitoring systems in the FPSO control room;
- Use of leak detection controls including infrared leak detection;
- Flood lighting for night operations; and
- Volumetric checks during offloading.

Section 2.13, Embedded Controls, provides additional information on spill prevention measures.

A representative list of spill prevention and mitigation measures and associated embedded controls for a typical FPSO development project (based on the Liza Phase 1 Development Project) can also be found in the OSRP.

In addition to the established spill prevention controls, EEPGL also has developed a detailed OSRP, which is included as part of the Project's ESMP, to ensure an effective response to an oil spill, if one were to occur. The OSRP builds on the coastal sensitivity mapping and oil spill modeling described herein and describes the response measures appropriate to the magnitude and complexity of a spill incident. The OSRP clearly delineates the responsibilities of each entity that would take part in a response and describes how EEPGL and its contractors would mobilize local oil spill response resources, which would be complemented by the regional and international resources provided by its oil spill response contractors. The OSRP describes the EEPGL process for notifying the Government of Guyana with respect to mobilizing its resources. The lead agency for oil spill response in Guyana is the Civil Defense Commission and the drat National Oil Spill Contingency Plan outlines how the Civil Defense Commission will coordinate the responses of other agencies, including MARAD.

Due to the precautionary measures used by EEPGL to prevent and control an oil spill, as described above and in Chapter 2, the likelihood of a Tier II or III oil spill occurring is considered to be **Unlikely**.

9.1.8. Potential Effects on Wildlife and Pros and Cons of Dispersant Use

The decision regarding whether to use chemical dispersants for spill response is based on the characteristics of the spill, the biological and socioeconomic resources that are at risk from exposure to the oil, and the expected net impact of available response options. Protection of different resources is prioritized and the risk to each is established through a process of NEBA, also known as Spill Impact Mitigation Assessment, which considers the relative impacts and performance of different response options.

Modern Type 3 dispersants that would be used in the unlikely event of a spill during the Project consist of a mixture of surfactants (such as those used in detergent products) and solvent. The formulation of dispersant types varies somewhat in order to target specific oil types, water salinities, and temperatures, but the mechanism by which the dispersants work is the same. Dispersants are not typically combined prior to application and the nature of dispersant use is such that in the event that more than one dispersant product is being used during a response, there will be some distance between the sites in most cases. For example, it is possible that two different products could be used for subsea dispersion and surface dispersion; however, the water depths in the PDA mean that these products are unlikely to mix. It is not considered feasible that synergistic toxicity would occur between different types of dispersants if they inadvertently came into contact with each other after application, as the mechanism of action and products are so similar for different Type 3 dispersants and the concentrations involved are very low.

While the dispersant products do have some inherent toxicity, a wide range of scientific ecotoxicity studies, discussed below in more detail, have concluded that dispersed oil toxicity is not driven by dispersant, but rather by the effect of the increased hydrocarbons in the water column and differences in the composition of different hydrocarbon fractions (as discussed in Alexander et al. 2017), and not due to the dispersant product itself. Additionally, it would be in only rare events (e.g., overspray) that exposure to dispersants alone would be expected to occur, as dispersant application is targeted to the oil surface rather than the water surface. In these events, the volume of dispersant will be very small. It is common for dispersants to be sprayed at a rate of approximately 50 liters per hectare (taking account of a typical oil slick thickness of 0.1 millimeter), providing a dispersant thickness of 0.005 millimeter that will immediately begin to rapidly dilute into the water column. Not accounting for horizontal dilution, this results in an initial dispersant concentration of 5 parts per million (ppm) when mixed into the top 1 meter (3.3 feet) and 0.5 ppm when mixed into the top 10 meters of the water column. The remainder of this discussion therefore focuses on the combination of dispersant and oil as this is the form in which it would be present in the environment.

The reported toxicity of a range of dispersant products indicates that these products mostly fall into the International Maritime Organization (IMO) GESAMP (1996) rank of *slightly toxic* (>10 ppm) or *practically non-toxic* (100 to 1,000 ppm).

The key purposes of surface or subsea dispersant application are to reduce the area of surface oil slicks and to enhance natural biodegradation so that both surface and entrained hydrocarbon concentrations are more rapidly depleted. In marine oil spills in open water, the main concern is generally acute toxicity resulting from a pulsed exposure to the surface slick, or elevated hydrocarbons immediately under the slick, as well as physical oiling of wildlife. Rapid 3-dimensional dilution of the spill in open ocean conditions will generally reduce concentrations of hydrocarbons in the water column to below acute toxicity thresholds such that toxic effects are unlikely (Lee et al. 2011). Furthermore, removing oil slicks from the water surface reduces risks to seabirds, marine mammals, and marine reptiles, which are most at risk from direct contact with surface slicks. Marine mammals and reptiles are also vulnerable to direct exposure to slicks as they surface to breathe, and they may also inhale high concentrations of hydrocarbon vapors from the air directly above a slick. It is generally accepted that the effective use of dispersants will significantly reduce the risk to birds, marine mammals, and marine reptiles.

Reducing the volume of surface oil also typically reduces the volume that strands on shorelines, where shorebirds, nesting turtles, or invertebrate species are vulnerable to direct contact or high concentrations of hydrocarbons. Oil on shorelines is also prone to much lower biodegradation rates and does not have the same potential for rapid toxicity reduction that can occur with open ocean dispersion.

The trade-off of dispersant use is that in-water hydrocarbon concentrations are initially elevated as more of the oil is moved into the water column. As a result, species in the water column, including plankton and fish, are temporarily exposed to higher concentrations of hydrocarbons than would be present at depth under a floating slick. The in-water concentrations then reduce quickly over time and distance from the treatment site as a result of 3-dimensional dilution and biological breakdown of the hydrocarbons. Rapid 3-dimensional dilution of the spill in open ocean conditions will generally reduce concentrations of hydrocarbons in the water column to levels where toxicity is unlikely (Lee et al. 2011).

Table 9.1-5 provides a summary of the potential benefits and risks associated with dispersant use on different environmental receptors. Further discussion on key receptors and effects is provided in the following sections. The assessment of impact severity in Table 9.1-5 considers the likelihood of injury to individual organisms, but also the extent to which populations are able to recover from impact (e.g., planktonic communities have rapid regeneration times, whereas mortality on species such as whales, marine turtles, and mangroves may result in longer-term population effects).

Table 9.1-5: Potential Severity and Mechanism of Impacts for Undispersed versus Dispersed Oil

Receptor	**Potential Impact Severity and Key Mechanisms**			
	Undispersed Oil		**Dispersed Oil [a]**	
Pelagic (Open Water)				
Marine Mammals	Medium/High	• Skin and eye irritation • Inhalation of hydrocarbons above slicks • Toxicity if bulk oil ingested	Low/Medium	• Some toxicity if oil ingested
Marine Reptiles	Medium/High	• Skin and eye irritation • Inhalation of hydrocarbons above slicks • Toxicity if bulk oil ingested	Low/Medium	• Some toxicity if oil ingested
Seabirds	High	• Fouling of feathers (hypothermia/drowning) • Skin and eye irritation • Toxicity if bulk oil ingested • Feeding interrupted by lack of visibility	Low	• Prey likely to avoid high concentrations of dispersed oil
Fish	Low	• Limited toxicity if fish are present near to surface where hydrocarbons are elevated beneath the slick • Fouling of gills if exposed to large oil droplets	Low/Medium	• Probable avoidance of high concentrations of dispersed oil • Depuration occurs in months
Plankton (including larval fish and invertebrate species)	Low	• Only impacted if present in surface waters	Medium	• Some toxicity if exposed to dispersed oil in water column
Commercial Fisheries	Medium	• Fouling of equipment and boats • Reduced value or stock or market restrictions due to fisheries closure or concerns of potential contamination	Medium	• Real or perceived contamination of fish results in reduced value or market restrictions due to fisheries closure
Benthic (Offshore)				
Invertebrates	Negligible	• Unlikely to be exposed	Low	• Dispersed oil in deep waters during subsea application
Benthic Fish	Negligible	• Unlikely to be exposed	Low	• Dispersed oil in deep waters during subsea application. Active avoidance of high concentrations of dispersed oil

Receptor	Potential Impact Severity and Key Mechanisms			
	Undispersed Oil		Dispersed Oil [a]	
Shoreline/Intertidal				
Shorebirds	High	• Fouling of feathers (hypothermia/drowning) • Skin and eye irritation • Toxicity if bulk oil ingested • Feeding interrupted by lack of visibility	Low	• Some toxicity if oil ingested
Invertebrates	Medium	• Smothering of animals or habitat • Toxicity from external contact or ingestion of oil	Low	• Toxicity from dispersed oil ingestion
Marine Algae	Low/Medium	• Mortality • Temporary reduction in photosynthesis and growth	Low	• Temporary reduction in photosynthesis and growth
Intertidal Plants	Medium/High	• Temporary reduction in photosynthesis and growth • Mortality where heavy smothering	Low	• Some mortality • Temporary reduction in photosynthesis and growth

[a] Assumes dispersion has been effective and no surface slicks remain. Assumes that dispersant is not applied in water less than 10-meter (33-foot) depth or closer than 5 kilometers (3 miles) from shore (i.e., high levels of 3-dimensional dilution will occur before dispersed oil reaches shallow water areas).

9.1.8.1. Marine Mammals and Marine Reptiles

Any animal that is directly contacted by hydrocarbons will be vulnerable to irritation of the external tissues, including skin and eyes, nasal, and other body cavities (AMSA 2013). This type of impact is relevant to marine mammals and marine turtles that may swim through the slick (Fingas 2011; St. Aubin and Lounsbury 1990).

Hydrocarbons may be ingested coincidentally with food, or may be inhaled from the air directly above a slick by animals such as marine turtles and marine mammals (Rainer Engelhardt 1983; Fingas 2011; St. Aubin and Lounsbury 1990).

Where shoreline oiling occurs, marine turtles and their hatchlings are vulnerable to direct exposure, leading to potential smothering and possible toxic effects.

There are no reports in the literature of experimental exposure of marine mammals or reptiles to chemically dispersed hydrocarbons, likely due to a combination of the practical and ethical challenges associated with subjecting captive marine mammals to potentially harmful biological testing. Dead dolphins and marine turtles were found during the Macondo spill, in which large amounts of dispersant was applied to the spill. It therefore cannot be discounted that impacts on these animals were related to their exposure to chemically dispersed oil, although there were also extensive surface slicks to which animals were likely exposed and which could be responsible for the observed impacts. However, dispersion of oil will generally reduce risk to marine mammals and marine reptiles by preventing their direct contact with untreated oil or inhalation of high concentrations of hydrocarbon vapors. Both groups have the capacity to process toxins internally and depurate harmful chemicals. The rapid dilution of dispersed oil means that typically only low levels of exposure to toxic compounds would occur.

While there are few reported cases of mortality of marine mammals or reptiles during any documented oil spills, it is generally accepted that effective dispersion will reduce the risk of injury to these species, particularly where dispersion reduces exposure of wildlife to surface slicks and stranded oil.

9.1.8.2. Birds

Direct contact with undispersed oil may cause irritation of sensitive tissues, such as eyes, skin, and internal cavities (Fingas 2011; St. Aubin and Lounsbury 1990; AMSA 2013).

Hydrocarbons may be ingested coincidentally with food or during preening (Rainer Engelhardt 1983; Fingas 2011; St. Aubin and Lounsbury 1990).

Eggshells are known to be permeable to hydrocarbons that may be transferred from parents or through direct contact such as when an oiled bird returns to the nest from feeding (Finch et al. 2012; Peakall et al. 1987).

The greatest risk to birds from an oil spill is reported to be where their feathers become fouled by oil, subsequently damaging the feather structure, interfering with or inhibiting flying and waterproofing, and rendering the birds vulnerable to hypothermia and drowning. If present in the area, large numbers of seabirds may be impacted or killed where there is heavy surface oiling. They may also avoid or limit hunting in areas where surface slicks limit the visibility of prey; however, such avoidance may reduce more serious harm than if the bird was to dive through the surface slick.

Effective dispersion of oil will reduce the area of surface slicks and shoreline oiling, avoiding the most significant impacts on birds that result from direct contact with the oil. There is also evidence that dispersed oil is less toxic to developing embryos (where oil is transferred from the parent bird to an egg) than undispersed oil (Albers 1979, cited in Eastin and Rattner 1982).

The use of dispersant will reduce the potential impacts on seabirds and shorebirds relative to potential impacts from an untreated oil spill.

9.1.8.3. Fish and Commercial Fisheries

Toxicity in adult fish has been reported in response to crude oils, heavy fuel oil, and diesel (Holdway 2002; Shigenaka 2011). Fish will generally only be exposed to harmful concentrations of oil from an undispersed slick where they are present in shallow waters beneath a slick or in a location of high concentrations of entrained oil from a subsurface release.

While fish are known to take up hydrocarbons in their tissues, the majority of studies, either from laboratory trials or of fish collected after spill events (including the Hebei Spirit, Macondo, and Sea Empress spills) exhibit evidence of fish tissues returning to normal levels within 2 months of exposure (Challenger and Mauseth 2011; Davis et al. 2002; Gagnon and Rawson 2011; Gohlke et al. 2011; Jung et al. 2011; Law et al. 1997; Rawson et al. 2011).

The use of dispersant will result in a higher concentration of hydrocarbons in the water column, where fish species may be exposed. The degree of exposure will depend on the water depth and the proximity of the animals to the dispersant application and length of time they remain in the area of the spill. Studies comparing chemically dispersed hydrocarbon mixtures, including crude oil and Corexit 9500, to mechanically dispersed oil on fish species have found similar results (Hemmer et al. 2011; Wetzel and Van Fleet 2001). The National Academy of Sciences published a workshop consensus describing exposure concentration thresholds of concern (toxicological-relevant concentrations) for dispersed oil on adult fish of 0.5 ppm for a 96 hour exposure, increasing to 100 ppm over 0 to 3 hours (high concern) and 10 ppm over 0 to 3 hours (low concern) (NRC 2005). Rapid dilution of dispersed oil at sea is expected to reduce water column exposure below these thresholds within minutes to hours.

Predatory fish may be exposed to, and accumulate, hydrocarbons from prey species. However, the concentrations of hydrocarbon to which they would be exposed through this route would be small unless very large amounts of contaminated prey were consumed, although short-term elevated hydrocarbons or biomarkers of contamination may be present in the tissues of predatory species exposed in this way.

Fish are at greater risk from dispersed oil than undispersed surface slicks; however, effects from dispersed oil will be limited in area due to high rates of dilution that would rapidly reduce concentrations below harmful levels.

A marine oil spill will typically result in concern regarding contamination of fish stocks. This can result in fisheries closures while fish are assessed for safety, and can affect market value of fish. Additionally, surface oil slicks can foul fishing vessels and equipment. As noted above, there is a slightly higher potential for fish exposure to hydrocarbons in the water column where dispersants are used, but overall impacts on a fishery are not likely to be greater or of longer duration as a result of dispersant use.

9.1.8.4. Benthic Species

Except in shallow waters and intertidal areas where significant hydrocarbon concentrations may occur, surface slicks pose very limited risks to benthic species. Dispersants may somewhat facilitate the likelihood of contamination of sediments by increasing the concentration of hydrocarbons deeper in the water column, although dispersants do not cause oil to sink. However, in deep water, the concentrations that would become entrained in sediments are likely to be very low. Conversely, the reduced viscosity of the hydrocarbon as a result of chemical dispersion may also reduce the subsequent tendency for the product to persist in sediments.

The majority of benthic invertebrates reproduce rapidly and many have broadcast spawning modes of reproduction. As a consequence, localized impacts are unlikely to result in significant population level impacts. The potential risks to benthic species are generally cited as the basis for avoiding dispersant application in shallow or confined waters; however, dispersant use in deep waters with good mixing is considered unlikely to result in additional harm to benthic species relative to undispersed oil.

9.1.8.5. Plankton

Like fish, the exposure of planktonic species (including phytoplankton, zooplankton, and larval invertebrates and fish) to undispersed oil will be determined by their proximity to the water surface. Where plankton exhibiting diurnal cycles rise to the surface, they are vulnerable to becoming entrained in surface oil and mortality would inevitably result.

Where oil has been dispersed, elevated concentrations of entrained and dissolved hydrocarbons in the water column have the potential to result in smothering or toxic effect to planktonic species, which are considered to be highly sensitive to contamination. However, impacts are expected to be localized based on dilution of the dispersed oil, and plankton are abundant and typically have rapid reproductive times.

Dispersed oil is expected to pose a greater threat to planktonic species than undispersed oil; however, other than where protection of large numbers of fish or invertebrate larvae is a priority, impacts on plankton alone would generally not be considered a barrier to dispersant use, particularly if use reduces impacts on more vulnerable environmental or socioeconomic resources.

9.1.8.6. Marine Algae and Marine Plants

Marine algae and marine plants are considered to not be particularly susceptible to impacts from untreated hydrocarbons. Studies of actual spills found no significant differences between oiled and unoiled seagrass meadows following large spills of crude oil (Kenworthy et al. 1993), or of heavy fuel oil contaminated by lighter fuel products (Taylor and Rasheed 2011). Short-term laboratory exposure (up to 10 hours) of seagrasses to various oils likewise did not have a significant impact, although longer exposures did result in reduced growth rates and or photosynthetic activity for some species (Thorhaug and Marcus 1987; Wilson and Ralph 2012). Mortality of intertidal seagrasses have occurred at a site heavily oiled with medium weight crude in Galeta, in which oil became trapped in mangroves and sediments and continued releases occurred over an extended period of many years (Burns et al. 1994).

Smothering of macroalgae may occur if it is exposed on the falling tide; however, the slick would generally be lifted off by the returning tide, particularly in the case of light oils, reducing the period of exposure. Studies identified no significant impacts on algal communities following the *Hebei Spirit* spill of heavy fuel oil (Edgar and Barrett 2000), the *Prestige* crude oil spill (Lobón et al. 2008), or the *World Prodigy* spill of marine diesel (Peckol et al. 1990).

Dispersed oils have been shown to impact growth rates of seagrasses and have increased toxicity to algae compared to those where untreated surface slicks were floating above the plants (Thorhaug and Marcus 1987; Wilson and Ralph 2012). Concentrations in these experiments were typically very high, representative of dispersant application to an oil slick in shallow water.

Except in shallow, confined waters, there is not expected to be any significant benefit to marine algae or plants from either leaving a slick undispersed or dispersing the slick.

9.1.8.7. Intertidal Plants

Hydrocarbons can impact terrestrial plants as a result of smothering of parts of the plant (e.g., mangroves) used for gas exchange or by the loss of leaves due to chemical burning in the less likely event of direct contact of the leaves with the slick (Duke et al. 1999). It is also known that mangroves take up hydrocarbons from contact with leaves, roots, or sediments, and it is suspected that this uptake has the potential to cause defoliation through leaf damage and tree death (Wardrop 1987).

Intertidal sediments can retain hydrocarbons and act as long term reservoirs, where continued releases and fresh slicks can occur for up to 5 years after the initial spill. These sediments can still contain elevated levels of hydrocarbons up to 20 years after a crude oil or diesel spill (Corredor et al. 1990; Teal et al. 1992). This can result in long-term impacts on vegetation, including mangroves and saltmarsh species (Getter et al. 1985; Ward et al. 2003; Sadaba and Barnuevo 2011; DeMicco et al. 2011).

Results from a 25-year study examining the effects of dispersed crude oil versus non-dispersed crude oil on tropical marine ecosystems in Panama indicate that dispersants prevent long-term contamination to mangrove forests and provided the conditions for ecosystem and habitat recovery, as opposed to the site where untreated oil led to chronic exposure to aromatic hydrocarbons and continued to inhibit recovery and repopulation (DeMicco et al. 2011). Experimental field exposures also found that fresh, dispersed crude had significantly less impact on mangroves than untreated oil (Ballou et al. 1989).

Effective dispersion of heavy oil prior to it reaching intertidal areas is also likely to reduce impacts related to smothering of vegetation.

9.1.9. Claims and Livelihood Remediation Processes

In the unlikely event of an oil spill causing losses to stakeholders, EEPGL would establish a claims process and, depending on the magnitude of the oil spill, a livelihood remediation program. The purpose of the claims process would be to provide compensation for asset losses and the purpose of a livelihood remediation program would be to restore the welfare and livelihoods of affected persons to conditions no less than pre-impact conditions. Both processes would be transparent, fair, and conducted in a timely manner. EEPGL, in consultation with the Government of Guyana and other jurisdictions (as required), would establish the designated geographic zones associated with the claims and, as applicable, livelihood remediation processes; these would be commensurate with the magnitude of the impacts of the spill. Eligible persons would be compensated based on the magnitude of Project-related impacts they individually experienced, either in regard to human health or as a result of economic loss.

It is anticipated that EEPGL would establish steering committees, working groups, and stakeholder engagement-specific entities to determine eligible stakeholders, standard entitlements, and eligibility criteria for further livelihood compensation and assistance. EEPGL would consider establishing an independent implementation entity as soon as reasonably practicable after the spill, to assist in the process of livelihood remediation planning while the initial compensation efforts are ongoing. Depending on the extent of losses, livelihood remediation efforts may potentially range from early support initiatives (within the first year), to transition support (typically from 1 to 2 years after impact), to longer-term support.

9.1.10. Vessel Collision with a Third-Party Vessel, Structure, or Animal (Non-Spill Related Impacts)

9.1.10.1. Vessel Collision with a Third-Party Vessel or Structure

Section 9.1.1.4, Nearshore Collision between a Project Supply Vessel and another (Third-Party) Vessel or Structure, or Grounding, and Section 9.1.1.6, Offshore Collision between Project Vessels or between a Project Vessel and another (Third-Party Vessel), describe potential scenarios in which a Project vessel collision could occur with a third-party vessel or structure, resulting in a spill of hydrocarbons. This section addresses the potential for such a collision, but focuses on the potential non-spill related aspects. This section also addresses the potential for a Project vessel to collide with a marine animal, specifically focusing on marine mammals, marine turtles, and riverine mammals.

As discussed in Section 9.1.1.4, a variety of Project vessels will supply and support drilling, installation, production operations, and decommissioning activities, and these vessels will transit between the Guyana shorebases and the PDA. There is a potential for collisions between these vessels and other third-party vessels/structures in the Georgetown Harbour/Demerara River area or for the nearshore grounding of a vessel. Such an incident may result from navigation error or a temporary loss of power that affects the ability of a vessel to steer. Damage to an impacted structure may require repairs, and in extreme cases, temporary closure of the structure; this has occurred before in Guyana (e.g., damage to and temporary closure of the Demerara Harbour Bridge). In the case of the Project, however, the Georgetown shorebases are downstream of the Demerara Harbour Bridge, which reduces the probability of a Project-related vessel colliding with this structure.

Section 9.1.1.4 includes a summary of the embedded controls that will be in place to reduce the potential for a nearshore collision to occur. Based on consideration of these controls, the likelihood of Project vessel accidents causing any significant damage to third party vessels or structures, or causing significant injury, is considered **Unlikely**.

Section 9.1.1.6 includes a summary of the embedded controls that will be in place and the additional mitigation measures that will be employed to reduce the potential for an offshore collision to occur. Based on these controls and measures, the potential for an offshore collision between a Project vessel and another third party vessel is also considered **Unlikely**.

9.1.10.2. Vessel Collision with a Marine Mammal

Collisions with vessels can injure or kill marine mammals. Marine mammals possess acute senses of hearing that they can use to detect approaching vessels, and they have the necessary swimming speed capability to avoid collisions. Nevertheless, marine mammals are inherently vulnerable to ship strikes when they surface to breathe or to feed. This vulnerability increases in shallow, nearshore areas, where opportunities to maneuver are reduced. Most Project activities will take place in deep ocean waters, and vessel speeds within the PDA will be low, reducing the potential for collisions. The only planned nearshore activities will be supply vessels entering/ exiting shorebases, but even at the peak of drilling and installation, the incremental increase in traffic near shorebases will represent a small increase in overall risk to marine mammals. There is very little potential for collisions to occur within the PDA, but the potential remains for individual dolphins or whales to collide with vessels transiting between the PDA and shorebases. The greatest potential for collisions to occur will be during drilling and installation, when vessel traffic is at its peak; accordingly, the risk of injury or mortality from vessel collisions will be higher during drilling and installation than during other stages of the Project.

With respect to the potential for injury and mortality from vessels strikes, EEPGL will use the following embedded controls for the Project (see Section 2.13, Embedded Controls):

- Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals at the sea surface.
- Provide standing instruction to Project-dedicated vessel masters to avoid marine turtles while underway, to reduce their speed within 300 meters (984 feet) of observed marine mammals, and to not approach the animals closer than 100 meters (328 feet), when possible, to reduce probability of collisions.

Although the embedded controls noted above are expected to greatly reduce the possibility of a Project vessel striking a marine mammal, it is conservatively assumed that over the duration of the Project life cycle (at least 20 years), such an event is **Possible**.

9.1.10.3. Vessel Collision with a Marine Turtle

Collisions with vessels can also injure or kill marine turtles. Marine turtles tend to spend most of their time at sea at or near the sea surface as verified by the dive profile data described in Section 7.7.2, Existing Conditions—Marine Turtles, and do not possess the acute sense of hearing or the swimming speed that cetaceans use to avoid collisions. Marine turtles are inherently more vulnerable to ship strikes in the shallow nearshore areas, where they congregate prior to coming ashore to nest, than they are in the open ocean. This increased vulnerability is caused by the higher concentrations of turtles in the shallow nearshore areas. Most Project activities will take place in deep ocean waters, and vessel speeds within the PDA will be low, further reducing the potential for collisions. The only planned nearshore activities will be supply vessels entering/exiting shorebases; the anticipated options for shorebases are all located more than 100 kilometers (62 miles) away from the nearest portion of the Shell Beach Protected Area (SBPA), where most marine-turtle nesting in Guyana occurs (and where turtles may aggregate pre- and post-nesting as suggested by tagging data).

There is very little potential for collisions to occur within the PDA, but the potential remains for individual turtles to collide with vessels transiting between the PDA and shorebases. The potential for the greatest number of collisions to occur will be during drilling and installation, when vessel traffic is at its peak, so the risk of injury or mortality from vessel collisions will be slightly higher during drilling and installation than during other stages of the Project.

With respect to the potential for injury or mortality from vessels strikes, EEPGL will use the following embedded control for the Project (see Section 2.13, Embedded Controls):

- Provide standing instruction to Project-dedicated vessel masters to avoid marine turtles while underway, to reduce their speed within 300 meters (984 feet) of observed marine turtles, and to not approach the animals closer than 100 meters (328 feet), when possible, to reduce probability of collisions.

The embedded control noted above is expected to greatly reduce the possibility of a Project vessel striking a marine turtle; accordingly, it is considered that such an event is **Unlikely**.

9.1.10.4. Vessel Collision with a Riverine Mammal

Collisions with vessels can injure or kill riverine mammals. As described in Section 7.6.3, Impact Assessment—Riverine Mammals, the West Indian manatee (*Trichechus manatus*) and the neotropical otter (*Lontra longicaudis*) are the most likely riverine mammals to occur within areas affected by planned Project activities, and these species do not possess the acute sense of hearing or the swimming speed and agility that marine mammals rely on to avoid collisions. Like marine turtles, these species tend to spend most of their time near the water's surface.

Most Project activities will take place in deep ocean waters, and the only portion of the Direct AOI where riverine mammals are likely to occur is the Demerara River. The only planned Project activities in the Demerara River will be supply vessels entering/exiting shorebases. Vessel speeds within the river will be low, reducing the potential for collisions. The likelihood of a collision is low due to these factors, but these factors notwithstanding, the potential remains for individual riverine mammals to collide with vessels transiting Georgetown Harbour and the Demerara River. The potential for the greatest number of collisions to occur will be during drilling and installation, when vessel traffic is at its peak, so the risk of injury or mortality from vessel collisions will be slightly higher during drilling and installation than during other stages of the Project.

With respect to the potential for injury or mortality from vessels strikes, EEPGL will use the following embedded controls for the Project (see Section 2.13, Embedded Controls):

- Provide awareness training to Project-dedicated marine personnel to recognize signs of riverine mammals at the sea surface.
- Provide standing instruction to Project-dedicated vessel masters to avoid riverine mammals, while underway and reduce speed or deviate from course, when possible, to reduce probability of collisions.

The embedded control noted above is expected to greatly reduce the possibility of a Project vessel striking a riverine mammal; accordingly, it is considered that such an event is **Unlikely**.

9.1.11. Untreated FPSO Wastewater Discharge

The FPSO will be equipped with onboard water treating systems, one of which will treat black water (waste from toilets or urinals) prior to discharge overboard. The FPSO also has a large storage tank with capacity to store up to 7 days of sewage in the event there is an upset to the treatment system. There are also multiple closed valves to prevent accidental release of black water to the ocean. In the unlikely event an upset to this treatment system lasts more than 7 days, this could result in untreated black water being discharged overboard for a short period of time. In summary, the potential for a discharge of untreated black water to occur is considered **Unlikely** for the following reasons:

- The black water treatment system will be subjected to routine inspection and maintenance, providing the opportunity to identify and correct issues requiring attention prior to an upset scenario occurring.
- The black water treatment system will be designed to include capacity for storage of 7 days of untreated wastewater generated on the FPSO in the event there is an upset to the treatment system. This affords time to avoid overboard discharge for a period of time while corrective actions on the treatment system can be implemented, without impacting the ability of the FPSO to continue operating.
- There are multiple closed valves to prevent accidental release of black water to the ocean.

Although such a release is **Unlikely**, computational modeling was conducted for an equipment failure scenario where there is an upset in the black water treatment system. Under this equipment failure scenario, it was assumed that untreated black water from accommodations and the clinic would bypass the macerator and the sewage-holding tank and be discharged directly overboard through an emergency outfall. Modeling was performed to assess the plume that would result from this scenario. Based on an average sewage generation rate per person and a capacity of 160 persons on board for the FPSO, incorporating a 10 percent contingency factor on the design discharge rate of 70 BPD, and using conservative estimates of wastewater characteristics (coliform: 10,000,000 colony forming units per 100 milliliters; 5-day Biochemical Oxygen Demand [BOD_5]: 350 milligrams per liter [mg/L]; and total suspended solids [TSS]: 650 mg/L), the modeling results show that the temporary release of untreated wastewater will result in a plume of limited extent. The maximum predicted BOD_5, TSS, and coliform concentrations never exceed the end-of-pipe levels recommended by the IMO's 2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants (IMO 2012). Additional detail regarding the modeling of this scenario is provided in Appendix J, Water Quality Modeling Report.

9.1.12. Onshore Vehicular Accident

Based on a traffic study conducted in 2018, the results of which are presented as an appendix to the Liza Phase 2 EIA, the Project will result in a minimal increase in onshore vehicular traffic around the existing shorebases that will be used by the Project. The Georgetown shorebases operations have been designed to minimize road movement of freight. An additional traffic study was conducted in 2019 for key intersections in the greater Georgetown area, and this study also indicated the Project will result in minimal impact on vehicular traffic at these intersections (see Appendix U, Traffic Impact Assessment).

Although the addition of Project-related traffic is expected to be incrementally insignificant with respect to existing traffic conditions in the vicinity of the shorebases and at the other key Georgetown area intersections evaluated, the potential for a vehicular accident involving a Project-related vehicle is considered **Possible**.

9.1.13. Collisions between Project Vessels/Helicopters and Seabirds

While individual seabirds could be significantly impacted through contact with the FPSO flare structure, its flame, or its radiant heat plume, the likelihood of a seabird being present in the heat zone when temporary, non-routine flaring is occurring is extremely low. Accordingly, this unplanned event is focused on direct mortality and injury related to vessel or helicopter strikes.

Rafting seabirds may suffer injury or mortality from collision with vessels transiting to and from the FPSO. However, rafters are not likely to be present in large aggregations in the PDA because of the metocean conditions offshore Guyana—namely a strong surface current, which is likely to make the surface waters unsuitable for the large aggregations of species that favor more calm and sheltered conditions. The EEPGL seismic surveys conducted in the Stabroek Block in 2015 and 2016 did not document any concentrations of rafting seabirds in the area during their survey period (RPS 2016). On the rare occasions that suitable conditions for rafting occur in the PDA and seabirds are present in high enough concentrations to form rafts, individual seabirds could be susceptible to vessel strike and related injury or mortality. However, large seabird rafts are easily detectible by oncoming vessels, and these vessels could maneuver to avoid them if the birds do not move out of the vessels' path.

Helicopters will be used as a form of transit to/from the Guyana shorebases and offshore vessels, and could adversely impact seabirds through helicopter strike of individuals flying near helicopters transiting around or in route to/from the drill ships, FPSO, and installation vessels. Helicopter trips to and from the PDA are not expected to exceed more than a few each day, so the potential for helicopter-bird interactions is expected to be low.

With respect to the potential for marine vessels colliding with rafting seabirds, EEPGL will use the following embedded control for the Project (see Section 2.13, Embedded Controls):

- Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from PDA.

The embedded control noted above is expected to greatly reduce the possibility of a Project vessel striking rafting seabirds (that do not move out of the vessel's path on their own).

Given the low likelihood of vessels encountering rafting seabirds and the above embedded control, as well as the limited number of helicopter flights per day between the PDA and shore, the likelihood of a vessel or helicopter interaction with a seabird is considered **Unlikely**.

9.1.14. Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume

The FPSO will have a flare system for the collection and safe disposition of produced hydrocarbon gases resulting from unplanned, non-routine maintenance or repairs, or emergency shutdown events. Should flaring occur, the flame and radiant heat plume will emanate from a flare tower located on top of the FPSO. While individual seabirds could be significantly impacted through contact with the FPSO flare tower, its flame, or its radiant heat plume, the likelihood of a seabird colliding with the tower or being present in the heat zone when temporary, non-routine flaring is occurring is extremely low. To date, marine bird surveys conducted on behalf of EEPGL since 2017 have not documented flocking birds in the Stabroek Block. While this does not preclude the possibility of a flock to occur, it is considered relatively rare and any such flocks would likely be small. Even during migration, most individuals are solitary or flying in loose groups (spread out spatially). Accordingly, in the circumstance that such an event occurred, it would likely only impact a single individual. However, it is conservatively assumed that over the duration of the Project life cycle (at least 20 years) such an event is **Possible**.

9.1.15. Summary of Unplanned Events Interactions with Resources/Receptors

Table 9.1-6 indicates which resources/receptors would potentially be impacted by a NADF release (Scenario 15), coastal oil spill (represented by Scenario 3), and marine oil spill (represented by Scenarios 12 through 14), vessel collisions (non-spill related impacts), a discharge of untreated wastewater from the FPSO, or vehicular accidents. While several other coastal and marine oil spill scenarios are described above, the higher-volume marine and coastal oil spill scenarios were the focus of the resource-specific assessments, so as to provide a conservative assessment of potential risk. The remainder of this chapter evaluates the risk of each of these potential impacts, considering the likelihood of the event and the potential consequence of the event with respect to resultant impacts on the relevant resources/receptors. For simplicity, although NADF is technically a “hydrocarbon” and not an “oil,” releases of both NADF and oil are generically referred to as “oil spills” in the remainder of this section.

Table 9.1-6: Resources/Receptors Potentially Impacted by Unplanned Events

Resource/Receptor	Oil Spill			Vessel Collision [a]	Untreated FPSO Wastewater Discharge	Vehicular Accident	Collision between Seabird and Project Vessel or Helicopter	Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume
	Marine	Coastal	NADF					
Physical Resources								
Air Quality and Climate	X	X						
Sound (Airborne)								
Marine Geology and Sediments		X	X					
Marine Water Quality	X	X	X		X			
Biological Resources/Receptors								
Protected Areas	X							
Special Status Species—Fish	X	X			X			
Special Status Species—Birds	X	X			X		X	X
Coastal Habitats	X	X						
Coastal Wildlife	X	X						
Seabirds	X				X		X	X
Marine Mammals	X	X		X	X			
Riverine Mammals	X	X		X				
Marine Turtles	X			X	X			
Marine Fish	X	X	X		X			
Marine Benthos	X	X	X					
Ecological Balance and Ecosystems	X	X	X		X			
Socioeconomic Resources/Receptors								
Economic Conditions/ Employment and Livelihoods	X	X		X				
Community Health and Wellbeing	X	X		X		X		
Marine Use and Transportation	X	X		X				
Social Infrastructure and Services	X	X				X		

Resource/Receptor	Oil Spill			Vessel Collision [a]	Untreated FPSO Wastewater Discharge	Vehicular Accident	Collision between Seabird and Project Vessel or Helicopter	Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume
	Marine	Coastal	NADF					
Waste Management Infrastructure and Capacity	X	X						
Cultural Heritage	X	X	X					
Land Use	X	X						
Ecosystem Services	X	X						
Indigenous Peoples	X							

[a] This scenario focuses on non-spill related impacts; fuel and crude oil spills from vessel accidents are addressed in the "Oil Spill" columns.

9.1.16. Embedded Controls and Mitigation Measures for Unplanned Events

Table 9.1-7 lists the embedded controls and mitigation measures relevant to the unplanned events described above.

Table 9.1-7: List of Embedded Controls and Mitigation Measures for Unplanned Events

Embedded Controls	Related Unplanned Event
Use water-based drilling fluids to the extent reasonably practicable (upper sections of the wells). For well sections requiring NADF, use only low-toxicity International Oil and Gas Producers Group III base fluid.	NADF release
Install a BOP system that can be closed rapidly in the event of an uncontrolled influx of formation fluids and that allows the well to be circulated to safety by venting the gas at surface and routing oil so that it may be contained.	Marine oil spill
Test BOP equipment at installation, after disconnection or repair of any pressure containment seal, and at regular intervals (at least every 14 days or as operations allow).	Marine oil spill
With respect to prevention of spills of hydrocarbons and chemicals during the drilling stage: • Change liquid hydrocarbon transfer hoses periodically; • Use dry-break connections on liquid hydrocarbon bulk transfer hoses; • Use a liquid hydrocarbon checklist before every bulk transfer; • Perform required inspections and testing of all equipment prior to deployment/installation; • Use overbalanced drilling fluids to control wells while drilling; • Perform operational training certification (including well-control training) for drill ship supervisors and engineers; • Regularly audit field operations on the drill ships to ensure application of designed safeguards; and • Use controls for mitigating a failure of the DP system on the drill ships and maintaining station-keeping, which include: – Use of a Class 3 DP system, which includes numerous redundancies; – Rigorous personnel qualifications and training; – Sea trials and acceptance criteria; – DP proving trials; – System Failure Mode and Effects Analysis; – DP failure consequence analysis; and • Establishment of well-specific operations guidelines.	Marine oil spill
Maintain marine safety exclusion zones to be issued through the Maritime Administration Department with a 500-meter (approximately 1,640-foot) radius around drill ships and major installation vessels, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Vessel collision with a third-party vessel
Ensure leak detection systems are in place for equipment, treatment, and storage facilities (fuel, chemical, etc.) on drill ships in accordance with international offshore petroleum industry standards	Marine oil spill, untreated FPSO wastewater discharge

Use leak detection controls during installation and operation of SURF equipment (e.g., pigging and pressure testing of lines, periodic remotely operated vehicle surveys of subsea trees, manifolds, flowlines, and risers).	Marine oil spill
Instead of continuous flaring, re-inject produced gas that is not used as fuel gas on the FPSO into the reservoir, to avoid routine flaring.	Seabird collision with FPSO flare tower, flame, or radiant heat plume
Maintain marine safety exclusion zones to be issued through the Maritime Administration Department with a 2-nautical-mile (approximately 12,150-foot) radius around FPSO during offloading operations, to prevent unauthorized vessels from entering areas with an elevated risk of collision	Vessel collision with a third-party vessel, marine oil spill
Ensure offloading activities are supervised by a designated Mooring Master, according to the conditions of the sea. The conditions and characteristics of the export tankers will be assessed by the Mooring Master and reported to the Offshore Field Manager prior to commencing offloading operations. Use only properly registered and well-maintained double-hull vessels.	Vessel collision with a third-party vessel, marine oil spill
Use support tugs to aid tankers in maintaining station during approach/departure from FPSO and during offloading operations.	Vessel collision with a third-party vessel, marine oil spill
Use a hawser with a quick release mechanism to moor the FPSO to the tanker at a safe separation distance during offloading operations.	Vessel collision with a third-party vessel, marine oil spill
Ensure FPSO offloading to tankers occurs within an environmental operating limit that is established to ensure safe operations. In the event that adverse weather occurs during offloading operations that is beyond the environmental operating limit, the tanker will cease offloading operations, and may disconnect and safely maneuver away from the FPSO as appropriate.	Vessel collision with a third-party vessel, marine oil spill
Use a certified marine-bonded, double-carcass floating hose system that complies with the recommendations of Oil Companies International Marine Forum's *Guide to Manufacturing and Purchasing Hoses for Offshore Moorings*, 2009 Edition or later (OCIMF 2009).	Marine oil spill
Use breakaway couplers on offloading hose that would stop the flow of oil from FPSO during an emergency disconnect scenario.	Marine oil spill
Use a load-monitoring system in the FPSO control room to support FPSO offloading.	Marine oil spill
Use leak detection controls during FPSO offloading (e.g., for breach of floating hose, instrumentation/procedures to perform volumetric checks).	Marine oil spill
Inspect and maintain onboard equipment (engines, compressors, generators, sewage treatment plant, and oil-water separators) in accordance with manufacturers' guidelines, in order to maximize efficiency and minimize malfunctions, and unnecessary discharges into the environment.	Marine oil spill, coastal oil spill, untreated FPSO wastewater discharge
Equip Project vessels with radar systems and communication mechanisms to communicate with third-party mariners.	Vessel collision with a third-party vessel, coastal oil spill

Regularly inspect and service shorebase cranes and construction equipment to mitigate the potential for spills and to reduce air emissions to the extent reasonably practicable.	Coastal oil spill
Use secondary containment for storage of bulk fuel, drilling fluids, and hazardous materials, where practicable.	Marine oil spill
Regularly check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks.	Marine oil spill, coastal oil spill, untreated FPSO wastewater discharge
Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and riverine mammals at the sea surface. Provide standing instruction to Project-dedicated vessel masters to avoid marine mammals, riverine mammals, and marine turtles while underway and reduce speed or deviate from course, when possible, to reduce probability of collisions.	Vessel collisions with marine mammals, marine turtles, and riverine mammals
Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from Project Development Area.	Vessel collisions with seabirds
Provide standing instructions to Project-dedicated vessel masters to reduce their speed within 300 meters (984 feet) of observed marine mammals and marine turtles, and to not approach the animals closer than 100 meters (328 feet).	Vessel collisions with marine mammals and marine turtles
Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.	Vessel collision with a third-party vessel, coastal oil spill
Implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The procedure will include, at a minimum, the following components: • Definition of typical, primary travel routes for ground transportation in Georgetown area; • Development of an onshore logistics/journey management plan to reduce potential conflicts with local road traffic when transporting goods to/from onshore support facilities; • Definition of required driver training for Project-dedicated drivers, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as applicable; • Designation and enforcement of speed limits through speed governors, global positioning system, or other monitoring systems for Project-dedicated vehicles; • Avoidance of deliveries during typical peak-traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; • Monitoring and management of driver fatigue; • Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment for Project-dedicated vehicles; and • Community outreach to communicate information relating to major delivery events or periods.	Vehicular accident

Maintain an OSRP to ensure an effective response to an oil spill, including maintaining the equipment and other resources specified in the OSRP and conducting periodic training and drills.	Marine oil spill, coastal oil spill
Mitigation Measures	**Related Unplanned Event**
Issue Notices to Mariners via the Maritime Administration Department, the Trawler's Association, and fishing co-ops for movements of major marine vessels (including the FPSO, drill ship, and installation vessels) to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.	Vessel collision with a third-party vessel, marine oil spill
Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.	Vessel collision with a third-party vessel, marine oil spill
Promptly remove damaged Project vessels (associated with any vessel incidents) to minimize impacts on marine use, transportation, and safety.	Vessel collision with a third-party vessel
Implement the OSRP in the unlikely event of an oil spill, including: • Conducting air quality monitoring during emergency response; • Requiring use of appropriate PPE by response workers; and • Implementing a Wildlife Oil Response Program, as needed.	Marine oil spill, coastal oil spill
Implement a claims process and, as applicable, a livelihood remediation program to address economic losses or impacts on livelihood as a result of an oil spill.	Marine oil spill, coastal oil spill
In case of a collision involving a Project vessel and a non-Project vessel that may result in a claim arising from such type of incident, provide appropriate restitution, consistent with governing contracts and applicable laws.	Vessel collision with a third-party vessel

PPE = personal protective equipment

9.2. Air Quality and Climate

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts to air quality or climate include a marine oil spill and a coastal oil spill.

9.2.1. Marine Oil Spill

9.2.1.1. Air Quality

Crude oil is a mixture of hydrocarbons, and is made up of light, medium, and heavy constituents. In the unlikely event of an oil spill, the lighter hydrocarbons in the spilled oil (including benzene, xylene, and toluene) tend to quickly evaporate into the air. Additionally, the oil that would be released from a spill in the PDA would be a medium crude oil. Medium and heavy crude oils contain less of the aromatic hydrocarbons than are found in light crude oils. Accordingly, atmospheric concentrations of these constituents associated with the spilled oil typically drop rapidly during the first 24 hours of a spill. Elevated hydrocarbon concentrations in air are primarily found in the immediate vicinity of a spill and some distance downwind, depending on wind speeds. Atmospheric concentrations would thus primarily be a source of potential impact for oil spill response workers; air-monitoring equipment would be deployed to monitor levels of air pollutants and appropriate personal protective equipment (PPE) would be provided, as necessary, to those oil spill response workers who are exposed. The remainder of this discussion is therefore focused on risk to potential onshore (community) receptors in Guyana.

Considering the above, in the case of a marine oil spill, the potential for potentially harmful concentrations of air contaminants to reach the Guyana coastline (where potential receptors could be located) is considered very low, even for a large spill, considering the distance to shore from the hypothetical source of the spill (approximately 207 kilometers [128 miles] northeast of the coastline of Georgetown) and the reduction in emissions coming off the plume that would occur as the plume migrates. In the unlikely event of a marine oil spill reaching or coming near a Guyana shoreline, elevated atmospheric concentrations of air contaminants in areas with potential human receptors would be localized to onshore areas proximal to where the spill was present or where the oil came ashore.

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

Deterministic modeling for the Most Credible WCD scenario predicts that an unmitigated spill would come within approximately 30 kilometers (approximately 19 miles) of the Guyana shoreline; deterministic modeling for the Maximum WCD scenario predicts that an unmitigated spill would come within approximately 90 kilometers (approximately 56 miles) of the Guyana shoreline.

On the basis of the predicted spill trajectories for the deterministic modeling of the loss-of-well-control scenarios described above, and considering that atmospheric emissions from the spilled oil would have reduced significantly as the spill migrates and weathers, the intensity of potential impacts to onshore Guyana air quality from an unmitigated marine oil spill would be **Negligible** (as the predicted swept area comes no closer than 30 to 90 kilometers [19 to 56 miles] from the Guyana shoreline). The geographic extent of air quality impacts of an unmitigated loss-of-well-control event would include limited portions of the **Indirect AOI**. On the basis that air quality impacts from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated (albeit with gradually reducing emissions as the oil weathers), the frequency is considered to be **Continuous**. Air quality impacts, even assuming no mitigation of the spill, would reduce significantly with time as the oil continued to weather, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Negligible**.

As noted in the discussion of potential air quality impacts from planned activities, the sensitivity of most potential onshore receptors to atmospheric emissions is considered **Medium**, with the potential for some receptors to have a **High** sensitivity. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**.

In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall pre-mitigation risk to onshore Guyana air quality from an unmitigated marine oil spill would be **Minor** (see Table 9.2-1).

With implementation of the OSRP, deterministic modeling for the Most Credible WCD and Maximum WCD both predict that the closest distances a mitigated spill would come from a Guyana shoreline are roughly equivalent to those predicted for an unmitigated spill. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts. On this basis, the intensity of potential impacts to onshore Guyana air quality from a mitigated marine oil spill would be **Negligible** for both spill scenarios considered. This leads to a magnitude rating of **Negligible**, maintaining the consequence/severity rating to **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to onshore Guyana air quality from an unmitigated marine oil spill would be **Minor** (see Table 9.2-1).

9.2.1.2. Climate

With respect to potential climate impacts from a marine oil spill, there would be a potential indirect impact associated with additional fossil fuel combustion by response vessels and fuel-fired equipment involved with the response effort, resulting in increased greenhouse gas (GHG) emissions as compared to that associated with planned Project activities. However, the scale of these additional GHG emissions would represent a very small incremental increase, leading to a consequence/severity rating with respect to risks to climate of **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall risk to climate from a marine oil spill would be **Minor** (see Table 9.2-1).

9.2.2. Coastal Oil Spill

9.2.2.1. Air Quality

In the case of a coastal oil spill, the potential for potentially harmful concentrations of air contaminants to reach the Guyana coastline (where potential receptors could be located) is higher than for a marine oil spill (based on the closer proximity of the spill to potential onshore receptors), but the spill volume (and thus affected surface area) would be expected to be one or more orders of magnitude smaller. Elevated concentrations of air contaminants in areas with potential human receptors would be localized to the nearshore area alongside the spilled oil.

Balancing the closer proximity of a coastal spill to potential receptors with the reduced volume of such a spill, the intensity of potential impacts to onshore Guyana air quality from an unmitigated coastal oil spill could be as much as **Medium**. The geographic extent of an unmitigated loss-of-well-control event would likely be limited to the **Direct AOI**. On the basis that air quality impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

As noted in the discussion of potential air quality impacts from planned activities, the sensitivity of most potential onshore receptors to atmospheric emissions is considered **Medium**, with the potential for some receptors to have a **High** sensitivity. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium** to **High**.

In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall pre-mitigation risk to onshore Guyana air quality from an unmitigated coastal oil spill would be **Minor** to **Moderate** (see Table 9.2-1).

With implementation of the OSRP, the intensity of potential impacts to onshore Guyana air quality from a mitigated coastal oil spill would be reduced to at the range of **Negligible** to **Low** (depending on the size of the spill), based on the expectation that these types of spills would typically involve non-persistent oils that can typically be relatively quickly mitigated. This leads to a magnitude rating of **Negligible** to **Small**, reducing the consequence/severity rating to a range of **Low** to **Medium**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall residual risk to onshore Guyana air quality from an unmitigated coastal oil spill would be **Minor** (see Table 9.2-1).

9.2.2.2. Climate

As with a marine oil spill, potential risk to climate from a coastal oil spill would stem from a potential indirect impact associated with additional fossil fuel combustion by response vessels and fuel-fired equipment, resulting in increased GHG emissions. However, the scale of these additional GHG emissions would be limited, leading to a consequence/severity rating with respect to impacts on climate of **Low**. In combination with a likelihood rating of **Unlikely** for a marine or coastal oil spill, the overall risk to climate from a coastal oil spill would be **Minor** (see Table 9.2-1).

Table 9.2-1: Risk Ratings for Unplanned Event Impacts on Air Quality and Climate

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Air Quality (onshore Guyana)	Unlikely	Low	Minor	Implement OSRP	Minor
	Climate	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Oil Spill	Air Quality (onshore Guyana)	Unlikely	Medium to High	Minor to Moderate	Implement OSRP	Minor
	Climate	Unlikely	Low	Minor	Implement OSRP	Minor

9.3. Marine Geology and Sediments

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on marine water quality include a coastal oil spill and an NADF release.

9.3.1. Coastal Oil Spill

In the unlikely event of a coastal oil spill, diesel fuel would not sink or accumulate on the seafloor unless adsorption occurs with sediment; however, it is possible for diesel fuel that is dispersed by wave action to form droplets that are small enough to be kept in suspension and moved by the currents. The oil dispersed in the water column can adhere to fine-grained suspended sediments, which can settle out and deposit on the seafloor. This is less likely to occur in open marine settings, and is not likely to result in measurable sediment contamination for small spills (NOAA 2018). Accordingly, the intensity of such an impact on marine geology and sediments, if it were to occur, would be considered **Low**. The geographic extent of an unmitigated spill event could potentially include portions of the **Indirect AOI**, assuming the spill is large enough to migrate outside of the transit corridor. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude of **Medium**. Using the definitions for sensitivity rating presented in the assessment of potential impacts on marine geology and sediments from planned Project activities, a sensitivity rating of **Medium** is conservatively assigned. Therefore, applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.1.9, Summary of Spill Scenario Considered, a coastal oil spill is considered **Unlikely**, so the overall risk to marine sediments from a coastal oil spill would be **Minor** (see Table 9.3-1).

9.3.2. NADF Release

In the unlikely event of an emergency disconnect of the drilling riser and hypothetical release of NADF near the seafloor, cuttings would also be released. Neither the NADF nor the cuttings would have any appreciable effect on the underlying marine geology of the PDA. The majority of the base oil in the NADF would separate and rise to the surface, whereas the remaining NADF would remain suspended in the water column and have a very limited effect on marine sediments. The cuttings would accumulate on the seafloor. Cuttings deposits would tend to be deeper and coarser in the immediate vicinity of the wellhead, and would decrease in thickness and grain size with increasing distance from the wellhead. The strength of the bottom currents in the PDA would likely transport any significant fines from deposition near the wellhead, dispersing all but the coarsest cuttings down current. The only lasting effect of such an event would likely be a change in the grain-size distribution of marine sediments within the deposition field, although this effect would diminish over time as benthic infauna and natural sediment deposition would bury the deposited cuttings.

The NADF to be used by EEPGL contains International Association of Oil and Gas Producers (IOGP) Group III NADF, with low to negligible aromatic content. This reduces the potential that changes in marine sediment chemistry as a result of discharge of the NADF would lead to toxicological impacts on benthic infauna.

Using the definitions in Table 6.3-6, the intensity of potential impacts of an NADF release on marine sediments is considered **High**. The geographic extent of an unmitigated NADF release would be limited to the **Direct AOI**. On the basis that impacts on marine sediments from an unmitigated NADF release would persist as long as it was exposed to the spilled material, the frequency is considered to be **Continuous**. Even without mitigation, currents would redistribute the spilled material and impacts would be expected to persist less than a year, yielding a **Medium-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions for sensitivity rating presented in the assessment of potential impacts on marine geology and sediments from planned Project activities, a sensitivity rating of **Medium** is conservatively assigned. Therefore, applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.1.9, Summary of Spill Scenario Considered, a coastal oil spill is considered **Unlikely**, so the overall risk to marine sediments from an NADF release would be **Minor** (see Table 9.3-1).

A mitigated release of NADF would be smaller in volume and the impacts would be shorter in duration than the unmitigated scenario described above, yielding an intensity rating of **Negligible** for all scenarios considered. This leads to a magnitude rating of **Negligible** and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for the accidental release of NADF, the overall residual risk to marine sediments from a mitigated release of NADF would be **Minor** (see Table 9.3-1).

Table 9.3-1: Risk Ratings for Unplanned Event Impacts on Marine Geology and Sediments

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Ranking	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Coastal Oil Spill	Marine Sediments	Unlikely	Medium	Minor	Implement OSRP	Minor
NADF Release	Marine Sediments	Unlikely	Low	Minor	Implement OSRP	Minor

9.4. Marine Water Quality

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on marine water quality include a marine oil spill, a coastal oil spill, and an NADF release.

9.4.1. Marine Oil Spill

As described in Section 9.1.3, Weathering Process, marine oil spills are subject to a range of weathering processes. These processes result in the oil partitioning into different phases (entrained, bubbles, etc.) of the marine environment, while experiencing dilution. Some of the spilled oil is removed from the water column via evaporation and photo-oxidation[3]. Additionally, biodegradation processes gradually reduce hydrocarbon concentrations in the marine environment following a spill. The proportion of the spill that mixes[4] through the water column through wave energy is subject to rapid, high levels of dilution along with this biodegradation. Some oil constituents, especially aromatics, are also soluble in water. The proportion of the spill that mixes through the water can increase hydrocarbon concentrations in the water column and result in localized, but temporary, changes to water quality.

Potential impacts on water quality from a marine oil spill are thus related to contamination within the water column from dissolved hydrocarbon concentrations (primarily polycyclic aromatic hydrocarbons). While contamination in the water column from a spill can be brief, a continuous release from an unmitigated loss-of-well-control event can cause a persistence of elevated toxic concentrations until the release is controlled. Oil spill monitoring has shown that concentrations of oil and its constituents in the water column rapidly decline after a spill, and are usually confined to an area near the origin of the spill (ITOPF Undated). The oil that would be released from a spill in the PDA would be a medium crude oil. Medium and heavy crude oils contain less of the water soluble, aromatic hydrocarbons than are found in light crude oils. However, as a result of the lower evaporation, dispersion, and dissolution in seawater, medium crude oils are more persistent in the environment relative to light crude oils. The medium crude would produce less biological effects than light crude oil, but due to the higher persistence, it would be important to focus the spill response on reducing or eliminating shoreline stranding. It is also noted that the mixing energy resulting from a loss-of-well-control event may result in

[3] Process of chemical breakdown caused by exposure to sunlight
[4] Mixing is achieved by a combination of entrainment and dissolution.

higher levels of entrained and dissolved hydrocarbons than would be associated with a surface spill, as the oil would tend to be fragmented into smaller droplets as a result of the reservoir pressure.

Accordingly, the intensity of impacts on water quality from a marine oil spill from an unmitigated loss-of-well-control event is considered **High** at the locations with the greatest dissolved aromatic concentrations. The geographic extent of an unmitigated loss-of-well-control event would include portions of the **Indirect AOI**. On the basis that the loss-of-well-control event would continue over a several-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

The sensitivity of the receptors (marine biota) to an oil spill may be as high as **Medium**. Applying the methodology in Chapter 4, the magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. This takes into consideration the higher toxicity of the light oil fractions and the magnitude and extent of the spill scenario, balanced against the limited geographic extent and duration of the toxicity impacts as a result of the relatively rapid loss of lighter fractions. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall risk to marine water quality from a marine oil spill is **Moderate**. Even with implementation of the OSRP, the residual risk rating would conservatively remain **Moderate** (see Table 9.4-1).

9.4.2. Coastal Oil Spill

With respect to the coastal oil spill scenario, a spill of diesel oil would also exhibit higher toxicity light oil fractions, but a smaller magnitude of the spill, limited geographic extent, and shorter duration of toxicity impacts, as compared to the marine oil spill scenario. This leads to a **High** intensity within the **Indirect AOI.** On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Therefore, applying the methodology described in Chapter 4, these characteristics lead to an overall magnitude rating of **Medium**. The sensitivity of the receptors (marine biota) to an oil spill may be as high as **Medium**. Applying the methodology in Chapter 4, the magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium** with respect to impacts on water quality. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall risk to marine water quality from a coastal oil spill is **Minor**. Even with implementation of the OSRP, the residual risk rating would remain **Minor** (see Table 9.4-1).

9.4.3. NADF Release

In the unlikely event of an emergency disconnect of the drilling riser and hypothetical release of NADF near the seafloor, NADF would start to undergo biological degradation after being released from the drilling riser. This process could result in localized decreases in dissolved oxygen concentrations, although this is more likely to be observed in the pore water between the cuttings grains deposited on the seafloor than in the water column, due to the dissolution of NADF in the water column caused by the strong marine currents in the region. Organic enrichment of sediments speeds the biodegradation process, which tends to accelerate oxygen depletion, and NADF cuttings tend to contain higher concentrations of biodegradable matter than water-based drilling fluids (WBDF). Conditions favoring eutrophication[5] and hypoxia[6] in the near-surface pore water within the deposition zone may exist temporarily following a release of NADF. Eutrophication and resulting hypoxia at the seafloor or within the pore water could be sufficient to cause effects to marine biota, but these changes would likely be short term. From a toxicological perspective, although the NADF used by EEPGL will contain IOGP Group III NADF, it will have low to negligible aromatic content, reducing the potential that changes in marine water quality as a result of discharge of the NADF would lead to toxicological impacts on marine biota.

Using the definitions in Table 6.4-3, the intensity of potential impacts of an NADF release on marine water quality is considered **High**. The geographic extent of an unmitigated NADF release would be limited to the **Direct AOI**. On the basis that impacts on marine water quality from an unmitigated NADF release would persist as long as it was exposed to the spilled material, the frequency is considered to be **Continuous**. Even without mitigation, currents would redistribute the spilled material and impacts would be expected to persist less than a year, yielding a **Medium-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions for sensitivity rating presented in the assessment of potential impacts on marine water quality from planned Project activities, a sensitivity rating of **Medium** is conservatively assigned. Therefore, applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.1.9, Summary of Spill Scenario Considered, a coastal oil spill is considered **Unlikely**, so the overall risk to marine water quality from an NADF release would be **Minor** (see Table 9.4-1).

A mitigated release of NADF would be smaller in volume and the impacts would be shorter in duration than the unmitigated scenario described above, yielding an intensity rating of **Negligible** for all scenarios considered. This leads to a magnitude rating of **Negligible** and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for the

[5] Over-enrichment of a waterbody with minerals and nutrients that can induce excessive growth of plants (including phytoplankton) or algae

[6] Deficiency in dissolved oxygen concentrations

accidental release of NADF, the overall residual risk to marine water quality from a mitigated release of NADF would be **Minor** (see Table 9.4-1).

9.4.4. Discharge of Untreated Wastewater from the FPSO

A discharge of untreated wastewater (i.e., sewage or black water) from the FPSO would only occur under an equipment failure scenario and would involve release of untreated wastewater directly overboard. Such a discharge would have localized impacts on marine water quality, but conditions that could cause such a release would generally be rectified within a short period of time. The primary constituents in wastewater include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), carbon, nutrients (primarily nitrogen and phosphorous), and pathogens such as coliform. The affected area of ocean would be somewhat larger than the mixing zone associated with normal operations, but not so large that the event would be regionally significant. As described in Section 9.1.11, Untreated FPSO Wastewater Discharge, modeling results show that a temporary release of untreated wastewater would result in a plume of limited extent and that constituent concentrations would not be expected to exceed the end-of-pipe levels recommended by the IMO's 2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants (IMO 2012).

The geographic extent of a discharge of untreated wastewater from the FPSO would be limited to the **Direct AOI**. Using the definitions established for assessment of potential impacts on marine water quality from planned Project activities, the intensity of potential impacts of a discharge of untreated wastewater from the FPSO is considered **Low**. The frequency of a discharge of untreated wastewater from the FPSO would be **Episodic** because it would occur infrequently (if ever). The duration of this impact would be **Short-term**, as it would assimilate into the ocean quickly. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessment of potential impact on marine water quality from planned Project activities, the sensitivity of marine water quality to impacts from a discharge of untreated wastewater from the FPSO is considered **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously in order for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. These factors yield a (pre-mitigation) risk rating to marine water quality from a discharge of untreated wastewater from the FPSO of **Minor**.

Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would be **Minor** (see Table 9.4-1).

Table 9.4-1: Risk Ratings for Unplanned Event Impacts on Marine Water Quality

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Water Quality	Unlikely	High	Moderate	Implement OSRP	Moderate
Coastal Oil Spill	Water Quality	Unlikely	Medium	Minor	Implement OSRP	Minor
NADF Release	Water Quality	Unlikely	Medium	Minor	Implement OSRP	Minor
Untreated Wastewater Discharge from FPSO	Water Quality	Unlikely	Low	Minor	None	Minor

9.5. Protected Areas and Special Status Species

As indicated in Table 9.1-6, the unplanned event with the potential for measureable impacts on protected areas would be a marine oil spill and the unplanned events with the potential for measureable impacts on special status species would be a marine oil spill, a coastal oil spill (fish only), a discharge of untreated wastewater from the FPSO, and a collision of a Project vessel or helicopter with a seabird.

Potential risks of unplanned events on special status marine mammals, riverine mammals, and marine turtles are assessed in Section 9.9, Marine Mammals, Section 9.10, Riverine Mammals, and Section 9.11, Marine Turtles. This is because for these resources, the assessments of impact significance for planned and unplanned events assume the affected receptors are all special status species. As such, the impacts described for these special status species are not repeated here. Marine fish, seabirds, and coastal birds were not assessed on the basis of special status in the planned or unplanned event sections of this EIA because most of the species in these taxa groups that occur in the PDA are not special status species. Hence, this section focuses on the impacts of unplanned events on the special status marine fish and bird (seabird and coastal bird) species known or expected to occur in the PDA that could be impacted by unplanned events.

9.5.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Section 7.1, Protected Areas and Special Status Species, contains the definitions for intensity of impact and sensitivity of receptor for impacts on protected areas and special status species.

9.5.1. Protected Areas

The only unplanned event with the potential for measureable impacts on protected areas would be a marine oil spill. As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Stochastic modeling indicates that the minimum time for oil to reach the Guyana shoreline in this area would be between 5 and 25 days, depending on spill scenario and season. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

The Region 1 coastline contains the SBPA, which has high importance for biodiversity and related social values (e.g., ecosystem services) (see Section 7.1, Protected Areas and Special Status Species). Coastal habitats within the SBPA, including mangrove forest, tidal and brackish wetlands, and sand beach, would be vulnerable to exposure to an oil spill because of their physical location adjacent to the saltwater interface. Habitats and wildlife species respond differently to interactions with oil. Based on the ecological sensitivity and importance of the SBPA, the intensity of potential impacts of an unmitigated marine oil spill on the SBPA is considered **High**. The geographic extent of an unmitigated loss-of-well-control event would encompass portions of the **Indirect AOI**. On the basis that impacts on coastal habitat from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, coastal habitat would gradually recover to some extent—depending on the degree of oiling—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

The sensitivity of the SBPA in the areas with the potential to be affected by a marine oil spill is considered **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to the SBPA is considered **Moderate**.

Mitigation for a marine oil spill would involve implementation of the OSRP. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill would not reach the Guyana shoreline. On this basis, the intensity of potential impacts on the SBPA from a mitigated marine oil spill would be **Negligible** for all spill scenarios considered. This leads to a magnitude rating of **Negligible**, reducing the consequence/severity rating to **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to the SBPA from a mitigated marine oil spill would be **Minor** (see Table 9.5-1).

9.5.2. Special Status Species

For the purposes of this assessment, special status species are defined as those that are listed on the International Union for Conservation of Nature (IUCN) Red List as Near Threatened (NT), Vulnerable (VU), Endangered (EN), or Critically Endangered (CR) on the IUCN Red List Version 2019.1 (IUCN 2019 that are known or expected to occur in the Project AOI (see Section 7.1.2, Existing Conditions—Protected Areas and Special Status Species, and

Appendix K, IUCN-Listed Coastal and Marine Species Known From Guyana with Red List Status Classified as Data Deficient).

There are 74 coastal and marine species known or expected to occur in the Project AOI that are listed on the IUCN Red List as NT or higher (i.e., NT, VU, EN, or CR), including 54 fish, 11 birds, 4 marine turtles, 1 terrestrial turtle, and 4 mammals (1 marine mammal and 3 coastal/riverine mammal species). The vast majority of these species are fish, including highly migratory species such as tunas and sharks, bentho-pelagic species including certain groupers, and demersal species including species of skates and rays. As noted in Section 8.1.2, Existing Conditions—Socioeconomic Conditions, many of these fish species are also targeted by the Guyanese commercial fishing industry, which can lead to cumulative effects on these species (see Chapter 10, Cumulative Impact Assessment).

Table 9.5-1 summarizes the IUCN Red List ranking and species type for the 74 marine and coastal species known or expected to occur in the Project AOI that are IUCN Red List ranked NT or higher.

Table 9.5-1: Summary of IUCN Red List Rankings for Special Status Species Known or Expected to Occur in the Project AOI

IUCN Ranking	Number of Species	Taxonomic Groups
CR	5	1 marine turtle 4 fish
EN	9	1 marine turtle 6 fish 1 marine bird 1 coastal/riverine mammal
VU	30	2 marine turtles 20 fish 4 coastal birds 1 marine bird 1 marine mammal 1 coastal/riverine mammal 1 terrestrial turtle
NT	30	24 fish 5 coastal birds 1 coastal/riverine mammal

As discussed above, the potential risks of unplanned events on special status marine mammals, riverine mammals, and marine turtles are assessed in Section 9.9, Marine Mammals, Section 9.10, Riverine Mammals, and Section 9.11, Marine Turtles. Accordingly, this section focuses on the impacts of unplanned events on the special status marine fish and bird species.

9.5.2.1. Marine Oil Spill

Special Status Marine Fish

Oil spill modeling indicates that the swept area for an unmitigated marine oil spill would be limited to the portion of Guyana's Exclusive Economic Zone (EEZ) off Regions 1 and 2 under all scenarios. The extent of the oil's predicted effect on the continental shelf[7] changes seasonally, with the highest probability of oil reaching the coast (and therefore a larger portion of the continental shelf) in winter. The implication of these model results is that pelagic, open-ocean fish species would have the highest potential for exposure to oil as the result of a loss-of-well-control event under all scenarios, but that under certain conditions continental shelf species could be exposed as well, and that a remote possibility exists for exposure to occur in shallow water.

Potential impacts on marine species from a marine oil spill are primarily related to water column concentrations of, and the duration of exposure to, dissolved hydrocarbons (primarily PAHs). Contamination in the water column changes rapidly in space and time, such that potentially harmful exposure levels are typically brief (i.e., typically measured in hours), except in the case of an ongoing release such as a loss-of-well-control event. Exposure to microscopic oil droplets may impact aquatic biota either mechanically (especially for filter feeders) or as a conduit for exposure to semi-soluble hydrocarbons (which might be taken up in the gills or digestive tract via dissolution from the micro-droplets).

Using the definitions presented in Table 7.9-6, the intensity of potential impacts of an unmitigated marine oil spill on special status marine fish is considered **High**. The geographic extent of an unmitigated loss-of-well-control event could encompass portions of the **Indirect AOI**. On the basis that impacts on marine fish from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, marine fish would gradually recover to some extent—depending on the degree of oil exposure—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Large**.

The listing status of special status fishes within the Indirect AOI ranges from NT to CR. Applying the sensitivity ratings from Section 7.1.3.2 yields a sensitivity rating of **High** for CR and EN species and **Medium** for all other special status species. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High** for all special status fish species. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to special status marine fish is considered **Moderate**.

Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under both oil spill scenarios considered in the modeling analysis. All of the CR special status fish species listed in Section 7.1.2.2 are coastal species. This would thus virtually eliminate the possibility of oil entering the CR-listed fishes' preferred habitat, which would reduce the intensity of impact on CR listed fish species to **Negligible** and the residual

[7] The relatively shallow area of seabed extending from the coast to the edge of the continental slope

consequence/severity of marine oil spill-related impacts on CR-listed fishes to **Low**. In combination with a likelihood of **Unlikely**, the residual risk rating associated with marine oil spill-related impacts on CR-listed fishes would therefore be **Minor.**

Implementation of the OSRP would also reduce the number of EN-, VU-, and NT-listed fish species that could encounter oil and the area within which those encounters could occur, but all three of these categories include several offshore pelagic species that could encounter oil even under a mitigated scenario. If applied, dispersants will increase the concentrations of oil entrained in the upper portions of the water column and thus pelagic species' exposure to near-surface entrained oil. The NEBA process would optimize use of dispersant such that the benefits would be expected to outweigh the negative effects of increased concentrations of emulsified or entrained oil near the surface. Accordingly, the intensity of such an impact would be reduced to **Low**, which would reduce the residual impact magnitude to **Small** and lower the residual consequence/severity of marine oil spill-related impacts on EN-listed fishes to **Medium**. In combination with a likelihood of **Unlikely**, the residual risk rating associated with marine oil spill-related impacts on these fishes would be **Minor.**

Similar to EN-listed fishes, implementation of the OSRP would reduce but not eliminate impacts on VU- or NT-listed fishes. Therefore, implementation of the OSRP would reduce the intensity rating for oil spill-related impacts on these species to **Low** and the residual consequence/severity of marine oil spill-related impacts on VU- and NT-listed fishes to **Medium**. The residual risk rating associated with marine oil spill-related impacts on VU- and NT-listed fishes would therefore be **Minor.**

Special Status Birds

The impacts of a marine oil spill on seabirds are described in Section 9.8, Seabirds. There are two special status bird species that could be impacted by a marine oil spill: Black-capped Petrel (EN) (*Pterodroma hasitata*) and Leach's Storm-Petrel (VU) (*Oceanodroma leucorhoa*).

Based on the potential impacts on seabirds from an unmitigated marine oil spill described in Section 9.8, Seabirds, (excluding transboundary effects which are discussed in Section 9.24, Transboundary Impacts), the intensity of impacts from an unmitigated marine oil spill on seabirds are considered to range from **Medium** (for non-breeding seabirds) to **High** (for breeding seabirds).

The geographic extent of an unmitigated loss-of-well-control event would include portions of the **Indirect AOI**. On the basis that impacts from a loss-of-well-control event would persist as long as the spill remains unmitigated, the frequency is considered to be **Continuous**. Assuming no mitigation, the effects would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Large** for both breeding and non-breeding special status seabirds.

Applying the sensitivity ratings from Section 7.1.3.2 yields a sensitivity rating of **High** for Black-capped Petrel and **Medium** for Leach's Storm-Petrel.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to special status seabirds is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by limiting the geographic extent of the oil spill, the duration over which the spill would be present on the water surface, and the number of individual birds potentially impacted.

In the case of Leach's Storm-Petrel, however, data from EEPGL-commissioned marine bird surveys conducted in the Stabroek Block since 2017 (see Section 7.4, Seabirds) indicate the offshore PDA is a migratory corridor for a relatively large number of this species. Accordingly, the residual risk rating for marine oil spills as they relate to Leach's Storm-Petrel is maintained at **Moderate** for a spill occurring during the fall or spring migratory period. In contrast, Black-capped Petrel is expected to occur in the PDA very rarely and only during the non-breeding season. In consideration of the extremely low likelihood that this species would be present in the AOI in the unlikely event of an oil spill, combined with implementation of the OSRP, the residual risk is maintained at **Minor** for this species.

9.5.2.2. Coastal Oil Spill

Special Status Marine Fish

None of the special status fish species listed in Table 7.1-4 have been documented in the Demerara River. A few of these species including bull shark (*Carcharhinus leucas*), daggernose shark (*Isogomphodon oxyrhynchus*), tarpon (*Megalops atlanticus*), and largetooth sawfish (*Pristis pristis*) are known to inhabit estuaries and could infrequently enter the lower Demerara River as transients, but are expected to occur only rarely in the area that could be affected by a coastal oil spill. Largetooth sawfish and daggernose shark are both listed as CR, tarpon is listed as VU, and bull shark is listed as NT. Using the definitions presented in Table 7.9-6 and in light of the marginal value of the Demerara River as habitat for special status fish species, the intensity of potential impacts of an unmitigated coastal oil spill on special status marine fish is considered **Low**.

The geographic extent of a coastal oil spill would include the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Using the definitions in Tables 7.1-6 and 7.1-8 in Section 7.1, Protected Areas and Special Status Species, the sensitivity of special status fish species that could potentially be impacted by a coastal oil spill is considered **High** to **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to an initial consequence/severity rating of **Medium** to **Low**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the (pre-mitigation) risk to special status marine fish from a coastal oil spill is considered **Minor** for all special status marine fish species.

Coastal spills would be quickly controlled and contained because of the relatively small volume of the spill and access to spill control equipment at the shorebases. Accordingly, implementation of the OSRP would reduce the residual intensity to **Negligible**, which would reduce the residual magnitude to **Negligible** as well. The residual consequence/severity rating would decrease to **Low** for all special status marine fish species. Combined with a likelihood of a coastal oil spill occurring of **Unlikely**, the residual risk rating associated with coastal oil spill-related impacts would be **Minor** for all special status marine fish species.

Special Status Birds

An unmitigated coastal oil spill that reaches a Guyana shoreline would likely only happen near the shorebases to be used by the Project, which are located near the mouth of the Demerara River. The three special status species birds that could be affected by a coastal oil spill in the lower Demerara River are Rufous Crab Hawk (*Buteogallus aequinoctialis*), Bicolored Conebill (*Conirostrum bicolor*), and White-bellied Piculet (*Picumnus spilogaster*). The White-bellied Piculet is listed as VU by the IUCN and the Rufous Crab Hawk and Bicolored Conebill are both listed as NT.

Despite the degraded and urbanized nature of coastal habitat in the area that could potentially be impacted by a coastal oil spill, the mangroves lining the west bank of the lower Demerara River and the adjacent coastline support populations of nesting, foraging, and roosting coastal birds, including the three special status species. Even though the area of impact from a coastal spill would likely be limited, the presence of three special status birds in this area that live or forage in the water or adjacent habitats makes them vulnerable to direct or indirect exposure to oil from a coastal oil spill. This exposure could cause similar injury, mortality, and/or behavioral changes in special status birds in and around the affected area to that described above for a marine oil spill, although to a much lower degree because of the limited geographic extent and duration of a coastal oil spill. The impacts would be greatest if the spill occurred during the nesting period when the adults have eggs and chicks in their nests or during the post-nesting season when juvenile birds stay in close vicinity to their nests and surrounding foraging habitats. As such, the intensity of potential impacts on the three special status species birds from an unmitigated coastal oil spill is considered **Medium**. The geographic extent of a coastal oil spill would include the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions in Tables 7.1-6 and 7.1-8 in Section 7.1, Protected Areas and Special Status Species, the sensitivity of special status birds in the area that could potentially be impacted by a coastal oil spill is considered **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium**.

In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall (pre-mitigation) risk to special status birds from an unmitigated coastal oil spill would be **Minor**.

Coastal spills would be quickly controlled and contained because of the relatively small volume of the spill and the ready access to spill-control equipment. These impacts would generally be temporary, limited in area and volume of oil released, and readily mitigated, with rapid habitat recovery expected. Accordingly, with implementation of the OSRP and assuming a low-volume spill, the intensity of potential impacts on the special status birds from a mitigated coastal oil spill would likely be reduced to a **Negligible** level. This leads to a magnitude rating of **Negligible**, and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall residual risk to special status birds from an unmitigated coastal oil spill would be **Minor** (see Table 9.5-2).

9.5.2.3. Discharge of Untreated Wastewater from the FPSO

Special status marine fish and seabirds would be impacted similarly by a discharge of untreated wastewater from the FPSO. The impacts of a discharge of untreated wastewater from the FPSO on non-special status marine fish and seabirds are discussed in Section 9.12, Marine Fish, and Section 9.8, Seabirds. The magnitude of the impacts of such a discharge to non-special status marine fish and seabirds was rated as **Negligible** and, thus when combined with **Low** sensitivity to this impact, the associated pre-mitigation and residual risk ratings for non-special status marine fish and seabirds were **Minor** (see Sections 9.12.5 and 9.8.4, respectively).

A discharge of untreated wastewater from the FPSO would only occur under an equipment failure scenario and involve release of untreated wastewater directly overboard through an outfall. Such a discharge would have localized impacts on water quality, but conditions that could cause such a release would generally be rectified within a short period of time. The primary constituents in wastewater include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), carbon, nutrients (primarily nitrogen and phosphorous), and pathogens such as coliform. The affected area of ocean would be somewhat larger than the mixing zone associated with normal operations, but not so large that the event would be regionally significant. As described in Section 9.1.11, Untreated FPSO Wastewater Discharge, modeling results show that a temporary release of untreated wastewater would result in a plume of limited extent and that constituent concentrations would never exceed the end-of-pipe levels recommended by the IMO's 2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants (IMO 2012).

Special status fish and birds foraging in the water or swimming on or at the water surface could come into dermal contact with the wastewater plume or an individual could ingest a small amount of wastewater during foraging. The character (constituents and concentration) of the wastewater plume would not expose special status fish and birds to toxic effects (injury or mortality) and no dermal effects from contact of the wastewater with a special status fish and birds' skin would be expected.

The geographic extent of a discharge of untreated wastewater from the FPSO would be limited to the Direct AOI. Using the definitions established for assessment of potential impact on special status fish and birds from planned Project activities, the intensity of potential impacts of a discharge of untreated wastewater from the FPSO is considered **Negligible**. The frequency of a discharge of untreated wastewater from the FPSO would be **Episodic** because it would occur infrequently (if ever). The duration of this impact would be **Short-term**, as it would assimilate into the ocean quickly and not persist at the water surface where special status fish and birds swim or forage. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessment of potential impact on special status fish and birds from planned Project activities, the 19 special status pelagic marine fish species and the two seabird species that could be exposed to this impact would have sensitivity ratings ranging from **Medium** to **High**, depending on the species' listing status. Despite the higher sensitivity ratings for these special status species, the effects of a discharge of untreated wastewater from the FPSO would not be any greater than that described for non-special status species because exposure to this impact would not be expected to cause injury or mortality of individuals. As such, the elevated conservation status of the special status species would not increase the intensity or magnitude of this impact on special status species.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. These factors yield a (pre-mitigation) risk rating to special status fish and birds from a discharge of untreated wastewater from the FPSO of **Minor**.

Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would be **Minor** (see Table 9.5-2)

9.5.2.4. Collision of a Project Vessel or Helicopter with Seabirds

The potential impacts of collision of a Project vessel or helicopter with seabirds are discussed in Section 9.8, Seabirds. The magnitude ratings for impacts from both vessel collision and helicopter collision to non-special status seabirds were **Small** (see Sections 9.8.5 and 9.8.6 and Table 9.8-1). The two special status seabirds that could be impacted by collision with a Project vessel or helicopter are Black-capped Petrel (EN) and Leach's Storm-Petrel (VU). The conservation status (IUCN rating) of these species yields sensitivity ratings of **High** and **Medium**, respectively. These sensitivity ratings, coupled with the magnitude rating of **Small** and likelihood rating of **Unlikely** for collision of a Project vessel or helicopter with seabirds as described in Section 9.8, Seabirds Unplanned Events, yield a (pre-mitigation) risk rating of **Minor** for both species and both types of impacts. Aside from the embedded controls of vessel captains being trained to recognize rafting seabirds and avoid them if possible, and pilot avoidance of flying seabirds, which is a standard safety protocol, there are no mitigation measures that can be applied to further reduce this potential impact. As such, the residual risk to special status seabirds from these impacts would remain **Minor** (see Table 9.5-2).

9.5.2.5. Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume

The potential impacts of a seabird collision with the FPSO flare tower, flame, or radiant heat plume are discussed in Section 9.8, Seabirds. The magnitude rating for impacts of non-special status seabirds colliding with the FPSO flare tower, flame, or radiant heat plume is **Negligible** (see Section 9.8.3 and Table 9.8-1). The two special status seabirds that could be impacted by collision with the FPSO flare tower, flame, or radiant heat plume are Black-capped Petrel (EN) and Leach's Storm-Petrel (VU). The conservation status (IUCN rating) of these species yields sensitivity ratings of **High** and **Medium**, respectively. These sensitivity ratings, coupled with the magnitude rating of **Negligible** and likelihood rating of **Unlikely** as described in Section 9.8, Seabirds Unplanned Events, yield a (pre-mitigation) risk rating of **Minor** for both species. There are no mitigation measures that can be applied to further reduce this potential impact. As such, the residual risk to special status seabirds from collision with the FPSO flare tower, flame, or radiant heat plume would remain **Minor** (see Table 9.5-2).

Table 9.5-2: Risk Ratings for Unplanned Event Impacts on Protected Areas and Special Status Species

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Protected Areas (SBPA)	Unlikely	High	Moderate	Implement OSRP	Minor
Marine Oil Spill	CR Fish Species	Unlikely	High	Moderate	Implement OSRP	Minor
	VU and NT Fish Species	Unlikely	Medium	Moderate	Implement OSRP	Minor
	EN Fish Species	Unlikely	Medium	Moderate	Implement OSRP	Minor
	EN Black Capped Petrel (*Pterodroma hasitata*)	Unlikely	High	Moderate	Implement OSRP	Minor
	VU Leach's Storm-Petrel (*Oceanodroma leucorhoa*)	Unlikely	High	Moderate	Implement OSRP	Moderate
Coastal Oil Spill	CR Fish Species	Unlikely	High	Moderate	Implement OSRP	Minor
	VU and NT Fish Species	Unlikely	Medium	Minor	Implement OSRP	Minor
	EN Fish Species	Unlikely	Medium	Minor	Implement OSRP	Minor
	Special Status Coastal Bird Species	Unlikely	Low	Moderate	Implement OSRP	Minor

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Untreated Wastewater Discharge from FPSO	Special Status Marine Fish and Seabirds	Unlikely	Low	Minor	None	Minor
Helicopter strike	EN Black-capped Petrel	Unlikely	Low	Minor	None	Minor
	VU Leach's Storm-Petrel	Unlikely	Low	Minor	None	Minor
Vessel strike	EN Black-capped Petrel	Unlikely	Low	Minor	None	Minor
	VU Leach's Storm-Petrel	Unlikely	Low	Minor	None	Minor
Collision with flare tower, flame, or radiant heat plume	EN Black-capped Petrel	Unlikely	Low	Minor	None	Minor
	VU Leach's Storm-Petrel	Unlikely	Low	Minor	None	Minor

9.6. Coastal Habitats

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on coastal habitats would be a marine oil spill and a coastal oil spill.

9.6.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Definitions for intensity of impact and sensitivity of receptor were not provided in the assessment of potential impacts on coastal habitats from planned Project activities because there are no potential impacts on coastal habitats from planned Project activities. As the methodology for determining a rating for risks to coastal habitats from an unplanned event involves consideration of the intensity of the impacts (assuming the unplanned event was to occur) and the sensitivity of the receptor(s), they are therefore provided in this section. Table 9.6-1 includes the definitions for the intensity of potential impacts on coastal habitats and Table 9.6-2 includes the definitions for the sensitivity of coastal habitats.

Table 9.6-1: Definitions for Intensity Ratings for Potential Impacts on Coastal Habitats

Criterion	Definition
Intensity	Negligible: No changes to habitat functions and values.
	Low: Minimal changes to habitat functions and values, limited to a localized area.
	Medium: Changes to habitat functions and values over a moderately sized area.
	High: Substantial habitat degradation leading to widespread reduction in habitat functions and values.

Table 9.6-2: Definitions for Sensitivity Ratings for Potential Impacts on Coastal Habitats

Criterion	Definition
Sensitivity	Low: Affected habitat(s) does not have elevated susceptibility to Project-related impacts, and can recover quickly from Project-related impacts.
	Medium: Affected habitat(s) has an elevated susceptibility to Project-related impacts, and/or cannot readily recover from Project-related impacts, but the impacted area represents a small fraction of the overall coastal habitat assemblage.
	High: Affected habitat(s) has an elevated susceptibility to Project-related impacts, and/or that cannot readily recover from Project-related impacts, and the impacted area represents a substantial fraction of the overall coastal habitat assemblage.

9.6.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

The shoreline where stochastic modeling indicates a 5 to 20 percent probability of the oil contacting the coast is in Region 1. Stochastic modeling indicates that the minimum time for oil to reach the Guyana shoreline in this area would be between 5 and 25 days, depending on spill scenario and season. The shoreline in Region 1 is dominated by mangrove forest of high or exceptional quality (see Section 7.2, Coastal Habitats). Mangroves, of which the largest remaining stands in Guyana occur in the SBPA in Region 1, are present along this entire section of Guyana's coast, just inland from the sand beach. Other coastal habitats that are particularly susceptible to oil spills (e.g., coral reefs, seagrass beds) are not found along the Guyana coast.

Mangroves are important providers of a number of ecological services upon which fish, wildlife, and humans rely. Mangroves provide valuable habitat for crabs and important nursery areas for fish and shrimp, and provide coastal protection from wave action. Mangroves are typically found along the margins of shorelines at the saltwater interface. Due to this physical location, mangroves are vulnerable to exposure during oil spills. Mangroves are considered to be sensitive to heavy contamination by oil for several reasons (ITOPF undated):

- Mangroves rely on oxygen supplied through small pores (lenticels) on their aerial roots. Smothering of the aerial roots by high loadings of heavy hydrocarbons can block this important oxygen pathway.
- The toxic component of oil can interfere with mangroves' systems for maintaining salt balance, impacting their ability to tolerate salt water; this risk is greatest for light oil types or unweathered oils that still have a high proportion of aromatic compounds (Payara oil is

considered medium oil type that would also be weathered by the time it contacted a Region 1 coastline).

- Oil can become trapped in mangrove sediments, where it may remain in a relatively unweathered state and gradually remobilize over a long period, causing repeated "pulses" of exposure.
- If impacted, mangrove habitats are typically slow to recover from oil exposure, often taking 10 years or longer, especially where the shoreline protection services of the mangroves has been compromised and there is an increase in erosion.

Almost all of the mangroves that line the shoreline in Region 1 are mature, and most have experienced significant erosion in recent years. A few mangroves, particularly near Iron Punt, have disappeared completely in recent years. There are a few small areas between Iron Punt and the mouth of the Pomeroon River where recent sediment accretion has promoted expansion of both young and mature mangroves. There are also two areas further northwest between Iron Punt and Kamwatta Beach where accretion has promoted expansion of mature mangroves. Despite these isolated areas of expansion, mangroves are currently in decline in areas where stochastic modeling shows potential for shoreline oiling from an unmitigated marine oil spill.

Using the definitions above, the intensity of potential impacts of an unmitigated marine oil spill on coastal habitats (mangroves) is considered **High**. The geographic extent of an unmitigated loss-of-well-control event would encompass portions of the **Indirect AOI**. On the basis that impacts on coastal habitat from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, coastal habitat would gradually recover to some extent—depending on the degree of oiling—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

Using the definitions presented above in Table 9.6-2, the sensitivity of coastal habitats in the areas with the potential to be affected by a marine oil spill is considered **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to coastal habitats is considered **Moderate**.

Mitigation for a marine oil spill would involve implementation of the OSRP. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill would not reach the Guyana shoreline. On this basis, the intensity of potential impacts on coastal habitats in Guyana from a mitigated marine oil spill would be **Negligible** for all spill scenarios considered. This leads to a magnitude rating of **Negligible**, reducing the consequence/severity rating to **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to coastal habitats from a mitigated marine oil spill would be **Minor** (see Table 9.6-3).

9.6.3. Coastal Oil Spill

An unmitigated coastal oil spill that reaches a Guyana shoreline would likely only happen near the shorebases to be used by the Project, which are located near the mouth of the Demerara River. As with a marine oil spill, the primary coastal habitat that could be affected by a coastal oil spill in the lower Demerara River is mangrove. Other coastal habitat types in this area include vegetated low banks and exposed, solid manmade structures, which are common in urbanized environments in Guyana. Mature, growing mangroves that are characterized as Critical Sensitivity in the coastal sensitivity mapping, despite being somewhat degraded by human activity (see Appendix P, Coastal Sensitivity Maps), line the west bank of the lower river and the adjacent coastline, while the east bank of the river is primarily characterized by exposed, solid man-made structures with some vegetated low bank habitats interspersed throughout. The mangroves and vegetated low banks would be susceptible to exposure to an oil spill.

Considering the degraded and urbanized nature of coastal habitat in the area that could potentially be impacted by a coastal oil spill and the likely limited area of impact from a coastal spill, the intensity of potential impacts on coastal habitats from an unmitigated coastal oil spill would likely be **Low**. The geographic extent of an unmitigated coastal oil spill would likely be limited to the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts from an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

Using the definitions above, the sensitivity of coastal habitat in the area that could potentially be impacted by a coastal oil spill is considered **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**.

In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall pre-mitigation risk to coastal habitat from an unmitigated coastal oil spill would be **Minor**.

Coastal spills would be quickly controlled and contained because of the relatively small volume of the spill and the ready access to spill control equipment. These impacts would generally be temporary, limited in area and volume of oil released, and readily mitigated, with rapid habitat recovery expected. Accordingly, with implementation of the OSRP and assuming a low volume spill, the intensity of potential impacts on coastal habitat from a mitigated coastal oil spill would likely be reduced to a **Negligible** level. This leads to a magnitude rating of **Negligible**, and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall residual risk to coastal habitats from an unmitigated coastal oil spill would be **Minor** (see Table 9.6-3).

Table 9.6-3: Risk Ratings for Unplanned Event Impacts on Coastal Habitats

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Coastal Habitats	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Oil Spill	Coastal Habitats	Unlikely	Low	Minor	Implement OSRP	Minor

9.7. Coastal Wildlife

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on coastal wildlife include a marine oil spill and a coastal oil spill.

9.7.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Definitions for intensity of impact and sensitivity of receptor were not provided in the assessment of potential impacts on coastal wildlife from planned Project activities because there are no potential impacts on coastal wildlife from planned Project activities. The methodology for determining a rating for risks to coastal wildlife from an unplanned event involves consideration of the intensity of the impacts (assuming the unplanned event was to occur) and the sensitivity of the receptor(s); therefore, they are provided in this section. Table 9.7-1 includes the definitions for the intensity of potential impacts from unplanned events on coastal wildlife, and Table 9.7-2 includes the definitions for the sensitivity of coastal wildlife to impacts from unplanned events.

Table 9.7-1: Definitions for Intensity Ratings for Potential Impacts on Coastal Wildlife

Criterion	Definition
Intensity	Negligible: No discernible change in coastal wildlife behavior or presence in the impacted area.
	Low: Minor behavioral changes exhibited in coastal wildlife or occasional injury or mortality of few individuals that would not measurably impact habitat use, regional population status, or viability of coastal wildlife populations.
	Medium: Regularly observed changes in behavior of coastal wildlife and/or injury and mortality of individuals, but not such that this would affect the long-term viability of regional coastal wildlife populations.
	High: Significant changes in behavior of coastal wildlife or significant injury or mortality that could affect the long-term viability of coastal wildlife populations.

Table 9.7-2: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Coastal Wildlife

Criterion	Definition
Sensitivity	Low: No coastal wildlife species known or expected to occur in the PDA possess unique susceptibilities to Project-related impacts. Impacts, should they occur, would be on individual animals.
	Medium: One or a limited number of coastal wildlife species with elevated susceptibility to Project-related impacts due to prolonged or regular presence in the PDA, and/or one or a limited number of species that exhibit habitat preferences or behaviors that limit their ability to avoid Project-related impacts, but representing a small fraction of the regional or global populations of affected species.

Criterion	Definition
	High: Several coastal wildlife species with elevated susceptibility to Project-related impacts due to prolonged or regular presence in the PDA, and/or several species that exhibit habitat preferences or behaviors that greatly limit their ability to avoid Project-related impacts, representing a substantial fraction of the regional or global populations of affected species.

9.7.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

The shoreline where stochastic modeling indicates a 5 to 20 percent probability of the oil contacting the coast in Region 1 is largely comprised of mangrove forest with high or exceptional quality, which provides habitat for a diversity and abundance of coastal wildlife species, particularly coastal birds and fish (see Section 7.3, Coastal Wildlife). Many coastal wildlife species are dependent on shoreline mangroves and other wetland habitats, which are particularly sensitive to oil spills because of their physical location along the margins of shorelines at the saltwater interface and their physiological responses to oil exposure (e.g., reduced oxygen transfer, reduced ability to maintain salt balance, etc.) (see Section 9.6, Coastal Habitats Unplanned Events). The mangroves, sand beaches, wetlands, and other coastal habitats that line the coast of Region 1 within the SBPA provide some of the highest quality and least disturbed wildlife habitats in Guyana and the area is characterized by rich bird, fish, herpetofauna, and mammal communities (see Section 7.1, Protected Areas and Special Status Species and Section 7.3, Coastal Wildlife). The impacts of unplanned events on marine turtles, marine fish, and riverine mammals are discussed in Sections 9.10, Riverine Mammals [Unplanned Events]; Section 9.11, Marine Turtles [Unplanned Events]; and Section 9.12, Marine Fish [Unplanned Events], respectively, so they are not discussed further in this section.

The EEPGL-commissioned coastal bird surveys conducted along the entire Guyana coastline from 2017 through 2019 identified four Important Bird Habitats along the coastline in Region 1: (1) the SBPA, (2) Pomeroon River mouth, (3) the stretch of beach encompassing Kamwatta Beach, Iron Punt Beach, and Luri Beach, and (4) Waini River Mouth (Section 7.3, Coastal Wildlife). These sites were identified as Important Bird Habitats because they support one or more of the following: (1) predictable congregations of migratory shorebirds; (2) concentrations of roosting and/or nesting wading birds; (3) unique habitat that supports large numbers of riverine forest- and mangrove-dependent species; and (4) important nesting sites for regional endemic species of conservation interest. Specifically, the SBPA contains critically important nesting and foraging habitats for over 200 species of waterbirds and land birds, including several special status species. The Kamwatta/Iron Punt/Luri Beach Complex supports hundreds of Flamingos (multiple species) and thousands of other waterbirds for nesting and feeding. The west bank of the mouth of the Waini River contains a pristine mangrove forest that supports large congregations of colonially roosting and nesting wading birds, such as herons, egrets, and ibis. These sites could be affected by shoreline oiling during an unmitigated marine oil spill.

The most significant impact on coastal birds from an unmitigated spill would occur if oil reached the shoreline or nearshore waters in areas near a large colonial waterbird nesting site during or immediately after the breeding period. During these periods, hundreds to thousands of colonial waterbirds (e.g., herons, ibis, etc.) congregate to nest and feed in nearshore coastal habitats. Waterbirds feed primarily on fish and other aquatic prey, so they would be susceptible to dermal contact and ingestion of oil in the unlikely event that significant quantities of oil were present. This could injure or kill the impacted individual, and oiled adults could transfer oil to their eggs or chicks in the nest, which are highly susceptible to the effects of oil. Such impacts could affect a breeding year for local populations. A similarly high impact would occur for birds if the nearshore or coastal habitats were oiled during spring or fall shorebird migration, when tens of thousands of migratory shorebirds stop over in coastal habitats (primarily mudflats) along Guyana’s coastline, including Region 1, to forage and rest.

Given the abundance and diversity of coastal wildlife and coastal wildlife habitats along the shoreline of Region 1 within the area that could potentially be oiled during an unmitigated oil spill and the definitions provided in Table 9.7-1, the intensity of potential impacts of an unmitigated marine oil spill on coastal wildlife and associated habitats (primarily mangroves) is considered **High**. The geographic extent of an unmitigated loss-of-well-control event would encompass portions of the **Indirect AOI**. On the basis that impacts on coastal wildlife from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, coastal wildlife could gradually recover to some extent—depending on the degree of oiling—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

Using the definitions presented in Table 9.7-2, the sensitivity of coastal wildlife in the areas with the potential to be affected by a marine oil spill is considered **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to coastal wildlife is considered **Moderate**.

With implementation of the OSRP, deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill would not reach the Guyana shoreline. On this basis, the intensity of potential impacts on coastal wildlife in Guyana from a mitigated marine oil spill would be **Negligible** for terrestrial wildlife (species living on land) and **Low** for coastal birds that regularly undergo long distance offshore foraging trips (up to hundreds of kilometers offshore) and so could be exposed to oil in the offshore environment. This leads to a magnitude rating of

Negligible to **Small**, reducing the consequence/severity rating to **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to coastal wildlife from a mitigated marine oil spill would be **Minor** (see Table 9.7-3).

9.7.3. Coastal Oil Spill

A coastal oil spill that reaches a Guyana shoreline would likely only happen near the shorebases to be used by the Project, which are located near the mouth of the Demerara River. The primary wildlife taxa that could be affected by a coastal oil spill in the lower Demerara River are birds, fish, and riverine mammals. The impacts of unplanned events on fish and riverine mammals are discussed in Sections 9.10, Riverine Mammals [Unplanned Events], and Section 9.12, Marine Fish [Unplanned Events], respectively, so they are not discussed further in this section.

Despite the degraded and urbanized nature of coastal habitat in the area that could potentially be impacted by a coastal oil spill, the mangroves lining the west bank of the lower Demerara River and the adjacent coastline support large and diverse populations of nesting, foraging, and roosting coastal birds, particularly waterbirds. Many of the species present in this area congregate in large groups for breeding and roosting and so would be particularly vulnerable to exposure from a coastal oil spill in the Demerara River and/or the Demerara Harbour. Even though the area of impact from a coastal spill would likely be limited, the presence of many birds and other coastal wildlife in this area that live or forage in the water or adjacent habitats creates a high risk of direct or indirect exposure to oil from a coastal oil spill. This exposure could cause similar injury, mortality, and/or behavioral changes in coastal birds in and around the affected area to that described for a marine oil spill above. As such, the intensity of potential impacts on coastal wildlife, particularly birds, from an unmitigated coastal oil spill could, depending on the volume of the release, be **High**. The geographic extent of an unmitigated coastal oil spill would likely be limited to the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather), and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions in Table 9.7-2, the sensitivity of coastal wildlife, particularly birds, in the area that could potentially be impacted by a coastal oil spill is considered **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium**.

In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall pre-mitigation risk to coastal wildlife from an unmitigated coastal oil spill would be **Minor**.

Coastal spills would be quickly controlled and contained because of the relatively small volume of the spill and the ready access to spill control equipment. These impacts would generally be temporary, limited in area and volume of oil released, and readily mitigated, with rapid habitat recovery expected. Accordingly, with implementation of the OSRP and assuming a low volume spill, the intensity of potential impacts on coastal wildlife from a mitigated coastal oil spill would likely be reduced to a **Negligible** level. This leads to a magnitude rating of **Negligible**, and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall residual risk to coastal habitats from an unmitigated coastal oil spill would be **Minor** (see Table 9.7-3).

Table 9.7-3: Risk Ratings for Unplanned Event Impacts on Coastal Wildlife

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Coastal Wildlife	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Oil Spill	Coastal Wildlife	Unlikely	Medium	Minor	Implement OSRP	Minor

9.8. SEABIRDS

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on seabirds include a marine oil spill, non-routine flaring on the FPSO, discharge of untreated wastewater from the FPSO, a collision of a Project vessel with rafting seabirds, and a collision of a Project helicopter with seabirds in flight.

9.8.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Tables 7.4-7 and 7.4-9 in Section 7.4, Seabirds, contain the definitions for intensity of impact and sensitivity of receptor, respectively, for potential impacts on seabirds.

9.8.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Deterministic modeling for both loss-of-well-control scenarios predicts that a spill would generally travel westward (northwest, southwest, and/or west depending on the case and the season) from the source based on the prevailing wind and current. If the oil were to encroach into nearshore environments (within 100 kilometers [62 miles] of the coastline), the affected area within Guyanese waters would be limited to the area off Regions 1 and 2 under all scenarios. The predicted extent of the oil's encroachment into nearshore areas changes seasonally, with the highest probability of oil reaching the coast (and therefore the nearshore environment) in winter. The implication of these model results is that pelagic seabirds would have the highest potential for exposure to oil as the result of a loss-of-well-control event but that under certain conditions nearshore marine birds (a group of seabirds that occurs offshore but most often within nearshore marine environments rather than the open ocean beyond the shelf) could be exposed as well.

In the unlikely event of a marine oil spill, implementation of the OSRP may include use of dispersants for certain types of spill scenarios. While providing a clear benefit for controlling an oil spill, recent research shows that exposure to high concentrations of dispersants can have immediate adverse impacts on some species of seabirds such as Common Murre (*Uria aalge*)

(Whitmer et al. 2018). Whitmer et al (2018) found that at high concentrations, dispersants can have immediate external impacts on affected individuals: murres exposed to high concentrations of dispersant experienced an immediate, life-threatening loss of waterproofing and buoyancy, both of which resolved within two days of exposure. The study also found that the effects of dispersant-treated oil on the birds were similar to those of oil alone. The same factors that would cause rapid dilution of oil in the open ocean (e.g., marine currents, wind, and wave action) would also act to rapidly dilute a dispersant-oil mixture. Since dilution in the marine environment occurs rapidly (especially in areas with strong current activity such as the PDA), the potential for exposure to high concentrations of dispersants and related acute impacts from dispersant or dispersed oil would be limited in duration and space, and chronic exposure is not expected to be a significant factor in the overall risks posed to seabirds during a marine oil spill event. Accordingly, it is concluded that the use of dispersants in alignment with NEBA, as described in the OSRP, generally does not represent an additional risk to seabirds compared to the effects of exposure to oil alone.

9.8.2.1. At Sea (Non-breeding) Exposure

Seabirds occurring in the Stabroek Block are usually flying over the area during migration (or shorter regional dispersals) or foraging for fish and other marine fauna at or just below the water surface. Seabirds also may rest or sleep for brief periods on the water surface. No nesting or other concentrations of seabirds occurs in the PDA or the broader Stabroek Block, although seabirds nesting in Venezuela, Trinidad and Tobago, and other islands in the southern Caribbean fly over the Stabroek Block during local dispersal movements or during long offshore foraging trips.

Seabirds spend most of their life at the air-water interface, where floating oil accumulates (surface slick) after an oil spill (Wiens 1996). As such, seabirds are particularly vulnerable to oil because of their distribution and foraging behavior, which is usually associated with the sea surface or just below the water surface in the open ocean. Contact with crude oil can cause a variety of immediate and direct impacts on seabirds, such as disrupting feather integrity (water-proofing), thermal insulation, and buoyancy (Troisi et al. 2016). Oil on a seabird's feathers can prevent them from diving and flying, which often leads to death because they cannot forage to feed (Troisi et al. 2016). According to Maggini et al. (2017), even small exposures to crude oil can reduce the integrity of feathers and impair flight performance, causing affected birds to use more energy during flight. Moreover, PAHs—a constituent of oil, if ingested through preening and feeding, can cause tissue and plasma contamination (Troisi et al. 2006).

In summary, an oil spill could pose a risk to seabirds through direct and indirect mechanisms, including the following:

- Loss of insulating and water-repelling properties from oiling of plumage, leading to increased mortality;
- Loss or impairment of flight and buoyancy from oiling of plumage, which can render birds unable to feed at sea, which can quickly lead to dehydration and starvation;

- Toxic impacts from the ingestion of hydrocarbons during preening, ingestion of contaminated prey, inhalation of fumes, or absorption of hydrocarbons through skin or eggs, leading to increased mortality;
- Habitat degradation at sea and at island or shoreline breeding sites; and
- Mortality of food resources.

Since most oils float, at least initially following a release, seabirds that spend significant time resting or foraging on the water's surface are most at risk from direct exposure. Diving birds are considered to have the highest risk of oiling: all seabirds dive while foraging.

Depending on the geographic extent of a spill, seabirds may avoid an area affected by a spill, as they are highly mobile and often fly over the Stabroek Block en route to preferred habitats instead of stopping there and coming into contact with the water surface. While some birds may avoid areas affected by a spill by flying over them, in order to do so in the case of an unmitigated marine oil spill, they would need to vacate a large area of the nearshore and offshore environment west of the spill source, depending on season and oceanographic conditions at the time of the spill. Such a widespread event could interrupt or delay migrations (including shorter regional dispersals) and related life-history events (breeding or post-breeding dispersal) during the year of impact but longer-term impacts on migration and related life-history events are not anticipated.

9.8.2.2. Exposure of Breeding Seabirds

For colonially nesting seabird species[8], if a spill occurs during the breeding period and oil reaches a breeding colony or impacts individuals offshore that then introduce oil to the colony, the impacts on seabirds would be more severe compared with spills that are limited to the open ocean and those that occur during the non-breeding season. This is because for most of the year outside the breeding season, seabirds are largely solitary, spending most of their time alone and at sea. But during the breeding season, colonially nesting seabirds typically nest close together on islands or shorelines and forage at higher density in proximity to their nesting sites (but in some cases great distances from the nest sites depending on food availability), making larger numbers of birds and their eggs susceptible to oiling. Reproduction requires a large amount of energy and a bird's demand for food resources can double or triple during the breeding season. If an oil spill causes mortality or contamination of the birds' food resources, it can inhibit the birds' ability to successfully mate and produce eggs (Henkel et al. 2012). Eggs and very young birds are particularly sensitive to oil exposure, which typically causes embryonic mortality in eggs or death from exposure in chicks (Finch et al. 2011). Some seabirds lay only one egg at a time, so they have an already low reproductive rate, which makes these species more susceptible to adverse impacts from spills that occur in the breeding season (because they could lose an entire recruitment year) (NOAA 2016). Unlike in temperate environments, where seabird-breeding

[8] Colonially nesting seabird species are seabirds that nest in groups called colonies. Most seabird species are colonial nesters.

seasons are seasonally restricted and highly predictable, seabird-nesting periods in tropical environments are highly variable and aligned closely with food availability.

No Marine Important Bird Areas (Marine IBAs) (e.g., seabird breeding colonies and surrounding foraging areas, non-breeding concentrations, feeding areas for pelagic species) have been designated in Guyana. Several marine IBAs of global or regional importance to seabirds designated in neighboring countries support globally important breeding populations of multiple seabird species, and breeding seabirds from these colonies are expected to transit the Stabroek Block at least occasionally during long-distance offshore foraging trips. Potential impacts on these areas from an unmitigated oil spill are discussed in Section 9.24, Transboundary Impacts.

Based on the potential impacts on seabirds from an unmitigated marine oil spill (excluding transboundary effects which are discussed in Section 9.24, Transboundary Impacts), the intensity of impacts on seabirds are considered to range from **Medium** (for non-breeding seabirds) to **High** (for breeding seabirds).

The geographic extent of an unmitigated loss-of-well-control event would include portions of the **Indirect AOI**. On the basis that impacts from a loss-of-well-control event would persist as long as the spill remains unmitigated, the frequency is considered to be **Continuous**. Assuming no mitigation, the effects would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large** for both nesting and non-nesting seabirds.

Based on the sensitivity ratings developed for potential impacts on seabirds from planned activities, a sensitivity rating of **Medium** is assigned for seabirds.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to seabirds is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by limiting the geographic extent of the oil spill, the duration over which the spill would be present on the water surface, and the number of individual birds potentially impacted.

9.8.3. Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume

The FPSO will have a flare system for the collection and safe disposition of produced hydrocarbon gases resulting from unplanned, non-routine maintenance or repairs, or emergency shutdown events. Should flaring occur, it would emanate from a flare tower located on top of the FPSO.

While individual seabirds could be significantly impacted through contact with the FPSO flare tower, its flame, or its radiant heat plume, the likelihood of a seabird colliding with the tower or being present in the heat zone when temporary, non-routine flaring is occurring is extremely low. To date, marine bird surveys conducted on behalf of EEPGL since 2017 have not documented flocking birds in the Stabroek Block. While this does not preclude the possibility of a flock to occur, it is considered relatively rare and any such flocks would likely be small. Even during migration, most individuals are solitary or flying in loose groups (spread out spatially). Accordingly, in the unlikely circumstance that such an event occurred, it would likely only impact a single individual and have no discernable effect on any bird population.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the intensity of potential impacts on seabirds from non-routine flaring on the FPSO is considered **Low**. The geographic extent of non-routine flaring on the FPSO would be limited to the **Direct AOI**. The frequency of non-routine flaring would be **Episodic** because it would occur infrequently and at irregular intervals. The duration of non-routine flaring is considered to be **Short-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the sensitivity of seabirds to impacts from non-routine flaring is considered **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. In combination with a likelihood rating of **Possible**, the (pre-mitigation) risk to seabirds from non-routine flaring is considered **Minor**. There are no mitigation measures that can be applied to further reduce this potential impact. As such, the overall residual risk to seabirds from non-routine flaring would be **Minor** (see Table 9.8-1).

9.8.4. Discharge of Untreated Wastewater from the FPSO

A discharge of untreated wastewater (i.e., sewage or black water) from the FPSO would only occur under an equipment failure scenario and would involve release of untreated wastewater directly overboard. Such a discharge would have localized impacts on water quality, but conditions that could cause such a release would generally be rectified within a short period of time. The primary constituents in wastewater include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), carbon, nutrients (primarily nitrogen and phosphorous), and pathogens such as coliform. The affected area of ocean would be somewhat larger than the mixing zone associated with normal operations, but not so large that the event would be regionally significant. As described in Section 9.1.11, Untreated FPSO Wastewater Discharge, modeling results show that the temporary release of untreated wastewater would result in a plume of limited extent and that constituent concentrations would not be expected to exceed the end-of-pipe levels recommended by the IMO's 2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants (IMO 2012).

A seabird foraging in the water or resting on the water surface could come into dermal contact with the wastewater plume or an individual may ingest a small amount of wastewater during foraging. The character (constituents and concentration) of the wastewater plume would not expose seabirds to toxic effects (injury or mortality) and no dermal effects from contact of the wastewater with a seabird's skin or feathers would be expected.

The geographic extent of a discharge of untreated wastewater from the FPSO would be limited to the **Direct AOI**. Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the intensity of potential impacts of a discharge of untreated wastewater from the FPSO is considered **Negligible**. The frequency of a discharge of untreated wastewater from the FPSO would be **Episodic** because it would occur infrequently (if ever). The duration of this impact would be **Short-term**, as it would assimilate into the ocean quickly. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the sensitivity of seabirds to impacts from a discharge of untreated wastewater from the FPSO is considered **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously in order for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. These factors yield a (pre-mitigation) risk rating to seabirds from a discharge of untreated wastewater from the FPSO of **Minor**.

Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would be **Minor** (see Table 9.8-1).

9.8.5. Collision of a Project Vessel with Rafting Seabirds

Rafting seabirds may suffer injury or mortality from collision with vessels transiting to and from the PDA. However, rafters are not likely to be present in large aggregations in the PDA because of the metocean conditions offshore Guyana—namely a strong surface current, which is likely to make the surface waters unsuitable for the large aggregations of species that favor more calm and sheltered conditions. Seabird data collected in the Stabroek Block from 2015 through 2019 did not document any concentrations of rafting seabirds in the area. No more than three individuals were observed at a time in offshore areas beyond 100 kilometers (approximately 62 miles) from shore. Should rafting seabirds be present in the PDA, individuals could be susceptible to vessel strike and related injury or mortality. However, large seabird rafts are easily detectible by oncoming vessels, and these vessels could maneuver to avoid them if the birds do not move out of the vessels' path. Observations recorded during EEPGL-commissioned marine bird surveys from 2017 through 2019 document that birds present on the water surface move in response to oncoming vessels. In the unlikely event such an interaction would occur, it would be limited to a few individuals.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the intensity of potential impacts on seabirds from collision of a Project vessel with rafting seabirds is considered **Low**. On the basis that vessel traffic will be a consistent presence in the **Direct AOI**, the frequency and duration are considered to be **Continuous** and

Long-term. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the sensitivity of seabirds to impacts from collision of a Project vessel with rafting seabirds is considered **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. As an embedded control, vessel captains are trained to recognize rafting seabirds and avoid them if possible. This, combined with the expected rare occurrence of rafting seabirds in the PDA, yields a likelihood rating of **Unlikely**; the (pre-mitigation) risk to seabirds from collision of a Project vessel with rafting seabirds is considered **Minor**. There are no additional mitigation measures that can be applied to further reduce this potential impact. As such, the residual risk to seabirds from this impact would remain **Minor** (see Table 9.8-1).

9.8.6. Collision of a Project Helicopter with Seabirds in Flight

Helicopters will be used as a form of transit to/from the Guyana shorebases and offshore vessels, and could adversely impact seabirds through helicopter strikes of individuals flying near helicopters transiting around or in route to/from the drill ships, the FPSO, and major installation vessels. Logistical support will be optimized and shared among Liza Phase 1, Liza Phase 2, and Payara. It is estimated that during development drilling and FPSO/SURF installation, helicopter flights may increase at peak to a total of approximately 45 to 55 round-trip flights per week. During FPSO/SURF production operations, an estimated maximum of 20 to 30 round-trip flights per week will be necessary to support FPSO/SURF production operations and continued development-drilling activities.

Considering this estimated quantity of flights, and based on the relatively low seabird density in the Project AOI during most of the year, the number of helicopter-bird interactions is expected to be very low. In the unlikely event such an interaction would occur, it would likely be limited to a single individual.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the intensity of potential impacts on seabirds from collision of a Project helicopter with seabirds in flight is considered **Low**. On the basis that helicopter traffic will be a consistent presence in the **Direct AOI**, the frequency and duration are considered to be **Continuous** and **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the sensitivity of seabirds to impacts from collision with a Project helicopter is considered **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely**, the (pre-mitigation) risk to seabirds from collision of a Project helicopter with seabirds in flight is considered **Minor**. Aside from pilot avoidance of flying seabirds, which is a standard safety protocol and an embedded control, there are no mitigation measures that can be applied to further reduce this potential impact. As such, the residual risk to seabirds from this impact would remain **Minor** (see Table 9.8-1).

Table 9.8-1: Risk Ratings for Unplanned Event Impacts on Seabirds [a]

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Seabirds	Unlikely	High	Moderate	Implement OSRP	Minor
Flaring	Seabirds	Unlikely	Low	Minor	None	Minor
Discharge of untreated wastewater from the FPSO	Seabirds	Unlikely	Low	Minor	None	Minor
Vessel strike	Seabirds	Unlikely	Low	Minor	None	Minor
Helicopter strike	Seabirds	Unlikely	Low	Minor	None	Minor

[a] Excludes listed seabirds, which are covered in Section 9.5, Protected Areas and Special Status Species [Unplanned Events]

9.9. Marine Mammals

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on marine mammals include a marine oil spill, a coastal oil spill, a collision of a Project vessel with a marine mammal, and a discharge of untreated wastewater from the FPSO.

9.9.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Tables 7.5-5 and 7.5-6 in Section 7.5, Marine Mammals, contain the definitions for intensity of impact and sensitivity of receptor, respectively, for impacts on marine mammals.

9.9.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

Twenty-six species of marine mammal species, including 10 species of dolphins and 16 species of whales, are known to occur off Guyana, including one species (the sperm whale [*Physeter microcephalus*]) that is classified by the IUCN as Vulnerable. As described in Section 7.5.2, Existing Conditions—Marine Mammals, the most common species identified during Protected Species Observer (PSO) surveys in the Stabroek Block conducted from 2015 through 2019 include spinner dolphins (*Stenella longirostris*), pantropical spotted dolphins (*Stenella attenuate*) and clymene dolphins (*Stenella clymene*). The two most common identified whales were Bryde's whales and sperm whales. There is little available information on the population size or seasonal distribution of marine mammals in the region.

Marine mammals are vulnerable to oil contamination in a variety of ways, including mortality. Marine mammals may be exposed to oil through inhalation, ingestion, and dermal pathways. Oil contamination can occur when they surface to breathe or breach in an area with oil. Exposure to oil may harm their respiratory tissue and eyes, and increase their susceptibility to infections. The risk to marine mammals would be greatest close to the spill location, where there is a higher proportion of volatile compounds still present in and around the surface slick. The impacts of oil contamination can vary by species. For instance, baleen whales may be more susceptible to such impacts than toothed whales because of the potential for oil to foul their baleen plates if the whales filter-feed in the vicinity of the oil spill. In addition to direct impacts, marine mammals also may be indirectly impacted by an oil spill through increased exposure to sound and risk of injury from strikes by response vessels (see below).

Based on the total number of visual and acoustic detections documented during PSO surveys in and near the Project AOI from 2015 through 2019 (see Section 7.5.2, Existing Conditions—Marine Mammals), the risk from an oil spill to marine mammals would likely be highest in November and lowest in May; for spills in the summer, dolphins and whales would both be at risk, but the risk to dolphins would be higher than to whales (based on a higher frequency of dolphins during this season). If a spill were to occur in the December to May season, the risk would shift primarily to dolphins, as the predicted swept area would shift to the comparatively shallower continental shelf[9], where whales have not been detected.

Based on the potential impacts on marine mammals from oil spills described above and using the definitions established for assessment of potential impacts on marine mammals from planned Project activities, the intensity of potential impacts of an unmitigated marine oil spill on marine mammals is considered **High**. The geographic extent of an unmitigated loss-of-well-control event would encompass portions of the **Indirect AOI**. On the basis that impacts on marine mammals from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, the marine environment would gradually recover to some extent—depending on the degree of oiling—but impacts could still persist beyond a year, yielding a **Long-term** duration.

Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**. Using the definitions established for assessment of potential impact on marine mammals from

[9] The relatively shallow area of seabed surrounding extending from the coast to the edge of the continental slope

planned Project activities, the sensitivity of marine mammals to impacts from an unmitigated marine oil spill is considered **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to marine mammals from a marine oil spill is considered **Moderate**.

Effective implementation of the OSRP limit the geographic extent of the oil spill, the duration over which the spill would be present on the water surface, and the number of individual marine mammals potentially impacted. As such, this would be expected to reduce the intensity of the impact of a mitigated oil spill on marine mammals to **Medium** and the duration of the spill event to **Medium-term**. This results in a reduced magnitude rating of **Medium** for a mitigated oil spill. Combined with the sensitivity rating of **Medium** assigned for potential impacts on marine mammals from planned activities, this yields a consequence/severity rating of **Medium**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the residual risk to marine mammals from a mitigated marine oil spill would be **Minor**.

9.9.3. Coastal Oil Spill

As described in Section 9.1.1.9, an unmitigated coastal oil spill that reaches a Guyana shoreline would likely only happen near the shorebases to be used by the Project, which are located near the mouth of the Demerara River. A temporary, visible oil sheen on the water surface may occur and water quality would be temporarily impaired in a localized area, but long-term or ecosystem-level impacts on marine mammal habitat would not likely occur because a coastal oil spill is expected to be contained within a small area and controlled in a short period.

Several marine mammals occur coastal waters and rivers in Guyana and could be impacted by a coastal oil spill if present in the affected area during or immediately after the spill event, including boto (*Inia geoffrensis*) and tucuxi (*Sotalia fluviatilis*), Guiana dolphin (*Sotalia guianensis*), and common bottlenose dolphin (*Tursiops truncatus*). An unmitigated coastal oil spill in the lower Demerara River could affect marine mammals in a similar way to that described above for a marine oil spill. However, fewer marine mammals are expected to occur in the lower Demerara River where exposure to a coastal oil spill could occur. Yet, in a confined area like the Demerara River, these species, if present, would have reduced ability to avoid contact with spilled oil, compared to the open ocean.

Despite the expected lower number of individuals to be impacted from an unmitigated coastal spill, the intensity of potential impacts on marine mammals from an unmitigated coastal oil spill would likely be **High**. The geographic extent of a coastal oil spill would include the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather), and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions established for assessment of potential impact on marine mammals from planned Project activities, the sensitivity of marine mammals that could potentially be impacted by a coastal oil spill is rated **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall (pre-mitigation) risk to marine mammals from an unmitigated coastal oil spill would be **Minor**.

Coastal spills would be quickly controlled and contained because of the relatively small volume of the spill and the ready access to spill control equipment. These impacts would generally be temporary, limited in area and volume of oil released, and readily mitigated, with rapid habitat recovery expected. Accordingly, with implementation of the OSRP and assuming a low volume spill, the intensity of potential impacts on marine mammals from a mitigated coastal oil spill would likely be reduced to no more than **Medium**. This leads to a magnitude rating of **Medium**, and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall residual risk to marine mammals from an unmitigated coastal oil spill would be **Minor** (see Table 9.9-1).

9.9.4. Vessel Collision

As described in Section 9.1.10.2, Vessel Collision with a Marine Mammal, marine mammals are inherently vulnerable to vessel strikes when they swim near the surface or surface to breathe or feed. This vulnerability increases in shallow, nearshore areas, where opportunities to maneuver are reduced by the water depth. Vessel collisions or strikes to whales are among the greatest threats and causes of death of whales, especially in regions with high aggregations (feeding and breeding) of whales and high volumes of vessel traffic (Peel et al. 2018). A vessel encounter can cause harm, injury, or mortality, and temporary behavior changes to marine mammals. Larger, faster vessels moving at speeds above 13 knots pose a greater risk for collision with a marine mammal than smaller, slower vessels, which are also more maneuverable (Laist et al. 2001). Currently, no records of vessel collisions with marine mammals are known for Guyana, but this lack of reports does not necessarily indicate vessel collision with marine mammals does not occur since such incidents may not be reported or vessel operators may not be even aware of a collision event. As described in Section 7.5.2, Existing Conditions—Marine Mammals, the largest and least maneuverable marine mammals (i.e., the large whales) are only found in the deep portions of the Project AOI. Vessel speeds will be lower within the PDA relative to transit to/from the shorebase, so only a portion of the Project AOI outside the PDA would have vessels operating at higher speeds (over 13 knots) that could reduce their ability to avoid a collision with a marine mammal and have a reasonable expectation of encountering a large whale. Support vessels will operate at higher speeds when transiting the continental shelf, but the only marine mammals they are likely to encounter on the continental shelf are dolphins, which are agile by comparison and much more likely to avoid a vessel strike than the larger whales.

As an embedded control, EEPGL will provide awareness training to Project-dedicated marine personnel to recognize and spot marine mammals, and will provide standing instructions to Project-dedicated vessel masters on what to do if they encounter marine mammals while in transit (e.g., reduce vessel speed or deviate from course, as needed, to lower the probability of a collision with a marine mammal).

Using the definitions established for assessment of potential impact on marine mammals from planned Project activities and considering the above information, the intensity of potential impacts on marine mammals as a result of vessel collision is considered **Medium**. The geographic extent of potential vessel collision with a marine mammal would be limited to the **Direct AOI**. On the basis that vessel traffic will be a consistent presence in the **Direct AOI**, the frequency and duration are considered to be **Continuous** and **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions established for sensitivity of marine mammals to impacts from planned Project activities, the sensitivity of marine mammals is considered **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium**.

As stated previously, few large whales occur in the PDA, vessels will be moving at low speeds in the PDA, and embedded controls will minimize the potential for a vessel collision with a whale. If it were to occur, it would be at most infrequent. However, given the length of the Project life cycle (at least 20 years), a collision with a marine mammal is considered **Possible**, so the overall (pre-mitigation) risk to marine mammals, particularly whales, from a vessel collision is considered **Moderate**. All of the available measures to minimize the risk of a collision have been included in the Project design as embedded controls and are therefore reflected in the initial risk rating. Accordingly, the residual risk rating is maintained at **Moderate** (see Table 9.9-1).

9.9.5. Untreated FPSO Wastewater Discharge

A discharge of untreated wastewater from the FPSO would only occur under an equipment failure scenario, and would involve the release of untreated wastewater directly overboard through an outfall. The untreated discharge would have localized impacts on water quality, but it is expected the release would be rectified and controlled within a short period of time. The primary constituents in wastewater would include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), carbon, nutrients (primarily nitrogen and phosphorous), and pathogens, such as coliform. The affected area would likely be somewhat larger than the mixing zone associated with normal operations, but not large enough to cause a regional significant event. As described in Section 9.1.11, Untreated FPSO Wastewater Discharge, modeling results show that a temporary release of untreated wastewater would result in a plume of limited extent and that constituent concentrations never exceed the end-of-pipe levels recommended by the IMO’s 2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants (IMO 2012).

Marine mammals in the area at the time of the accidental release could be exposed to the wastewater plume by ingesting of a small amount of wastewater during foraging or unintentionally swimming through the plume and having it contact their skin (dermal). However, given the constituents and associated concentrations, the wastewater plume would not expose marine mammals to toxic effects (injury or mortality). Untreated wastewater discharge is a major form of marine pollution in some locations around the world where wastewater treatment facilities are either limited or non-existent. Under specific conditions and concentrations, untreated wastewater discharge can harm marine organisms, especially in coastal waters with limited flow or water exchange (NRC 1993). An untreated wastewater discharge from the FPSO would occur in the open ocean and the discharge would be expected to rapidly assimilate into the ocean, significantly limiting potential exposure of a marine mammal to the discharge.

The geographic extent of an accidental discharge of untreated wastewater from the FPSO would be limited to the **Direct AOI**. Using the definitions established for assessment of potential impact on marine mammals from planned Project activities, the intensity of potential impacts of a discharge of untreated wastewater from the FPSO is considered **Negligible**. The frequency of a discharge of untreated wastewater from the FPSO would be **Episodic** because, if it were to occur, it would occur infrequently. The duration of this impact would be **Short-term**, as the discharge would assimilate into the ocean quickly and occur for less than a week in aggregate for the life of the Project (at least 20 years). Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessment of potential impact on marine mammals from planned Project activities, the sensitivity of marine mammals to impacts from a discharge of untreated wastewater from the FPSO is considered **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously in order for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. These factors yield a (pre mitigation) risk rating to marine mammals from a discharge of untreated wastewater from the FPSO of **Minor** (see Table 9.9-1). Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would therefore be retained at **Minor**.

Table 9.9-1: Risk Ratings for Unplanned Impacts on Marine Mammals

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Mammals	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Oil Spill	Marine Mammals	Unlikely	Medium	Minor	Implement OSRP	Minor
Vessel Collision	Marine Mammals	Possible	Medium	Moderate	None	Moderate
Untreated FPSO Wastewater Discharge	Marine Mammals	Unlikely	Low	Minor	None	Minor

9.10. RIVERINE MAMMALS

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on riverine mammals include a marine oil spill, a coastal oil spill, and collision of a Project vessel with a riverine mammal.

9.10.1. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

Two of the five riverine mammal species known to occur in Guyana—the West Indian manatee and the neotropical otter—occur in coastal environments during at least part of the year, but would only be vulnerable to exposure in the case of an unmitigated marine oil spill that reached the Guyana coastline. Very little is known about the population size and distribution of West Indian manatee and neotropical otter along Guyana's coastline, but both species have been documented in Region 1 within the SBPA (Mendonca et al. 2006; EPA et al. 2004; see Appendix Q, Flora and Fauna of Shell Beach). The other three riverine mammal species that occur in Guyana—the giant otter, gray river dolphin, and Amazon river dolphin—are freshwater species that are not likely to be encountered within areas that could be affected by an unmitigated marine oil spill that reaches the Guyana coastline.

Limited information is available describing the impacts of oil spills on the West Indian manatee and there are no published accounts linking an oil spill or dispersants to mortality of a manatee (Fingas 2015). Nonetheless, the manatee is highly vulnerable to an oil spill along the coast because manatees are aquatic herbivores that feed on seagrass and other aquatic vegetation at or near the water surface, so when feeding they could ingest oil that is present on or near the water surface (Fingas 2015). Further, manatees do not make long migrations because they are limited by water temperature and food. As such, an oil spill that reached coastal waters could negatively impact the available food supply for this species (Fingas 2015). Also, exposure to oil could directly impact a manatee by coating its skin and possibly causing toxic effects, such as irritation to the nose, eyes, and respiratory system (Fingas 2015). For many of the same reasons, neotropical otters also can be negatively impacted by oil spills, especially if the oil is carried into a riverine system. An oil spill that reaches the coastline could impact the neotropical otter's prey, which is mostly fish and crustaceans. In the unlikely event of a marine oil spill that reached the coast, West Indian manatees and neotropical otters occurring along the coastline in Region 1 that could be exposed to an unmitigated marine oil spill would be expected to move up river (inland) to avoid or escape oil contamination.

Using the definitions established for assessment of potential impact to riverine mammals from planned Project activities, the intensity of potential impacts of an unmitigated marine oil spill on riverine mammals is considered **Low** because any riverine mammals present along the coastline in Region 1 during an unmitigated spill event would be expected to move upriver away from the spill zone, limiting the number and exposure time of individuals that could be impacted. The geographic extent of an unmitigated loss-of-well-control event would encompass portions of the **Indirect AOI**. On the basis that impacts on riverine mammals from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, the coastal environment would gradually recover to some extent—depending on the degree of oiling—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Small**.

Using the definitions established for assessment of potential impact to riverine mammals from planned Project activities, the sensitivity of riverine mammals to impacts from an unmitigated marine oil spill is considered **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to coastal habitats is considered **Minor**.

Mitigation for a marine oil spill would involve implementation of the OSRP. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill would not reach the Guyana shoreline or come close enough to the Guyana shoreline to impact riverine mammal habitat. On this basis, the intensity of potential impacts on riverine mammals in Guyana from a mitigated marine oil spill would be **Negligible** for all spill scenarios considered. This leads to a magnitude rating of **Negligible** and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to riverine mammals from a mitigated marine oil spill would be **Minor** (see Table 9.10-1).

9.10.2. Coastal Oil Spill

As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, an unmitigated coastal oil spill that reaches a Guyana shoreline would likely only happen near the shorebases to be used by the Project, which are located near the mouth of the Demerara River. Of the five riverine mammal species known to occur in Guyana, only the West Indian manatee and river otter are known to occur in the brackish/intertidal waters of the Demerara Harbour and the lower Demerara River where a coastal spill could occur.

A temporary, visible oil sheen on the water surface may occur and water quality would be temporarily impaired in a localized area, but long-term or ecosystem-level impacts on riverine mammal habitat would not occur.

An unmitigated coastal oil spill in the lower Demerara River could affect West Indian manatees and neotropical otters in a similar way to that described above for a marine oil spill. Few manatees and neotropical otters are expected to occur in the lower Demerara River where exposure to a coastal oil spill could occur.

The habitat and water quality in the lower Demerara River is degraded from human use and has likely been exposed to small oil or fuel spills in the past. As such, riverine mammals in this area are expected to be somewhat tolerant of degraded environmental conditions. Coupled with the likely small area of impact from a coastal spill, this indicates the intensity of potential impacts on riverine mammals from an unmitigated coastal oil spill would likely be **Low**. The geographic extent of an unmitigated coastal oil spill would likely be limited to the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

Using the definitions established for assessment of potential impact to riverine mammals from planned Project activities, the sensitivity of riverine mammals that could potentially be impacted by a coastal oil spill is rated **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**.

In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall pre-mitigation risk to riverine mammals from an unmitigated coastal oil spill would be **Minor**.

Coastal spills would be quickly controlled and contained because of the relatively small volume of the spill and the ready access to spill control equipment. These impacts would generally be temporary, limited in area and volume of oil released, and readily mitigated, with rapid habitat recovery expected. Accordingly, with implementation of the OSRP and assuming a low volume spill, the intensity of potential impacts on riverine mammals from a mitigated coastal oil spill would likely be reduced to a **Negligible** level. This leads to a magnitude rating of **Negligible**, and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall residual risk to riverine mammals from an unmitigated coastal oil spill would be **Minor** (see Table 9.10-1).

9.10.3. Vessel Collision

Riverine mammals likely to occur within the nearshore and riverine zone of the PDA are vulnerable to vessel collision when they surface to breathe or to feed. This vulnerability increases in shallow areas, where there are fewer opportunities to maneuver compared to the open ocean. Vessel routes within the PDA are restricted to the channel of the Demerara Harbour, which is relatively deep, thereby increasing the opportunity for riverine mammals to maneuver away from passing vessels. Of the five riverine mammal species known to occur in Guyana, only the West Indian manatee and river otter are known to occur in in the brackish/intertidal waters of the Demerara Harbour and the lower Demerara River where Project-related vessel traffic will occur (and only the manatee has been observed in the first two riverine mammal survey events conducted in 2019).

The Neotropical otter, if present in the lower Demerara River, would most likely occur along the banks of the river and along the coastline of the Demerara Harbour. Vessel routes within the PDA are restricted to the main channel of the Demerara Harbour and river where neotropical otters are not expected to regularly occur. Further, otters are very agile swimmers and would be expected to swim away from approaching vessels, avoiding collision. As such, vessel collision with a neotropical otter is not expected to occur and is not discussed further.

The West Indian manatee, however, would be susceptible to vessel collision within the lower Demerara River. It is well documented that manatees are highly vulnerable to vessel collision, and vessel collision is one of the leading causes of death and considered the greatest adverse impact on the population growth rate of the Florida manatee population (Deutsch and Reynolds 2012; Runge et al. 2007). Less is known about the degree to which vessel collision affects the West Indian manatee population in the Caribbean, but vessel collision is listed by IUCN as one of the key threats to this subpopulation of manatees (IUCN 2019). In Florida, even with vessel restrictions aimed at reducing vessel collisions with manatees (e.g., no wake zones and reduced boat speeds), around 30 percent of annual manatee mortality is attributable to vessel collisions (Aipanjiguly et al. 2003; Nowacek 2004). One of the reasons that manatees are frequently struck by vessels is that manatees spend most of their time at the water surface or within several feet of the water surface, which is within the strike depth of most vessels (Edwards et al. 2016). Rycyk et al. (2018) reported that manatees responded to boats, changing their orientation, depth, and fluking (i.e., using tail fluke for movement or positioning in the water) behavior most often when a boat approached closely (within about 10 meters [30 feet]). Manatees were also more likely to change their depth or swimming behavior when not on a seagrass bed. Boat speed did not affect the occurrence or intensity of manatee response, but slower passes allowed the manatee more time to respond, and behavioral change occurred earlier relative to the time of the boat's closest point of approach. Faster boats therefore likely pose a greater risk of collision with manatees than slower boats.

Collision between a Project vessel and a West Indian manatee could cause injury or mortality to the affected individual or temporary behavioral changes, but manatees in this area are accustomed to the presence of vessels and are therefore expected to exhibit some level of avoidance behavior when vessels are passing through. No records of vessel collisions with manatees are known from Guyana, although the lack of documentation of vessel collisions with manatees does not necessarily indicate that this impact does not occur - since such incidents may not be reported or vessel operators may not be aware of a collision event. Very few manatees are expected to occur in the lower Demerara River, so vessel collision with a manatee, if it were to occur, would be very infrequent.

As an embedded control, EEPGL will provide awareness training to Project-dedicated marine personnel to recognize signs of riverine mammals at the river or harbor surface, and will provide standing instruction to Project-dedicated vessel masters to avoid riverine mammals while in transit and reduce speed or deviate from course, as needed, to reduce the probability of collision with a riverine mammal.

Using the definitions established for assessment of potential impact to riverine mammals from planned Project activities and considering the above information, the intensity of potential impacts on riverine mammals as a result of vessel collision is considered **Low**. The geographic extent of potential vessel collision with a riverine mammal would be limited to the **Direct AOI**. On the basis that vessel traffic will be a consistent presence in the **Direct AOI**, the frequency and duration are considered to be **Continuous** and **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

Using the definitions above in Table 9.10-2, the sensitivity of riverine mammals is rated **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**.

As stated previously, very few manatees occur in the PDA so vessel collision with a manatee, if it were to occur, would be very infrequent. However, given the length of the Project life cycle (at least 20 years), a collision with a riverine mammal is considered **Possible**, so the overall (pre-mitigation) risk to riverine mammals from a vessel collision is considered **Minor**. All of the available measures to minimize the risk of a collision have been included in the Project design as embedded controls and are therefore reflected in the initial risk rating. Accordingly, the residual risk rating is maintained at **Minor** (Table 9.10-3).

Table 9.10-1: Risk Ratings for Unplanned Events on Riverine Mammals

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Riverine Mammals	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Oil Spill	Riverine Mammals	Unlikely	Low	Minor	Implement OSRP	Minor
Vessel Collision	Riverine Mammals	Possible	Low	Minor	None	Minor

9.11. MARINE TURTLES

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on marine turtles include a marine oil spill, a collision between a Project vessel and a marine turtle, and a discharge of untreated wastewater (i.e., sewage or black water) from the FPSO.

9.11.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Tables 7.7-4 and 7.7-5 in Section 7.7, Marine Turtles, contain the definitions for intensity of impact and sensitivity of receptor, respectively, for impacts on marine turtles.

9.11.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Deterministic modeling for both loss-of-well-control scenarios predicts that a spill would generally travel westward (northwest, southwest, and/or west depending on the case and the season) from the source based on the prevailing wind and current. If the swept area were to encroach onto the continental shelf[10], the affected area within Guyanese waters would be limited to the portion of the continental shelf off Regions 1 and 2 under all scenarios. The predicted extent of the oil's encroachment onto the continental shelf changes seasonally, with the highest probability of oil reaching the coast (and therefore a larger portion of the continental shelf) in winter. The implication of these model results is that marine turtles in the open ocean would have the highest potential for exposure to oil as the result of a loss-of-well-control event, but that under certain conditions marine turtles on the continental shelf or near the shore could be exposed as well.

Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

The shoreline where stochastic modeling of an unmitigated marine oil spill indicates a 5 to 20 percent probability of the oil contacting the coast (Region 1) provides nesting habitat for four species of marine turtles (see Section 7.7, Marine Turtles) (Alvarez-Varas 2016). Stochastic modeling indicates that the minimum time for oil to reach the Guyana shoreline in this area would be between 5 and 25 days, depending on spill scenario and season.

In the unlikely event of a marine oil spill, several aspects of marine turtle biology place them at particular risk across all of their life stages. Marine turtles nest on sandy beaches. If such beaches were to become oiled, the laid eggs may be contaminated from oil entering the nest or adult turtles picking up oil and depositing it in the nest as they cross the beach. The eggs are susceptible to oil through absorption, which can inhibit their development, but that can depend on various factors, such as oil concentration and exposure durations (USFWS 1982). For instance, the USFWS (1982) reported that hatchling morphology (smaller hatchlings) was adversely impacted by the oil amount (increasing amounts). Besides oiling of nests, newly hatched turtles can be exposed to oil after emerging from their nests and crossing an oiled beach on their way to the water. All life stages of marine turtles (hatchlings, juvenile, sub-adults, and adults) can be exposed to oil through inhalation, ingestion, and dermal contact with varying effects (USFWS 1982; Mitchelmore et al. 2017).

Several aspects of marine turtle behavior compound their biological susceptibility to oil:

- Lack of avoidance behavior—there is no evidence that marine turtles will avoid areas of oil contamination (NOAA 2010);

[10] The relatively shallow area of seabed surrounding extending from the coast to the edge of the continental slope

- Indiscriminate feeding—marine turtles have a habit of ingesting floating objects (NOAA 2010; Schuyler et al. 2012), which can include the ingestion of oil-fouled food and floating tar balls they mistake for food; and
- Large pre-dive inhalations—if turtles surface to breathe in a fresh slick, the oil can impact their eyes and damage their airways and/or lungs, especially with their large pre-dive breaths, which can introduce airborne toxins deep into their respiratory system (NOAA 2010). This risk will be greatest in areas where fresh oil is present that has high levels of aromatic compounds and volatiles directly above the slick.

Using the definitions established for assessment of potential impact on marine from planned Project activities, the intensity of impacts from an unmitigated marine oil spill is considered **High**.

The geographic extent of an unmitigated loss-of-well-control event would encompass portions of the **Indirect AOI**. On the basis that impacts on marine turtles from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, the marine environment (and hence the turtles present there) could gradually recover to some extent—depending on the degree of oiling—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

Using the definitions presented in Table 9.11-1, the sensitivity of marine turtles in the areas with the potential to be affected by a marine oil spill is considered **High**. This takes into consideration their susceptibility to oil contamination, the presence of individual turtles, important nesting sites in the Project AOI, and their protected status.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to marine turtles is considered **Moderate**.

Effective implementation of measures to stop the spill and/or contain it would reduce the geographic extent of the spill, the duration over which the spill would be present on the water surface, and the number of individual turtles potentially impacted. If applied, dispersants may increase the geographic extent of the slick and/or concentrations of oil entrained in the upper portions of the water column and thus marine turtles' exposure to near-surface entrained oil; however, the NEBA process would optimize use of dispersant such that the benefits would be expected to outweigh the negative effects of increased concentrations of emulsified or entrained oil near the surface. Accordingly, the intensity of such an impact would be reduced to **Medium** for marine turtles. The geographic extent of an unmitigated loss-of-well-control event would include portions of the **Indirect AOI**. On the basis that the loss-of-well-control event would continue for several weeks, the frequency is considered to be **Continuous**. Assuming mitigation of the spill, the effects would be reduced to less than a year, so duration would be reduced to **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of a mitigated marine oil spill of **Medium** for marine turtles.

With the sensitivity rating for marine turtles rated as **High**, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High** for marine turtles. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**, so the overall risk of a marine oil spill to marine turtles would remain **Moderate**.

9.11.3. Vessel Collision

Project support vessels (marine vessels) will consist of multiple platform-supply vessels and a fast-supply vessel conducting resupply trips to the FPSO and drill ships, tug vessels supporting tanker-offloading activities, and multi-purpose vessels supporting subsea installation and maintenance activities. Based on current drilling activities and past experience with similar developments, it is estimated that during development drilling and FPSO/SURF installation an average of approximately 12 to 15 round-trips per week may be made to the Payara PDA by marine vessels. During FPSO/SURF production operations, it is estimated that this number will be reduced to approximately 7 to 10 round-trips per week. The vessels will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad.

Similar to marine mammals, marine turtles are vulnerable to vessel strikes when they surface to breathe. Marine turtles are inherently more vulnerable to vessel strikes when they swim near the surface or surface to breathe because they are within the strike zone of vessels. This vulnerability extends to shallow, nearshore areas, where turtles congregate prior to coming ashore to nest. Vessel speeds will be low within the PDA and higher when transiting the continental shelf, where the water is shallower in proximity to the shoreline, but no planned Project vessel movements will occur on the western portion of Guyana's continental shelf near the marine turtles' nesting beaches, and hence, where they congregate during the pre-nesting period. Therefore, Project vessels do not have a reasonable expectation of encountering a mature turtle with eggs on her way to the nesting beaches, or encountering dense congregations of turtles.

Further, as an embedded control, EEPGL will provide standing instructions to Project-dedicated vessel masters on what to do if they encounter marine turtles while in transit (i.e., reduce vessel speed or deviate from course, when possible, to lower the probability of a collision with a marine turtle). Vessel masters will be instructed to reduce their speed within 300 meters (984 feet) of observed sea turtles and will not approach within 100 meters (328 feet) of the animals.

Using the definitions established for assessment of potential impact on marine turtles from planned Project activities and considering the above information, the intensity of potential impacts on marine turtles as a result of vessel collision is considered **Medium**. The geographic extent of potential vessel collision would be limited to the **Direct AOI**. On the basis that vessel traffic will be a consistent presence in the **Direct AOI**, the frequency and duration are considered to be **Continuous** and **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions established for sensitivity of marine turtles to impacts from planned Project activities, the sensitivity of marine turtles to a vessel strike was assessed based on the conservative assumption that a Critically Endangered or Endangered species would be affected, which assigns a sensitivity rating of **High**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**.

Although no formal population estimates for the number of turtles occurring in the region at any given time of the year exist, based on the number of turtles (15) observed during nearly 5 years of Marine Mammal Observer data collected during various surveys conducted within the Stabroek Block and between the Stabroek Block and the Guyana coast (see Section 7.7, Marine Turtles), the abundance of turtles offshore Guyana is expected to be low. The likelihood of a vessel colliding with a marine turtle is based on the chance that a Project vessel's path would cross that of a surfacing turtle when either in the PDA or when transiting between the shorebases and the PDA and that the vessel could not maneuver to avoid the turtle. Hence, a collision with a marine turtle is considered **Unlikely**, so the overall (pre-mitigation) risk to marine turtles from a vessel collision is considered **Moderate**. All of the available measures to minimize the risk of a collision have been included in the Project design as embedded controls, so the residual risk rating remains **Moderate** (see Table 9.11-1).

9.11.4. Untreated FPSO Wastewater Discharge

A discharge of untreated wastewater (i.e., sewage or black water) from the FPSO would only occur under an equipment failure scenario and involve release of untreated wastewater directly overboard. Such a discharge would have localized impacts on water quality, but conditions that could cause such a release would generally be rectified within a short period of time. The primary constituents in wastewater include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), carbon, nutrients (primarily nitrogen and phosphorous), and pathogens such as coliform. The affected area of ocean would be somewhat larger than the mixing zone associated with normal operations, but not so large that the event would be regionally significant. As described in Section 9.1.11, Untreated FPSO Wastewater Discharge, modeling results show that a temporary release of untreated wastewater would result in a plume of limited extent and that constituent concentrations would never exceed the end-of-pipe levels recommended by the IMO's 2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants (IMO 2012).

A marine turtle foraging in the water or swimming on the water surface could come into dermal contact with the wastewater plume or an individual could ingest a small amount of wastewater during foraging. The character (constituents and concentration) of the wastewater plume would not expose marine turtles to toxic effects (injury or mortality) and no dermal effects from contact of the wastewater with a marine turtle's skin would be expected.

The geographic extent of a discharge of untreated wastewater from the FPSO would be limited to the **Direct AOI**. Using the definitions established for assessment of potential impact on marine turtles from planned Project activities, the intensity of potential impacts of a discharge of untreated wastewater from the FPSO is considered **Negligible**. The frequency of a discharge of untreated wastewater from the FPSO would be **Episodic** because it would occur infrequently (if ever). The duration of this impact would be **Short-term**, as it would assimilate into the ocean quickly and not persist at the water surface where turtles surface to breathe. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessment of potential impact on marine turtles from planned Project activities, the sensitivity of marine turtles to impacts from a discharge of untreated wastewater from the FPSO is considered **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. These factors yield a (pre-mitigation) risk rating to marine turtles from a discharge of untreated wastewater from the FPSO of **Minor**.

Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would be **Minor** (see Table 9.11-1).

Table 9.11-1: Risk Ratings for Unplanned Event Impacts on Marine Turtles

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Turtles	Unlikely	High	Moderate	Implement OSRP	Moderate
Vessel Collision	Marine Turtles	Unlikely	Medium	Moderate	None	Moderate
Untreated FPSO Wastewater Discharge	Marine Turtles	Unlikely	Low	Minor	None	Minor

9.12. MARINE FISH

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on marine fish include a marine oil spill, a coastal oil spill, a release of NADF, or a discharge of untreated wastewater from the FPSO.

9.12.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Tables 7.8-4 and 7.8-5 in Section 7.8, Marine Fish, contain the definitions for intensity of impact and sensitivity of receptor, respectively, for impacts on marine fish.

9.12.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

As described in Section 9.1.5, the trajectory of the spilled oil would be influenced by wind and current patterns, which vary seasonally. The extent of the oil's predicted effect on the continental shelf[11] changes seasonally, with the highest probability of oil reaching the coast (and therefore a larger portion of the continental shelf) in winter, but the affected area would be limited to the portion of the continental shelf off Regions 1 and 2 under all scenarios. The implication of these model results is that pelagic, open-ocean fishes would have the highest potential for exposure to oil as the result of a loss-of-well-control event but that under certain conditions continental shelf species could be exposed as well, and that a remote possibility exists for exposure to occur in shallow water where fishes' normal ability to avoid entrained oil would be compromised by water depth.

Potential impacts on marine fish from a marine oil spill are related to both water column concentrations of, and the duration of exposure to, dissolved hydrocarbons (primarily PAHs). Contamination in the water column changes rapidly in space and time, such that potentially harmful exposure levels are typically brief (i.e., typically measured in hours), except in the case of an ongoing release such as a loss-of-well-control event or slow leak from a vessel. Exposure to microscopic oil droplets may impact aquatic biota either mechanically (especially for filter feeders) or as a conduit for exposure to semi-soluble hydrocarbons (which might be taken up in the gills or digestive tract via dissolution from the micro-droplets).

Fish are generally only slightly impacted by oil spills because of their limited exposure to surface slicks and the dispersed oil being rapidly diluted to very low concentrations in open water environments. Fish may also actively avoid oil, as they can detect hydrocarbons in the water. Juvenile life stages of marine fish tend to be more susceptible to impacts from oil spills than adults for several reasons:

- Oil tends to concentrate at the surface and near-surface, at least initially following a release.
- Most marine fishes spend at least their initial larval stages in the plankton (referred to as ichthyoplankton).
- Although ichthyoplankton are capable of volitional movement over small scales, they tend to concentrate near the surface (SFSC 2014; de Freitas and Meulbert 2004; Cowen et al. 2000).
- In addition to acute ingestion- and dermal-contact-related impacts, early life stages are also exposed to developmental-related impacts (which may include deformities in heart, jaw, and eye tissues) that may manifest later in life (NOAA 2015).

Despite the susceptibility of juvenile stages of fish to relatively low concentrations of oil in the water column, high mortality of planktonic life stages of fish would be expected to have minor

[11] The relatively shallow area of seabed surrounding extending from the coast to the edge of the continental slope

impacts on the long-term populations of most open-ocean species. Very high natural mortality rates for larval life stages (exceeding 99 percent for most marine fishes) (MBC 2011) suggest that most ichthyoplankton that could be killed during an oil spill event would die naturally from other causes in the absence of a spill. Therefore, localized, high losses of these juvenile life stages rarely equate to any measurable loss of adult life stages in the population.

In the unlikely event of a marine oil spill, implementation of the OSRP may include use of dispersants for certain types of spill scenarios, based on NEBA analysis. The OSRP references the use of the four primary (i.e., most broadly approved and studied) dispersants: Corexit 9500, Corexit 9527A, Finasol OSR 52, and Dasic Slickgone NS. These dispersants have been found to have low toxicity, are effective across a broad range of oil types and environmental conditions, and are readily available globally. For reference, in a 2010 study conducted by the U.S. Environmental Protection Agency, Corexit 9500A was found to be practically non-toxic[12] to *Menidia* spp. (which is commonly used as a biological model representing juvenile marine fish) during standard acute toxicity tests (USEPA 2010). Although it is impossible to predict the exact quantity of dispersant that would be required under every foreseeable oil spill scenario, based on previous industry experience, the loss-of-well-control scenarios identified in the OSRP for which application of dispersants would be recommended could require the application of up to 3,000 cubic meters of dispersant at the ocean surface and up to 5,000 cubic meters applied at the well head, depending on how the dispersant is applied, the volume of oil spilled, the relative speed with which other mitigation measures could be applied and their effectiveness, and sea conditions at the time of the spill, as well as other factors. Further discussion of potential impacts on marine fish from the use of dispersants is included in Section 9.1.8, Potential Effects on Wildlife and Pros and Cons of Dispersant Use.

The same factors that would cause rapid dilution of oil in the open ocean (e.g., marine currents, wind, and wave action) would also act to rapidly dilute a dispersant-oil mixture. Since dilution in the marine environment occurs rapidly (especially in areas with strong current activity such as the PDA), the potential for acute impacts from dispersed oil is limited in duration and space, and chronic exposure is not expected to be a significant factor in the overall risks posed to marine biota during a spill event. Undispersed oil generally has similar toxicity as most dispersant-oil mixtures (even when different dispersant types may mix after application), so the responsible use of dispersants in alignment with NEBA, as described in the OSRP, generally does not represent an additional risk to marine biota.

Adult fish may avoid an area affected by a spill, as they are not physiologically required to breathe at the surface where oil would accumulate. Conversely, the early life stages of marine fish (which are most susceptible to the effects of a spill and, in terms of planktonic life stages, also the least able to avoid spilled oil) that come into contact with the spill would naturally experience high mortality. Pelagic species' habitat coincides with the portion of the water column that would be most affected by the spill. Adults would have the ability to avoid areas

[12] The U.S. Environmental Protection Agency classifies substances with LC50 values (concentration that will kill 50 percent of the test animals with a single exposure) of greater than 100 ppm as "practically nontoxic."

affected by the spill. Demersal species would have only a limited exposure, if any, to the spill as the oil would rise through the water column and away from demersal species' bottom habitats. Accordingly, the intensity of such an impact is considered **Medium** for pelagic species and **Low** for demersal species.

The geographic extent of an unmitigated loss-of-well-control event would include portions of the **Indirect AOI**. On the basis that the impacts from an unmitigated marine oil spill would continue over a several week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large** for pelagic species and **Small** for demersal species. Consistent with the sensitivity ratings assigned for potential impacts on marine fish from planned activities, a sensitivity rating of **Low** is assigned for pelagic species and a sensitivity rating of **Medium** is assigned for demersal species.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium** for pelagic species and **Low** for demersal species. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**, so the overall risk of an unmitigated marine oil spill to marine fish is considered **Minor**.

Effective implementation of measures to stop the spill or contain it would reduce the geographic extent of the spill, and would reduce the amount of oil at the water's surface. If applied, dispersants would increase the concentrations of oil entrained in the upper portions of the water column and thus pelagic species' exposure to near-surface entrained oil. The NEBA process would optimize use of dispersant such that the benefits would be expected to outweigh the negative effects of increased concentrations of emulsified or entrained oil near the surface. Accordingly, the intensity of such an impact would be reduced to **Low** for pelagic species and would remain **Low** for demersal species. The geographic extent of a mitigated loss-of-well-control event would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated loss-of-well-control event could persist over several weeks, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration would be reduced to **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium** for pelagic and demersal species. Consistent with the sensitivity ratings assigned for potential impacts on marine fish from planned activities, a sensitivity rating of **Low** is assigned for pelagic species and a sensitivity rating of **Medium** is assigned for demersal species.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low** for pelagic and **Medium** for demersal species. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**, so the overall risk of a marine oil spill to marine fish would remain **Minor**.

9.12.3. Coastal Oil Spill

Although adult fish tend to be resilient to the impacts of oil spills in the open ocean and even to some extent along the coast, fish at all life stages can be substantially impacted in some circumstances, especially when oil spills occur in shallow or confined waters such as the Demerara River. In exceptional circumstances, depletion of a year class for a particular species has been recorded, but mass fish mortalities as a result of an oil spill are rare. Mass mortalities that have occurred have in some cases been associated with spills in rivers (ITOPF Undated). If a spill were to occur in the Demerara River and penetrate the shallow creeks and lagoons within the mangroves, mortality of adult and subadult life stages could be much higher than for a comparable spill in the open ocean. Adult and subadult fish would have some ability to avoid the area affected by a spill, but this ability would be constrained within the confines of the lower Demerara River and early life stages (which cannot avoid affected areas as readily as adults) would likely comprise a higher proportion of the community in the river than in the open ocean; accordingly, the intensity of such an impact is considered **High**.

The geographic extent of a coastal oil spill would include the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for potential impacts on marine fish from planned activities, a sensitivity rating of **Low** is assigned for pelagic species and a sensitivity rating of **Medium** is assigned for demersal species.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium** for pelagic species and **High** for demersal species.

As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a coastal oil spill is considered **Unlikely**, so the overall risk of a coastal oil spill to marine fish is considered to be **Minor** to **Moderate**. Effective implementation of the OSRP would reduce the geographic extent of the spill and, depending on the specific response strategies implemented in shallower waters, could reduce the amount of oil at the water's surface; accordingly, the residual risk rating would remain **Minor.**

9.12.4. Release of NADF

In the unlikely event of a release of NADF caused by an emergency riser disconnect due to DP station-keeping failure of a drill ship, lighter oil fractions would likely rise into the mid water column and dissipate laterally as they rise, while the remaining heavier oil fractions of the NADF would remain at or near the seafloor. Such an event would expose fish in the middle depths within the PDA to low concentrations of dissolved light oils and expose deepwater-adapted fishes and benthos within the PDA to NADF, but an NADF release would be expected to only temporarily affect a small area around the release point. In consideration of these factors, the intensity of such an impact is considered **Low**.

The geographic extent of a release of NADF would include the **Direct AOI**. On the basis that impacts on marine fish from an unmitigated NADF release would persist as long as they were exposed to the spilled material, the frequency is considered to be **Continuous**. The effects would last less than a year, so duration would be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on marine fish from planned activities, a sensitivity rating of **Low** is assigned for pelagic species and a sensitivity rating of **Medium** is assigned for demersal species.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low** for pelagic and demersal species.

As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a release of NADF is considered **Unlikely**, so the overall risk of a NADF release on marine fish is considered **Minor**. Response actions would focus on identifying and rectifying the condition that caused the release, and the residual risk would remain **Minor**.

9.12.5. Discharge of Untreated Wastewater from the FPSO

A discharge of untreated wastewater from the FPSO would only occur if equipment onboard the FPSO were to fail, and would involve the release of untreated wastewater directly overboard through an outfall. The untreated discharge would have localized impacts on water quality, but it is expected that the equipment would be repaired and the release would be controlled within a short period of time. The primary constituents in wastewater would include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), carbon, nutrients (primarily nitrogen and phosphorous), and pathogens, such as coliform. The affected area would likely be somewhat larger than the mixing zone associated with normal operations, but not large enough to cause a regionally significant event. As described in Section 9.1.11, Untreated FPSO Wastewater Discharge, modeling results show that a temporary release of untreated wastewater would result in a plume of limited extent and that constituent concentrations would never exceed the end-of-pipe levels recommended by the IMO's 2012 *Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants* (IMO 2012).

Marine fish in the area at the time of the accidental release could be exposed to the wastewater plume by swimming through the plume and having it contact their skin and/or gills (i.e., dermal and respiratory contact). However, given the constituents and associated concentrations, the wastewater plume would not be expected to expose marine fish to significant toxicity effects (injury or mortality), nor would it be likely to induce hypoxia. Under specific conditions and concentrations, untreated wastewater discharge can harm marine organisms, especially in coastal waters with limited flow or water exchange (National Research Council 1993). An untreated wastewater discharge from the FPSO would occur in the open ocean and the discharge would be expected to rapidly assimilate into the ocean, significantly limiting potential exposure of marine fish to the discharge.

The geographic extent of an accidental discharge of untreated wastewater from the FPSO would be limited to the **Direct AOI**. Using the definitions established for assessment of potential impact on marine fish from planned Project activities, the intensity of potential impacts of a discharge of untreated wastewater from the FPSO is considered **Negligible**. The frequency of a discharge of untreated wastewater from the FPSO would be **Episodic** because, if it were to occur, it would occur infrequently. The duration of this impact would be **Short-term**, as the discharge would assimilate into the ocean quickly. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessment of potential impacts on marine fish from planned Project activities, and considering that exposure to impacts from a release of untreated wastewater from the FPSO would be limited to pelagic fish, the sensitivity of marine fish to impacts from a discharge of untreated wastewater from the FPSO is considered **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously in order for untreated wastewater to be released to the environment; therefore, such an event is considered **Unlikely**. These factors yield a (pre-mitigation) risk rating to marine fish from a discharge of untreated wastewater from the FPSO of **Minor** (see Table 9.12-1). Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would therefore be retained at **Minor**.

Table 9.12-1: Risk Ratings for Unplanned Event Impacts on Marine Fish

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Fish	Unlikely	Medium	Minor	Implement OSRP	Minor
Coastal Oil Spill	Marine Fish	Unlikely	High	Moderate	Implement OSRP	Minor
NADF Release	Marine Fish	Unlikely	Low	Minor	Implement OSRP	Minor
Discharge of Untreated Wastewater from the FPSO	Marine Fish	Unlikely	Low	Minor	None	Minor

9.13. MARINE BENTHOS

As indicated in Table 9.1-6, the only unplanned events with the potential for any measureable impacts on marine benthos would be a marine oil spill and an NADF release.

9.13.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Tables 7.9-6 and 7.9-7 in Section 7.9, Marine Benthos, contain the definitions for intensity of impact and sensitivity of receptor, respectively, for impacts on marine benthos.

9.13.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

Most of the oil released from a marine oil spill would be expected to rapidly travel to the surface, but a limited amount of oil may bind with sediments in the water column and settle to the bottom, which could expose benthic organisms to toxic constituents. After the Deepwater Horizon oil spill, low taxa richness and high nematode/harpacticoid-copepod ratios, which are indicative of contamination, were found in areas within about 3 kilometers (1.8 miles) of the wellhead (Montagna et al. 2013). These impacts were considered to have resulted from attempts to regain well control by injecting drilling fluids into the open wellhead rather than the loss-of-well-control event and resulting oil spill itself. Polychaete worms, the most common benthic species in the PDA, display varied responses to oil pollution. After an initial die-off, some disturbance- and pollution-tolerant polychaete species may increase in abundance and rapidly colonize damaged habitat, while other species, particularly crustaceans and mollusks, may experience reduced populations (Blackburn et al. 2014; Fisher et al. 2014).

Using the definitions presented in Table 7.9-6, the intensity of potential impacts of an unmitigated marine oil spill on marine benthos is considered **Low**. The geographic extent of an unmitigated loss-of-well-control event could encompass portions of the **Indirect AOI**. On the basis that impacts on marine benthos from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, marine benthos would gradually recover to some extent—depending on the degree of oil exposure at the seafloor—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Small**.

The most sensitive component of the benthic community is likely to be the sponges living on the hard seafloor features (HSFs). Due to their immobile adult life form, sponges located on the HSFs that could be impacted would be unable to relocate to avoid impacts. Sponges tend to be slow-growing and long-lived, so impacted populations would not be expected to recover quickly. Although the sponge-dominated community would be more sensitive to impacts than the rest of the benthic community in the Subsea PDA, the HSF community accounts for less than 2 percent of the seafloor within the Subsea PDA. Since a small fraction of the overall benthic community would have an elevated sensitivity to these potential impacts, the overall sensitivity of marine benthos is rated as **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to marine benthos is considered **Minor**.

Although there is little in the way of mitigation that would further reduce the potential impacts of a marine oil spill on marine benthos in proximity to the well, EEPGL has a number of embedded controls to prevent a spill from occurring, and implementation of the OSRP would reduce the level of impact if a spill were to occur. Even with this reduction, however, the intensity of potential impacts on marine benthos from a mitigated marine oil spill would still likely be **Low**. The duration would likely be reduce to no more than **Medium-term**. This maintains the magnitude rating of **Low** and the consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to marine benthos from a mitigated marine oil spill would be maintained at **Minor** (see Table 9.13-1).

9.13.3. Coastal Oil Spill

Modeling indicates that an unmitigated coastal oil spill would likely only happen near the mouth of the Demerara River. Limited information is available describing the marine benthos near the mouth of the Demerara River; however, based on historical and ongoing human activities in this area, it is likely that the benthic community in this area is comprised of disturbance-tolerant benthic species. As stated in Chapter 9, Unplanned Events, coastal spills would be quickly controlled and contained because of the relatively small volume of the spill and the ready access to spill control equipment. A coastal spill would thus be short-lived and limited in area and volume of oil released, with rapid recovery of any affected benthos expected. As such, a coastal oil spill is not expected to impact marine benthos and the potential impacts from a coastal oil spill on marine benthos are not assessed further.

9.13.4. Release of NADF

Marine benthos would be the most sensitive of all the marine biological resources/receptors to an unplanned release of NADF from an emergency riser disconnect and loss of DP on a drill ship due to their close proximity to the release point and the tendency of the NADF and cuttings plume to remain at or near the seafloor. In addition, marine benthos have limited mobility to move away from the impacted area compared to other marine organisms. However, the material discharged would be limited in volume (i.e., limited to the volume of the riser), with a release that would be short-term nature, and low-toxicity (containing IOGP Group III NADF, with low to negligible aromatic content).

A review of potential impacts of NADF and cutting deposition on marine benthos indicates marine benthos would not only be buried, but sediment texture would be altered, and water quality would deteriorate leading to hypoxia (IOGP 2016). The smaller and less mobile organisms (burrowing species, worms, and immobile lifeforms [sponges, bryozoans, gorgonians, and most mollusks]) would generally be affected to a greater degree than larger and more mobile species that would have the ability to move away from impacted areas (e.g., large crustaceans, cephalopods).

As described in Sections 9.3, Marine Geology and Sediments, and 9.4, Marine Water Quality, marine currents in the Project AOI would reduce the potential for burial of benthos and the formation of hypoxic zones within the sediment. When such events occur, recovery through natural recruitment from adjacent undisturbed areas is typically well underway within a year of the impact having occurred, but the potential does exist for short-term impacts on marine benthos in the unlikely event of a release, and such an event would likely cause at least a temporary decrease in both the abundance and diversity of marine benthos within the deposition zone.

Using the definitions in Table 7.9-6, the intensity of potential impacts of an NADF release on marine benthos is considered **Low**. The geographic extent of an unmitigated NADF release would be limited to the **Direct AOI**. On the basis that impacts on marine benthos from an unmitigated NADF release would persist as long as they were exposed to the spilled material, the frequency is considered to be **Continuous**. Even without mitigation, marine benthos would gradually recover to some extent, and the currents would redistribute the spilled material and impacts would be expected to persist less than a year, yielding a **Medium-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

As discussed above, the most sensitive component of the benthic community is likely to be the sponges living on the HSFs in the Subsea PDA, but this community accounts for less than 2 percent of the seafloor within the Subsea PDA. Since a small fraction of the overall benthic community would have an elevated sensitivity to potential impacts of an NADF release, the overall sensitivity of marine benthos is rated as **Medium**.

A mitigated release of NADF would be smaller in volume and the impacts would be shorter in duration than the unmitigated scenario described above, yielding an intensity rating of **Negligible** for all scenarios considered. This leads to a magnitude rating of **Negligible** and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for the accidental release of NADF, the overall residual risk to marine benthos from a mitigated release of NADF would be **Minor** (see Table 9.13-1).

Table 9.13-1: Risk Ratings for Unplanned Event Impacts on Marine Benthos

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Benthos	Unlikely	Low	Minor	Implement OSRP	Minor
NADF Release	Marine Benthos	Unlikely	Low	Minor	Implement OSRP	Minor

9.14. Ecological Balance and Ecosystem Services

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on ecological balance and ecosystems include a marine oil spill, a coastal oil spill, a release of NADF, and a discharge of untreated wastewater from the FPSO.

9.14.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Tables 7.10-2 and 7.10-4 in Section 7.10, Ecological Balance and Ecosystems, contain the definitions for intensity of impact and sensitivity of receptor, respectively, for impacts on ecological balance and ecosystems.

9.14.2. Marine Oil Spill

9.14.2.1. Impacts on the Marine Nutrient Cycle

Impacts on the marine nutrient cycle from a marine oil spill would be determined by the impact of the spill on phytoplankton. The available literature suggests that toxicological impacts of oil on phytoplankton vary widely according to nutrient content of the water, temperature, type of oil, and exposure (Wang et al. 2008; Ozhan et al. 2014). A persistent, heavy surface slick has the potential to reduce gas exchange and light transmission at the water's surface, which generally reduces photosynthetic activity and primary productivity in the impacted area (Ozhan et al. 2014). Reduced cellular activity in the phytoplankton would reduce the uptake of nutrients (nitrogen, phosphorous, and silicates) into the base of the aquatic food web. However, due to the rapid spreading and thinning of surface oil, in most cases these impacts would be short-lived and localized, and the proportions of the phytoplankton populations impacted would be limited. As the slick breaks up and thins, light transmission would be restored, and the plankton community would be replenished by plankton carried into the Project AOI by the Guiana Current from unaffected areas to the east. Except in the case of an ongoing release where localized contamination may remain high, hydrocarbons in the water column would be rapidly diluted to levels below those expected to cause toxicity to planktonic species. The phytoplankton community would be expected to recover quickly due to the influx of unaffected plankton and the phytoplankton's short generation times relative to those of other marine taxa (NRC 2003).

Several studies have documented post-spill shifts in feeding behavior in birds and fish, but studies of spill-related impacts on other marine taxa are generally lacking. Most studies cite short-term adjustments in feeding strategies by birds or fish following a spill, but many cite the need for longer-term study to document the role of spills in these shifts or an inability to identify hydrocarbon contamination as a driving factor due to confounding environmental impacts, or both (GOMRI 2015; Piatt and Anderson 1996). Studies that successfully control for such factors and purport to document a causal relationship between oil spills and trophic shifts typically document a shift back to pre-spill conditions within a few years (Moreno et al. 2013; GOMRI 2015).

A large marine oil spill could have ecosystem-level trophic level impacts if hydrocarbons persist in the food web and have toxic impacts on organisms, or if underlying changes in abundance or distribution of prey cause shifts in feeding behavior or effectiveness in upper trophic levels. Although the assimilation of hydrocarbons into living tissues is well established at multiple trophic levels (Teal and Howarth 1984; Neff 2002; Chanton et al. 2012; GOMRI 2015), there has been no conclusive documentation of biomagnification of hydrocarbons up the food chain following a major oil spill. Researchers conducting studies on fish following oil spills have documented the residence of polycyclic aromatic hydrocarbons in fatty tissues, but that fish and other higher vertebrates are able to dispose of the hydrocarbons through metabolic means. The ability to metabolize hydrocarbons and the length of time it takes to metabolize the hydrocarbons varies by species (Law et al. 1997; Neff 2002; Jung et al. 2011). Law et al. (1997) reported that PAH levels returned to normal (i.e., baseline) within 4 months for finfish and 6 months for bivalve mollusks after the Sea Empress oil spill in Pembrokeshire, Wales in 1996.

9.14.2.2. Impacts on Gene Flow

As described in Section 7.10.3, Impact Assessment—Ecological Balance and Ecosystems, obstacles to efficient gene flow occur when physiochemical barriers to migration, breeding, or dispersal/colonization occur. A marine oil spill could represent a potential short-term physiochemical barrier to migration through the Project AOI, although the significance of this barrier impact would vary across species and seasons. Impacts on gene flow in marine fish would be negligible, because there are no known sensitive spawning aggregations or habitat that would support such aggregations in the PDA or in the vicinity of the Project AOI and because it is unlikely the oil spill would encompass such a large geographical area and duration to impact overall genetic flow in resident or migratory fish populations given their mobility. Non-mobile organisms (e.g., benthic species) are more vulnerable to gene flow impacts (oceanographic discontinuities) than highly mobile animals (pelagic highly migratory fish) (Pascual et al. 2017). Most marine animals in the upper water column of the Project AOI are mobile. Marine mammals would also be expected to avoid the impacted area, although in the initial stages of a spill they could be impacted to a greater degree than the fish (e.g., if they inhaled vapors or oil at the surface prior to vacating the area). Marine turtles and seabirds would be more sensitive to impacts on gene flow because they do congregate to breed in portions of the Project AOI (see Sections 9.8, Seabirds, and Section 9.11, Marine Turtles).

9.14.2.3. Impacts on Biodiversity

A marine oil spill has the potential to cause a short-term decline in biodiversity. Some species may exhibit avoidance behavior, and sensitive species that remain in the area may experience localized population declines or a reduction in vigor. Small spill events would have little if any long-term impact on biodiversity across the North Brazil Large Marine Ecosystem (LME), because these events would impact relatively localized areas, and although there can be minor local decreases in biodiversity associated with even a small spill, recovery would be expected to occur relatively rapidly. The same factors would impact biodiversity in the unlikely event of a more extensive oil spill, but declines in biodiversity within the Project AOI may occur over a larger area and impact a larger number of ecosystem types, so recovery may occur more slowly.

Overview of Impacts on Ecological Balance and Ecosystems from a Marine Oil Spill

Using the definitions presented in Table 7.10-2, the intensity of potential impacts of an unmitigated marine oil spill on ecological balance and ecosystems is considered **Medium**. This rating is based on the range of ecological receptors that could be affected, their different tolerances for spill-related impacts, the numerous interdependencies between the biological and physical elements of the marine ecosystem, and the variety of induced and indirect impacts that those interdependencies create. The geographic extent of an unmitigated loss-of-well-control event could encompass portions of the **Indirect AOI**. On the basis that impacts on ecological balance and ecosystems from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, ecological balance and ecosystems would gradually recover to some extent—depending on the degree of oil exposure—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

Based on the sensitivity rating definitions presented in Table 7.10-4, the receptor sensitivity for ecological balance and ecosystems is considered **Low** for impacts on nutrient cycling and gene flow, and **Medium** for impacts on biodiversity. The **Low** sensitivity rating for nutrient cycling and gene flow are principally due to the assimilative capacity of the LME afforded by its large size, and the assumption that genetic exchange between the North Brazil LME and adjacent LMEs is robust due to the general lack of obstacles to gene flow in the ocean. The **Medium** sensitivity rating for impacts on biodiversity is principally due to the numerous species in the LME with elevated conservation status.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium** to **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to ecological balance and ecosystems is considered **Minor** to **Moderate**.

EEPGL has a number of embedded controls to prevent a spill from occurring, and implementation of the OSRP would reduce the level of impact if a spill were to occur. Even with this reduction, however, the intensity of potential impacts on ecological balance and ecosystems from a mitigated marine oil spill would still likely be **Low**. The duration would likely be reduced to no more than **Medium-term**. This reduces the magnitude rating to **Medium** and the consequence/severity rating to **Low** to **Medium**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to ecological balance and ecosystems from a mitigated marine oil spill would be **Minor** (see Table 9.14-1).

9.14.3. Coastal Oil Spill

9.14.3.1. Impacts on the Marine Nutrient Cycle

The impacts of a coastal oil spill on the nutrient cycle would be similar to the impacts of a marine oil spill in the sense that they would be largely controlled by the nature of the spill's impact on phytoplankton and primary production rates. However, the types of phytoplankton and their sensitivity to environmental degradation are expected to be different in the lower Demerara River than offshore. Effects on light transmission at the water's surface is expected to be much less significant in regulating primary production in the Demerara River than offshore, because turbid conditions in the river naturally limit light transmission in the river. This would imply a greater phytoplankton resilience to oil spills in the river than offshore. However, to the extent that phytoplankton in the river would be impacted by toxicological effects or reduced gas exchange, they may not be as easily replaced from surrounding populations, as they would be in the open ocean. Therefore, oil-spill induced reductions in primary productivity may be lower in the river than in the ocean, but the nutrient cycle in the river may also be slower to recover.

9.14.3.2. Impacts on Gene Flow

Similar to a marine oil spill, a coastal oil spill would represent a potential short-term physiochemical barrier to migration through the Demerara River, and the significance of this barrier impact would vary across species and seasons. The most sensitive groups of organisms to these effects would probably be fish and crustaceans, which use the lower river as nursery habitats on a seasonal basis. Impacts would likely be more severe during and immediately following spawning seasons, when entire year classes of juvenile fish and crustaceans would potentially be subject to the effects of a spill on a localized basis. Impacts would likely be less in non-spawning seasons.

9.14.3.3. Impacts on Biodiversity

Impacts on biodiversity from a marine oil spill and a coastal oil spill in or near the Demerara River would be similar in terms of their mechanisms, but would affect different species. A coastal oil spill would probably affect more species of birds, more riverine mammals, fewer marine mammals, and different species of fish than a marine oil spill, and would have little or no impact on marine turtles. As previously discussed, some species groups such as marine mammals, and to some degree marine fish, may be able to avoid the effects of a spill within the river. Coastal birds and shorebirds that forage in the river and along its shores probably would not be as readily able to avoid a spill's effects because their foraging areas are defined by water depth, tides, and other factors that would not change in response to a spill event.

Overview of Impacts on Ecological Balance and Ecosystems from a Coastal Oil Spill

Using the definitions presented in Table 7.10-2, the intensity of potential impacts of an unmitigated coastal oil spill on ecological balance and ecosystems is considered **Medium**. This rating is based on the range of ecological receptors that could be affected, their different tolerances for spill-related impacts, the numerous interdependencies between the biological and physical elements of the marine ecosystem, and the variety of induced and indirect impacts that those interdependencies create. The geographic extent of an unmitigated coastal oil spill would be limited to the **Indirect AOI**. On the basis that impacts on ecological balance and ecosystems from an unmitigated coastal oil spill would persist as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Medium**.

Based on the sensitivity rating definitions presented in Table 7.10-4, the receptor sensitivity for ecological balance and ecosystems is considered **Low** for impacts on nutrient cycling and gene flow, and **Medium** for impacts on biodiversity.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low** to **Medium**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the (pre-mitigation) risk to ecological balance and ecosystems is considered **Minor**.

EEPGL has a number of embedded controls to prevent a spill from occurring, and implementation of the OSRP would reduce the level of impact if a spill were to occur. Even with this reduction, however, the intensity of potential impacts on ecological balance and ecosystems from a mitigated coastal oil spill would still likely be **Low**. The duration would likely be reduced to no more than **Medium-term**. This reduces the magnitude rating to **Small** and the consequence/severity rating to **Low**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall residual risk to ecological balance and ecosystems from a mitigated coastal oil spill would be **Minor** (see Table 9.14-1).

9.14.4. Release of NADF

9.14.4.1. Impacts on the Marine Nutrient Cycle

Deep-sea foodwebs are highly dependent on inputs from the upper portions of the water column such as marine snow[13] and other larger detrital inputs (e.g., carcasses of larger animals). A release of NADF would have no effect on the rate at which these nutrient inputs reach the deep ocean and would have too short a duration to significantly affect the rate at which they would be consumed, so a release of NADF would have little if any effect on marine nutrient cycling.

[13] Fine biological debris and other organic material that descend from upper portions of the water column to the deep ocean

Release of NADF near the seafloor would enrich the nutrient content of the marine sediment down current of the affected wellhead due to the presence of biodegradable organic material in the fluid, and this enrichment could temporarily shift the food chain as the makeup of the marine benthos changes. It is unlikely that these changes in the benthic community would cause substantial changes in upper trophic levels, however.

9.14.4.2. Impacts on Gene Flow

A release of NADF would mostly affect benthic biota and deepwater/midwater fishes. Empirical data on the rates of genetic exchange in these communities are scarce. Based on the similarities in the benthic communities within the Stabroek Block as discussed in Section 7.9.2.3, Existing Conditions in the Project Development Area, the area of seafloor that could be affected by an NADF release is unlikely to contain genetically distinct populations of benthos or demersal fish. Therefore, in the event that an NADF release were to temporarily cause localized mortality or reduced reproduction, the area would probably be recolonized by organisms with a similar genetic composition as the affected population.

9.14.4.3. Impacts on Biodiversity

As discussed in previous sections, exposure to the impacts of a release of NADF would largely be limited to benthos and fish, and these impacts would be temporally and spatially limited. Considering that benthos and fish communities would be expected to recover rapidly from the effects of an NADF release, an NADF release would not pose a significant risk to biodiversity.

Overview of Impacts on Ecological Balance and Ecosystems from an NADF Release

A release of NADF would have little to no lasting effect on nutrient cycles, gene flow, or biodiversity. Based on the definitions presented in Table 7.10-2, the intensity of the impact of an NADF release on ecological balance and ecosystems is considered **Low**. The geographic extent of an unmitigated NADF release would be limited to the **Direct AOI**. On the basis that impacts on ecological balance and ecosystems from an unmitigated NADF release would persist as long as ecological receptors were exposed to the spilled material, the frequency is considered to be **Continuous**. Even without mitigation, ecological balance and ecosystems would gradually recover to some extent, and the currents would redistribute the spilled material and impacts would be expected to persist less than a year, yielding a **Medium-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

Coupled with the sensitivity rating of **Low** to **Medium** for nutrient cycling/gene flow and biodiversity, respectively, the consequence/severity of such a release on ecological balance and ecosystems would be **Low**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a release of NADF is considered **Unlikely**, so the overall risk of a NADF release to ecological balance and ecosystems is considered **Minor**. Response actions would focus on identifying and rectifying the condition that caused the release, and the residual risk would be **Minor** (see Table 9.14-1).

9.14.5. Untreated FPSO Wastewater Discharge

9.14.5.1. Impacts on the Marine Nutrient Cycle

A release of untreated wastewater from the FPSO would enrich the nutrient content of the marine water column down current of the FPSO due to the presence of biodegradable organic material in the discharge. This would have the effect of temporarily expanding the area of higher concentration adjacent to the FPSO, and if it persisted, could cause localized hypoxia within the expanded mixing zone. This enrichment could temporarily shift the food chain as the composition of the marine plankton community changes. It is unlikely that these changes would cause substantial or longer-term changes in upper trophic levels, however.

9.14.5.2. Impacts on Gene Flow

A discharge of untreated wastewater from the FPSO would likely cause the more sensitive organisms in the immediate vicinity of the FPSO to vacate the expanded zone of higher concentration temporarily, but this effect would not last sufficiently long to affect reproductive cycles. Similar to the impacts described above in the discussion of the effects of an NADF release, the zone of higher concentration that would form as a result of an untreated wastewater discharge from the FPSO is unlikely to contain genetically distinct populations. Therefore, in the event such a discharge were to temporarily cause localized mortality or reduced reproduction, the area would probably be recolonized by organisms with a similar genetic composition as the affected population.

9.14.5.3. Impacts on Biodiversity

Impacts from a discharge of untreated wastewater from the FPSO would be temporally and spatially limited. Considering that benthos and fish communities would be expected to recover rapidly from the effects of such a release as described in previous sections, this event would not pose a significant risk to biodiversity.

Overview of Impacts on Ecological Balance and Ecosystems from Discharges of Untreated FPSO Wastewater

A discharge of untreated wastewater from the FPSO would have little to no lasting effect on nutrient cycles, gene flow, or biodiversity, so the intensity of the impact of the discharge on ecological balance and ecosystems is considered **Low**. The geographic extent of a discharge of untreated FPSO wastewater would be limited to the **Direct AOI**. Releases of untreated discharges from the FPSO would be **Episodic** and impacts would have a **Short-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**.

Coupled with the sensitivity rating of **Low** to **Medium**, the consequence/severity of such a release on ecological balance and ecosystems would be **Low**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a release of untreated wastewater discharges from the FPSO is considered **Unlikely**, so the overall risk of discharges of untreated FPSO wastewater to ecological balance and ecosystems is considered **Minor**. Response actions would focus on identifying and rectifying the condition that caused the release, and the residual risk would be **Minor** (see Table 9.14-1).

Table 9.14-1: Risk Ratings for Unplanned Event Impacts on Ecological Balance and Ecosystems

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Ecological Balance and Ecosystems	Unlikely	Medium to High	Minor to Moderate	Implement OSRP	Minor
Coastal Oil Spill	Ecological Balance and Ecosystems	Unlikely	Low to Medium	Minor	Implement OSRP	Minor
NADF Release	Ecological Balance and Ecosystems	Unlikely	Low	Minor	Implement OSRP	Minor
Untreated FPSO Wastewater Discharge	Ecological Balance and Ecosystems	Unlikely	Low	Minor	None	Minor

9.15. Socioeconomic Conditions/Employment and Livelihoods

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on socioeconomic conditions or employment and livelihoods in the Project AOI would be a marine oil spill, a coastal oil spill, and a collision between a Project vessel and a non-Project vessel. Oil spills could result in decreased fishery and/or coastal agricultural yields and could potentially impact the fishery and agriculture sectors that currently account for a large part of the country's gross domestic product (GDP). A vessel collision could result in damage to a vessel used for fishing or other commercial/subsistence purposes, leading to an impact on income or livelihood for the affected individual(s).

The economies in Regions 1, 2, 3, 5, and 6 are highly dependent on fishing and agriculture for employment, income generation, and subsistence. Although the economy in Region 4 is comparatively more diversified, populations in the rural areas also rely on agriculture and fishing, and this region accounts for a significant number of fisherfolk and some of the largest landing sites in the country. These economies would be sensitive to impacts on fisheries and coastal crop production that could result from an oil spill, if it were to reach near-coastal waters or the coast. Impacts of an oil spill on river and coastal transportation networks that link communities and provide access to markets could also affect economies, especially in Region 1 and between Regions 2 and 3, where aquatic transportation is the only method of transportation available. These potential impacts are discussed below.

9.15.1. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

Fisheries potentially could be impacted by an unmitigated marine oil spill, especially if the oil reaches near-coastal waters, where most artisanal and commercial fishing occurs. Deep-sea tuna fishing, which occurs at a small scale (12 Guyanese vessels in operation) in deep-sea waters, could also be potentially impacted. Fisheries may be impacted by any reduction in fish populations or closure of active fishing areas to allow for clean up or to avoid potential public health impacts, or as a result of actual or perceived tainting of commercial fish products. Potential impacts on mangrove habitats could impact fishery nursery grounds and future-year class populations. Adult fish, however, are relatively resilient to oil spills because they are mobile and can quickly relocate away from an oil spill (see Section 9.12, Marine Fish). In the unlikely event of an unmitigated marine oil spill, there would be several days advance notice before any oil would possibly reach the Guyana coast, so fisherfolk would have ample time to move their boats to unaffected alternate fishing areas.

The intensity of an unmitigated marine oil spill impacting commercial and artisanal fisherfolk and other economic users of marine waters is considered **High**. This is based on the importance of the fishing industry to the economy of the Guyanese coastal populations. The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill would continue over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for socioeconomic impacts from planned events on individuals and households within Region 4 (which can be more economically diverse) and those of lower socioeconomic status in other regions, a sensitivity rating of **Medium** to **High** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High.** As described above, a marine oil spill reaching the Guyana coast is considered **Unlikely**. Therefore, the (pre-mitigation) risk to fisherfolk is considered **Moderate**.

In the unlikely event of a marine oil spill, EEPGL would deploy emergency response equipment to mitigate the effects of the spill, and to protect sensitive coastal resources such as mangroves, as appropriate. Accordingly, considering effective implementation of the OSRP, the intensity of such an impact would be reduced to **Medium**. The geographic extent of a mitigated marine oil spill would still include portions of the **Indirect AOI**, although the area affected would be substantially reduced with mitigation. On the basis that the impacts from a mitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration is considered to be **Medium-term**. Additionally, a claims process and, as appropriate, a livelihood remediation program (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established at the onset of a marine oil spill of sufficient magnitude to affect livelihoods of fisherfolk or other affected stakeholders (e.g., should mobility of transport and access to markets via aquatic networks be impacted). Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

A mitigated spill would be confined to waters further offshore than artisanal fisherfolk operate in Guyana, so the fisherfolk operating in the vicinity of a mitigated oil spill would likely be limited to commercial fisherfolk. In any case, both commercial and artisanal fisherfolk are assigned a sensitivity rating of **Medium** for planned impacts on employment and livelihood.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**. Therefore, the residual risk to socioeconomic conditions and employment and livelihood from this type of unplanned event is reduced to **Minor** (see Table 9.15-1).

As discussed in Section 9.21, Land Use, in the unlikely event of an unmitigated marine oil spill, stochastic modeling indicates the potential exists for subsistence farming along the SBPA in Region 1 to be impacted, but there are only a few plots of land used for agricultural purposes along or in close proximity to the coast, specifically Father's Beach and Almond Beach. A marine oil spill would only directly affect these areas if it was sufficiently large enough to reach these areas along the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill onto the sites in question. In the communities further north, such as Three Brothers, Smith's Creek, and Morowhanna, river water occasionally overflows the empoldered[14] areas created for farming, resulting in salt-water intrusion. Similarly, spilled oil that reaches the river systems could end up in these farming areas. These effects are considered highly unlikely, as the movement of oil upstream would be limited by tidal action.

However, due to the relatively limited diversification of the economy in Region 1, the intensity of a marine oil spill that reaches the Guyana coast on socioeconomic conditions and employment and livelihoods in coastal agricultural communities is considered **Medium**. The geographic extent of an unmitigated marine oil spill would include coastal areas within the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill would continue over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the

[14] Empoldering refers to the act of making land that is periodically flooded available for cultivation through the erection of banks and levees to control inundation and drainage.

marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for socioeconomic impacts from planned events on vulnerable populations in SBPA and coastal Region 1 areas, a sensitivity rating of **High** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. As described above, a marine oil spill is considered **Unlikely**. The risk to socioeconomic conditions and employment and livelihood for coastal agriculture individual(s) from an unmitigated marine oil spill is considered **Moderate** (see Table 9.15-1).

In the unlikely event of a marine oil spill, farmers in coastal communities in potentially affected area would have ample notice to close sluice gates, and spill responders would have time to install absorbent booms or other spill control equipment to prevent oil from reaching farmers' crops or drainage inlets. These actions and the mitigation measures of OSRP implementation would serve to considerably reduce the intensity of such an impact from a marine oil spill to **Low**. On the basis that a mitigated marine oil spill in the **Indirect AOI** coastal areas would continue over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Considering the claims and/or livelihood remediation processes would further reduce the risk to livelihoods by compensating for economic losses, a sensitivity rating of **Medium** is assigned for the residual risk rating. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described above, a marine oil spill is considered **Unlikely**, and the residual risk to socioeconomic conditions and employment and livelihood for coastal agriculture individual(s) from a mitigated marine oil spill is therefore considered **Minor** (see Table 9.15-1).

9.15.2. Coastal Oil Spill

The intensity of an unmitigated coastal oil spill impacting commercial and/or subsistence fisheries would be **High** given the importance of the fishing industry to the national Guyanese economy, the likelihood that a response within the Demerara River would interfere with normal vessel traffic in the river, and the fact that the most important fishing port in Guyana (Meadowbank) is located in Region 4 on the Demerara River. This port is nationally significant not only because of the amount of fish landed there, but also because of its proximity to the population center of the greater Georgetown area.

The geographic extent of an unmitigated coastal oil spill would include (limited) portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for socioeconomic impacts from planned events on individuals and households within Region 4 (which can be more economically diverse) and those of lower socioeconomic status from other regions who fish in the Demerara River and use the Meadowbank port, a sensitivity rating of **Medium** to **High** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High.** As described above, a coastal oil spill is considered **Unlikely**. Therefore, the (pre-mitigation) risk to socioeconomic conditions and employment and livelihood for fisherfolk or other economic users of affected coastal waterways from an unmitigated coastal oil spill is considered **Moderate**.

Effective implementation of the OSRP would reduce the intensity of this risk to **Medium** by reducing the area affected by such a spill, likely to only a portion of the **Indirect AOI**. On the basis that impact from a mitigated coastal oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Additionally, a claims process and, as appropriate, a livelihood remediation program (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established at the onset of a coastal oil spill of sufficient magnitude to affect livelihoods of fisherfolk as well as other affected stakeholders (e.g., should mobility of transport and access to markets via aquatic networks be impacted). Considering the claims and/or livelihood remediation processes would further reduce the risk to fisherfolk by compensating for economic losses, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium.** As described above, a marine oil spill is considered **Unlikely**, and the residual risk to socioeconomic conditions and employment and livelihood for coastal agriculture individual(s) from this unplanned event is considered **Minor** (see Table 9.15-1).

As described in Section 9.21, Land Use, depending on the location of a coastal oil spill, marine diesel could enter the Georgetown Harbour/Demerara River estuary. There are only a few areas along the shore zone or coastal areas near Georgetown and on the western bank of the Demerara River bank that are used for agricultural purposes—specifically, subsistence farming and/or grazing of livestock in Region 3. These areas are set back from the coast and protected by either manmade structures (e.g., seawall) or mangroves. A potential coastal spill would only affect land use in these areas if it occurred in proximity to one of the sites, were sufficiently large to reach the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill over the bank and onto the sites in question.

Rice farming, which makes up the majority of agricultural activity in the coastal area of Regions 2 and 3, would not be directly impacted by a coastal oil spill since rice fields are irrigated from inland water conservancies. However, the islands at the mouth of the Essequibo River, including

Leguan and Wakenaam, use freshwater from the river for irrigation of rice crops. It is unlikely that a coastal oil spill in the vicinity of Georgetown Harbour would reach the Essequibo River area.

Depending on tidal conditions and extent of spread of the spill, a coastal oil spill also could prevent the opening up of sluices to allow for drainage of lands along the Demerara River. Closure of sluices could prevent the spill moving inland into canals, but if such closure happens in the rainy season, it could affect area drainage and lead to water accumulation on lands and flooding as a result. However, if this were to occur, the limitation on opening sluices would be expected to be short-term in nature, reducing the consequence from a flooding perspective.

Due to the relatively limited diversification of the economy in Region 3, the intensity of a coastal oil spill that reaches the Guyana coast on socioeconomic conditions and employment and livelihoods in coastal agricultural communities is considered **Medium**. The geographic extent of an unmitigated coastal oil spill could include coastal areas within a small portion of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned for socioeconomic impacts from planned events on individuals and households of lower socioeconomic status, a sensitivity rating of **High** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. As described above, a coastal oil spill is considered **Unlikely**. The risk to socioeconomic conditions and employment and livelihood for coastal agriculture individual(s) in Region 3 from this unplanned event is considered **Moderate** (see Table 9.15-1).

In the event of a coastal oil spill, the spill would be quickly controlled and contained because of the smaller volumes and the ready access to spill control equipment. The mitigation measures of OSRP implementation would serve to considerably reduce the intensity risk of such an impact from a coastal oil spill to **Low**. The affected area within the **Indirect AOI** would be limited and of short duration, and a relatively rapid environmental recovery would be expected. On this basis, the frequency is considered to be **Continuous** and duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Considering the claims and/or livelihood remediation processes would further reduce the risk to livelihoods by compensating for economic losses, a sensitivity rating of **Medium** is assigned. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**.

As described above, a coastal oil spill is considered **Unlikely**, and the residual risk to socioeconomic conditions and employment and livelihood for coastal agriculture individual(s) from a mitigated coastal oil spill is considered **Minor** (see Table 9.15-1).

9.15.3. Project Vessel Collision with a Third-Party Vessel

There is a potential for collisions between Project vessels and other non-Project vessels in the Georgetown Harbour/Demerara River area. Such an incident may result from navigation error or a temporary loss of power that affects the ability of a Project vessel to steer. From a socioeconomic conditions and employment and livelihoods perspective, the potential impact of such an event could include loss of the equipment necessary for the affected individual to retain his/her livelihood, or an injury which could result in the same effect. On this basis, the intensity of such an event could potentially be **High**.

The geographic extent of a project vessel collision would be within the **Direct AOI**. On the basis that impacts from a project vessel collision would occur only occasionally, the frequency is considered to be **Episodic**. The unmitigated effects of loss of livelihood as a result of a significant vessel collision could have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned for socioeconomic impacts from planned events, a sensitivity rating of **Medium** to **High** is assigned depending upon the individual/third-party vessel affected.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium** to **High**. Section 9.1.1.4, Nearshore Collision between a Project Supply Vessel and Another (Third-Party) Vessel or Structure, or Grounding, includes a summary of the embedded controls that will be in place to reduce the potential for a nearshore collision to occur. Based on consideration of these controls, the likelihood of Project vessel accidents causing any significant damage to third party vessels, or causing significant injury, is considered **Unlikely**. Similarly, Section 9.1.1.6, Offshore Collision between Project Vessels or between a Project Vessel and Another (Third Party) Vessel, includes a summary of the embedded controls that will be in place and the additional mitigation measures that will be employed to reduce the potential for an offshore collision to occur. Based on these controls and measures, the potential for an offshore collision between a Project vessel and another third party vessel is also considered **Unlikely**.

In combination with a likelihood rating of **Unlikely** for a vessel collision, the (pre-mitigation) risk to socioeconomic conditions and employment and livelihood from this unplanned event is considered **Minor** to **Moderate** (see Table 9.15-1). Mitigation measures consistent with industry practices, together with existing embedded controls, will be implemented in the unlikely event of a vessel collision. In case of a collision involving a Project vessel and a non-Project vessel that may result in a claim arising from such type of incident, appropriate restitution will be provided, consistent with governing contracts and applicable laws. On this basis, the intensity would be reduced (reducing the magnitude to **Medium**) and the sensitivity would be reduced to no more than **Medium**, resulting in a residual risk rating of no more than **Minor**.

Table 9.15-1: Risk Ratings for Potential Unplanned Event Impacts on Economic Conditions/Employment and Livelihoods

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Fisherfolk Other economic users of marine waters	Unlikely	High	Moderate	Implement OSRP Implement claims and/or livelihood remediation processes for affected individuals	Minor
	Coastal agricultural communities in Region 1	Unlikely	High	Moderate		Minor
Coastal Oil Spill	Fisherfolk Other economic users of marine waters	Unlikely	High	Moderate		Minor
	Coastal Agricultural Communities	Unlikely	High	Moderate		Minor
Vessel Collision	Non-Project vessel operators	Unlikely	High	Minor to Moderate	Restitution consistent with applicable law	Minor

9.16. Community Health and Wellbeing

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on community health and wellbeing include a marine oil spill, a coastal oil spill, a vehicular accident involving a Project vehicle, and a collision between a Project vessel and a non-Project vessel.

9.16.1. Marine Oil Spill

Although Guyana as a nation is considered self-sufficient for food, disparities in food supply and family incomes create challenges in maintaining food security and proper nutrition in some communities, particularly rural populations. The result is that malnutrition and anemia are among the leading causes of death in Guyanese children.

Rural communities on the Guyanese coast are dependent on fishing and agriculture for subsistence and livelihoods. Fish catches and traditional crops such as vegetables and fruits are consumed or often sold locally at markets or roadside stands in all regions. Crabbing, shrimping, and hunting of coastal game, such as iguanas, deer, agouti, labba, and shorebirds, are also practiced for subsistence in many coastal communities, and are especially critical for indigenous communities in Regions 1 and 2. Adverse impacts on these resources as a result of an oil spill could have direct health impacts through entry of harmful substances into the food chain, or through malnutrition if local food supplies become unavailable. Impacts on these sectors could also have impacts via the social determinants of health: if livelihoods are impacted, increased household poverty can impact economic security, quality of life, access to education, and other health-promoting and health-protective resources. Increased economic hardship can also lead to or exacerbate familial problems and mental health impacts, including increased anxiety and suicide, especially for already vulnerable populations.

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

The intensity of an unmitigated marine oil spill impacting food availability in coastal communities, and therefore the health of affected coastal communities, is considered **High**. This is due to the following factors: (1) dependence on the coastal environment for subsistence and income and the use of rivers for transportation and daily household activities such as washing as well as bathing; (2) the high rate of poverty; and (3) the current health challenges faced by the coastal population in Guyana. The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing for receptors outside of Georgetown from planned activities, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. A marine oil spill reaching the Guyana coast is considered **Unlikely**. Accordingly, the overall (pre-mitigation) risk to community health and wellbeing from a marine oil spill is considered **Moderate**.

Effective implementation of the OSRP would reduce this risk by reducing the geographic area affected by such a spill. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating for economic losses (which would further mitigate potential follow-on community health and wellbeing effects due to loss of sustenance). Accordingly, the intensity of such an impact would be reduced to **Medium**. The geographic extent of an unmitigated marine oil spill would still include portions of the **Indirect AOI**. On the basis that the impact from a mitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing for receptors outside of Georgetown from planned activities, a sensitivity rating of **Medium** is assigned. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**. On this basis, the residual risk rating is reduced to **Minor**.

9.16.2. Coastal Oil Spill

The potential health effects associated with a coastal oil spill could be similar; however, the intensity of such a spill impacting food availability and therefore the health of affected coastal communities is considered **Medium** based on the fact that the affected geographic area within the **Indirect AOI** would be more limited, which would create more potential for subsistence fisherfolk to access alternative areas for fishing. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather), and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing for receptors outside of Georgetown from planned activities, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.5, Oil Spill Modeling Results, a coastal oil spill is considered **Unlikely**. Accordingly, the overall (pre-mitigation) risk to community health and wellbeing from a coastal oil spill is considered **Minor**.

Effective implementation of the OSRP would reduce this risk by reducing the geographic area affected by such a spill. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating for economic losses (which would further mitigate potential follow-on community health and wellbeing effects due to loss of sustenance). Accordingly, the intensity of such an impact would be reduced to **Low**. The geographic extent of an unmitigated coastal oil spill would still include portions of the **Indirect AOI**. On the basis that impacts from a mitigated coastal oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on community health and well-being outside of Georgetown from planned activities, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a coastal oil spill is considered **Unlikely**; therefore, the residual risk rating remains at **Minor**.

9.16.3. Vehicular Accident

With regard to the potential impact of onshore traffic accidents on community health and wellbeing, additional vehicular trips generated by the Project would be expected to increase the risk of vehicular accidents. The relatively low traffic speeds in Georgetown due to existing congestion may reduce the likelihood of serious injuries resulting from a vehicular accident, although the risk to bicyclists and pedestrians would not be reduced as much due to low vehicle speeds. However, vehicular accidents involving Project and non-Project vehicles could lead to consequences ranging from minor vehicle damage to injury or loss of life.

Consistent with international best practice, as an embedded control, EEPGL has developed and implemented an EEPGL-wide Road Safety Management Procedure, which covers drivers and equipment dedicated to the Project to mitigate these risks. The Procedure includes, but is not limited to, the following components:

- Definition of required driver training, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, if applicable;
- Designation and enforcement of speed limits, through speed governors, GPS, or other monitoring systems;
- Avoidance of deliveries during typical peak traffic hours as well as scheduled closures of the Demerara Harbour Bridge to road traffic (i.e., when traffic conditions worsen along the East Bank Demerara Road), to the extent reasonably practicable;
- Monitoring and management of driver fatigue;
- Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment;
- Implementation of a community safety program for impacted schools and neighborhoods to improve traffic safety; and
- Community outreach to communicate information relating to major delivery events or periods.

The intensity of the impact of onshore traffic accidents in and around Georgetown (within the **Direct AOI**) on community health and wellbeing would depend on the nature of the accident and extent of injury, and thus could range from **Negligible** to **High**. The duration of the impact (from **Short-term** to **Long-term**) would be a function of the nature of the accident. The frequency of the impact would be **Episodic**, as an onshore traffic accident would occur no more than occasionally and at irregular intervals. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible** to **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing in Georgetown from planned activities, the sensitivity rating is considered **Medium**.

Applying the methodology in Chapter 4 and considering the above-referenced suite of embedded controls (many of which would serve to reduce the severity of a vehicular accident, were it to occur) these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low** to **Medium**.

Based on the results of a traffic survey completed for key road intersections across Georgetown anticipated to potentially be among those more heavily used by EEPGL-related vehicle movements (see Appendix U, Traffic Impact Assessment), additional EEPGL-related vehicle trips (considering the Project and other anticipated EEPGL activities) will not meaningfully change traffic congestion at any of the 2019 study intersections. This suggests the likelihood of a vehicular accident involving a Project vehicle is **Unlikely**. However, considering the planned life cycle for the Project (at least 20 years), the likelihood of an event is conservatively considered to be **Possible**.

In combination with a consequence ranging from **Low** to **Medium**, this leads to a risk rating for vehicular accidents of **Minor** to **Moderate**. Beyond the embedded controls described above, no additional mitigation measures are reasonably practicable. Accordingly, the residual risk rating for vehicular accidents remains **Minor** to **Moderate** (see Table 9.16-1).

9.16.4. Marine Vessel Collision

Accidents involving Project and non-Project vessels could lead to consequences ranging from minor vessel damage to injury or loss of life. The consequence of such an event would be a function of the nature of the accident, and could range from **Low** to **High** depending on the extent of damage and severity of any resultant injuries.

The Project-related increase in vessel traffic is expected to be an insignificant incremental addition to the existing vessel traffic in Georgetown Harbour (the most likely location where a vessel collision could occur, as compared to the open ocean). Based on the results of a marine vessel traffic survey conducted along the Demerara River in the vicinity of the shorebases that will be used by the Project (see Section 8.4.2.2, Existing Conditions in the Project Area of Influence), the average daily marine vessel traffic in Georgetown Harbour is on the order of 700 to 1,000 vessel movements per week. In comparison, based on current drilling activities and past experience with similar developments, it is estimated that during Payara Project development well drilling and FPSO/SURF installation, an average of approximately 12 to 15 round-trips (24 to 30 one-way trips) per week may be made between the Stabroek Block and shorebases by marine installation and support vessels. During Payara FPSO/SURF production operations, it is estimated that this number will be reduced to approximately 5 to 10 round-trips (10 to 20 one-way trips) per week. These vessel round-trips will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad and Tobago. These additional Project-related marine vessel trips represent an approximately 2 to 4 percent increase (during drilling and installation) and an approximately 1 to 3 percent increase (during production operations).

The intensity of the impact of a marine vessel collision within the **Direct AOI** on community health and wellbeing would depend on the nature of the accident and extent of injury, and thus could range from **Negligible** to **High**. The duration of the impact (from **Short-term** to **Long-term**) would be a function of the nature of the accident. The frequency of the impact would be **Episodic**, as a marine vessel collision would occur no more than occasionally and at irregular intervals. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible** to **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing in/around Georgetown from planned activities, the sensitivity rating is considered **Medium**.

Applying the methodology in Chapter 4 and considering the above-referenced suite of embedded controls, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low** to **Medium**. As an embedded control measure, Project vessels operating near the coast will adhere to speed restrictions and navigation aids, which should further reduce the likelihood of a collision. Considering these factors, the likelihood of a collision between a Project vessel and a non-Project vessel is considered **Unlikely**.

In combination with a consequence ranging from **Low** to **Medium**, this leads to a risk rating for vessel collisions of **Minor**. Beyond the embedded controls described above, no additional mitigation measures are reasonably practicable. Accordingly, the residual risk rating is maintained as **Minor**.

Table 9.16-1: Risk Ratings for Potential Unplanned Event Impacts on Community Health and Wellbeing

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Community Health and Wellbeing	Unlikely	High	Moderate	Implement OSRP; institute claims and livelihood remediation process, as necessary	Minor
Coastal Oil Spill	Community Health and Wellbeing	Unlikely	Medium	Minor	Implement OSRP; institute claims and livelihood remediation process, as necessary	Minor
Vehicular Accident	Community Health and Wellbeing	Possible	Low to Medium	Minor to Moderate	None	Minor to Moderate
Marine Vessel Collision	Community Health and Wellbeing	Unlikely	Low to Medium	Minor	None	Minor

9.17. Marine Use and Transportation

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on marine use and transportation would be a marine oil spill, a coastal oil spill, and a collision between a Project vessel and a non-Project vessel.

9.17.1. Marine Oil Spill or Coastal Oil Spill

Depending on the extent of the spill, an oil spill could render offshore or nearshore areas inaccessible until response measures are sufficiently complete to permit use of the affected marine areas. This limitation on accessibility could affect the locations in which commercial or subsistence fishing could be conducted. For oil spills that reach near-shore waters, this could also affect river and coastal transportation networks that link communities and provide access to markets, especially in Region 1 and between Regions 2 and 3, where aquatic transportation is the only method of transportation available. Both of these impacts could result in follow-on impacts on livelihoods. These potential follow-on impacts are discussed in Section 9.15, Socioeconomic Conditions/Employment and Livelihoods.

A marine or coastal oil spill could also have some impact on marine use and transportation as a result of the additional marine vessels and resources that would be mobilized to support spill response (as described in the OSRP), resulting in increased marine congestion in and around Georgetown Harbour. The consequence of increased congestion with respect to impacts on marine use and transportation in and around Georgetown Harbour would depend on the number of additional vessel movements resulting from response efforts, which would itself depend on the nature and extent of the oil spill. In the case of a response to the Tier III marine oil spill scenario discussed in Section 9.1.5, Oil Spill Modeling Results, the level of response activity would be moderate to high over the response period. On this basis, in the case of a marine oil spill, increased congestion (as a result of response) could cause vessel operators or other users of infrastructure to consistently and frequently change their typical daily behavior during the response duration.

Therefore, with respect to impacts on marine use and transportation, intensity of the impact from a marine oil spill is considered **High**. In the case of a coastal oil spill, the extent of the spill would likely be comparatively smaller than a marine oil spill, creating less potential for marine transportation impacts to be experienced by receptors. On this basis, in the case of a coastal oil spill, the intensity of increased congestion with respect to impacts on marine use and transportation is considered **Medium**.

The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. The geographic extent of a coastal oil spill would likely be more limited, but could still include portions of the **Indirect AOI**. In the absence of mitigation, the impacts of both events would likely occur over a multi-week basis, so their frequency is considered to be **Continuous**. Depending on the size of the spill, the effects of a marine spill, assuming no mitigation of the spills, would have the potential to extend beyond a year, so duration is conservatively considered to be **Long-term**. Impacts from a coastal oil spill, assuming no mitigation, would be expected to reduce significantly with time as the spilled diesel fuel continued to weather, reducing the likely duration to **Medium-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large** for marine oil spills and **Medium** for coastal oil spills. Consistent with the sensitivity ratings assigned for potential impacts on marine use and transportation from planned activities, a sensitivity rating of **Low** is assigned for commercial vessels—with a greater means of adapting to changes—and **Medium** for subsistence fishing vessels—with lesser means to adapt to changes.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low** to **High**. As described in Section 9.1.5, Oil Spill Modeling Results, a marine or coastal oil spill (and thus the response to such) is considered **Unlikely**. Accordingly, the overall (pre-mitigation) risk to marine use and transport as a result of additional marine vessels and resources is considered **Minor** to **Moderate**.

Effective implementation of the OSRP would reduce the direct risk of the oil spill by reducing the geographic area affecting marine users. While there would be still be impacts due to increased vessel congestion during the response, the overall intensity of a mitigated spill would likely be reduced to **Medium**. The duration would be reduced to **Medium-term**, thus reducing the magnitude of a marine oil spill or coastal oil spill to **Medium** and the consequence/severity to **Low** to **Medium**. Accordingly, the residual risk rating of potential impacts of marine and coastal oil spills is reduced to **Minor**.

9.17.2. Project Vessel Collision with a Third-Party Vessel

As in the case of an oil spill, a collision between a Project vessel and a third-party vessel could result in follow-on impacts from a livelihood perspective (e.g., if a commercial or subsistence fishing vessel were damaged to the extent that its usability is impacted). These potential follow-on impacts are discussed in Section 9.15, Socioeconomic Conditions/Employment and Livelihoods.

In addition to this type of follow-on impact, marine vessel collisions in Georgetown Harbour or coastal areas could interfere with marine use and transportation if the collision results in one or both of the vessels becoming temporarily immobilized such that it presents an obstruction to other marine traffic. However, even if a collision is of sufficient magnitude to result in this outcome, it is likely the affected vessel could be relocated relatively quickly. Furthermore, Georgetown Harbour is sufficiently wide to allow vessels to pass around a potential obstruction until such time as the obstruction is cleared. On this basis, the intensity of a vessel collision with respect to potential impacts on marine use and transportation is considered **Low** to **Medium**, depending upon severity of the incident. The geographic extent would be limited to the **Direct AOI.** On the basis that collisions would occur only occasionally and at irregular intervals, and the impact on marine use and transportation would likely not be felt past a week, the frequency and duration are considered **Episodic** and **Short-term**, respectively. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**. Consistent with the sensitivity ratings assigned for potential impacts on marine use and transportation from planned activities, a sensitivity rating of **Low** to **Medium** is assigned depending on the type of vessel (i.e., **Medium** for a subsistence fishing vessel with lesser means to avoid an obstruction resulting from another vessel becoming immobilized as a result of a collision, and **Low** for a commercial vessel with a greater means of avoiding such an obstruction). This leads to a consequence/severity rating of **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As discussed in Chapter 13, Recommendations, Project vessels will be operated in accordance with standard international and local navigation procedures, which will reduce the likelihood (as well as the potential consequence) of a vessel collision. On this basis, the likelihood of a collision between a Project vessel and a third-party vessel in or around Georgetown Harbour is considered **Unlikely**.

Accordingly, the (pre-mitigation) risk to marine use and transportation as a result of a vessel collision is considered **Minor**. While prompt response and removal of any grounded or damaged vessel would serve to further reduce the consequence of such an impact, the residual risk rating is maintained at **Minor**.

Table 9.17-1: Risk Rating for Unplanned Events/Vessel Collisions on Marine Use and Transportation

Unplanned Event	Resource	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Use and Transportation	Unlikely	Medium to High	Minor to Moderate	Implement OSRP	Minor
Coastal Oil Spill	Marine Use and Transportation	Unlikely	Low to Medium	Minor	Implement OSRP	Minor
Vessel Collision	Marine Use and Transportation	Unlikely	Low	Minor	Prompt removal of damaged vessel	Minor

9.18. Social Infrastructure and Services

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on social infrastructure and services include a marine oil spill, a coastal oil spill, and a vehicular accident.

9.18.1. Marine Oil Spill (Response Efforts)

A marine oil spill could impact social infrastructure and services primarily as a result of spill response efforts. Depending on the extent of the required response, the highest potential for an impact from response teams on social infrastructure and service would likely be an increased demand for lodging. These increased demands would only be temporary (for the duration of required clean-up, likely on the order of a few weeks to months, depending on the extent of the spill and whether any oil reaches the Guyana coast). If the spill remains offshore, most of these infrastructure and service demands would likely be concentrated in Georgetown, where most response vessels would likely be based, but also where infrastructure and services capacities are greater. If oil were to reach the Guyana shoreline, land-based response efforts would be required, and the duration of response efforts would be greater.

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. However, as discussed above, the consideration in terms of potential impacts from a mitigated marine oil spill on social infrastructure and services is related to the actual response effort itself, and not whether a spill reaches the Guyana coastline.

Referring to the definitions used for assessment of potential impacts on temporary lodging from planned Project activities, the intensity of potential impacts on lodging in Georgetown (where the response workforce would likely be concentrated) as a result of response to a mitigated marine oil spill would likely be no higher than **Low** considering the potential size of a response workforce as compared to the inventory of available lodging in Georgetown—and the expectations that associated increases in demand for lodging would be perceptible but would likely only cause slight changes in availability. The geographic extent of such impacts would be focused on Georgetown (i.e., within the **Direct AOI**). On the basis that the additional lodging demands would persist throughout the spill response effort, the frequency is considered to be **Continuous**. Response efforts would likely be completed for the most part or entirely within a year or less, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Small**.

As noted in the discussion of potential impacts on lodging from planned activities, the sensitivity of Georgetown receptors to lodging impacts is conservatively rated as **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**.

In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall pre-mitigation risk to Georgetown lodging infrastructure from a marine oil spill would be **Minor**.

Although deterministic modeling of a mitigated scenario predicts no anticipated Guyana shoreline impact for both loss-of-well-control scenarios (see Section 9.24, Transboundary Impacts for a discussion of potential transboundary impacts), it is possible that logistical needs of a response effort may warrant establishing workforce operating bases down-current of the spill origin (e.g., in Region 1). Such a response effort could conceivably consist of more than 100 Guyanese and foreign responders who would require temporary lodging. Depending upon the nature of the spill, it is probable that EEPGL would establish housing or berthing for the response teams by building temporary camp structures (e.g., tents) or using a berthing vessel. This would reduce the need to rely on the minimal lodging infrastructure and service capacity that exists in Region 1. Therefore, the intensity of a potential impact on Region 1 lodging as a result of the response effort to a marine oil spill involving workforce presence in Region 1 would be **Medium**. This impact would affect (limited) portions of the **Indirect AOI**. On the basis that the additional lodging demands would persist throughout the spill response effort, the frequency is considered to be **Continuous**. Response efforts would likely be completed for the most part or entirely within a year or less, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Consistent with the sensitivity ratings assigned for potential impacts on social infrastructure and services, specifically lodging, a sensitivity rating of **Medium** is assigned assuming that the impact would affect lodging capacity and prices primarily in Region 1, where capacity is limited.

In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall pre-mitigation risk to Region 1 lodging infrastructure from a marine oil spill would be **Minor**.

9.18.2. Coastal Oil Spill (Response Efforts)

A coastal oil spill would likely only happen near the shorebases or near the mouth of the Demerara River. The available capacity of social infrastructure and services in Regions 3 and 4 is comparatively larger than in Region 1. Accordingly, the assessment of risks to lodging infrastructure for coastal oil spills was focused on Georgetown infrastructure.

Referring to the definitions used for assessment of potential impacts on temporary lodging from planned Project activities, the intensity of potential impacts on lodging in Georgetown (where the response workforce would likely be concentrated) as a result of response efforts to an mitigated coastal oil spill would likely be no higher than **Low**. This takes into consideration the limited size of a response workforce as compared to the inventory of available lodging in Georgetown, and the expectations that associated increases in demand for lodging would be perceptible but would likely only cause slight changes in availability. The geographic extent of such impacts would be focused on Georgetown (i.e., within the **Direct AOI**). On the basis that the additional lodging demands would persist throughout the spill response effort, the frequency is considered to be **Continuous**. Response efforts would likely be completed for the most part or entirely within a year or less, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

As noted in the discussion of potential impacts on lodging from planned activities, the sensitivity of Georgetown receptors to lodging impacts is conservatively rated as **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**.

In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall pre-mitigation risk to Georgetown lodging infrastructure from a coastal oil spill would be **Minor**.

9.18.3. Vehicular Accident

A vehicular accident could have a potential impact on social infrastructure and services as a result of temporary increases in road congestion (i.e., until an accident is cleared) or burdening of healthcare infrastructure in the case of an accident requiring medical services. In the case of potential road congestion, an accident would be expected to be cleared from the roadway relatively quickly. In the case of potential health infrastructure needs, the burden from a given accident—even a more serious one—would not be expected to overwhelm the existing capacity in Georgetown.

Accordingly, the intensity of potential impacts on social infrastructure and services in Georgetown would likely be **Negligible**. The geographic extent of such an impact would be focused on Georgetown (i.e., within the **Direct AOI**). Any additional burden on social infrastructure and services would persist throughout the time period during which the accident response and associated medical attention was provided (**Continuous)**, but such response efforts would likely be **Short-term** in duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**.

Drawing from the discussions of potential impacts on community health services and additional traffic congestion, the sensitivity of Georgetown receptors to these types of impacts is rated as **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**.

The Project-related increase in traffic is expected to be an insignificant incremental addition to the existing traffic levels in Georgetown. As discussed in Section 9.16, Community Health and Wellbeing, additional EEPGL-related vehicle trips (considering the Project and other anticipated EEPGL activities) are not expected to meaningfully change traffic congestion in the greater Georgetown area. This level suggests the likelihood of a vehicular accident involving a Project vehicle is **Unlikely**. However, based on the planned life cycle for the Project (at least 20 years), the likelihood of such an event is conservatively considered to be **Possible**.

Accordingly, the (pre-mitigation) risk to social infrastructure and services as a result of a vehicular accident is considered **Minor**. While prompt response and removal of any damaged vehicle would serve to further reduce the consequence of such an impact, the residual risk rating is maintained at **Minor**.

While EEPGL has developed and implemented a Road Safety Management Procedure, as summarized in Section 9.16, Community Health and Wellbeing, to further reduce the likelihood (and consequence) of a vehicular accident, the residual risk rating is maintained at **Minor**.

Table 9.18-1: Risk Rating for Unplanned Events and Vehicular Accident Risks to Social Infrastructure and Services

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill (response efforts)	Social Infrastructure and Services (Lodging)	Unlikely	Low	Minor	None	Minor
Coastal Oil Spill (response efforts)	Social Infrastructure and Services (Lodging)	Unlikely	Low	Minor	None	Minor
Vehicular Accident	Social Infrastructure and Services	Possible	Low	Minor	None	Minor

9.19. WASTE MANAGEMENT INFRASTRUCTURE CAPACITY

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on waste management infrastructure capacity would be a marine oil spill or a coastal oil spill. A marine oil spill or coastal oil spill could impact waste management infrastructure capacity primarily as a result of spill response efforts. In contrast, due to the physical nature and qualities associated with a NADF release, such weighted mud/fluids would sink if released as the result of a riser failure during drilling operations. There would be potential for a light sheen to occur, but this would dissipate rapidly. Potential impacts on marine biota, marine geology and sediments, and marine water quality from an NADF release are discussed in other sections of the EIA, but this event would not be expected to result in a material increase in waste generation and, therefore, in potential impacts on waste management infrastructure capacity. In the unlikely event of a hydrocarbon spill, the following types of wastes could be generated:

- Recovered oil
- Oily water mixed with recovered oil
- Sorbent materials
- Oiled containment boom
- Oiled PPE
- Oiled soil or sediment
- Oiled vegetation
- Oiled debris
- Deceased wildlife

All waste generated as a result of spill response activities would be managed in accordance with EEPGL's countrywide Waste Management Plan (WMP), OSRP, and Guyana laws and local regulations. Should a significant oil spill occur, an incident-specific WMP (to complement the EEPGL countrywide WMP in the ESMP) may be developed as part of the response. Further, the WMP may be adapted as required if a spill is likely to produce more waste than can be handled by EEPGL's regular waste contractors.

Currently, a private-sector contractor has the only existing facility in Guyana capable of treating hazardous wastes, and this facility has the technologies to treat the bulk of the wastes that would be generated in a spill response. Non-hazardous solid wastes from EEPGL's operations and residuals from solid wastes treated with the vertical infrared thermal unit or incinerator at this facility that are not recyclable are currently disposed at the Haags Bosch landfill. The Haags Bosch landfill could therefore be used for the disposal of the treated residues and other non-hazardous wastes that would be expected to be generated during a spill response.

As discussed in Section 8.6, Waste Management Infrastructure Capacity, the results of a recent assessment of the above-referenced hazardous-waste treatment facility indicate that, without modifications, the infrastructure capacity of the facility will likely be unable to treat (from a capacity perspective) the entire predicted inventory of EEPGL's hazardous solids and waste oil liquids produced from routine operations (all EEPGL projects and operations in Guyana) by late 2020. Plans are currently underway by private-sector hazardous waste contractors to expand their current hazardous waste handing, storage, and treatment facilities in Guyana. Additionally, the Haags Bosch landfill operator has estimated that the capacity of the landfill (which is currently operating only a single cell) will be exhausted by the end of 2019 (Kaieteur News 2019; EMC Personal Communication 19); construction of a second cell within the existing landfill footprint is currently being planned by the Ministry of Communities to be completed by the end of 2019.

The intensity of impact of a spill on the Georgetown-based hazardous waste treatment facility capacity would be a function of the scale of the spill and the volume of waste materials generated by the response effort. However, based on consideration of the above-noted current constraints and considering that any hazardous wastes generated as a result of a spill response would likely represent a significant portion of the total demand for Georgetown-based hazardous waste treatment facilities, the intensity of potential Project impacts on Georgetown-based hazardous waste treatment facilities (in the absence of capacity expansions and/or the introduction of additional facilities of a sufficient quality) is considered to be **High**. Potential impacts would be limited to the **Direct AOI** (i.e., Georgetown). On the basis that the impacts would persist throughout the spill response effort, the frequency is considered to be **Continuous**. Response efforts would likely be completed for the most part or entirely within a year or less, so duration is considered to be **Medium-term**. Therefore, the magnitude of this potential impact is rated as **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on non-Project users of Georgetown-based hazardous waste treatment facilities from planned activities, a sensitivity rating of **Low** is assigned, on the basis that these users have the ability to access alternate regional providers for this service.

Applying the methodology in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.5, Oil Spill Modeling Results, a likelihood rating of **Unlikely** for a marine oil spill and a coastal oil spill is applied. Accordingly, the overall (pre-mitigation) risk to the Georgetown-based hazardous waste treatment facilities component of waste management infrastructure capacity from a marine oil spill or coastal oil spill is considered **Minor** (see Table 9.19-1).

As with hazardous waste treatment facilities, the intensity of impact of a spill on Georgetown-based landfill capacity would be a function of the scale of the spill and the volume of waste materials generated by the response effort. However, even with a large spill, it is not likely that response-related wastes would comprise a significant proportion of the total current demand on Georgetown-based landfill facilities (on the order of approximately 12,000 tonnes per month [Kaieteur News 2019]). However, under the assumption that a large spill could produce a significant increase in the Project's waste volume during the response effort, the intensity of potential Project impacts on Georgetown-based landfill facilities (in the absence of capacity expansions and/or the introduction of additional facilities of a sufficient quality) is conservatively rate as **Medium**. Potential impacts would be limited to the **Direct AOI** (i.e., Georgetown). On the basis that the impacts would persist throughout the spill response effort, the frequency is considered to be **Continuous**. Response efforts would likely be completed for the most part or entirely within a year or less, so duration is considered to be **Medium-term**. Therefore, the magnitude of this potential impact is rated as **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on non-Project users of Georgetown-based landfill facilities from planned activities, a sensitivity rating of **High** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. As described in Section 9.1.5, Oil Spill Modeling Results, a likelihood rating of **Unlikely** for a marine oil spill and a coastal oil spill is applied. Accordingly, the overall (pre-mitigation) risk to the Georgetown-based landfill component of waste management infrastructure capacity from a marine oil spill or coastal oil spill is considered **Moderate** (see Table 9.19-1).

As described in Section 8.6, Waste Management Infrastructure Capacity, the Project has initiated a number of mitigation measures to ensure the Project has access to a reliable supply of waste management infrastructure capacity for its routine operations; these same mitigation measures would be directly applicable in the case of spill response-related waste management needs. With implementation of these mitigation measures, and considering that EEPGL has a robust plan for managing waste (i.e., through a combination of the OSRP and WMP, as well as provisions for adapting these plans as needed based on the nature of the response effort), the intensity ratings for potential spill response-related impacts on waste management infrastructure capacity from a marine oil spill or coastal oil spill would be reduced to **Low** for Georgetown-based hazardous waste treatment facilities and **Negligible** for Georgetown-based landfills.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low** for both Georgetown-based hazardous waste treatment facilities and Georgetown-based landfills. In combination with the likelihood rating of **Unlikely** for a marine oil spill and a coastal oil spill, the residual risk to waste management infrastructure capacity from these types of unplanned events is considered **Minor** (see Table 9.19-1).

Table 9.19-1: Risk Ratings for Unplanned Event Impacts on Waste Management Infrastructure Capacity

Unplanned Event	Resource/Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill or Coastal Oil Spill (response efforts)	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based hazardous waste treatment facilities)—exceedance of capacity	Unlikely	Low	Minor	Enable increases to existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facility or facilities, or identify suitable alternative solutions.	Minor
Marine Oil Spill or Coastal Oil Spill (response efforts)	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based landfill facilities)—exceedance of capacity	Unlikely	High	Moderate	Monitor the Ministry of Communities' planned construction of Cell 2 at the Haags Bosch landfill, and/or identify suitable alternative (interim) local solutions for non-hazardous waste management.	Minor

9.20. Cultural Heritage

As indicated in Table 9.1-6, the only unplanned events with the potential to result in measureable impacts on cultural heritage would be a marine oil spill, a coastal oil spill, or an NADF release. This section considers the risk to coastal cultural heritage and underwater cultural heritage as a result of these potential unplanned events.

9.20.1. Marine Oil Spill

As noted in Section 8.7.2.2, Coastal Cultural Heritage, data obtained from the National Trust of Guyana show that there are several archaeological sites along the Guyana coast, including shell mounds, seashell deposits, quarries, pollen sections, tool/implements, and ceramic/pottery sites (i.e., scatters). In Regions 1 and 2, there are approximately 68 and 12 of these sites, respectively (EMC Personal Communication 6). Desktop research has identified two known ceramic/pottery sites nearest to the coastline. Additionally, Section 8.9.2, Existing Conditions—Ecosystem Services, describes cultural heritage sites identified by local community members during the late 2017 and early 2018 ecosystem services baseline data collection and 2019 validation efforts. In Region 1, these include shell mounds near Haimacobra Village, Waramuri Village, and Assakata Village, as well as a sacred site (a 200-year-old church) near Santa Rosa Village. In Region 2, a historic landmark (a Dutch chimney) in the Supenaam area was identified. In Region 3, identified historical sites included a monument and an eighteenth-century Dutch koker, both located near Best/Klien/Pouderoyen (ERM/EMC 2018). Based on the ubiquity of past human occupations (and thus archaeological sites), especially along coastlines, it is possible that there are additional unidentified archaeological resources along Guyana's coastline.

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

If an unmitigated marine oil spill were to reach a Guyana shoreline, the spill would generally only impact the intertidal zone, unless the spill coincides with a significant storm surge. Additionally, while archaeological sites are common along coastlines, sites in the intertidal zone tend to lack stratigraphic integrity due to the dynamic interface between the ocean and the land, especially along beaches. Accordingly, the intensity of such an impact would be considered **Low** on coastal cultural heritage. The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that the marine oil spill would continue over several weeks, the frequency is considered to be **Continuous**. Assuming no mitigation of the spill, the effects could extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the

Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on coastal cultural heritage, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**, so the overall risk of a marine oil spill to coastal cultural heritage is considered **Minor**.

Effective implementation of the OSRP would further reduce the risk of an oil spill reaching the coast by limiting the geographic extent the oil could travel. Accordingly, the intensity of a marine oil spill on coastal cultural resources would be reduced to **Negligible**. The geographic extent of a mitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that the impacts from a marine oil spill could persist over several weeks, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**. Consistent with the sensitivity ratings assigned for potential impacts on coastal cultural heritage, a sensitivity rating of **Medium** is assigned. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.1.9, a marine oil spill is considered **Unlikely**, so the overall residual risk of a marine oil spill to coastal cultural heritage (see Table 9.20-1) remains as **Minor**.

9.20.2. Coastal Oil Spill

A coastal oil spill, if it were to occur, would likely happen near the shorebases or near the mouth of the Demerara River. The coastline in this area is highly developed, significantly reducing the likelihood that coastal cultural resources would be present at any locations where a coastal oil spill resulted in an impact on the shoreline (no such resources were identified in the ecosystems services field validation work described above). Accordingly, the intensity of a coastal oil spill on coastal cultural resources is considered **Low**. The geographic extent of an unmitigated coastal oil spill could include portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on coastal cultural heritage, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.1.9, a marine oil spill is considered **Unlikely**, so the overall risk of a marine oil spill to coastal cultural heritage is considered **Minor**.

While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of an impact on coastal cultural heritage from an oil spill, the residual risk rating remains **Minor**.

9.20.3. NADF Release

With respect to potential impacts on underwater cultural heritage, in the unlikely event of an NADF release, some oil would be expected to settle to the seafloor and could damage submerged cultural heritage (e.g., shipwrecks), but the highest probability for this to occur would be in proximity to the spill source. Based on geophysical surveys conducted in the PDA and surrounding vicinity, no shipwrecks or associated artifact scatters were identified within the PDA or vicinity (see Section 8.7.2.1, Underwater Cultural Heritage). Based on these factors, the intensity of an NADF release with respect to impacts on underwater cultural heritage is therefore considered **Low**.

The geographic extent of an unmitigated NADF release to underwater cultural heritage would be limited to the **Direct AOI**. On the basis that impacts from an unmitigated NADF release would persist as long as cultural heritage sites were exposed to the spilled material, the frequency is considered to be **Continuous**. Even without mitigation, the currents would redistribute the spilled material and impacts would be expected to persist less than a year, yielding a **Medium-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on underwater cultural heritage, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.1.9, an NADF release is considered **Unlikely**, so the overall risk of an NADF release to underwater cultural heritage is considered **Minor** (see Table 9.20-1). While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of an impact on underwater cultural heritage from an oil spill, the residual risk rating remains **Minor**.

Table 9.20-1: Risk Ratings for Unplanned Event Impacts on Cultural Heritage

Unplanned Event	Resource	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Coastal Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Oil Spill	Coastal Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor
NADF Release	Marine Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor

9.21. LAND USE

As indicated in Table 9.1-6, the only unplanned events with the potential to result in measureable impacts on land use would be a marine oil spill or a coastal oil spill. The principal concerns with respect to potential land use impacts from a marine or coastal oil spill relate to the scenario where an oil spill would affect a portion of the shoreline being used for agriculture purposes (e.g., subsistence farming or livestock) or where an oil spill could indirectly result in adverse impacts on land drainage (i.e., through sluice closures). Accordingly, the assessment of potential impacts on land use from unplanned events is focused on these scenarios.

As described in Section 9.1.10.1, Vessel Collision with a Third-Party Vessel or Structure (Non-Spill Related Impacts), if a coastal oil spill were to occur at the shorebases or as a result of the nearshore grounding of a vessel or a vessel collision, marine diesel could enter the Georgetown Harbour/Demerara River estuary. As shown in Figure 9.21-1, there are only a few areas along the shore zone or coastal areas near Georgetown and on the western bank of the Demerara River bank that are used for agricultural purposes—specifically, subsistence farming and/or grazing of livestock. As shown in the figure, these areas are set back from the coast and protected by either manmade structures (e.g., seawall) or mangroves. A potential coastal spill would only affect land use in these areas if it occurred in proximity to one of the sites, were sufficiently large to reach the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill over the bank and onto the sites in question.

9.21.1. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, stochastic modeling of an unmitigated marine oil spill from a loss-of-well-control event indicates a 5 to 20 percent probability of the oil contacting the coast in Region 1. The area of potential effect in this scenario includes the SBPA, where only a few plots of land are used for agricultural purposes along or in close proximity to the coast, specifically at Father's Beach and Almond Beach (see Figure 9.21-2). As with a potential coastal spill, a marine oil spill would only affect these areas if it were sufficiently large to reach these areas along the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill onto the sites in question. Accordingly, the intensity of a marine oil spill with respect to potential impacts on land use for agricultural purpose is considered to be **Low**.

The geographic extent of a marine oil spill would include portions of the **Indirect AOI**. In the absence of mitigation, impacts from a marine oil spill could persist over a multi-week basis, so the frequency is considered to be **Continuous**. Depending on the size of the spill, the effects, assuming no mitigation of the spills, would have the potential to extend beyond a year, so duration is conservatively considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on land use from planned activities, a sensitivity rating of **Medium** is assigned assuming that the impact would affect land used for income generation.

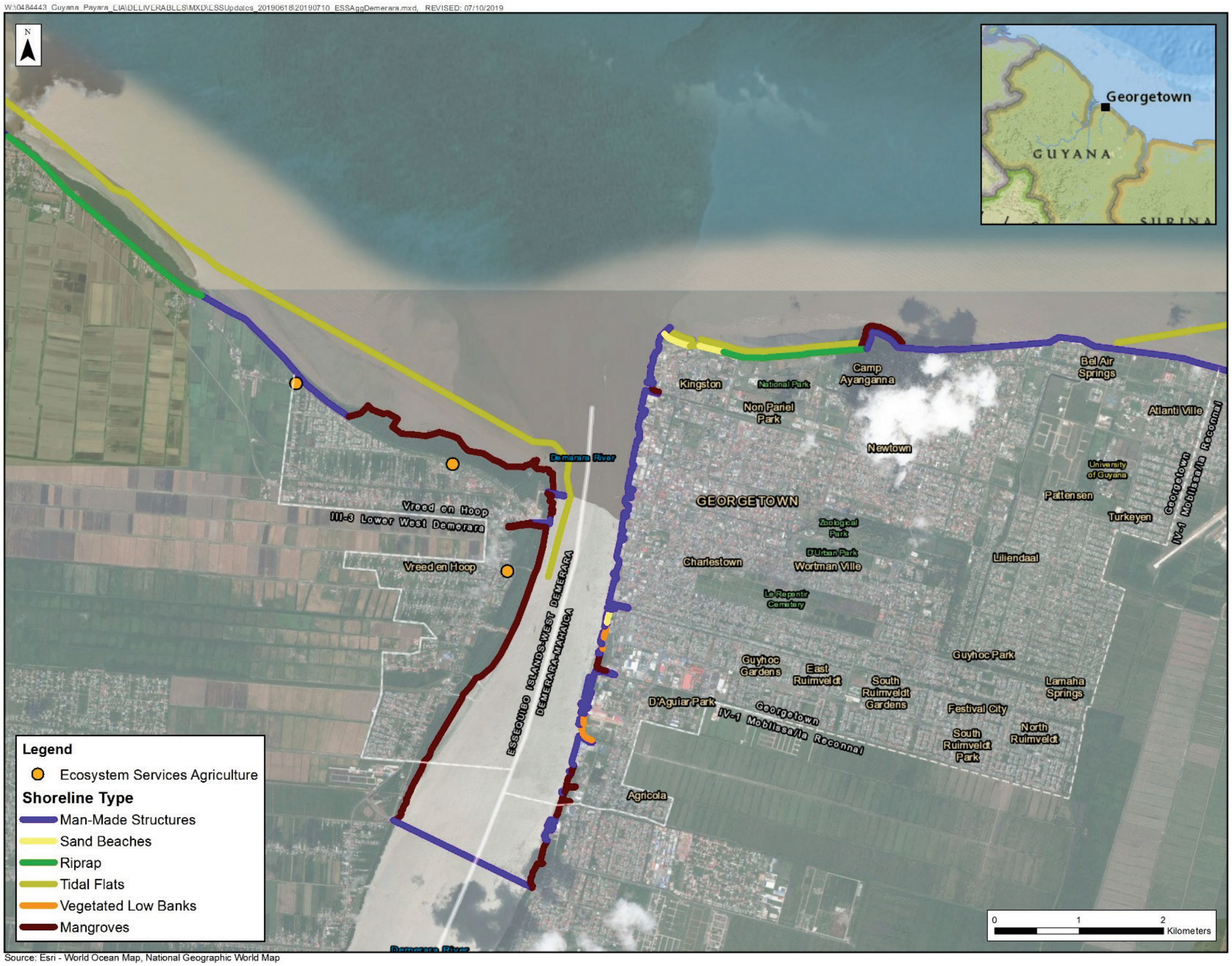


Figure 9.21-1: Agricultural Areas along Coast in Georgetown/Demerara River Vicinity

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the risk to land use from this unplanned event is considered **Minor** (see Table 9.21-1). While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of an impact on land use from a marine oil spill, the residual risk rating is maintained at **Minor**.

9.21.2. Coastal Oil Spill

Depending on tidal conditions and extent of spread of the spill, a coastal oil spill also could prevent the opening up of sluices to allow for drainage of lands along the Demerara River. Closure of sluices could prevent the spill moving inland into canals, but if such closure happens in the rainy season, it could affect area drainage and lead to water accumulation on lands and flooding as a result. However, if this were to occur, the limitation on opening sluices would be expected to be short-term in nature, reducing the consequence from a flooding perspective.

Based on the factors above, the intensity of a coastal oil spill with respect to potential impacts on land use for agricultural purpose is considered to be **Low**.

The geographic extent of an unmitigated coastal oil spill would include portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4 these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on land use from planned activities, a sensitivity rating of **Medium** is assigned assuming that the impact would affect land used for income generation.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.5, Oil Spill Modeling Results, a coastal oil spill is considered **Unlikely**. Accordingly, the overall (pre-mitigation) risk to land use from this unplanned event is considered **Minor** (see Table 9.21-1). While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of an impact on land use from a coastal oil spill, the residual risk rating is maintained at **Minor**.

Table 9.21-1: Risk Ratings for Unplanned Event Impacts on Land Use

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Land Use	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Oil Spill	Land Use	Unlikely	Low	Minor	Implement OSRP	Minor

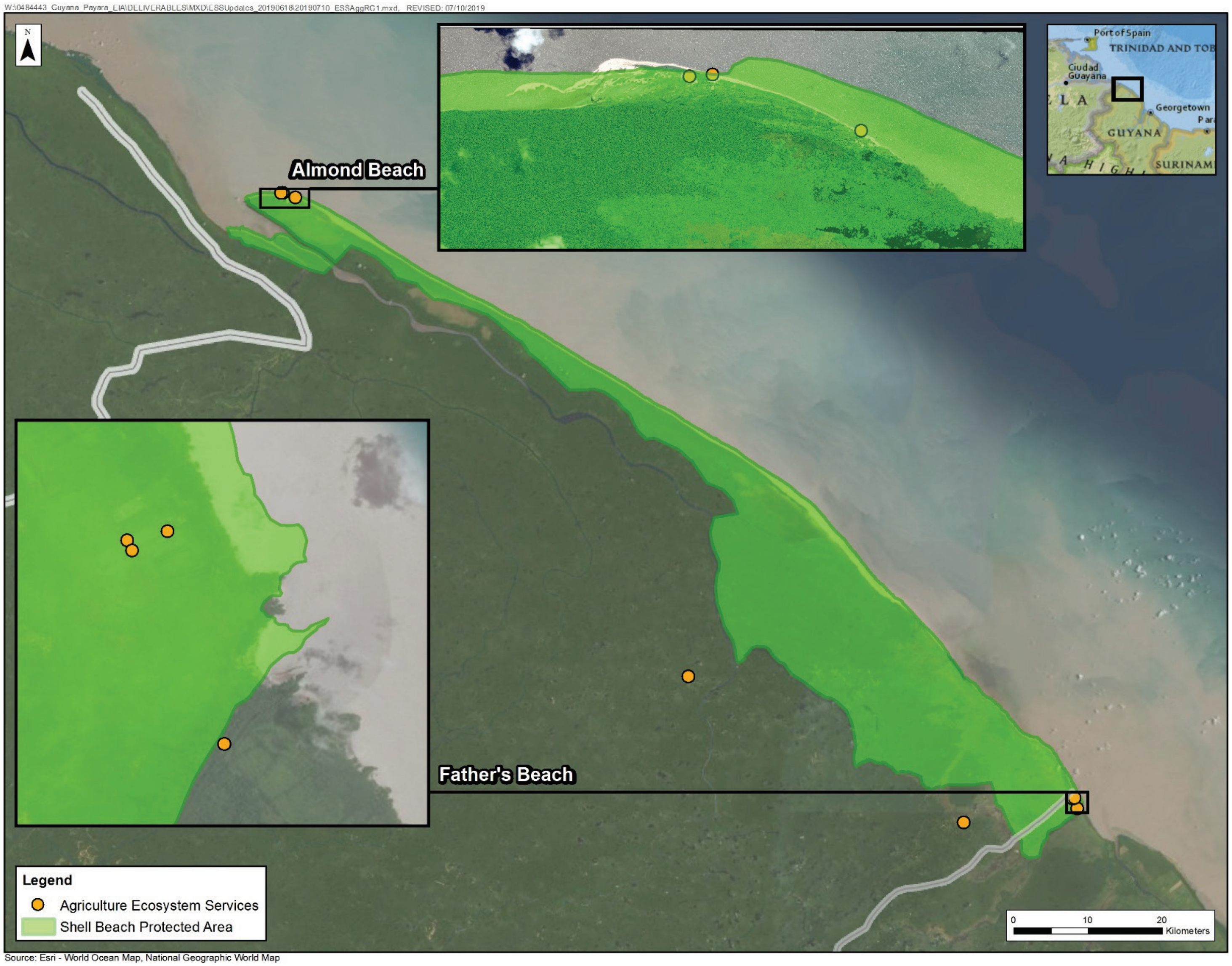


Figure 9.21-2: Agricultural Areas along Coast in Region 1

9.22. ECOSYSTEM SERVICES

As indicated in Table 9.1-6, the unplanned events with the potential for any measureable impacts on ecosystem services would be a marine oil spill and a coastal oil spill.

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

As described in Section 9.21, Land Use, depending on the location of a coastal oil spill, marine diesel could enter the Georgetown Harbour/Demerara River estuary, potentially affecting coastal ecosystem services in Regions 3, 4, or (depending on the magnitude of the spill) possibly Region 2. For these reasons, the discussion of potential impacts on ecosystem services is focused on Region 1 (in the case of a marine oil spill) and Regions 2 to 4 (in the case of a coastal oil spill).

Guyana is a country that is rich in natural resources and a large proportion of the population still relies on these resources for livelihoods and subsistence. Fisheries and agriculture are still among the top contributors to the country's GDP, and these activities occur primarily in the coastal areas. The Region 2 and 3 economies derive a large share of their income from farming, with rice being predominant in Region 2 and rice and sugarcane being predominant in Region 3. Populations in these regions also grow many non-traditional crops for local sale and consumption. In Region 1, agriculture occurs at a relatively small scale—for subsistence use mainly—but a number of other natural resource-based activities take place, particularly by indigenous communities. Along the coast and at the river mouths, these activities include fishing, crabbing, hunting, and trapping. Some communities also hunt shorebirds, wild animals, and marine turtles, and collect marine turtle eggs and medicinal plants from the Shell Beach area. While the Region 4 economy is more diverse compared to the other coastal regions, there is still a large fishing sector and considerable agricultural activity in the rural parts of the region, as is the case for Regions 5 and 6.

Other provisioning services that could be potentially impacted by an unmitigated marine oil spill include the coastal transportation networks that link communities and provide access to markets, especially in Region 1 and between Regions 2 and 3, where aquatic transportation is the only method of transportation available.

In addition to provisioning services, the marine and coastal ecosystems in Guyana provide a range of other important services that offer protection and are necessary for the functioning and support of ecosystems and both human and non-human life. These include regulating services such as the coastal flood protection offered by mangrove forests and wildlife habitat provided by mangrove forests, mud banks, and coastal swamps.

In terms of cultural services, areas along the coast in Regions 2 to 4 are important for religious and traditional ceremonies for ethnic groups in Guyana. Many members of the Hindu community conduct funeral ceremonies on the seashore, with disposal of ashes in the ocean. Throughout the year and during holy festivals, Hindus also perform cleansing ceremonies on the seashore. African cultural organizations perform traditional emancipation ceremonies at a specific seawall location in the Georgetown area once a year. Additionally, seawalls, beaches, and coastal parks are important to locals for tourism, recreation, and leisure.

Table 9.22-1 provides a summary of the potential ecosystem services impacts that could result from a marine oil spill or a coastal oil spill.

Table 9.22-1: Potential Ecosystem Services Receptors and Impacts from a Marine Oil Spill or Coastal Oil Spill

Receptor(s)	Key Potential Impacts
Coastal population in Regions 2, 3, 4	• Impacts on commercial fisheries and subsistence fishing • Impacts on coastal agriculture (subsistence farming and non-traditional crops, e.g., coconut, palm hearts) and grazing of animals • Impacts on aquatic transportation systems and trade • Impacts on shoreline protection provided by mangroves • Impacts on recreation, leisure and tourism
Hindu population in Regions 2, 3, 4	• Disruption of religious ceremonies (funeral and cleansing ceremonies)
Coastal population in Region 1, predominately Indigenous Peoples	• Impacts on agriculture, fishing, crabbing, hunting, trapping • Impacts on shoreline protection provided by river mangroves • Impacts on mangroves on Shell Beach • Impacts on aquatic transportation systems and trade • Impacts on (burgeoning) ecotourism

9.22.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Definitions for intensity of impact and sensitivity of receptor were not provided in the assessment of potential impacts on ecosystem services from planned Project activities because there are no potential impacts on ecosystem services from planned Project activities. Because the methodology for determining a rating for risks to ecosystem services from an unplanned event involves consideration of the intensity of impact (assuming the unplanned event were to occur) and sensitivity of receptor, they are therefore provided in this section.

The intensity of potential impacts on ecosystem services is defined according to the definitions provided in Table 9.22-2.

Table 9.22-2: Definitions for Intensity Ratings for Potential Impacts on Ecosystem Services

Criterion	Definition
Intensity	Negligible: No changes to ecosystem services functions and values.
	Low: Changes to function(s) and/or value(s) of ecosystem services, but limited to a localized area.
	Medium: Changes to function(s) and/or value(s) of ecosystem services over a moderately sized area.
	High: Widespread changes to function(s) and/or value(s) of ecosystem services.

The sensitivity of ecosystem services to individuals and households is defined according to the definitions provided in Table 9.22-3.

Table 9.22-3: Definitions for Sensitivity Ratings for Potential Impacts on Ecosystem Services

Criterion	Definition
Sensitivity	Low: Individuals and/or households are not highly dependent on the benefits obtained from any one critical or high rated ecosystem service (or its location), and can recover quickly from Project-related impacts to such ecosystem service(s).
	Medium: Individuals and/or households cannot readily recover from Project-related impacts to a critical or high rated ecosystem service(s), but can take advantage of benefits resulting from other ecosystem service(s) or economic/recovery opportunities.
	High: Individuals and/or households cannot readily recover from Project-related impacts to a critical or high rated ecosystem service(s), and that ecosystem service(s) represents a substantial fraction of an ecosystem service type.

9.22.2. Marine Oil Spill

As noted above, for both loss-of-well-control scenarios modeled, stochastic modeling indicates a 5 to 20 percent probability of an unmitigated marine oil spill reaching a Guyana shoreline (in Region 1). Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

As described in Section 9.23, Indigenous Peoples, indigenous communities in remote areas of Region 1 rely on coastal habitats for subsistence and livelihoods and have fewer alternative food sources and livelihood opportunities. In the unlikely event of a marine oil spill reaching the coast, provisioning ecosystem resources in Region 1 could potentially be adversely impacted. In the event that mangrove forests and swamps along the coast are impacted by an oil spill, species such as fish, crabs, birds, and wild animals (iguanas, deer, wild hog, agouti, labba, etc.), which are depended upon by indigenous communities as a source of protein, would potentially be impacted.

Crabbing and fishing (but especially crabbing) sites are particularly widespread across the entirety of Region 1's coastline, whereas hunting areas are most densely concentrated in the northwest corner of Region 1, around the Waini River. The area around the Waini River provides a particularly diverse set of ecosystem services including crabbing, fishing, hunting areas, mangroves, agricultural areas, and traditional/religious sites. The area surrounding the boundary between Regions 1 and 2 is similarly important, although there are a higher number of traditional/religious sites in this area than in the far northwestern portion of Region 1. Agriculture is also slightly more important in this area than in the far northwestern portion of Region 1. Between these two extremes, in the middle portion of Region 1's coast, crabbing is the most prevalent ecosystem service, with general biodiversity, foraging/gathering sites, and traditional/social sites playing a less important role.

Therefore, with respect to provisioning ecosystem services, the key concerns would be potential impacts on fishing and crabbing from an unmitigated marine oil spill, especially if the oil reaches near-coastal waters (where most artisanal and commercial fishing occurs). Potential impacts on trapping and hunting would also be a concern, especially in the area around the Waini River. In the far southeastern portion of Region 1, closer to the Pomeroon River, effects on agricultural and cultural/religious activities could be of concern. Impacts on the growing ecotourism sector in some villages in Region 1, most notably Warapoka, could also be of concern, as a marine oil spill could discourage tourists from visiting the region.

9.22.2.1. Fisheries Resources and Aquatic Transportation

If oil was to reach near coastal waters where most fishing occurs, the intensity of a marine oil spill with respect to potential impacts on fisheries resources and aquatic transportation is considered to be **Medium**.

The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**. Individuals and households within Region 1 typically have a higher vulnerability to change and derive significant benefit from fisheries resources and aquatic transportation for their livelihoods. While the ecosystem provisioning service of cultivating crops is also of critical benefit, that service could not replace the benefits derived from fishing and aquatic transport. Consistent with the sensitivity rating definitions in Table 9.22-3, individuals and households within Region 1 are assigned a sensitivity rating of **High**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. As described in Section 9.1.5, Oil Spill Modeling Results, a marine oil spill is considered **Unlikely**. Accordingly, the overall (pre-mitigation) risk to fisheries resources and aquatic transportation from an unmitigated marine oil spill is considered **Moderate**.

In the unlikely event of a marine oil spill, EEPGL will deploy emergency response equipment to mitigate the effects of the spill and to protect sensitive coastal resources such as mangroves, as appropriate. Effective implementation of the OSRP would reduce this risk by reducing the probability of oil reaching near-coastal waters or the Guyana coast. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and

Livelihood Remediation Processes) would be established to further reduce this risk by compensating for livelihoods affected as a result of effects to fisheries-related ecosystem services or effects to other near-shore provisioning services (e.g., should mobility of transport and access to markets via aquatic networks be impacted). On this basis, the residual risk rating is reduced to **Minor**.

9.22.2.2. Coastal Agriculture

With respect to potential impacts on coastal agriculture in Region 1, in the unlikely event of an unmitigated marine oil spill, stochastic modeling indicates the potential for subsistence farming along the SBPA in Region 1 to be impacted; however, there are only a few plots of land used for agricultural purposes along or in close proximity to the coast, specifically Father's Beach and Almond Beach. Furthermore, there are only a few coastal areas where hunting and trapping occur. A marine oil spill would only directly affect these areas if it were sufficiently large enough to reach these areas along the shoreline and the tide was sufficiently high at the time of the spill to carry the spill onto the sites in question. In the communities further north, such as Three Brothers, Smith's Creek, and Morawhanna, river water occasionally overflows the empoldered areas created for farming, resulting in salt-water intrusion. Similarly, spilled oil that reaches the river systems could potentially end up in these farming areas. These effects are considered highly unlikely, as the movement of oil upstream would be limited by tidal action. Further, farmers would have ample notice to close sluice gates, and spill responders would have time to install absorbent booms or other spill control equipment to prevent oil from reaching farmers' crops or drainage inlets. Therefore, the intensity of the potential impact on coastal agriculture would be **Low**.

The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity rating definitions in Table 9.22-3, individuals and households within Region 1 - who typically have a higher vulnerability to change and value agricultural ecosystem services as critical, are assigned a sensitivity rating of **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.5, a coastal oil spill is considered **Unlikely**. Accordingly, the overall (pre-mitigation) risk to coastal agriculture from a marine oil spill is considered **Minor**.

While effective implementation of the OSRP would reduce this risk by reducing the probability of oil reaching near-coastal waters or the Guyana coast, and a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9) would be established to further reduce this risk by compensating economic losses related to loss of these provisioning services, the residual risk rating is maintained at **Minor**.

9.22.2.3. Shoreline Protection

With respect to regulating ecosystem services, specifically shoreline protection, in the unlikely event of a marine oil spill reaching the coast, important habitats such as mangrove forests, mud flats, swamps, and beaches could be impacted. These provide a range of ecosystem services to coastal populations in Region 1. If oiling is severe enough to cause the loss of some mangrove forests, this would weaken a critical component of the country's sea defense system and expose the coastal population to increased coastal flooding hazard, especially in Region 1, where agricultural areas are not protected from flooding by the same system of sea defense as in Regions 2 to 6. On this basis, the intensity of a marine oil spill with respect to potential impacts on shoreline protection in Region 1 is considered **Medium**.

The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity rating definitions in Table 9.22-3, individuals and households within Region 1 who typically have a higher vulnerability to change and would be impacted by the coastal flooding hazard are assigned a sensitivity rating of **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High.** As described in Section 9.1.5, a coastal oil spill is considered **Unlikely**. Accordingly, the overall (pre-mitigation) risk to shoreline protection-related ecosystem services from this unplanned event is considered **Moderate**.

In the unlikely event of a marine oil spill, EEPGL will deploy emergency response equipment to mitigate the effects of the spill and to protect sensitive coastal resources such as mangroves, as appropriate. Effective implementation of the OSRP would reduce this risk by reducing the probability of oil reaching near-coastal waters or the Guyana coast. On this basis, the residual risk rating is reduced to **Minor**.

9.22.2.4. Ecotourism

During the 2019 ecosystem services validation field efforts, village leaders in Warapoka described increased ecotourism in their village as a result of targeted efforts by the village and regional government to build ecotourism opportunities in the area. Other villages, such as Waramuri and Assakata, also indicated their plans to build ecotourism-related infrastructure. Areas in Region 1, especially Warapoka and the SBPA, have high aesthetic and educational value—and constitute an important cultural ecosystem service. In the unlikely event of a marine oil spill reaching the Guyana coast, ecotourism could be impacted. However, ecotourism in SBPA is not prevalent and an oil spill deterring tourists from visiting Warapoka would therefore be minimal. Accordingly, the intensity of a marine oil spill with respect to potential impacts on ecotourism in Region 1 is considered **Low**.

The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill would continue over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. For these villages that benefit from ecotourism, there are no other critical or high rated ecosystem cultural services that could replace ecotourism. For this reason, and consistent with the sensitivity rating definitions in Table 9.22-3, individuals and households within Region 1—who typically have a higher vulnerability to change—are assigned a sensitivity rating of **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium.** As described in Section 9.1.5, a marine oil spill is considered **Unlikely**. Accordingly, the overall (pre-mitigation) risk to ecotourism from this unplanned event is considered **Minor**. While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a marine oil spill, the residual risk rating is maintained at **Minor**.

9.22.3. Coastal Oil Spill

9.22.3.1. Fishing and Aquatic Transportation

A coastal oil spill, depending on the location, could potentially affect coastal ecosystem services in Regions 3, 4, or (depending on the magnitude of the spill) possibly Region 2. Fisheries services are critical ecosystem provisioning services in all of these regions, with aquatic transportation being most critical in Regions 2 and 3. Therefore, the intensity of a coastal oil spill with respect to potential impacts on fisheries resources and aquatic transportation is considered to be **Medium**.

The geographic extent of an unmitigated coastal oil spill could include (limited) portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather), and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity rating definitions in Table 9.22-3, individuals and households within Regions 2, 3, and 4 would have a sensitivity rating of **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. As described in Section 9.1.5, a coastal oil spill is considered **Unlikely**. Accordingly, the overall (pre-mitigation) risk to provisioning ecosystem services related to fishing or other economic uses of affected coastal waterways from a coastal oil spill is considered **Moderate**. Effective implementation of the OSRP would reduce this risk by reducing the area affected by such a spill. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9) would be established to further reduce this risk by compensating affected fisherfolk for loss of harvest due to regional fisheries closures attributed to the oil spill, as well as other affected stakeholders (e.g., should mobility of transport and access to markets via aquatic networks be impacted). On this basis, the residual risk rating is reduced to **Minor**.

9.22.3.2. Coastal Agriculture

Depending on the location of a coastal oil spill, marine diesel could enter the Georgetown Harbour/Demerara River estuary. There are only a few areas along the shore zone or coastal areas near Georgetown and on the western bank of the Demerara River bank that are used for agricultural purposes—specifically, subsistence farming and/or grazing of livestock in Region 3. These areas are set back from the coast and protected by either manmade structures (e.g., seawall) or mangroves. A potential coastal spill would only affect land use in these areas if it occurred in proximity to one of the sites, were sufficiently large to reach the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill over the bank and onto the sites in question.

Rice farming, which makes up the majority of agricultural activity in the coastal area of Regions 2 and 3, would not be directly impacted by a coastal oil spill since rice fields are irrigated from inland water conservancies. However, the islands at the mouth of the Essequibo River, including Leguan and Wakenaam, use freshwater from the river for irrigation of rice crops. It is unlikely that a coastal oil spill in the vicinity of Georgetown Harbour would reach the Essequibo River area. Therefore, the intensity of a coastal oil spill with respect to potential impacts on coastal agriculture is considered to be **Low**.

The geographic extent of an unmitigated coastal oil spill could include (limited) portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity rating definitions in Table 9.22-3, individuals and households within Regions 2 and 3 who rely on these ecosystem services typically have the means to seek benefits from other critical or high rated ecosystem services and therefore have a sensitivity rating of **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.5, a coastal oil spill is considered **Unlikely**. Accordingly, the overall (pre-mitigation) risk of a coastal oil spill that reaches the Guyana coast on coastal agricultural-related ecosystem services communities is considered **Minor**. In the unlikely event of a coastal oil spill, the spill would be quickly controlled and contained because of the smaller volumes and the ready access to spill control equipment. There is the potential for a spill in these coastal areas to impact fisherfolk because of its proximity to nearshore fishing grounds. The affected area would be limited and of short duration, and a relatively rapid environmental recovery would be expected. While effective implementation of the OSRP would reduce this risk by reducing the area affected by such a spill; and a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9) would be established to further reduce this risk by compensating for economic losses, the residual risk rating is maintained at **Minor**.

9.22.3.3. Shoreline Protection

With respect to shoreline protection, in the unlikely event of a coastal oil spill, important habitats such as mangrove forests, mud flats, swamps, and beaches could be impacted. However, agricultural areas in Regions 2 to 4 are better protected by manmade sea defense than in Region 1. On this basis, the intensity of a coastal oil spill with respect to potential impacts on shoreline protection in Region 2 to 4 is considered **Low**.

The geographic extent of an unmitigated coastal oil spill could include (limited) portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned in Table 9.22-3, individuals and households within Regions 2, 3, and 4 would be impacted by a change in shoreline protection or sea defense systems but would have the ability to adapt and therefore have a sensitivity rating of **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Minor**. As described in Section 9.1.5, a coastal oil spill is considered **Unlikely**. Accordingly, the overall (pre-mitigated) risk to shoreline protection-related ecosystem services from this unplanned event is considered **Minor**. While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a coastal oil spill, the residual risk rating is maintained at **Minor**.

9.22.3.4. Recreation and Tourism

With respect to potential impacts on recreation and tourism, in the unlikely event of a coastal oil spill reaching the coast, recreational uses of coastline areas could be impacted. Based on the high prevalence of use of most of the coastline for recreation and local tourism on a consistent basis, the intensity of such an impact is considered **Medium**.

The geographic extent of an unmitigated coastal oil spill could include (limited) portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned in Table 9.22-3, individuals and households who would be impacted could find alternate locations and therefore have a sensitivity rating of **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.5, a coastal oil spill is considered **Unlikely**. Accordingly, the (pre-mitigation) risk to local tourism and recreation-related ecosystem services from this unplanned event is considered **Minor**. While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a coastal oil spill, the residual risk rating is maintained at **Minor**.

9.22.3.5. Religious Ceremonies

With respect to potential impacts on traditional use and religious ceremonies, in the unlikely event of a coastal oil spill reaching the coast, use of coastline areas for religious purposes could be impacted. Based on the use of the coastline for traditional and religious services, and the large Hindu population in the potentially affected coastal regions, the intensity of such an impact is considered **Medium**.

The geographic extent of an unmitigated coastal oil spill could include (limited) portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal oil spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned in Table 9.22-3, individuals and households who would be impacted could find alternate locations and therefore have a sensitivity rating of **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.5, a coastal oil spill is considered **Unlikely**. Accordingly, the (pre-mitigation) risk to religious use-related ecosystem services from this unplanned event is considered **Minor**. While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a coastal oil spill, the residual risk rating is maintained at **Minor**.

Table 9.22-4 summarizes the pre-mitigation and residual risks to ecosystem services from unplanned events.

Table 9.22-4: Risk Ratings for Potential Unplanned Event Impacts on Ecosystem Services

Unplanned Event	Ecosystem Service	Likelihood of Event	Consequence/ Severity Rating	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill (Region 1)	Fishing and aquatic transport	Unlikely	High	Moderate	Implement OSRP	Minor
	Coastal agriculture, trapping hunting	Unlikely	Medium	Minor	Implement claims and/or livelihood remediation processes for affected individuals	Minor
	Ecotourism	Unlikely	Medium	Minor		Minor
	Shoreline protection	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Oil Spill (Region 2, 3, or 4)	Fishing and aquatic transport	Unlikely	High	Moderate	Implement OSRP	Minor
	Coastal agriculture	Unlikely	Low	Minor	Implement claims and or livelihood remediation processes for affected individuals	Minor
	Shoreline protection	Unlikely	Low	Minor	Implement OSRP	Minor
	Recreation	Unlikely	Low	Minor		Minor
	Religious ceremonies	Unlikely	Low	Minor		Minor

9.23. INDIGENOUS PEOPLES

As indicated in Table 9.1-6, the only unplanned event with the potential to result in measureable impacts on indigenous peoples would be a marine oil spill. A coastal oil spill, if it were to occur, would likely happen near the shorebases or near the mouth of the Demerara River. Significant indigenous populations are not present in this area; accordingly, potential risk to indigenous peoples from a coastal oil spill is not discussed further herein.

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). The potential for shoreline contact is highly dependent on wind and current conditions at the time of the spill. Stochastic modeling for both scenarios indicates a 5 to 20 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain well offshore of Guyana under all oil spill scenarios considered in the modeling analysis. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill also would not reach the Guyana shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

As discussed in Section 8.9.3, Impact Assessment—Ecosystem Services, indigenous populations in the more remote coastal areas of Regions 1 and 2 make use of a range of coastal resources for subsistence and livelihoods. Communities that are directly adjacent to the coast include Three Brothers, Almond Beach, and Father's Beach. Indigenous villages located 5 to 10 kilometers (approximately 3 to 6 miles) inland from the coast in Regions 1 and 2 include Santa Rosa, Waramuri, Manawarin, Assakata, Imbotero, Smith's Creek, and Wakapau. These communities engage in a number of natural resource-based activities including small-scale agriculture (coconuts in particular), fishing, crabbing, hunting, trapping, heart of palm harvesting, and natural-medicine harvesting on the coast. Most of the indigenous communities from Region 1, and a few communities from Region 2 that are located inland from the coast, venture to the Shell Beach coastline (within the SBPA) to engage in these activities (ERM/EMC 2018). The communities depend on the waterways for potable and domestic water supply and, in most cases, the waterways are the only form of transportation available. Additionally, some of the indigenous villages within Region 1 are experiencing an influx of migrants from neighboring Venezuela. Communities are allowing these migrants to use the resources present within their communities for sustenance.

In the SBPA, fishing and crabbing are common activities at the westernmost end of Shell Beach (at the mouth of the Waini River) and easternmost end of Shell Beach (at the mouth of the Moruca River). An area along Shell Beach referred to as "Iron Punt," which can be accessed from the ocean and from Luri Creek, is also a common fishing and crabbing area. Aside from serving as a transit route, Luri Creek also provides communities with opportunities for fishing, crabbing, and bird hunting, particularly in the dry season, some hunting (labba, deer, land turtles, ducks) in the wet season, and tourism-related sport fishing.

Indigenous communities in remote areas of Region 1, and to a much lesser extent in Region 2, rely on the coastal habitats for subsistence and livelihoods and fewer alternative food sources and livelihood opportunities. In the unlikely event of an oil spill reaching the coast, provisioning resources used by indigenous communities could potentially be adversely impacted. In the event that mangrove forests and swamps along the coast are impacted by oil, species such as fish, crabs, birds, and wild animals (iguanas, deer, wild hog, agouti, labba, etc.), which are depended upon by indigenous communities as a source of protein, would potentially be impacted.

For these reasons, the intensity of an unmitigated marine oil spill on coastal indigenous communities is considered to be potentially **High**. The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. In the absence of mitigation, the impacts could persist over a multi-week basis, so the frequency is considered to be **Continuous**. Depending on the size of the spill, the effects, assuming no mitigation of the spill, would have the potential to extend beyond a year, so duration is conservatively considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for potential impacts on employment and livelihoods, a sensitivity rating of **High** is assigned assuming that the receptors are vulnerable populations and cannot adapt to the change without difficulty and cannot easily transition to alternate livelihood activities.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to indigenous peoples from this unplanned event is considered **Moderate** (Table 9.23-1).

The Project will establish an OSRP that will be implemented in the unlikely event of a spill. Effective implementation of the OSRP would reduce this risk by reducing the probability of oil reaching near-coastal waters or the Guyana coast. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating affected individuals (including indigenous peoples, if affected) for effects to livelihood as a result of an oil spill. Accordingly, the intensity of a mitigated marine oil spill on coastal indigenous communities is reduced to **Medium**.

The geographic extent of a mitigated marine oil spill would still include portions of the **Indirect AOI**, although the area affected would be substantially reduced with mitigation. On the basis that the impacts from a mitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on employment and livelihoods, the sensitivity rating of is reduced to **Medium**, as the receptor may be able to adapt to the change or shift to alternate livelihood activities as a result of the livelihood assistance.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**, so the residual risk of a (mitigated) marine oil spill to coastal indigenous communities (see Table 9.23-1) is considered **Minor**.

Table 9.23-1: Risk Rating for Potential Unplanned Event Impacts on Indigenous Peoples

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Indigenous Peoples	Unlikely	High	Moderate	Implement OSRP Implement claims and/or livelihood remediation processes for affected individuals	Minor

9.24. Transboundary Impacts

The planned Project activities are not predicted to have any measureable "transboundary impacts" (i.e., impacts outside the Guyana EEZ). All predicted impacts from planned Project activities will occur within the Guyana EEZ. However, there is the potential for transboundary impacts on result from unplanned events that may occur, such as oil spills. As the oil spill modeling indicates, transboundary impacts could potentially occur under Scenarios 12 (2,500 bbl offloading spill), 13 (20,000 BOPD release from a loss-of-well-control event over 30 days), and 14 (202,192 BOPD release from a loss-of-well-control event over 30 days) as defined in Section 9.1.1.9, Summary of Spill Scenarios Considered. These WCD rates represent the maximum daily flow of oil from a loss-of-well-control scenario, and are used to understand the scope of the response that would be necessary in the event that such a release occurred. These types of releases are very rare; worldwide, there have been nine offshore loss-of-well-control incidents (with the oldest dating back to 1969) that discharged 100,000 barrels or more to the environment (BSEE 2016). The unmitigated deterministic modeling results for these scenarios indicate there is the potential for oil to reach portions of Trinidad and Tobago, Venezuela, Grenada, St. Vincent and the Grenadines, Bonaire, Curaçao, Aruba, the Dominican Republic, Haiti, Jamaica, and Colombia. The mitigation that was applied to these WCD events was not scaled up for the higher discharge rates so that the performance could be compared among the releases. In the event that a higher-volume event occurred, additional resources would be applied to the response.

Modeling of an unmitigated spill predicts that surface oil would travel towards the northwest in all scenarios during both the Jun–Nov and Dec–May seasons. Differences in seasonal wind speed and direction result in a range of shoreline length predicted to be oiled. Stronger easterly winds would result in the potential for more significant shoreline oiling, particularly in Venezuela and Trinidad and Tobago, while lower wind speeds would allow the surface plume to be transported to the north of Trinidad and Tobago and into a portion of the Caribbean Sea.

Impacts on resources and receptors in these other countries would be similar to those discussed in this chapter for Guyana. Although the likelihood of a marine oil spill remains **Unlikely**, there would be the potential to impact the same resources and receptors discussed in the chapter for Guyana. Further, there are some additional resources that could potentially be affected (e.g., corals), which recent marine surveys have documented are sparsely distributed across the middle and outer continental shelf and continental slope (ERM 2018a and ERM 2018b). The coastal sensitivity mapping conducted for the transboundary area potentially affected by a spill, as described in Section 9.1.6, Coastal Sensitivity Mapping, included the coastal regions of the countries that could potentially be impacted by unmitigated marine oil spills associated with FPSO offloading activities and/or loss-of-well-control events. A general overview of potential effects on these countries is provided below.

9.24.1. Potential Effects from an Offloading Spill (Scenario 12)

The effects of an FPSO offloading spill are discussed separately from the loss-of-well-control events because deterministic oil spill modeling predicts that an unmitigated offloading spill would only have the potential to oil the shoreline of one country outside of Guyana: Trinidad and Tobago. The probability of oil reaching Trinidad and Tobago's shoreline would be remote, approximately 5 to 10 percent. If oil did reach the coast, the extent of impacts would vary seasonally. A 2,500 BOPD spill in the Jun–Nov season would only have the potential to contact the northern end of Trinidad (Figure 9.1-5a). Effects from the same spill in the Dec–May season could contact the southeast coasts of Tobago, but would not come ashore in Trinidad (Figure 9.1-6a).

The coastal sensitivity mapping indicates that Trinidad and Tobago has several marine resources that could be potentially impacted by an offloading spill. Most of Tobago's coral reefs are on the west side of the island and would therefore be sheltered from oil carried westward from an offloading spill, but a few are located on the southern end of the island and could be exposed to oiling in the unlikely event that oil reached the island. Several other smaller reefs and seagrass meadows that fringe Tobago's southeast coast would also be exposed to oiling. There are also at least nine known marine turtle nesting beaches on Tobago's southeast coast that would be exposed to potential oiling from an offloading spill.

Four species of marine turtles (hawksbill [*Eretmochelys imbricata*], leatherback [*Dermochelys coriacea*], green [*Chelonia mydas*], and olive ridley [*Lepidochelys olivacea*]) nest on Trinidad, and all of these except olive ridley nest on Tobago as well. Portions of both islands' nesting beaches would be exposed to oiling by an unmitigated spill approaching from the east; slightly more than half of Tobago's nesting beaches are located on the west coast and would be protected from an offloading spill in any season. Nearly all of Trinidad's nesting beaches are located along the northern and eastern coasts and would be at risk of oiling if an unmitigated spill reached Trinidad, but the extent of this risk in Trinidad would be greater in the Jun–Nov season. The most sensitive coastal species to an oil spill reaching Trinidad and Tobago is probably the West Indian manatee (*Trichechus manatus*). Its known habitat in the country is exclusively located on the east coast of Trinidad in an area that would have a slight chance (5 to 10 percent probability) of being oiled from an offloading spill. Trinidad's seagrass communities are mostly located along the northwest coast near Chaguaramas and should be sheltered from an offloading spill, but one large seagrass meadow off Galera Point at the extreme northern end of the island could be exposed to oiling from an offloading spill, especially in the Jun–Nov season.

9.24.2. Potential Effects from a Loss-of-Well-Control Event

A loss-of-well-control event could impact three main geographic regions:

- Trinidad and Tobago, the northern South American coast, and the so called "ABC Islands" (Aruba, Bonaire, and Curaçao);
- The southern Lesser Antilles (i.e., Grenada and St. Vincent and the Grenadines); and
- The southwestern Greater Antilles (i.e., Dominican Republic, Haiti, and Jamaica).

In the most general terms, oil spill modeling indicates that during the Dec–May season, a slick from an unmitigated oil spill from a loss-of-well-control event would take a west-northwesterly route through the Gulf of Paria and across the southern edge of the Caribbean Sea. This scenario would expose the northern coast of South America and the southern Lesser Antilles to the bulk of the exposure to oiling. An equivalent slick from the same spill during the Jun–Nov season would track slightly more to the north, across the central Caribbean Sea and the central and southern portions of the Lesser Antilles.

Modeling the most credible of the loss-of-well-control scenarios (i.e., the Most Credible WCD) does not indicate a risk of an unmitigated oil spill making landfall north of Tobago in either season. For the larger loss-of-well-control event (i.e., Maximum WCD), the shift northward in the Jun–Nov season and additional volume associated with this scenario indicate a risk of oil making landfall in several countries north of Tobago. Toward the western end of the model domain for the Maximum WCD scenario, the affected region would also be sufficiently wide to contact the central Greater Antilles including the Dominican Republic, Haiti, and Jamaica in both seasons. Table 9.24-1 summarizes the differences in predicted risk of oil landfall from unmitigated spill scenarios according to scenario and season.

Table 9.24-1: Predicted Risk of Oil Landfall by Unmitigated Loss-of-Well-Control Scenario and Season

Country	Most Credible WCD 20,000 BOPD [a]		Maximum WCD 202,192 BOPD [a]	
	Jun–Nov	Dec–May	Jun–Nov	Dec–May
Venezuela	X	X	X	X
Colombia		X		X
Aruba		X		X
Curaçao		X		X
Bonaire	X	X		X
Trinidad and Tobago	X	X	X	X
Grenada			X	X
St. Vincent and the Grenadines			X	X
Dominican Republic			X	
Haiti			X	
Jamaica			X	

[a] All well-control scenarios are assumed to be unmitigated.

The following sections describe the specific coastal sensitivities in each of the countries that could be affected by a loss-of-well-control event and are organized according to the three main regions described above.

9.24.2.1. Trinidad and Tobago and the Northern South American coast, including Aruba, Bonaire, and Curaçao

Potential Effects on Trinidad and Tobago

Owing to its unique location at the southern end of the Lesser Antilles, Trinidad and Tobago is the only country that would have the potential to be affected by the transboundary effects of any unmitigated loss-of-well-control event, regardless of season (see Figures 9.1-22a and 9.1-22b). The probability of shoreline oiling on the coast of Trinidad and Tobago ranges from a minimum of 50 to 60 percent for an unmitigated Most Credible WCD scenario to approximately 90 to 100 percent for an unmitigated Maximum WCD scenario. The time of predicted first arrival ranges from 5 to 10 days. Most if not all of the east coasts of both Trinidad and Tobago as well as Trinidad's southern coast would have a higher probability (50 to 100 percent) of being oiled under any of the unmitigated loss-of-well-control event scenarios in the Dec–May season. Sensitive coastal resources in this area include all of Trinidad's eastern and southern mangroves, manatee habitat, marine turtle nesting beaches, and forest reserves from Redhead in the north to Guayaguayare in the south. In Tobago, it includes numerous marine turtle nesting beaches and coral reefs, as well as several large seagrass meadows in the south near the Mount Pleasant area.

Tobago's western coast would also have a smaller chance (5 to 10 percent probability) of being oiled under the unmitigated Most Credible WCD scenario in the Jun–Nov season (Figure 9.1-22a), which would pose a lower-level risk to Tobago's remaining marine turtle nesting beaches and its largest coral reef, Buccoo Reef, located adjacent to the southwest tip of the island. Risks to these resources increase to 90 to 100 percent probability of oiling under the larger scenario, regardless of season. Trinidad's west coast would remain sheltered from oiling under any of the loss-of-well-control event scenarios.

Several marine IBAs (e.g., seabird breeding colonies and surrounding foraging areas, non-breeding concentrations, feeding areas for pelagic species) of global or regional importance to seabirds have been designated in Trinidad and Tobago.

Numerous fishing areas are located east of Trinidad and could be impacted by a large unmitigated subsea release of crude oil. The largest and most concentrated coastal/nearshore fishing activities in this part of Trinidad's EEZ are located along the southeastern coast from Cocos Bay in the north to Guayaguayare Bay in the south. These areas extend from the coast to approximately 20 kilometers (12 miles) offshore. Further north in the vicinity of Salybia, Sena, and Saline Bays, fishing is concentrated slightly further offshore, approximately 15 to 30 kilometers (9 to 18 miles) from the coast. All of these areas would have a high probability of being impacted by a large unmitigated subsea release of crude oil from a loss-of-well-control event.

Potential Effects on Venezuela

Stochastic modeling indicates a 5 to 60 percent probability of surface oil from an unmitigated spill reaching the coast or nearshore waters across essentially the entire Venezuelan Coast, with the exception of the Gulf of Venezuela. Within this area, deterministic modeling predicts that the only unmitigated loss-of-well-control scenario that would pose a risk of shoreline oiling in Venezuela in both the Jun–Nov and Dec–May seasons would be the Most Credible WCD scenario. The higher-volume loss-of-well-control scenario would pose oiling risks to mainland Venezuelan shores only in the Dec–May season (see Figure 9.1-23b). The only portion of Venezuela that would be at risk of oiling from the Maximum WCD Scenario in the Jun–Nov season would be Isla La Blanquilla, a very small offshore island north of eastern Venezuela. Deterministic modeling of an unmitigated spill identifies five main areas of the Venezuelan coast as being at risk of oiling:

- The Orinoco Delta;
- The Paria Peninsula;
- Margarita Island;
- The central coast from approximately Puerto Píritu to Caracas; and
- Los Roques and other offshore islands.

These areas support several categories of sensitive coastal resource including marine turtle nesting beaches, manatee habitat, seagrass meadows, mangroves, and coral reefs.

The Orinoco River Delta is located south of Trinidad in eastern Venezuela, and is the most important coastal area that could be affected by a loss-of-well-control event from a biodiversity perspective. The Orinoco River Delta supports numerous biological resources of regional and global significance, including extensive mangroves, diverse shorebird and estuarine fish communities, threatened and endangered marine turtles and marine mammals, and artisanal and commercial fisheries (Miloslavich et al. 2011). The northern portion of the Orinoco River Delta would have a 10 to 50 percent probability of being oiled depending on scenario and location, with the risk generally increasing with spill scenario volume and in a westerly direction. Modeling indicates that the shortest time of arrival in the delta for an unmitigated spill would be about 15 to 20 days for a spill occurring during the Jun–Nov season and approximately 5 to 10 days during the Dec–May season, although oil could take longer to reach some areas. The western portion of the Orinoco Delta, particularly the more exposed outer shorelines of the hundreds of small islands scattered through the delta, constitute one of two primary concentrations of marine turtle nesting activity in the country (the other being the Paria Peninsula, as discussed below).

The Paria Peninsula contains the second large concentration of marine turtle nesting beaches in Venezuela, most of which are located west of Rio Caribe on the northern and extreme eastern coasts. Mangroves are also widespread on the northern and southern coasts of the peninsula, and the northeastern portion of the peninsula is mapped as an important bird nesting area. The peninsula has an approximately 5 to 40 percent probability of being oiled under an unmitigated loss-of-well-control scenario. The main factor in determining risk in this area is location, with the western portion of the peninsula exposed to substantially higher risk in all seasons and scenarios.

Margarita Island has several important coastal bird habitats, two coral reefs, mangrove areas along its southern coast, and several shallow marine lagoons. Risks of oiling along the coast of Margarita Island and adjacent waters from an unmitigated spill range from approximately 5 to

40 percent, with the highest risk occurring on the western end of the island. The most important area on the island from a biodiversity perspective is the Laguna de la Restinga National Park in the center of the island, which is recognized as an IBA and is a Ramsar[15] wetland site. Margarita Island is a popular tourist destination for Venezuelans and has numerous sandy beaches.

The central coast has fewer environmental sensitivities than the other areas of Venezuela that could be affected by an oil spill. Scattered marine turtle nesting beaches occur in this area, and the offshore zone is mapped as generalized marine mammal habitat. This area has a less than 5 percent probability of being oiled by an unmitigated loss-of-well-control event.

Several offshore islands would be at risk of oiling under most loss-of-well-control scenarios (with the exception of the Maximum WCD Scenario in the Jun–Nov season, during which a spill would only pose risk to Isla La Blanquilla, as described above). The most well-known of these islands is the Los Roques Archipelago. Los Roques was designated as a national park by the Venezuelan government in 1972 and contains a network of coral reefs, seabird colonies, seagrass meadows, and at least one marine turtle-nesting beach. Located approximately 210 kilometers (130.5 miles) north of Caracas, the park encompasses over 220,000 hectares, is the largest marine park in the Caribbean, and is an internationally known tourist destination. Venezuela's marine IBAs are mostly centered on offshore islets, many of which are remote, uninhabited, and difficult to access due to hazardous cliffs and fringing limestone and coral reefs. Two important islets that are predicted to be exposed in the unlikely event of an unmitigated loss-of-well-control event are Isla la Orchila and Isla la Blanquilla. Most of Venezuela's coral reefs are also located around the offshore islands. The probability of oiling from an unmitigated spill varies widely for the offshore islands, ranging from approximately 10 percent to 40 percent depending on location, spill volume, and time of year.

Outside the main areas discussed above, stochastic modeling analysis predicts relatively lower risks of oiling (<10 percent) resulting from a loss-of-well-control event. Seagrass is one of the most ubiquitous coastal marine habitats in Venezuela, and is widespread in these areas. It can be found in numerous locations from just southeast of Caracas east along the mainland coast to the Orinoco Delta, including much of the Paria Peninsula and several of the offshore islands. Essentially the entire portion of this area west of Rio Caribe would have a low risk of oiling regardless of the time of year, so approximately half of Venezuela's known seagrass meadows would not be at significant risk of being exposed by a loss-of-well-control event.

Potential Effects on Colombia

The only portion of Colombia that could be affected by an unmitigated loss-of-well-control event would be the northeastern portion of the La Guajira Peninsula, which is a very remote area at the extreme northern tip of the country. Deterministic model results suggest oiling risks for the Most Credible WCD and Maximum WCD scenarios in the Dec–May season (See Figures 9.1-38a and 9.1-38b). The most prominent feature on the peninsula is Macuira National Park, which is an

[15] The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. A Ramsar site is a wetland site designated to be of international importance under the Ramsar Convention.

inland park that approaches but does not reach the east coast, and therefore would not be affected by a spill. The only significant coastal sensitivity in this area that could be affected by a loss-of-well-control event would be two fringing reef complexes near the southern edge of the area that deterministic modeling predicts could be oiled by an unmitigated spill. The only risks to these features would be in the Dec–May season.

Potential Effects on Bonaire

Similar to Venezuela, deterministic modeling suggests that both unmitigated loss-of-well-control scenarios would result in oiling of the west coast of Bonaire in the Dec–May season. The only well-control scenario that would pose a risk of shoreline oiling in Bonaire in the Jun–Nov season would be the Most Credible WCD scenario (see Figure 9.1-30a). Under this scenario, much of the east coast would be at risk of oiling. This same scenario in the Dec–May season would only risk oiling the northern and southern tips of the island (see Figure 9.1-30a). Bonaire is a rocky, arid island and is surrounded for the most part by fringing coral reefs. The most prominent environmental feature of the island is the Bonaire Marine Park, which includes all of the waters around Bonaire and Klein Bonaire to a depth of 60 meters (197 feet) from the high water mark. The eastern-facing portion of the park and its coral reef communities would be exposed to oiling from either unmitigated loss-of-well-control event in the Dec–May season. Dive-oriented ecotourism is a substantial driver of the local economy; however, most commercial dive sites are located on the west side of the island, which would be mostly protected from oiling under all loss-of-well-control scenarios.

Potential Effects on Aruba

Like Bonaire, much of Aruba's east coast would be at risk of oiling for both unmitigated loss-of-well-control scenarios in the Dec–May season. There would be no risk of coastal oiling in Aruba during the Jun–Nov season under either of the scenarios (see Figures 9.1-32a and 9.1-32b). The most prominent environmental feature that would be at risk is Arikok National Park, which encompasses approximately 7 kilometers (4.4 miles) of rocky coastline in the south-central portion of the island. No significant corals, mangroves, or other coastal sensitivities exist in the area that could be at risk of oiling, although limited marine turtle nesting activity has been reported in Arikok National Park. There are several kilometers of mangrove-lined coastline on the south-central portion of the west coast and a coastal bird sanctuary on the northwest coast, but these would be naturally protected from oiling under all scenarios.

Potential Effects on Curaçao

Similar to Aruba, much of Curaçao's east coast would be at risk of oiling for the larger unmitigated loss-of-well-control scenario in the Dec–May season; however, the Most Credible WCD scenario would pose only limited risks of shoreline oiling on the southern coastline (see Figures 9.1-31a and 9.1-31b). There would be no risk of coastal oiling in Curaçao during the Jun–Nov season under either of the scenarios (see Figures 9.1-31a and 9.1-31b). The most prominent environmental feature that would be at risk is the Christoffel/Shete Boka Park, which protects approximately 6 km of rocky coastline in the northeastern portion of the island. No significant corals, mangroves, or other coastal sensitivities exist in the area that could be at risk of oiling, although marine turtle nesting activity has been reported in small so called “pocket beaches” in the park. The Curaçao Underwater Park stretches approximately 20 km along the southeastern coast from Willemstad to the southern end of the island and is Curaçao’s only MPA. It reportedly supports 65 species of coral, more than 350 species of fish, mangroves, and seagrass. The park would be naturally protected from oiling under all scenarios owing to its location on the leeward side of the island.

9.24.2.2. Southern Lesser Antilles (excluding Trinidad and Tobago)

The only Lesser Antillean countries north of Tobago that would be at risk of oil coming ashore from a loss-of-well-control event in both the Jun–Nov and Dec–May seasons are Grenada and St. Vincent and the Grenadines. According to deterministic modeling, the risk of oil coming ashore would occur in both countries in both seasons for the unmitigated Maximum WCD scenario (see Figures 9.1-24b and 9.1-25b).

Although deterministic modeling (unmitigated) shows limited potential for shoreline oiling north of Tobago, stochastic modeling (unmitigated) shows that nearshore waters would be at risk of being affected by a slick. Probabilities vary according to location, season, and volume, and range from 80 to 90 percent probability along the southern coast of Grenada for the Maximum WCD scenario in the Jun–Nov season to a 5 to 10 percent probability near Dominica for both loss-of-well-control scenarios in both seasons.

Potential Effects on St. Vincent and the Grenadines

The most significant coastal sensitivities on St. Vincent proper are seagrass meadows, which have been mapped along much of the island’s east coast. St. Vincent also has coral reefs along its west coast, but these would be protected from oiling regardless of seasonality. The numerous smaller islands to the south of the main island of St. Vincent (i.e., the Grenadines) have much more extensive coral reefs, many of which are exposed to the east and would therefore be at risk of oiling. The Tobago Cays Marine Park, located near Mayreau Island near the southern end of the Grenadines, contains several such easterly-facing reefs and would be mostly exposed to oil drifting from the east.

Potential Effects on Grenada

Like St. Vincent, Grenada also has extensive seagrass meadows adjacent to much of its east coast and portions of its west coast, but unlike St. Vincent it has significant coral growth as well. These seagrass meadows and reefs are located not only adjacent to the main island but also several of the smaller offshore cays, including Ronde Island and the South Carricou Islands. Because most of the seagrass and coral habitats are located along the east coast, they would be exposed to oiling in the Jun–Nov season, but some important habitats that would be protected from oiling events exist along the west coast. These include a large seagrass meadow near Saint Georges and two smaller coral reefs in Grand Anse Bay near the southwestern end of the island. Grenada does not have large mangrove areas, but there are several small mangroves on the south coast and several more small mangroves on the west coast near Hillsborough. The outer portions of the southern mangroves would probably experience minor oiling from a loss of well-control event that reached Grenada, but owing to their nearly due-south exposure, their inner portions would likely be sheltered from the worst effects of such an event. The western mangroves near Hillsborough would be protected from oiling regardless of seasonality.

9.24.2.3. Greater Antilles

Potential Effects on the Dominican Republic

The southwestern Dominican Republic is predicted to be at risk of oiling during an unmitigated Maximum WCD spill during the Jun–Nov season (see Figure 9.1-34b). The nearshore marine zone along this entire area is contained in the Arrecifes de Suroeste (Southwest Reefs) Marine Sanctuary and Scientific Reserve, which is an array of coral reefs and seagrass meadows located along the coast. The preserve was established to conserve natural habitats between La Espanola Island and the Jaragua National Park, and encompasses South Yaque River estuary and wetlands. This area is purported to support the West Indian manatee, dolphins, and marine mammals (CaMPAM undated). Jaragua National Park occupies much of the land and nearshore marine territory in this area. The park has cultural significance due its numerous caverns that contain pictograms and petroglyphs from the Taino culture, as well as other pre-Columbian archaeological sites. The park is reported to support 130 bird species (10 of them are endemic), solenodons and hutias, as well as West Indian manatees and bottlenose dolphins (UNESCO undated_b).

Potential Effects on Haiti

Similar to the Dominican Republic, Haiti would be exposed to potential shoreline oiling from an unmitigated Maximum WCD during the Jun–Nov season (see Figure 9.1-35b). The greatest risk of oil reaching Haiti would be along the southern shore of the Tiburon Peninsula, from the border with the Dominican Republic in the east to approximately Les Cayes in the west. This section of coast is dominated by series of sandy beaches interspersed with rocky shoreline. Mangroves occur, but are sparse. No other environmental sensitivities have been mapped in this area.

Potential Effects on Jamaica

Similar to Haiti, Jamaica’s southern coast is predicted to be at risk of oiling during an unmitigated Maximum WCD spill during the Jun–Nov season (see Figures 9.1-36b). The most significant environmentally sensitive area within this zone is the Portland Bight Protected Area (PBPA), which is the largest protected area in Jamaica. Its terrestrial area is 520 square kilometers (201 square miles) in the southern sections of St. Catherine and Clarendon parishes, including the coastline from east of Hellshire to almost Milk River in the west. It includes contiguous coastal land and the marine area out to the 200-meter (656-foot) depth contour (1 nautical mile, or approximately 20 kilometers [12.4 miles] south of Portland Point). Sections of the PBPA were officially designated as a Ramsar site in 2006. Sandy beaches and cays are also part of the biodiversity of the PBPA. The coast is a combination of sandy beaches (several of which support nesting marine turtles, nesting seabirds), nearshore islands which support endemic lizards, and mangroves. Benthic marine resources in the PBPA include seagrass and coral reefs (C-CAM 2013). The Black River Lower Morass is another Ramsar site located approximately 15 km west of the PBPA and Jamaica's largest wetland. It supports the IUCN-listed American crocodile (Vulnerable). It is listed as an IBA by Birdlife International.

Outside of the PBPA, there are several significant reefs along Jamaica's southern coast. Three reef areas exist between the PFPA and the Black River Morass. Two other reef areas exist at the Pallisidoes, a series of sand banks south of Kingston. Another prominent reef system exists between Morant Bay and Morant Point on the southeast corner of the island.

9.24.3. Impacts of International Importance

In addition to the country-specific impacts listed above, seabirds would have the potential to be affected at a regional scale. Since 2010, BirdLife International has focused its efforts on identifying Marine IBAs with specific significance to seabirds. The types of sites that qualify as Marine IBAs include seabird breeding colonies, foraging areas around breeding colonies, non-breeding (usually coastal) concentrations, migratory bottlenecks, and feeding areas for pelagic species (BirdLife International 2019). No Marine IBAs have been identified in Guyana, but there are 49 Marine IBAs of global or regional importance to seabirds that lie within the swept zone of the Maximum WCD scenario unmitigated loss-of-well-control scenario (considering both seasons together). These sites contain regionally or globally important breeding and foraging sites for numerous species of seabirds, including species with elevated conservation status (i.e., IUCN listing status of Vulnerable or higher). Two of these 49 Marine IBAs that are located along the southern coastline of Hispaniola (Haiti and the Dominican Republic) are particularly significant as they support the world's only known breeding sites for Black-capped Petrel (*Pterodroma hasitata*) (IUCN Endangered).

During the seabird breeding period, the timing of which shifts from year to year based on the availability of food resources, many of the 49 Marine IBA sites within the swept zone of an unmitigated loss-of-well-control spill support hundreds to thousands of breeding seabirds. If a marine oil spill occurs during the seabird-breeding period and oil reaches a breeding colony or impacts individuals offshore that then introduce oil to the colony, the impacts on seabird populations could be substantial. Seabirds typically nest close together on islands or shorelines and forage at higher density in proximity to their nesting sites, making large numbers of birds and their eggs susceptible to oiling. Some seabirds lay only one egg at a time, so they have an already low reproductive rate, which makes these species more susceptible to adverse impacts from oil spills that occur in the breeding season (because they could lose an entire recruitment year) (NOAA 2016).

9.24.4. Mitigation of Transboundary Impacts

It should be noted that the unmitigated oil spill modeling used to characterize potential transboundary impacts did not take into consideration any emergency response actions. Implementation of the OSRP would help to significantly reduce potential transboundary impacts just as it would reduce impacts within the Guyana EEZ, as demonstrated by oil spill modeling that considers OSRP implementation (i.e., mitigated scenarios). In particular, EEPGL has put in place an interim solution that will facilitate installation of a capping stack on well location within 9 days in certain circumstances (e.g., where there is no debris that prevents or delays installation of the capping stack). Mitigated scenario modeling (see Section 9.1.5) demonstrates that this, in combination with other response measures (e.g., dispersant application), would significantly reduce the extent of transboundary impacts. In any case, EEPGL will work with representatives of the respective countries that could be potentially impacted by a large oil spill to be prepared for the unlikely event of a spill by:

- Coordinating operations and communications between different command posts;
- Creating a transboundary workgroup to manage waste from a product release, including identifying waste-handling locations in the impacted regions and managing commercial and legal issues;
- Identifying places of refuge in the impacted region where response vessels could go for repairs and assistance;
- Determining how EEPGL and the impacted regional stakeholders can work together to allow equipment and personnel to assist in a spill response outside the region while still retaining a core level of response readiness within the jurisdictions;
- Determining financial liability and establishing claims and/or livelihood remediation processes during a response to a transboundary event; and
- Working with local communities within the impacted areas to raise awareness of oil spill planning and preparations.

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10. CUMULATIVE IMPACT ASSESSMENT

10.1. INTRODUCTION

The Project Development Area (PDA) is located approximately 207 kilometers (approximately 128 miles) northeast of the coastline of Georgetown, so there are few opportunities for the Project to cumulatively impact resources that would be impacted by other activities with the exception of other EEPGL activities (e.g., Liza Phase 1 Project development, Liza Phase 2 Development, ongoing exploration drilling); potential future offshore Guyana oil and gas exploration by other developers; and other non-oil and gas projects (e.g., Guyana mariculture project, replacement of Demerara Harbour Bridge). These Project and non-Project activities together could cumulatively impact some resources such as the following:

- Climate via emissions of greenhouse gases (GHGs);
- Marine water quality via discharge of drill cuttings that could increase total suspended solids (TSS) concentrations in the water column;
- Special status marine fish species (via changes in distribution due to altered water quality) and special status seabird species (via attraction to offshore facilities or disturbance from Project facilities);
- Marine mammals via vessel strikes or potential disturbance from underwater sound;
- Riverine mammals via vessel strikes and displacement;
- Marine turtles via vessel strikes;
- Marine fish via degraded water quality;
- Community health and wellbeing via increased demand on limited medical treatment capacity;
- Marine use and transportation via additional marine congestion, especially near Georgetown Harbour;
- Employment and livelihood via interference with artisanal fishing activities;
- Social infrastructure and services via increased demand for limited housing and lodging; and
- Waste management infrastructure capacity via increased burden on hazardous waste treatment or disposal facilities in Georgetown.

This section discusses a cumulative impact assessment (CIA) conducted to evaluate the potential contribution of the Project toward the cumulative impacts on the resources identified as Valued Environmental Components (VECs) by stakeholders.

Following good international industry practice, this section follows the International Finance Corporation's (IFC's) *Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets* ("the Handbook") (IFC 2013). The Handbook provides a methodology for identifying the most significant cumulative impacts;

the methodology includes a desktop review of publicly available information and consultation with key stakeholders. This methodology focuses on environmental and social components referred to in the handbook as VECs, which are: (1) rated as "critical" by potential Project-Affected Communities (PACs)[1] and/or the scientific community; and (2) cumulatively impacted by the Project under evaluation, by other projects, and/or by natural environmental and social external drivers (IFC 2013). Although the Project is not subject to the IFC Performance Standards (PS), the methodology applied herein is generally consistent with the relevant IFC PS, especially PS 1—Assessment and Management of Environmental and Social Risks and Impacts (IFC 2012a), and PS 6—Biodiversity Conservation and Sustainable Management of Living Natural Resources (IFC 2012b).

10.2. Objectives and Scope

The overall objective of this CIA is to identify and assess the contribution by the Project to cumulative impacts. It is based on information included throughout prior sections of this EIA, information generated for the Liza Phase 1 and Liza Phase 2 Development Project EIAs, the Liza Phase 1 Post-Permit Studies (ERM/EMC 2018), and other studies commissioned by EEPGL, information provided by EEPGL, and information available in the public domain. The specific objectives are:

- Identify VECs that could be impacted cumulatively in the onshore and offshore areas potentially affected by the Project, considering input from stakeholders and potential PACs through the consultation process;
- Identify other existing and planned projects and external environmental and social drivers that could cumulatively impact VECs;
- Undertake a high-level assessment of potential cumulative impacts on VECs, considering the Project and the other identified existing and planned projects and external drivers in the area; and
- Recommend a management framework for the integrated management of potential cumulative impacts.

[1] PACs are defined as local communities potentially directly affected by the Project (consistent with IFC Performance Standard 1, paragraph 1 [IFC 2012a]).

10.3. METHODOLOGY

10.3.1. Definitions of Key Terminology for the Cumulative Impact Assessment

The following are definitions of key terminology used in the CIA.

Cumulative Impact: Impacts that result from the successive, incremental, and/or combined effects of an action, project, or activity added to other existing, planned, and/or reasonably anticipated actions, projects, or activities. For practical reasons, the identification, assessment, and management of cumulative impacts are limited to those effects generally recognized as important on the basis of scientific concern and/or concerns of PACs.

CIA: Process to identify and evaluate cumulative impacts.

Other Projects: Existing, planned, or reasonably expected future developments, projects and/or activities potentially affecting VECs.

External Drivers: Sources or conditions that could affect or cause physical, biological, or social stress on VECs, such as natural environmental and social drivers, human activities, and external stressors. These can include climate change, population influx, natural disasters, or deforestation, among others. These are typically less defined and planned than Other Projects.

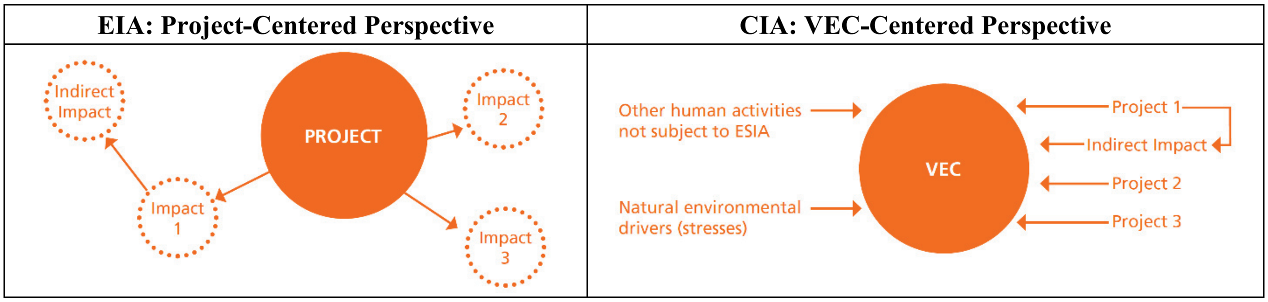
VECs: Environmental and socioeconomic components considered as important by the scientific community and/or PACs. VECs may include:

- Physical features, habitats, wildlife populations (e.g., biodiversity, water supply);
- Ecosystem services (e.g., protection from natural hazards, provision of food);
- Natural processes (e.g., water and nutrient cycles, microclimate);
- Socioeconomic conditions (e.g., community health, economic conditions); and
- Cultural heritage or cultural resources aspects (e.g., archaeological, historic, traditional sites).

VECs reflect the public and scientific community's "concern" or special interest about environmental, social, cultural, economic, or aesthetic values (IFC 2013). According to the IFC's methodology, VECs are considered the ultimate recipients of cumulative impacts because they tend to be at the ends of impact pathways.

10.3.2. Overall Cumulative Impact Assessment Approach

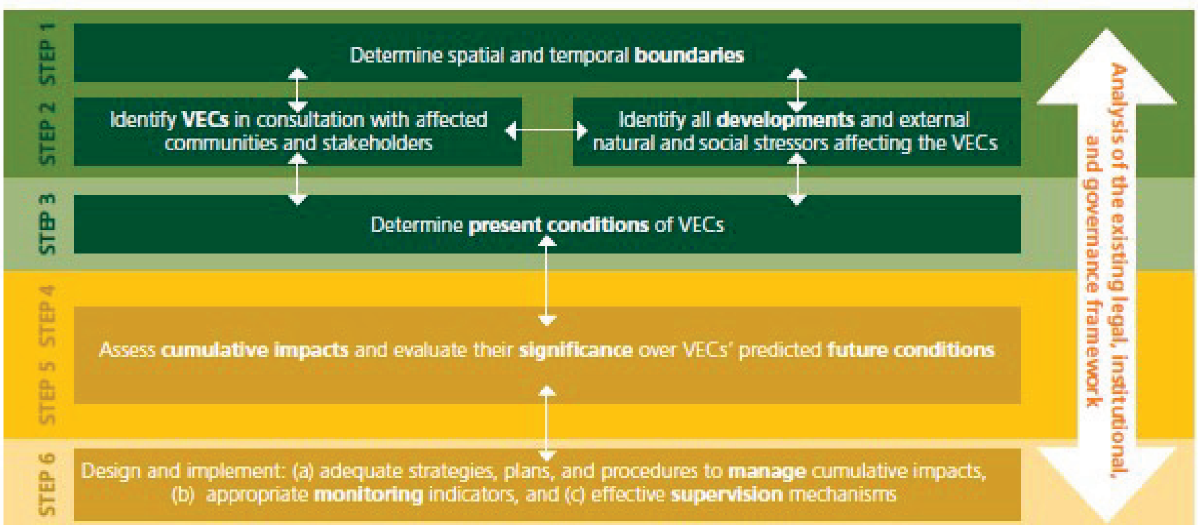
Unlike an EIA, which focuses on a project as a generator of impacts on various environmental and social receptors, a CIA focuses on VECs as the receptors of impacts from different projects and activities (see Figure 10.3-1). In a CIA, the overall resulting condition of the VEC and its related viability are assessed.



Source: IFC 2013

Figure 10.3-1: Comparing EIA and CIA

As previously described, the CIA is derived from desktop reviews of publicly available information, information obtained during the EIA process for the Liza Phase 1 and Liza Phase 2 Development Project EIAs, the Liza Phase 1 Post-Permit Studies (ERM/EMC 2018), and other studies commissioned by EEPGL, ongoing exploration activities, and information provided by EEPGL. The assessment follows the six steps for a CIA (see Figure 10.3-2). The process is iterative and flexible, with some steps having to be revisited in response to the results of others. For example, the VEC selection step usually needs to be adjusted after the potential impacts of the Project are identified. The steps are described in detail below.



Source: IFC 2013

Figure 10.3-2: Summary of IFC's Cumulative Impact Assessment Methodology

10.3.3. Limitations

The Handbook takes into consideration the limitations that a private developer may face carrying out a CIA as part of an EIA; the Guyana Environmental Protection Act requires preparers of EIAs to identify any limitations on availability of information to support the EIA, or difficulties encountered in compiling such information.

The limitations applicable to this CIA, include: (1) incomplete information about Other Projects and activities (e.g., the information is not available in the public domain); (2) uncertainty with respect to the implementation of future projects; and (3) difficulty in establishing thresholds or limits of acceptable change for VECs, and therefore the significance of cumulative impacts.

10.3.4. Determination of Spatial and Temporal Boundaries

The geographic scope of the EIA was defined as the direct and indirect Project Area of Influence (AOI) (see Chapter 5, Scope of the Environmental Impact Assessment). Based on an assessment of the VECs for the CIA, it was determined that the Indirect AOI is sufficient to serve as the spatial boundary of the CIA, in that it covers: (1) the extent of the selected VECs, and (2) the extent of the potential impacts from the Project, Other Projects, and external drivers. Figure 10.3-3 shows the spatial boundary of the CIA.

Temporal delimitation for a CIA is frequently a challenge due to the uncertainty inherent to potential future projects. For this reason, Good International Oil Field Practice suggests consideration of a 3-year temporal boundary when conducting a CIA. While the CIA uses this time horizon for non-EEPGL projects, a temporal boundary through the expected life cycle of the Project (i.e., through 2044) is used with respect to other potentially planned EEPGL projects based on the fact that EEPGL has a greater level of certainty for other potentially planned EEPGL projects (see Figure 10.3-4). As discussed further in Section 10.4.1, Other EEPGL Projects, the other planned EEPGL projects considered in the CIA include the following:

- Continued exploration drilling;
- Liza Phase 1 Development Project;
- Liza Phase 2 Development Project;
- A future development project that is referred to herein as “FPSO Development Project #4” (FPSO #4);
- A future development project that is referred to herein as “FPSO Development Project #5”; (FPSO #5)
- The Guyana Fiber Optic Enablement Project, which involves installation of a fiber optic cable from the Stabroek Block to onshore cable landing sites (“the FOC Project”); and
- A project to transport associated gas from the Liza Phase 1 PDA to shore for creation of natural gas liquids (NGLs) and natural gas power production, referred to as the “Gas to Shore Project.”

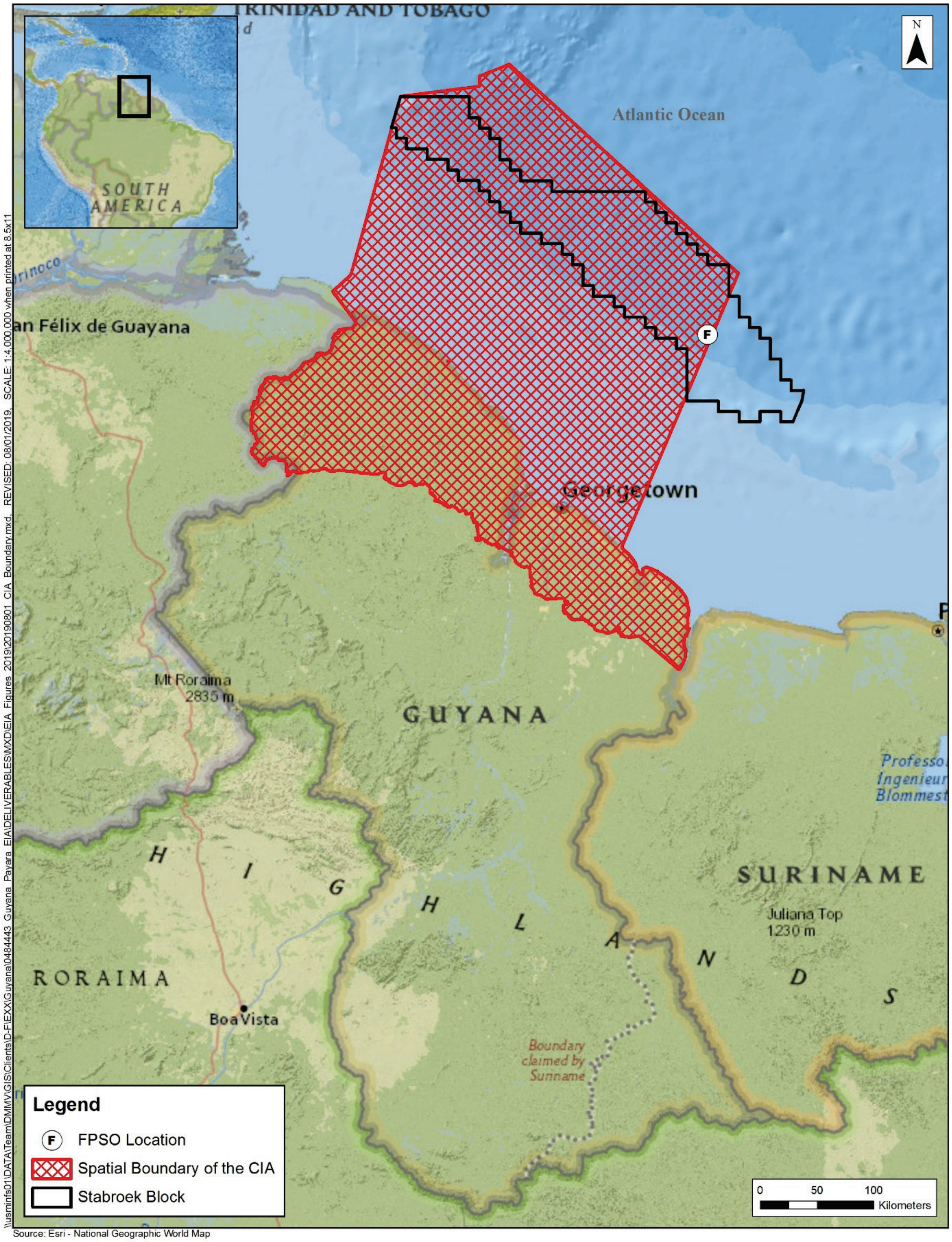


Figure 10.3-3: Spatial Boundary of the Cumulative Impact Assessment

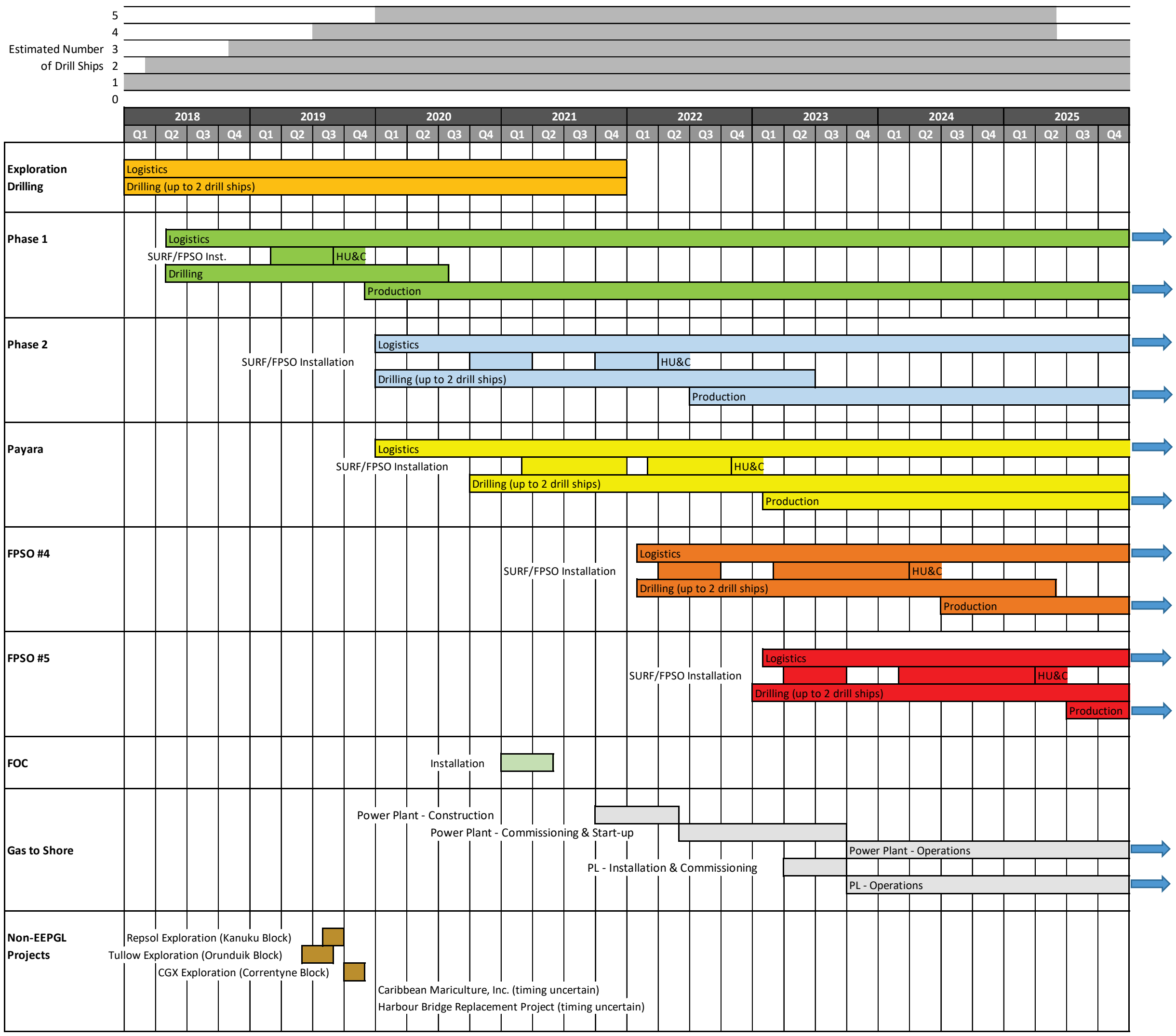


Figure 10.3-4: Temporal Boundary of the CIA for EEPGL's Projected Offshore Activities and other Non-EEPGL Projects (Conceptual for CIA Purposes)

As described in Section 2.2, Project Schedule, the Project's drilling and installation stages are expected to occur from 2020 to 2025 and the production operations stage is expected to start at the beginning of 2023 and last at least 20 years (2023 to at least 2044). Other non-EEPGL projects identified as reasonably foreseeable future developments in the vicinity of the Project include: (1) Repsol exploration activities in the Kanuku Block; (2) Tullow exploration activities in the Orunduik Block; (3) CGX exploration activities in the Correntyne Block; (4) a mariculture project referred to as Caribbean Mariculture, Inc.; and (5) the Harbour Bridge Replacement Project in Georgetown. The timelines of all EEPGL projects and future exploration activities, as well as estimated timelines for non-EEPGL projects – where information regarding their estimated timing was available, are represented conceptually in Figure 10.3-4 for the purposes of the CIA; these timelines are preliminary in nature and would be refined as needed in the future based on evolving EEPGL plans in Guyana.

10.3.5. Identification of Valued Environmental Components, Other Projects, and External Drivers

10.3.5.1. *Valued Environmental Components*

To be included in a CIA, a VEC must first be confirmed to be valued by some identifiable stakeholder group and/or the scientific community. Second, the VEC must be reasonably expected to be affected by ***both*** the project under evaluation (i.e., the Payara Development Project) and some combination of Other Projects and external drivers.

Since 2017 and through the time of writing this EIA, EEPGL and its Consultants have held hundreds of stakeholder engagement events in coastal Regions 1, 2, 3, 5, and 6, and more than 1,000 engagements events and individual stakeholder meetings in Region 4 related to Liza Phase 1, Liza Phase 2, and Payara development activities. These include key informant interviews, EIA public scoping consultation and disclosure meetings, coastal mapping efforts, fisherfolk engagement, oil spill response training, community outreach events (e.g., informational booths, school fairs, job fairs), and capacity-building efforts. As part of the engagement effort, the Consultants reached vulnerable groups, including indigenous communities in the coastal areas of Region 1. The Consultants also took specific care during public engagements to take the opinions of women, the elderly, and youth into consideration by ensuring they were represented at public meetings and in focus groups (for detailed information on Project-specific engagement see Section 4.5.3, Stakeholder Engagement Process). These engagements with key stakeholders included local and national government agencies, non-governmental organizations, academia, local communities, civil society, and local industries. Information collected during these meetings allowed the Consultants to develop a list of preliminary VECs and establish the value or importance of receptors to the stakeholders. Table 10.3-1 lists the scoping consultation meetings conducted for the Payara Development Project; information from these meetings was considered in the selection of VECs.

Table 10.3-1: Scoping Consultation Meetings

Meeting	Town	Location	Date
Region 1	Mabaruma	L&D Resort, Kamaka Waterfront	22 March 2019
Region 2	Anna Regina	Anna Regina Town Council	28 March 2019
Region 3/4	Georgetown	Umana Yana	26 March 2019
Region 5	Hopetown	Hopetown Community Center	13 March 2019
Region 6	No. 66 Village	No. 66 Village Port	14 March 2019

In many cases, other relevant stakeholders (see Section 4.5.3) were also asked about preliminary VECs and other current or planned projects and activities, which could be important for the Consultants to consider. Such topics include land use, agriculture, cultural heritage, private sector development, tourism developments, energy projects, or new infrastructure. For stakeholders with relevant information, further questions were asked about mitigation, monitoring, and safeguarding of any related impacts on valued components as a result of those other anticipated projects and activities.

In 2017/2018, the Consultants carried out 64 focus group engagements for validation of data collected as part of the Liza Phase 1 post-permit ecosystem services study (ERM/EMC 2018). The following stakeholders participated in these meetings:

- Coastal Neighborhood Democratic Councils, Town Councils, Village Councils in Regions 1 through 6;
- National Toshaos Council representative; and
- Coastal Amerindian communities in and around the Shell Beach Protected Area in Region 1.

During these engagements, the Consultants used a screening exercise involving a series of questions about VECs, as detailed below:

- What are the environmental, social, or cultural attributes or components in this area (of the Project) that you value most? These may include:
  - Rivers/bodies of water
  - Air quality
  - Acoustic environment
  - Infrastructure
  - Forest cover
  - Wild species of plants
  - Biodiversity and animals
  - Landscape
  - Land use
  - Economic activities (e.g., tourism)
  - Fisheries and agriculture
  - Livelihoods
  - Cultural values
- Why are these valuable?
- What is the current condition of the component?
- What do you think is an acceptable condition of the component?
- Is this component currently affected by some human activity or natural factor?

This helped the Consultants understand and establish the value of the component to beneficiaries and scope-in those components that would be further evaluated as part of the cumulative assessment. The prioritization of VECs used the same approach as the ecosystem services evaluation (ERM/EMC 2018) and focused on identifying components that were important to local stakeholders, that would be difficult to replace, and whose loss or degradation could adversely affect stakeholders. The prioritization process considered the component’s importance to beneficiaries (including intensity of use, scope of use, degree of dependence, and general importance expressed by stakeholders) as well as the availability, accessibility, cost, and sustainability of spatial alternatives (including both natural replacements and anthropogenic substitutes). A priority rating was given to the components and any that were rated medium, high, and critical were included in the VEC selection process under “confirmed to be valued by an identifiable stakeholder group," as detailed in Section 10.5.1, Selected VECs for Inclusion in the Cumulative Impact Assessment.

In May 2019, the Consultants returned to each of these focus groups to perform a validation exercise, whereby stakeholders provided input on the data previously recorded and provided updates on the function and value of each ecosystem service in their community based on recent activities (see Appendix V, Interim Ecosystem Services Validation Data Summary).

10.3.5.2. *Other Projects*

Through a thorough review of publicly available information and interviews with EEPGL, government authorities, and proponents of other potential planned projects, the Consultants identified existing, and future planned projects located within the spatial and temporal boundaries of the CIA, having the potential to result in cumulative impacts on identified VECs (see Section 10.4.1, Other EEPGL Projects, and Section 10.4.2, Other Non-EEPGL Projects).

10.3.5.3. *External Drivers*

Regionally present external drivers and stressors were identified by the Consultants through EIA-generated information and publicly available information (see Section 10.4.4, External Drivers).

10.3.6. Description of Valued Environmental Component Conditions

The existing conditions of the selected VECs were characterized based on the data presented in the environmental and social existing conditions sections of the current EIA (Chapters 6 to 8). The VEC baselines provide information on the VECs' current conditions and anticipated resilience against external stressors and potential impacts (cumulative impacts and sources of stress) and thus provide an indication of their viability and sustainability.

10.3.7. Assessment of Cumulative Impacts on Valued Environmental Components

CIAs are future-oriented and project contributions are assessed as the difference between the expected future condition of the VEC in the context of all possible known stressors plus the project(s) under evaluation. This step of the CIA assesses the future conditions of the VECs, considering the Project, Other Projects, and external drivers. The cumulative impacts are then given a priority level, based not in terms of the amount of change, but in terms of the potential resulting impact to the vulnerability and/or risk to the sustainability of the VEC. If the residual impact significance for a VEC was rated as **Minor** or higher for at least one potential impact associated with planned Project activities (refer to Chapters 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, for residual impact significance ratings) the VEC was identified as potentially eligible for the CIA. Additionally, if the residual risk rating for any VEC was rated as **Moderate** or higher for at least one unplanned event (refer to Chapter 9, Assessment and Mitigation of Potential Impacts from

Unplanned Events, for residual risk ratings), the VEC was identified as potentially eligible for the CIA.

The results of the CIA are presented in tabular format in Section 10.6, Assessment of Cumulative Impacts on VECs, and each potential cumulative impact is prioritized based on the following definitions:

- **High Priority:** The VEC is expected to be adversely impacted by Other Projects and/or External Drivers and the future addition of the Project could incrementally contribute to the potential adverse impact and vulnerability of the VEC. Actions should be implemented in the short-term to mitigate potential adverse cumulative impacts on the VEC.
- **Medium Priority:** The VEC could potentially be impacted by Other Projects and/or External Drivers, and the Project could potentially incrementally contribute to the adverse impact and vulnerability of the VEC. Actions should be implemented in the medium-term to mitigate potential adverse cumulative impacts on the VEC.
- **Low Priority:** The VEC could potentially be impacted by Other Projects and/or External Drivers, but the Project would not be expected to contribute to the adverse impact or its contribution would be expected to be negligible. No additional actions are required to mitigate potential adverse cumulative impacts on the VEC; the mitigation measures and embedded controls of the Project itself are sufficient to manage the Project's contribution to potential cumulative impacts.

10.3.8. Cumulative Impact Management Framework

Internationally recognized good practices for managing cumulative impacts include:

- "Effective application of the mitigation hierarchy (avoid, reduce, and remedy) in the environmental and social management of the specific contributions of a project to expected cumulative impacts; and
- Undertaking best efforts to engage, leverage, and/or contribute in multi-stakeholder collaborative initiatives or discussion groups to implement management measures that are beyond the capacity and responsibility of any individual project developer." (IFC 2013)

The embedded controls and management measures included in the EIA provide a means to mitigate the specific contributions of the Project to effects on VECs, following the mitigation hierarchy (refer to mitigation measures in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources; management framework in Chapter 11, Environmental and Social Management Plan Framework; and a summary of embedded controls and mitigation measures in Chapter 13, Recommendations). Supplementing these controls and management measures, the CIA provides recommendations for EEGPL to apply in the context of the Project (and/or in its other projects) to manage potential cumulative impacts on these VECs.

10.4. OTHER PROJECTS AND EXTERNAL DRIVERS

Given the exploration success within the Stabroek Block to date and growing international interest, there is reasonable likelihood that oil and gas exploration and/or development offshore Guyana will continue for the foreseeable future. For example, in addition to the original Liza discovery, EEPGL has made several additional discoveries since 2016. There is also potential for oil and gas activities by other operators in the region. Other than for periodic vessel transit across the Stabroek Block, such operations would take place outside of the Stabroek Block. Therefore, the closest that another operators' activities could be expected to approach the Project would be approximately 20 kilometers (approximately 12.4 miles), which is the shortest distance from the Payara PDA to the boundary with a non-EEPGL license block)[2].

Twelve other (non-Project) activities have been identified as relevant with respect to the potential for their impacts to interact with Project impacts on a given VEC. These are described below, organized as Other EEPGL projects (Section 10.4.1) and Other Non-EEPGL projects (Section 10.4.2). Section 10.4.3, Potential Impacts from Other Projects by Sector, summarizes the Other Projects' potential impacts.

10.4.1. Other EEPGL Projects

After consulting with EEPGL, the Consultants identified the following Other EEPGL Projects to be included in the CIA:

- Continued exploration drilling
- Liza Phase 1 Development Project
- Liza Phase 2 Development Project
- FPSO #4 Development Project
- FPSO #5 Development Project
- FOC Project
- Gas to Shore Project

Summaries of these projects are presented below. Figure 10.4-1 shows the locations of the Liza Phase 1 Floating Production, Storage, and Offloading (FPSO) vessel, the Liza Phase 2 FPSO, the Payara FPSO, and nominal areas in which the FPSO #4 and FPSO #5 PDAs are assumed for the purpose of this assessment to be located. Continued exploration drilling could occur throughout the Stabroek Block or possibly into adjacent blocks (this is not shown on the figure due to commercial sensitivities and lack of definition of exploration program outlook). The Gas to Shore pipeline will originate from the vicinity of the Liza Phase 1 FPSO. The pipeline route and landing location for the Gas to Shore Project are not yet finalized, so these are also not shown on the figure.

[2] Other operators could request permission from EEPGL to conduct geophysical or geotechnical survey operations within the Stabroek Block. However, for safety reasons any such activities would not be allowed to overlap with EEPGL operations in space and time. Therefore, the potential impacts associated with such operations (e.g., marine discharges, traffic, sound) would not significantly contribute to cumulative impacts.

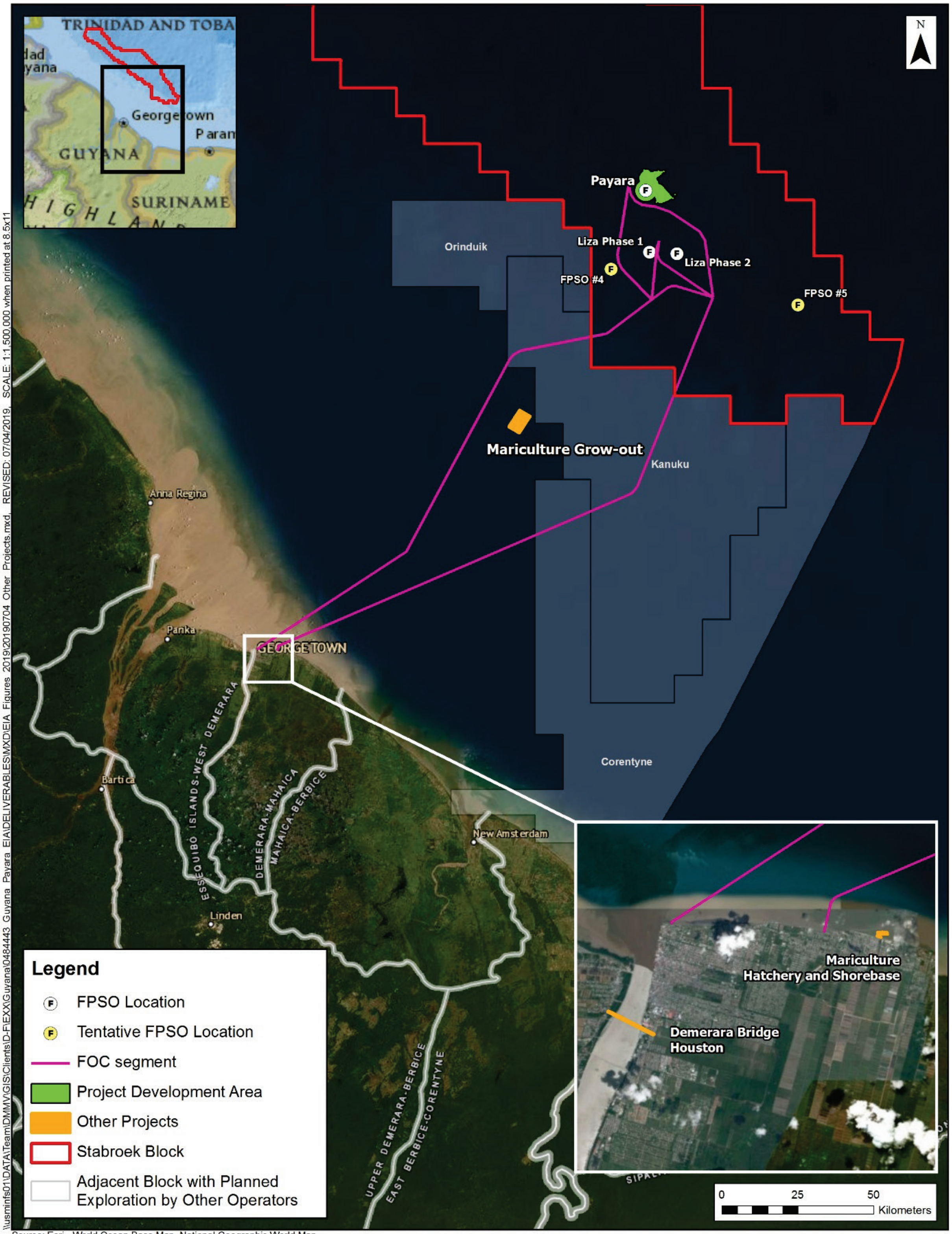


Figure 10.4-1: Conceptual Locations of Other Projects

10.4.1.1. *Liza Phase 1 and Liza Phase 2 Development Projects*

Project Summary

The Liza Phase 1 and Liza Phase 2 Development Projects have been permitted to develop their respective offshore resources by drilling approximately 17 subsea development wells (Liza Phase 1) and up to 33 development wells (Liza Phase 2) in the eastern half of the Stabroek Block. Each of these projects will use an FPSO to process, store, and offload the recovered oil. The FPSO will be connected to the wells via associated Subsea, Umbilicals, Risers, and Flowlines (SURF), which will transmit produced fluids (i.e., oil, gas, produced water) from production wells to the FPSO, as well as treated gas and water from the FPSO to injection wells. The Liza Phase 1 PDA, where the drilling and production operations activities will collectively occur, is a 50 square kilometers (km^2) (19.3 square miles [mi^2]) area located approximately 190 kilometers (approximately 120 miles) offshore. The Liza Phase 2 Subsea PDA, where activities related to drilling and installation will take place, covers an approximate 76 km^2 (29.3 mi^2) area, and the Surface PDA, where activities related to the production operations stage will occur, could cover an estimated 45 to 50 km^2 (17.4 to 19.3 mi^2). The Liza Phase 2 PDAs are located approximately 183 kilometers (114 miles) northeast of the coastline of Georgetown. The Liza Phase 1 and Phase 2 Development projects will each consist of three stages: (1) Drilling and Installation, (2) Production Operations, and (3) Decommissioning.

Shorebases, laydown areas, warehouses, fuel supply, and waste management facilities will support both projects across project stages. Both projects have similar logistics, with a combined average of 12 trips per week during drilling and installation and about 5 to 10 trips per week during production operations. These vessels are planned to originate from shorebases in Guyana and/or Trinidad. Combined aviation support is expected to average about 30 to 35 flights per week during drilling and installation and about 20 to 25 flights during production operations.

Natural gas will be produced in association with the produced oil. EEPGL will use some of the recovered gas as fuel on the FPSO, and is planning on re-injecting the remaining gas back into the Liza reservoir, which will assist in optimizing management of the reservoir.

Project Schedule and Distance from the Payara Development Project

The drilling and installation stages for Liza Phase 1 and Liza Phase 2 are projected to overlap for about three quarters during 2020. Drilling for Liza Phase 1 initiated in May 2018; installation is expected to complete in the fourth quarter of 2019 and extend through the first half of 2020, followed by initiation of the production operations phase. The distance between the Liza Phase 1 and Liza Phase 2 FPSOs is approximately 8.5 kilometers (approximately 5.3 miles). The distance from the Liza Phase 2 FPSO to the Payara FPSO location is approximately 20 kilometers (approximately 12.4 miles), as shown in Figure 10.4-1.

10.4.1.2. *Continued Exploration Drilling*

Project Summary

Exploration drilling by EEPGL is planned to continue to take place in the Stabroek Block, and possibly in adjacent blocks, over the next few years, subject to continued exploration success (i.e., discoveries). Since 2018, there have been two exploration drilling rigs working in the Stabroek Block. While continued exploratory drilling is contingent on the results of exploration, the current EEPGL exploration program is nominally envisioned to consist of eight additional wells (for the environmental authorization already in place); Applications for Environmental Authorization for exploration drilling programs in the Stabroek, Canje, and Kaiteur Blocks have been submitted to the EPA and are under review.

Project Schedule and Distance from the Payara Development Project

One drill ship is actively drilling exploration wells in the Stabroek Block and is expected to continue through the end of 2021; the second exploration drill ship started working in the area in the fourth quarter of 2018 and is estimated to continue for approximately 3 years (until the end of the fourth quarter of 2021; Figure 10.3-4). The duration, extent, and location of exploration drilling, however, is entirely dependent on continued successful results. While exploration drilling could occur in one of the other EEPGL license blocks adjacent to the Stabroek Block (Canje or Kaiteur), for the purpose of this CIA, it is conservatively assumed that all exploration drilling activity would occur inside the Stabroek Block.

10.4.1.3. *FPSO #4 and FPSO #5 Development Projects*

Project Summary

The FPSO #4 and FPSO #5 Development Projects are assumed for the purpose of this CIA to be designed, in concept, similar to the Payara Development Project (i.e., an FPSO with a subsea tieback system, with an equivalent production capacity). They are tentatively assumed be located in the eastern half of the Stabroek Block. Although the sizing and capacity of the FPSO #4 and FPSO #5 facilities are not currently defined, for the purposes of this CIA it is assumed that they will be similar to the Payara Development Project FPSO size/ capacity, with an estimated 45 development wells each (including production, water injection, and gas re-injection wells). Each of these projects would require the installation and operation of SURF equipment and installation and operation of an FPSO.

For the purposes of this CIA, the preliminary areas within which FPSO #4 and FPSO #5 and subsea infrastructure are expected to be located (southwest and southeast of the Payara FPSO respectively) are shown on Figure 10.4-1. Although labeled FPSO #4 and FPSO #5, the actual sequencing of these developments is conceptual in nature and is provided only for the purposes of the CIA.

Project Schedule and Distance from the Payara Development Project

The estimated timeline for the FPSO #4 Development Project shows SURF installation starting during the first quarter of 2022 (assuming an environmental authorization is issued) and continuing through mid-2024; and production would start in the third quarter of 2024 (Figure 10.3-4). The estimated timeline for FPSO #5 would follow the same timing, lagging approximately 1 year behind FPSO #4, projecting the start of SURF installation in the first quarter of 2023, with production starting in the third quarter of 2025 (Figure 10.3-4).

For the purposes of this CIA, the distances from the Payara Development Project to the assumed FPSO #4 and FPSO #5 locations are approximately 30 kilometers (approximately 19 miles) to FPSO #4, and 60 kilometers (approximately 37 miles) to FPSO #5 (Figure 10.4-1).

10.4.1.4. *Fiber Optic Cable Project*

Project Summary

To meet the long-term network connectivity needs to support the automation, process control, communications, and computing requirements for EEPGL's offshore facilities planned for installation in the Stabroek Block, EEPGL proposes to construct a fiber optic network (i.e., the FOC Project; Figure 10.4-1). This will be executed via a submarine fiber optic cable connecting offshore EEPGL facilities to onshore network services. This connection will establish a foundation for high-speed/low-latency connectivity of onshore and offshore facilities as they become operational. The link will connect existing EEPGL onshore and offshore facilities to Guyana foundation infrastructure, enabling implementation of digital technology.

The network will need two landing sites; at the time of this CIA, EEPGL is in discussions with the government about the potential location for these sites and intends to finalize site recommendations in late 2019. The final location selection is dependent on review by government agencies and other business criteria.

Route: Preliminary route and cable engineering are based on industry-recognized criteria for cable crossings, using parallel cables and down-slope routing wherever possible. Fishing and other marine activity were taken into consideration in preliminary route engineering. Just east of the mouth of the Demerara River, there is a restricted area due to permanently installed fishing stakes. The cable will run through this area for approximately 4 kilometers (2.5 miles). The fishing stakes are visible during the day and can be removed by the fisherfolk if required. EEPGL plans to reach a formal, written agreement with the Guyana Association of Trawler Owners and Seafood Processors for the removal of fishing stakes prior to any marine installation activities.

Methodology: During construction, the proposed plan is to use a variety of installation methods depending on the water depth and the on-site conditions. To protect the cable as much as possible through the fishing grounds, the cable would be plow-buried from approximately 32 kilometers (20 miles) from shore up to a water depth of 150 meters (492 feet); from this point seaward, seabed laying is sufficient and the cable will self-bury (i.e., the cable will be laid on the ocean floor and will bury itself through natural processes). For burial portions, the cable will be trenched to a depth of 1.5 meters (5 feet). The FOC Project will use an estimated five vessels to support deepwater cable laying and nearshore trenching operations over an approximate 6-month duration.

Project Schedule and Distance from the Payara Development Project

For the purpose of this CIA, the estimated timeline for the FOC Project assumes starting construction in the first quarter of 2021, with completion by the end of the second quarter of 2021. The proposed plan is to begin with a connection to the Liza Phase 2 offshore development, followed by a connection to the Payara offshore development.

10.4.1.5. *Gas to Shore Project*

Project Summary

For gas disposition, EEPGL is currently doing preliminary planning work for a potential Gas to Shore Project. A Gas to Shore Project may transport associated gas from the Liza Phase 1 PDA to shore, with NGLs stripped from the gas and dry gas used in a possible gas-fired power plant. Purposes of the potential project include beneficial use of associated natural gas, reducing Guyana's reliance on imported heavy fuel oil, lowering national GHG emissions through cleaner-burning natural gas, and bridging to a greener energy economy for Guyana. It is estimated that the Gas to Shore Project scope would include new facilities, including a pipeline from the Liza Phase 1 PDA to shore, a new NGL facility, and associated onshore facilities. The Gas to Shore Project may include or be developed concurrently with a new onshore power plant and some additional power transmission.

Project Schedule and Distance from the Payara Development Project

The project schedule is yet to be determined, but it could potentially occur in the early- to mid-2020s. The location of the onshore facilities for the Gas to Shore Project has not yet been selected.

10.4.2. Other Non-EEPGL Projects

10.4.2.1. *Replacement of Demerara Harbour Bridge*

Project Summary

The Demerara Harbour Bridge in Georgetown has been in operation for approximately 40 years and is no longer able to efficiently service either the present or estimated future traffic demands. The Government of Guyana is currently considering replacement of the heavily used bridge as a means of relieving congestion of both vehicular road and river-based vessel traffic induced by the opening and closing of the retractor spans that allow large vessels to pass. In 2013, a pre-feasibility study identified three alternative locations for the new bridge: Houston, Peters Hall (the existing location), and New Hope. In November 2015, the Ministry of Public Infrastructure sought Expressions of Interest to complete a feasibility study and design for a new bridge across the Demerara River (Kaieteur News 2015). The Government of Guyana commissioned LievenseCSO to execute the feasibility and design study and a final study was submitted in August 2017 (LievenseCSO 2017).

The design proposed by LievenseCSO consists of a low bridge with three lanes and a movable section to transit seagoing vessels. The bridge would be designed with a minimum clearance of 17.5 meters (57.4 feet) above chart datum to allow uninterrupted passing of trawlers, tugs and barges and smaller coastal and service vessels. The feasibility study found this to be the preferred solution, and concluded the preferred location would be at Houston–Versailles. The study also points out that traffic is estimated to continue to grow at 5 percent per year, and that new linking roads would be required to fully use the new bridge capacity.

Project Schedule and Distance from Liza Phase 2 Development Project

The new bridge is proposed to be located in close proximity to one of the shorebases that EEPGL is planning to use to support the Payara Development Project (Figure 10.4-1). If construction of a new bridge moves forward within the next 20 years, the construction-related activities for the bridge might occur at the same time as some stages of the Payara Development Project. At the time of this CIA, the Demerara Harbour Bridge Project continues to be actively pursued, but there is no set timeline yet for financial closure or start of construction. However, it is being included in the CIA as a reasonably foreseeable project.

10.4.2.2. *Caribbean Mariculture Project*

Project Summary

A mariculture project by Caribbean Mariculture Inc. (CMI) has been proposed for development offshore Guyana. In December 2017, an updated project summary was submitted to the EPA. According to the project summary document, the project is designed to farm the following marine fish species: southern red snapper (*Lutjanus purpureus*), Atlantic grouper (*Epinephelus itajara*), cobia (*Rachycentron canadum*), grey snapper (*Cynoscion acoupa*), and gillbacker (*Sciades parkeri*), which are currently caught by the marine capture fisheries in Guyana. The project asserts that by growing selected species of fish through aquaculture, the supply of fish will become more reliable and that it will reduce the pressure on wild fish stocks.

The project would have three main components: (1) hatchery; (2) shorebase area; and (3) growout area. The hatchery location has been updated, with the revised location slightly offshore, away from residential and protected areas, at Le Ressouvenir, East Coast Demerara. The proposed shorebase operations would be land-based, at Le Ressouvenir, East Coast Demerara, located next to the hatchery, and bordered by mangroves to the east and west, the Atlantic Ocean to the north, and by residential areas and drainage structures to the south. The proposed growout operations would be located in the open ocean.

Based on recent conversations between EEPGL and CMI, the Consultants understand that the size and location of the proposed growout area has been updated from what is shown in the Project Summary, and is currently proposed as an area approximately 24 km^2 (9.3 mi^2) in size, approximately 109 kilometers (approximately 68 miles) from an area north of Devonshire Castle, and approximately 160 kilometers (approximately 99 miles) from an area north of the boundary between Administrative Regions 1 and 2. Figure 10.4-1 shows the proposed (updated) location of the project components, as determined from the publicly available project summary document and subsequent correspondence between EEPGL and CMI. The project proponent considers the growout area location to be preliminary, and indicates it will be further refined following consultations with government agencies to determine suitability for the proposed activities. If agreed upon by the various government agencies, the project proponent intends to make the approved final location publicly available.

The summary document briefly describes the mariculture operation:

- **Hatchery:** Broodstock of the various species would be captured alive from the wild, and transported to the hatchery. This broodstock would be placed in eight concrete tanks, each with a capacity of 28 cubic meters. The broodstock would then be induced using environmental manipulation (i.e., photoperiod, temperature, water quality and nutrition), so as to facilitate spawning. Chlorine bleach would be used for cleaning the tanks, and the hatchery in general. No additives would be used. In the hatchery, the broodstock would be spawned, producing eggs, which would then hatch into fry (very small fish). These fry would be grown to fingerlings (slightly larger fish). Lastly, the fingerlings would be transported to the growout area, where they would be stocked and grown to market-sized fish. While in the hatchery, the broodstock, fry, and fingerlings would be fed a high quality feed.
- **Shorebase:** This operation would service the hatchery and growout areas, providing storage areas, locations for the mooring of vessels, and other supporting facilities.
- **Growout area:** In the growout area, the project would use large mesh pens with a mesh size that would accommodate the size of fingerlings to be stocked from the hatchery operations, prevent the entry of predators, and facilitate adequate water exchange. Fingerlings will be grown to market size in these pens. Each pen will be 6,400 cubic meters in size. The growout operation would be serviced by feeding, holding, and harvesting support infrastructure, as well as logistics support, so as to be able to get inputs onto, and products off of, the facility. The growout operation would also have accommodations for staff, who would be required to supervise operations and conduct required tasks on a 24-hour basis.

The capital investment for the project is estimated at more than $3.1 billion Guyanese dollars ($15 million U.S. dollars). Production capacity is projected to be 100,000 pounds of fish per month.

Project Schedule and Distance from the Payara Development Project

The December 2017 version of the project summary report indicated that construction would take approximately 3 years; however, a start date for the construction has not been published by CMI. According to the 2017 version of the Project Summary, the project lifespan is expected to be 50 years. Based on the coordinates provided in the project summary report, the onshore components of the mariculture project would be located approximately 10 kilometers (approximately 6 miles) southeast of the mouth of the Demerara River. The offshore component (growout area) would be located somewhere within a 24 km^2 (9.3 mi^2) area, with its closest boundary approximately 100 kilometers (approximately 62 miles) south-southwest from the Payara FPSO (Figure 10.4-1).

10.4.2.3. *Oil and Gas Exploration*

Three other companies are conducting exploration activities in the area: (1) Repsol in the Kanuku Block; (2) Tullow in the Orunduik Block; and (3) CGX in the Correntyne Block. All three are expected to start and complete their currently announced exploration activities in the second half of 2019. No more details are available at the time of writing this CIA. The Consultants have not made assumptions about the potential success of the exploration activities, and therefore are not including in the CIA a prolonged exploration program or any associated development projects that could be contemplated if discoveries are made.

10.4.3. Potential Impacts from Other Projects by Sector

Table 10.4-1 provides a list of the Other Projects and a summary of their potential impacts. Some of the projects are other EEPGL developments in the area and there is some level of detailed preliminary information to inform the CIA; however, detailed information is not available for all of the Other Non-EEPGL Projects. Therefore, the discussion of their potential impacts were complemented where needed with general industry-specific potential impacts such as those identified in the IFC´s Environmental, Health and Safety General Guidelines (IFC 2007a) and the guidelines for each sector: aquaculture (IFC 2007b), offshore Oil and gas development (IFC 2015), and liquefied natural gas facilities (IFC 2017).

The identified Other Projects that have a similar nature, such as the development projects and exploration drilling, are grouped and their potential impacts discussed together. For each project or group of projects, the potential impacts are summarized by project stage.

Table 10.4-1: Potential Impacts from Other Projects by Sector

Other Projects (by sector)	**Oil and Gas Exploration and Development Projects [a]**		**Fiber Optic Cable Project**		**Gas to Shore Project**		**Replacement of Demerara Harbour Bridge**		**Caribbean Mariculture Project**	
Project Stage	**Drilling and Installation**	**Production Operations (Development Projects)**	**Construction**	**Operation**	**Construction**	**Operation**	**Construction**	**Operation**	**Construction**	**Operation**
Potential Impacts	**Coastal Habitats:** These projects are not expected to disturb natural onshore habitats. **Land Traffic:** There may be a minor increase in traffic congestion in or near the onshore shorebases, and a Road Safety Management Procedure should mitigate those impacts. **Air Quality and Climate:** • The primary source of emissions for these projects will be emissions from marine vessels. Air quality modeling results for all EEPGL development projects and exploration campaigns show that the maximum predicted concentrations of air quality pollutants at potential onshore receptor locations are **Negligible**. • While GHG emissions associated with drilling represent a short- to medium-term source, they are considered to be a **Moderate** impact. **Marine Mammals:** • Exposure to permitted discharges, potentially leading to toxicological or metabolic impacts (**Negligible**) • Injury from sound exposure (**Negligible**); and underwater sound disturbance leading to deviation from area (**Moderate**) • Vessel strikes (an unplanned event) (**Moderate**) **Marine Turtles:** • Disturbance from artificial lighting (**Negligible**)	**Air Quality and Climate:** • The primary source of emissions for these projects will be emissions from the FPSOs. Air quality modeling results for all EEPGL development projects show that the maximum predicted concentrations of the assessed pollutants at potential onshore receptor locations are **Negligible**. • GHG emissions associated with the production operations phase are considered to be a **Moderate** impact. **Marine Mammals:** • Exposure to permitted discharges, potentially leading to toxicological or metabolic impacts (**Negligible**) • Vessel strikes (an unplanned event) (**Moderate**) **Marine Turtles:** Expected to be the same as those identified for the drilling and installation stage. **Marine Fish:** • Pelagic species entrainment via water withdrawals (**Negligible**) • Pelagic species attraction to artificial light (**Negligible**) • Distribution changes due to altered water	**Marine Water Quality:** • During cable laying, sources of impacts on marine water quality include treated wastewater and macerated food discharges from the installation vessels (similar to that considered for the development projects) • Temporary increases in suspended solids concentration during periods where trenching or jetting are used to bury the fiber optic cable • Conditions in the water column are expected to return to pre-disturbance conditions shortly after cessation of the activity **Marine Turtles:** • Auditory impacts—cable laying will not involve any activities that produce a level of sound equivalent to that of a VSP operation; accordingly, auditory impacts on marine turtles are expected to be **Negligible**. • Potential vessel strikes—cable laying activities will involve a relatively low number of vessel movements, and the limited number of marine turtles expected to be passing through the work area, as demonstrated by recent telemetry data, indicates that a collision with a marine turtle is unlikely.	NA	***Power Plant*** **Air Quality:** Emissions from diesel engine combustions from vehicles and heavy equipment used during construction. **Noise and Vibration:** Increased onshore noise due to general construction activities, and construction-related traffic. **Biodiversity:** Activities such as vegetation removal and earth movement may result in distribution and habitat changes for terrestrial fauna, death of fauna from collision with vehicles and elimination of terrestrial flora within the project´s layout including access roads and laydown area. ***Pipeline*** It is estimated that potential environmental and socioeconomic impacts from offshore pipeline development would be similar to those associated with SURF components of the Liza Phase 1, Liza Phase 2, and other FPSO development projects. **Employment and Livelihoods:** Potential interference with fishing and other marine use activities	***Power Plant*** **Air Quality:** The principal source of air quality and GHG emissions will be from the onshore natural gas plant facilities, although natural gas-fired plants generally produce negligible quantities of particulate matter and sulfur oxides, and levels of nitrogen oxides lower than those from coal plants. **Aquatic Habitat Alterations:** • Elevated temperature due to once-through cooling systems that use large quantities of water which are then discharged back to receiving surface water with elevated temperature • Elevated temperature may affect aquatic organisms, including phytoplankton, zooplankton, fish, crustaceans, shellfish, and many other forms of aquatic life • Aquatic organisms drawn into cooling water intake structures can be impinged or entrained **Hazardous Materials Management:** Hazardous materials stored and used at combustion facilities include solid, liquid, and gaseous fuels; air, water, and wastewater treatment chemicals; and equipment and facility maintenance	**Community Infrastructure:** • Resettlement of houses • Potential impacts on the current drainage channel • Potential impacts on commercial businesses adjacent to the bridge **Biodiversity:** Damage or modification to mangroves in the east and west bank of the Demerara River. According to the feasibility study, mangroves on the east bank are already impacted by anthropogenic activities, and the fringe mangrove on the east bank is also characterized as being considerably smaller than the fringe mangrove on the west bank. The study suggests technical solutions could be proposed to ensure low impact on biodiversity. **River Navigation:** Procedures for river navigation would have to be reconsidered and new lead lines developed. The Summary Report (2018) concludes that all these potential impacts and challenges are manageable. **Community Health and Safety:** Increased noise and air quality emissions during construction; and increased road safety risks.	**Land Traffic:** The feasibility study predicted traffic growth and the results were used to assess impacts on environmental components such as noise, air quality, safety, nuisance, and health. To mitigate potential traffic-related impacts, the study suggests construction of bypasses on the west and east sides of the bridge. **Noise:** Increased noise levels as the bridge would allow for higher volume of traffic. **Air Quality:** Decreased air quality as the bridge would allow for higher volume of traffic, and consequently more vehicle emissions.	**Biodiversity:** Conversion of natural habitats (e.g., removal of mangroves, alteration of natural hydrology of lagoons). **Hazardous Materials:** During construction of the hatchery and shore base area, the activities may involve the handling and use of hazardous materials (e.g. oil and other chemicals).	**Biodiversity:** • Potential release of alien species into natural environment • Potential loss of genetic resources due to collection of larvae, fry, or juveniles for aquaculture production • Potential release of artificially propagated seed into the wild • Development of antibiotic resistance in pathogenic bacteria that could then spread from farms to wild stock **Hazardous Materials:** The aquaculture sector may involve the handling and use of hazardous materials (e.g. oil, fertilizers, and other chemicals). **Eutrophication of Surrounding Area:** The main negative environmental effects in aquaculture are associated with discharge of effluent, containing fish waste products, from farms into the environment, and potentially result in water eutrophication. **Predation of Fingerlings of Wild Fish Species:** It is probable that fingerlings of various species of wild fish will enter the pens, which are used as growing structures for the fish. Once in the cages, it is likely that these fingerlings will be subject to predation. Four of the five species that would be grown are predaceous, and one is omnivorous.

Other Projects (by sector)	**Oil and Gas Exploration and Development Projects [a]**		**Fiber Optic Cable Project**		**Gas to Shore Project**		**Replacement of Demerara Harbour Bridge**		**Caribbean Mariculture Project**	
Project Stage	**Drilling and Installation**	**Production Operations (Development Projects)**	**Construction**	**Operation**	**Construction**	**Operation**	**Construction**	**Operation**	**Construction**	**Operation**
	• Displacement from habitat to avoid disturbance from vessel activity (**Negligible**) • Acoustic injury from sound exposure (**Negligible**) • Exposure to permitted discharges, potentially leading to toxicological or metabolic impacts (**Negligible**) • Vessel strikes (unplanned event) (**Moderate**) **Marine Fish:** • Auditory impacts on fish (pelagic species) from vessel activity (**Negligible**) • Disturbance from or attraction to offshore lighting that would affect pelagic species (**Negligible**) • Auditory impacts on demersal species from pile driving and VSP (**Negligible**) • Distribution and habitat changes for demersal species from altered water quality (**Minor**) **Marine Water Quality:** Increased TSS concentrations in water column, potentially contributing to health impacts on marine life (**Minor**). **Marine Use and Transportation:** • Increased vessel traffic in coastal waters between Georgetown and the PDA (**Negligible**) • Reduced availability of ocean surface areas for non-Project activities (**Negligible**) • Negative effect on commercial cargo and commercial fishing vessels (**Minor**) and on subsistence fishing vessels (**Minor**)	quality for pelagic species (**Negligible**) **Marine Water Quality:** • Changes in water quality and temperature from liquid effluent discharges from drill ships and marine support vessels, potentially contributing to health impacts on or avoidance of marine life (**Negligible**) • Elevated temperature from cooling water discharge, and changes in water quality from routine effluent discharges (**Negligible**) **Marine Use and Transportation:** Expected to be the same as those identified for the drilling and installation stage. **Employment and Livelihoods:** Expected to be the same as those identified for the drilling and installation stage. **Waste Management Infrastructure Capacity:** Expected to be the same as those identified for the drilling and installation stage.	**Marine Mammals:** • Auditory impacts—cable laying will not involve any activities that produce a level of sound equivalent to that of a VSP operation; accordingly, auditory impacts on marine mammals are expected to be **Negligible**. • Potential vessel strikes—unlikely. As embedded controls, the Project will provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals at the sea surface, and will provide standing instruction to Project-dedicated vessel masters to avoid marine mammals while underway and reduce speed or deviate from course, as needed, to reduce probability of collisions. **Marine Use and Transportation:** Fishing vessels operating near the project work areas will temporarily lose access to these areas for fishing activities.		during pipeline construction activities. **Marine Water Quality:** • Changes to water quality as a result of permitted discharges from pipeline construction-related vessels and from hydrotesting. • Discharge of hydrotest waters could affect marine water quality. Hydrostatic testing of marine pipelines involves pressure testing with water to verify equipment and pipeline integrity. Chemical additives (corrosion inhibitors, oxygen scavengers, biocides, and dyes) may be added to the water to prevent internal corrosion or to identify leaks.	chemicals (e.g., paint, lubricants, and cleaners). **Noise and Vibration:** • Principal sources: turbine generators; boilers; fans and ductwork; pumps; compressors; condensers; precipitators; piping and valves; motors; transformers; circuit breakers; and cooling towers. • Generation of low frequency noise (between 10 Hz to 200 Hz), which has been identified as a nuisance with potential health effects for the residents living near the source.				**Water Quality Changes:** Due to the activities associated with the proposed culture of a significant biomass of fish, there could be changes in the baseline water parameters around the culture site. It is likely that in the immediate vicinity of the growout or culture area, there could be an increase of certain compounds, such as ammonia and nitrates, resulting from protein metabolism by the cultured species. **Noise Pollution:** The operation of diesel generators would generate noise. These generators are expected to be operational between eight to twelve hours per day, depending on the power requirements. **Spills and Leakages:** There is the possibility of spills and leakages of fuel, which could cause localized pollution of the surrounding environment until it is cleaned up. **Sewerage:** Both the onshore and offshore operations will generate sewage, which represents a potential source of pollution.

Other Projects (by sector)	Oil and Gas Exploration and Development Projects [a]		Fiber Optic Cable Project		Gas to Shore Project		Replacement of Demerara Harbour Bridge		Caribbean Mariculture Project	
Project Stage	**Drilling and Installation**	**Production Operations (Development Projects)**	**Construction**	**Operation**	**Construction**	**Operation**	**Construction**	**Operation**	**Construction**	**Operation**
	Employment and Livelihoods: • Increased employment, local business activity, household income (**Positive**) • Adverse impacts on fishing livelihoods. Marine safety exclusion zones within the PDA for commercial fishing operations (**Negligible**); nearshore navigation and safety for subsistence fishing (**Minor**) **Waste Management Infrastructure Capacity:** • Increased burden on waste management infrastructure capacity for local landfill facilities and hazardous waste approved facilities.									

Hz = hertz; NA = not applicable; VSP = Vertical Seismic Profile
[a] Exploration drilling by EEPGL, Repsol, Tullow, and CGX; Liza Phase 1; Liza Phase 2; FPSO #4; and FPSO #5 Development Projects)

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10.4.4. External Drivers

10.4.4.1. *Natural Hazards and Climate Change*

The disaster risk profile for Guyana indicates that floods, droughts, and landslides pose the most significant risks (UNISDR 2014; World Bank 2019). The primary natural hazards faced by the population are floods. The low-lying coastal plains in the northern areas of Regions 1 to 6 face severe risk of flooding. In the recent past, floods have produced significant health impacts, direct economic losses for agriculture, livestock, fisheries, and forestry industries, and significant damage to roads and other infrastructure. Floods can also potentially increase the transmission of water-borne diseases, such as typhoid fever, cholera, leptospirosis, and hepatitis A; and vector-borne diseases, such as malaria, dengue and dengue hemorrhagic fever, yellow fever, and West Nile Fever (WHO 2018).

The World Bank estimates that Guyana is one of the most vulnerable countries to global climate change due to its low-lying coastal areas, many below mean sea-level, and a high percentage of the population and critical infrastructure located along the coast (World Bank 2016). In addition, increases in the global mean temperatures could have a significant impact, especially on the coastal plain and on activities such as the dominant agriculture sector in Guyana (UNDP 2018).

Changes in rainfall patterns and a predicted sea-level rise associated with climate change pose threats to the Guyanese coastal population and its livelihoods. As such, the country invests continuously in the construction and maintenance of sea and river defense infrastructure. In addition, significant efforts are being made to protect and enhance natural sea defense mechanisms, in particular mangrove ecosystems.

10.4.4.2. *Commercial and Artisanal Fishing*

Marine fisheries and subsistence fishing occur throughout Guyana's coastal waters, from the shore to the edge of the continental shelf, approximately 150 kilometers (approximately 93 miles) from shore, although most fishing activity occurs well inshore from the edge of the continental shelf. There are four main types of marine fisheries in Guyana (see Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources), as differentiated by the species targeted, gear types used, and the depth of water where the fishery takes place:

- Industrial fisheries use trawls to target seabob, shrimp, and prawns, at depths of 13 to 16 meters (42.6 to 52.5 feet) primarily, but can also occur shallower or deeper depending on seasonal movements of the resource on the continental shelf.
- Semi-industrial fisheries use fish traps and lines to target red snapper and vermilion snapper at the edge of the continental shelf.
- Artisanal fisheries use gillnets, drift seines, Chinese seines, and other gear (e.g. caddell line) to target shrimp and a mix of fish species, at depths of 0 to 28 meters (0 to 92 feet).

- Shark fisheries use trawls, gillnets, and hook and line to target sharks throughout the continental shelf waters, although these fisheries capture a number of species as bycatch.

Guyana's marine fishing activities are directed at exploiting its shrimp resources using trawlers, and its ground-fisheries (with the exception of the deepwater, semi-industrial, trap-based fishery) are based on wooden vessels and employ a variety of gear by artisanal fisherfolk. Fishing yields vary by season, with fisherfolk reporting the highest yields in June through September. From October to early February, catches are at their lowest due to seasonally colder waters coming from the north. There has been a declining trend for artisanal finfish, prawns, and seabob catches in recent years, although the recent decline follows an increasing trend for 2010 through 2012. The prawn industry has been voluntarily scaled back in response to limited catches resulting from overfishing in previous years, with approximately 15 Guyanese-registered boats in operation in 2016. Prawn fishing boats operate from the coast out to about 70 meters (230 feet) (ERM Personal Communication 2). Fishing by small vessels is generally focused along the coastlines of the vessels' respective landing sites. Larger artisanal vessels that have engine sizes of greater than 40 horsepower travel greater distances and have fishing trips of longer durations. There is limited exploitation of pelagic resources over the outer continental shelf and towards the continental slope.

Interviews with fisherfolk conducted as part of the Liza Phase 1 post-permit studies and the 2019 Participatory Fishing Survey (Appendix T) indicated that gillnets are the most productive type of gear in the smaller-scale fisheries that operate closer to the coast, although gillnets are among the most susceptible gear types to fouling by sargassum, which presents an increasing and significant challenge to fisherfolk. The spread of mangrove vegetation along the shoreline, and the dynamic accretion and erosion of the Guyanese coastline as a result of natural forces also pose challenges for fisherfolk. This resultant loss of access to shore has caused some landing sites to close and fisherfolk to relocate to other landings sites.

Industrial fishing operators in Guyana are based mainly in Region 4 and have private wharves where their vessels dock. The large-scale commercial trawl fishery mainly targets seabob, a short-lived shallow water shrimp (*Xiphopenaeus kroyeri*), and various finfish species (MacDonald et al. 2015). This includes red snapper, shark, and tuna. The deepwater tuna fleet is currently at 12 vessels (ERM/EMC Personal Communication 5; ERM Personal Communication 26). The fishing industry is one of the most important direct and indirect economic drivers in Guyana (see Section 8.1.2, Existing Conditions—Socioeconomic Conditions). However, unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish and turtles, damaging the seafloor, and leading to overfishing. Bottom trawl nets can also harm coral reefs, sharks, and marine turtles (Stiles et al. 2010). The Liza Phase 1 post-permit studies documented some remnant coral growth in some areas on the continental shelf, and indicated the trawl fishery as a probable factor preventing recovery of Guyana's corals and other shallow benthic communities (ERM 2018).

10.5. VEC Selection and Description

10.5.1. Selected Valued Environmental Components for Inclusion in the Cumulative Impact Assessment

All the potentially eligible VECs were analyzed against the following criteria: (1) confirmed to be valued by an identifiable stakeholder group; (2) reasonably expected to be potentially significantly impacted by the Project (i.e., at least one potential residual impact significance rating of **Minor** or above for a planned Project activity or at least one residual risk rating of **Moderate** or above for an unplanned event); ***and*** (3) reasonably expected to be potentially impacted by some combination of other projects and external drivers. Table 10.5-1 summarizes the VECs considered in this CIA. This selection step considers potential risks from unplanned events assessed for the Project in prior sections, with the exception of oil spills. There is no credible scenario in which two loss-of-well-control events would happen simultaneously. In the event that a loss-of-well-control event would occur at one well location, the teams attending to other wells in the field being actively drilled would modify plans and procedures at those wells as appropriate and would provide assistance as necessary until the affected well is brought back under control.

Table 10.5-1: Selected VECs for Inclusion in CIA

VEC	Valued by Stakeholders	Potentially Affected by the Payara Development Project [a]	Potentially Affected by One or More "Other Projects"	Potentially Affected by One or More "External Drivers"
Air Quality and Climate	Yes	Yes	Yes	No
Marine Water Quality	Yes	Yes	Yes	No
Special Status Species	Yes	Yes	Yes	Yes
Marine Mammals	Yes	Yes	Yes	Yes
Marine Turtles	Yes	Yes	Yes	Yes
Marine Fish	Yes	Yes	Yes	Yes
Riverine Mammals	Yes	Yes	Yes	Yes
Marine Benthos	Yes	Yes	Yes	Yes
Ecological Balance and Ecosystems	Yes	Yes	Yes	Yes
Employment and Livelihoods	Yes	Yes	Yes	Yes
Community Health and Wellbeing	Yes	Yes	Yes	Yes
Marine Use and Transportation	Yes	Yes	Yes	Yes
Social Infrastructure and Services	Yes	Yes	Yes	Yes
Waste Management Infrastructure Capacity	Yes	Yes	Yes	No

[a] At least one potential residual impact significance rating of **Minor** or above for a planned Project activity or at least one residual risk rating of **Moderate** or above for an unplanned event.

10.5.2. Valued Environmental Components Not Selected for Inclusion in Cumulative Impact Assessment

Several environmental and socioeconomic receptors or components were not selected as potentially eligible for the CIA, in all cases because they were not reasonably expected to be significantly impacted by the Payara Development Project (i.e., at least one potential residual impact significance rating of **Minor** or above for a planned Project activity or at least one residual risk rating of **Moderate** or above for an unplanned event)—and in some cases were also not reasonably expected to be potentially impacted by some combination of Other Projects and External Drivers. Table 10.5-2 presents the components that were not selected as VECs for the CIA.

Table 10.5-2: VECs Not Selected for Inclusion in CIA

Potential VEC	Valued by Stakeholders	Potentially Affected by Payara Development Project [a]	Potentially Affected by One or More "Other Projects"	Potentially Affected By One or More "External Drivers"
Sound (Airborne)	Yes	No	No	No
Marine Geology/Sediments	Yes	No	No	Yes
Protected Areas	Yes	No	No	Yes
Coastal Wildlife	Yes	No	No	Yes
Coastal Habitats	Yes	No	No	Yes
Economic Conditions	Yes	No (positive)	Yes (positive)	Yes
Cultural Heritage	Yes	No	No	No
Land Use	Yes	No	No	Yes
Ecosystem Services	Yes	No	No	Yes
Indigenous People	Yes	No	No	Yes

[a] At least one potential residual impact significance rating of **Minor** or above for a planned Project activity or at least one residual risk rating of **Moderate** or above for an unplanned event.

10.5.3. Valued Environmental Component Description

The existing conditions sections of this EIA present the existing conditions of the selected VECs; please refer to the following sections for details on the current status of each component:

- Air Quality and Climate: Section 6.1.2
- Marine Water Quality: Section 6.4.2
- Protected Areas and Special Status Species: Section 7.1.2
- Marine Mammals: Section 7.5.2
- Riverine Mammals: Section 7.6.2
- Marine Turtles: Section 7.7.2
- Marine Fish: Section 7.8.2
- Marine Benthos: 7.9.2
- Ecological Balance and Ecosystems: 7.10.2
- Employment and Livelihoods: Section 8.2.2
- Community Health and Wellbeing: Section 8.3.2

- Marine Use and Transportation: Section 8.4.2
- Social Infrastructure and Services: 8.5.2
- Waste Management Infrastructure Capacity: Section 8.6.2

10.6. Assessment of Cumulative Impacts on VECs

For the CIA, the potential impacts from the Other EEPGL Projects (Liza Phase 1 Development Project, Liza Phase 2 Development Project, continued exploration drilling, FPSO #4 Development Project, FPSO #5 Development Project, FOC Project, and Gas to Shore Project) being planned or contemplated by EEPGL are discussed together, and are assumed to be similar to those associated with the Payara Development Project (for the planned activities shared with the Payara Development Project). The potential impacts from Other Non-EEPGL Projects are discussed separately.

In addition to the air quality modeling conducted for the cumulative emissions from the Liza Phase 1 and Liza Phase 2 Development Projects (see Section 10.6.1.1), quantitative analyses of cumulative effects were also conducted for potential water quality impacts resulting from simultaneous production operations discharges from the Liza Phase 1 and Liza Phase 2 FPSOs (see Section 10.6.2), and for potential traffic congestion impacts (an aspect of social infrastructure and services) resulting from simultaneous use of the shorebase by the Liza Phase 1, Liza Phase 2, and Payara projects, as well as continued exploration drilling (see Section 10.6.4).

10.6.1. Air Quality and Climate

10.6.1.1. *Air Quality*

Emissions generated by the Project generally emanate from two source categories: (1) specific point sources such as the power-generating units and diesel engines on drill ships and on the FPSO, flares used (non-routinely) to combust produced gas when not consumed as fuel gas on the FPSO or re-injected, and vents; and (2) general area sources such as support vessels, construction vessels, tug boats, and helicopters.

Air dispersion modeling was carried out to assess air quality impacts for onshore human receptors. Additionally, in the Air Quality Modeling Report (Appendix F), the cumulative impacts from the following EEPGL offshore activities (in addition to those from the Payara Project) were modeled:

- Exploration drilling through end of 2021;
- Liza Phase 1 Development Project (development well drilling, SURF/FPSO installation, and FPSO operation);
- Liza Phase 2 Development Project (development well drilling, SURF/FPSO installation, and FPSO operation);
- FPSO #4 (development well drilling, SURF/FPSO installation, and FPSO operation); and
- FPSO #5 (development well drilling, SURF/FPSO installation, and FPSO operation).

The model assessed for their combined impact on onshore air quality, and the resulting cumulative impact significance was found to be negligible. Specifically, for all modeled pollutants, the maximum onshore concentrations predicted to result from planned Project activities are less than 2 percent of the respective WHO ambient air quality guidelines (WHO 2005), and the maximum onshore concentrations predicted to result from the cumulative scenario, based on Payara plus the five above-referenced EEPGL activities, are no more than 5.4 percent of the WHO ambient air quality standard.

10.6.1.2. *Climate*

Considering the Project and the other offshore EEPGL exploration and development activities included in the scope of the CIA[3], the peak annual cumulative GHG emissions across the considered EEPGL activities are presented in Figure 10.6-1. The primary sources of GHG emissions are the combustion turbines and flares on the FPSOs, with smaller amounts from other fuel combustion sources. GHG emissions were calculated in three parts: the quantity of carbon dioxide (CO_2) in the fuel that is emitted directly as CO_2; products of combustion of various fuel components based on the potential for each component to contribute to GHG emissions; and the CO_2-equivalent (CO_2e) emissions of other emitted compounds such as methane and nitrous oxides. As noted in Section 6.1, Air Quality and Climate, emission factors from the AP-42 document were used to calculate combustion-related GHG emissions.

As shown in Figure 10.6-1, cumulative GHG emissions will increase through the drilling and installation stage of the Project, driven in 2020 and 2021 by production operations for the Liza Phase 1 Development Project and development drilling for the Payara Project and the Liza Phase 2 Development Project. GHG emissions increase in 2022 with the initiation of production operations for the Liza Phase 2 Development Project, and then again in 2023 with the initiation of production operations for the Payara Project. Cumulative GHG emissions peak in 2025, when the last of the five considered development projects passes through commissioning and all five projects are in the production operations stage, and then decrease steadily over the next 15 years from approximately 6,500 kilotonnes per year to approximately 5,900 kilotonnes per year, as predicted production levels gradually decrease for the five development projects. GHG emissions decrease more substantially as the Liza Phase 1 and Liza Phase 2 FPSOs reach their projected ends-of-life toward the end of the Payara Project production operations stage.

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[3] GHG emission estimates are not included for the FOC Project because the GHG emissions for this project are expected to be *de minimus* in comparison to production operations from development projects. GHG emissions estimates are not included for the Gas to Shore Project because the scope and timing of this project are still very preliminary, and the onshore location is undecided.

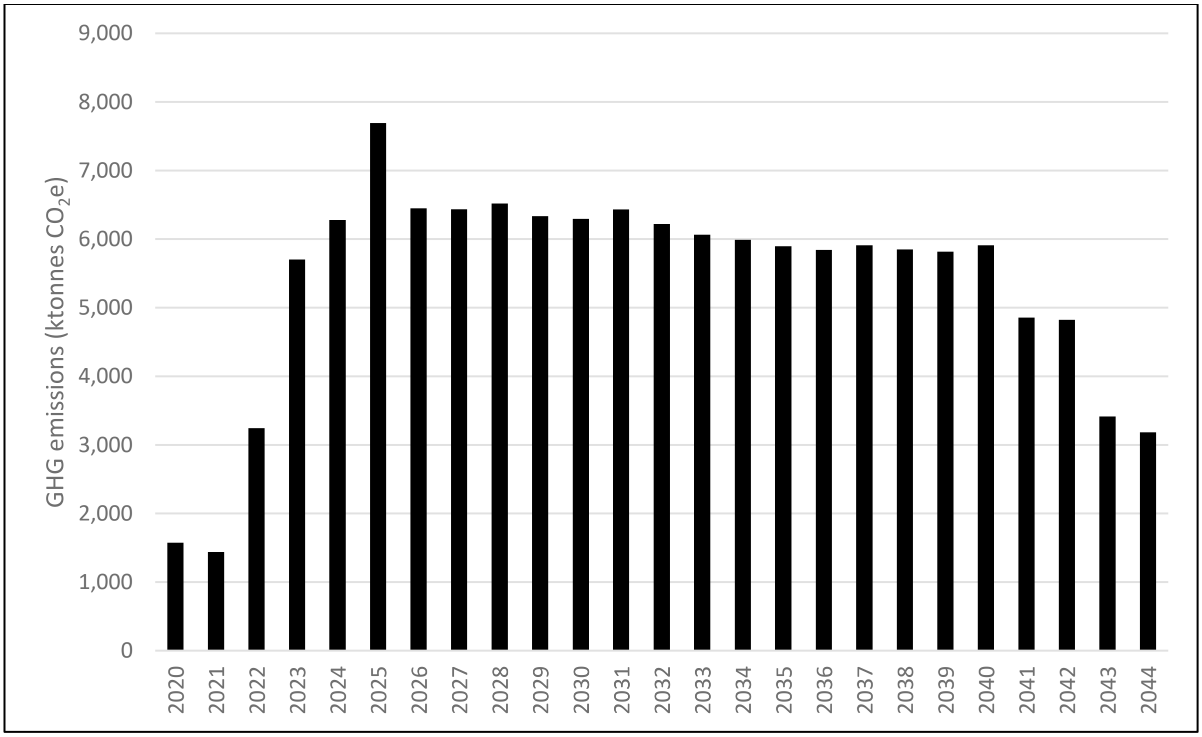

Figure 10.6-1: Summary of Estimated Peak Annual GHG Emissions—Cumulative EEPGL Exploration and Development Activities

As described in Section 6.1, Air Quality and Climate, Guyana's reported net annual removals were approximately 58 million tonnes of CO_2e in 2012, comprising total removals of approximately 60 million tonnes of CO_2e and total emissions of approximately 2 million tonnes of CO_2e. Considering these figures, although the cumulative GHG emissions from the projects considered above (i.e., exploration drilling through 2021 and five operating development projects by 2025) would represent a roughly three-fold increase in emissions at a country level, Guyana's net removals would decrease only slightly from 58 million tonnes of CO_2e per year to approximately 52 million tonnes of CO_2e per year (i.e., an approximately 10 to 11 percent decrease) during the period of the Payara Project life cycle when all five development projects are operating.

10.6.2. Water Quality Modeling for Simultaneous Operations

Although the Payara Project's FPSO will be approximately 20 kilometers (12.4 miles) away from the Liza Phase 1 Project FPSO and 22 kilometers (13.7 miles) away from the Liza Phase 2 Project FPSO, modeling was conducted to assess whether there is a potential for cumulative impacts on water quality due to simultaneous offshore discharges from the respective developments. The modeling included the major operational discharges and assessed the potential for plumes from the three FPSOs to overlap and result in cumulative impacts. None of the plumes constituents that were included in the assessment showed overlaps. The only constituent with a reference standard (less than 3 degrees Celsius (ºC) above ambient beyond 100 meters [328 feet]) is temperature rise. With all three of these FPSOs operating simultaneously, and each FPSO discharging both produced water and cooling water (both of which add a thermal load), there was no overlap in plumes, even when the "plume" from each FPSO was defined as a temperature rise as low as 0.05 ºC. Based on the results of the detailed modeling of all discharges, the significance of cumulative impacts on water quality from simultaneous operation of the Liza Phase 1, Liza Phase 2, and Payara FPSOs is considered negligible. Because the nominal locations for FPSO #4 and FPSO #5 are much further separated from these three FPSOs, the results of the modeling also demonstrate no cumulative impacts from simultaneous operations of these additional development projects. A detailed discussion of the methodology and results is presented in Appendix J, Water Quality Modeling Report.

10.6.3. Waste Management

This VEC was included in the CIA because the Project´s potential impact on waste management was determined to be of **Minor** significance (see Section 8.6, Waste Management Infrastructure Capacity). Considering the Project and the other offshore EEPGL exploration and development activities included in the scope of the CIA (i.e., exploration through 2021, Liza Phase 1, Liza Phase 2, Payara, FPSO #4, and FPSO #5)[4], the types and estimated quantities of wastes that will not be discharged to the sea after appropriate treatment are summarized below in Table 10.6-1.

Table 10.6-1: Summary of Estimated Annual Project Waste Generation and Management Methods—Cumulative EEPGL Exploration and Development Activities

Waste Generated by Category	Estimated Annual Waste Generation Volume (metric tonnes) [a]							
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026-2043**	**2044**
Non-Hazardous	3,000	2,985	3,750	4,680	4,665	4,645	2,450	1,590
Hazardous (total)	16,070	15,860	19,190	22,630	19,990	17,335	2,220	1,440
Totals by Management Method / Final Destination								
Landfill	1,820	1,810	2,240	2,830	3,095	3,125	2,580	1,050
Recycle [c] (if feasible) or Landfill	1,540	1,535	1,930	2,350	2,510	2,425	1,870	630
Solids Thermal Treatment at Approved Third-Party Facility / Landfill [d]	1,910	1,915	2,370	2,770	2,855	2,590	1,810	360
Liquids Wastewater Treatment / Thermal Treatment and/or Discharge Onshore at Approved Third-Party Facility	13,750	13,530	16,310	19,230	19,445	17,060	11,790	870
Special Waste / Send to Approved Facility	62	70	90	120	145	175	160	120

[a] The annual totals reflect the current preliminary schedules for the Project and other EEPGL exploration and development activities, which could change.
[c] Includes items recycled into offshore operations process
[d] After treatment of hazardous wastes onshore, the residual non-hazardous solid wastes that are not recycled, reclaimed, or reused will be transported for disposal in an approved landfill.

[4] Waste estimates are not included for the FOC Project because the volume of waste generation for this project is expected to be *de minimus* in comparison to offshore exploration and development activities. Waste estimates are not included for the Gas to Shore Project because the scope and timing of this project are still very preliminary, and the onshore location is undecided.

The **Minor** residual significance rating for the Project was driven by the Haags Bosch landfill operator's estimation that the capacity of the landfill's current operating cell will be exhausted by the end of 2019. The cumulative waste volumes estimated for landfill disposal for the activities included in the CIA scope peak at a level of approximately 8,500 tonnes per year. At this level, these activities would account for approximately 6 to 7 percent of the overall landfill demand (currently on the order of 128,000 to 146,000 tonnes per year). EEPGL is in discussions with Haags Bosch landfill management regarding the planned Cell 2 design, construction, and usage; landfill management indicates Cell 2 is planned to be operational prior to the end of 2019.

While assigned a **Negligible** residual significance for the Project, an EEPGL assessment of the currently available Georgetown-based hazardous waste treatment facilities concluded that, without modifications, the infrastructure capacity of the facility would likely be unable to treat the full volume of EEPGL's hazardous solids and waste oil liquids by late 2020. In the absence of other oil and gas/industrial operations exerting a significant demand on the existing Georgetown-based hazardous waste treatment facilities, it is assumed that EEPGL activities would represent a significant portion of the total demand for Georgetown-based hazardous waste treatment facilities. EEPGL has issued a Request for Information for additional hazardous waste management services to address volume capacity concerns with hazardous solids and waste oil liquids.

10.6.4. Traffic Impact Modeling for Simultaneous Operations

In March 2018, a survey of existing traffic conditions was completed along the East Bank Demerara Road, in the general vicinity of the existing shorebase facility that is planned to be used by the Project. Using the data from this survey, a traffic analysis model was used to complete an assessment of the Level of Service (LOS) for each of the study intersections, for the various movements (through, right turn, left turn, U-turn) completed at each intersection. LOS is a standard numerical measure of the delay expected to be experienced at an intersection, compared to expected norms; it is expressed as a letter grade between A (least delay) and F (most delay, gridlock). Modeling was completed for morning peak hours, afternoon peak hours and afternoon peak hours when the Demerara Harbour Bridge was closed.

In addition to modeling LOS ratings for existing conditions along the East Bank Demerara Road, the Caribbean Transportation Consultancy Services Company Limited (CARITRANS) traffic study (see Section 8.5.2.7, Ground Transportation Infrastructure) modeled LOS ratings for the following scenarios:

- Existing conditions under current road network, with the inclusion of additional Project traffic (a.m. peak, p.m. peak, and Bridge Closed);
- Conditions under current road network in 2023—with assumed non-Project traffic growth (a.m. peak, p.m. peak, and Bridge Closed);
- Conditions under current road network in 2023—with assumed non-Project traffic growth—with the inclusion of additional Project traffic (a.m. peak, p.m. peak, and Bridge Closed);

- Conditions with the proposed New Demerara Harbour Bridge and bypass lanes in 2023—with assumed non-Project traffic growth (a.m. peak, p.m. peak, Bridge Closed);
- Conditions with the proposed New Demerara Harbour Bridge and bypass lanes in 2023—with assumed non-Project traffic growth—with the inclusion of additional Project traffic (a.m. peak, p.m. peak, Bridge Closed);
- Existing conditions under current road network, with the inclusion of additional Project traffic from Liza Phase 1, Liza Phase 2, exploration drilling, and Payara ("the Cumulative Project traffic");
- Conditions under current road network in 2023—with assumed non-Project traffic growth, with the inclusion of additional Cumulative Project traffic (a.m. peak, p.m. peak, and Bridge Closed;
- Conditions with the proposed New Demerara Harbour Bridge and bypass lanes in 2023—with assumed non-Project traffic growth—with the inclusion of additional Cumulative Project traffic (a.m. peak, p.m. peak, Bridge Closed).

The LOS ratings are summarized in Appendix U, Traffic Impact Assessment.

The LOS modeling for the various projected scenarios confirms that the additional Project-related traffic scenarios, including the Cumulative Project traffic scenario, will not meaningfully change LOS ratings along the East Bank Demerara Road; therefore, it is expected that cumulative additions to traffic from the Other EEPGL Projects will not measurably change existing traffic congestion in Georgetown. This holds true for existing traffic conditions, either currently or in 2023, as well as the scenario that envisions construction of a new Demerara Harbour Bridge, which is itself expected to improve traffic congestion along the East Bank Demerara Road.

In 2019, CARITRANS conducted additional LOS modeling focused on road segments across Georgetown, in particular those anticipated to potentially be among the road segments more heavily used by EEPGL-related vehicle movements. The 2019 study modeled the anticipated cumulative EEPGL-related activities (i.e., those related to the Project, plus other non-Project EEPGL activities [inclusive of exploration drilling through 2021, Liza Phase 1, Liza Phase 2, Payara, FPSO #4, and FPSO #5]).

To provide a basis for CARITRANS to simulate EEPGL-related vehicle movements in the LOS modeling, the Consultants worked with EEPGL to develop projections of EEPGL-related vehicle movements for three simulation years: 2021 (during which Payara drilling activity prior to production operations will occur), 2023 (during which Payara production operations activity, with continued drilling activity will occur), and 2025 (during which Payara production operations activity, after completion of drilling activity will occur). The Consultants worked with EEPGL to develop estimates of the anticipated EEPGL fleet vehicle traffic for the selected modeling periods (2021, 2023, and 2025), and estimates of non-personnel EEPGL vehicle movements, over these same periods. This exercise showed that the estimated additional crossings of study intersections for 2023 and 2025 are very similar across the study intersections.

Accordingly, the Consultants and CARITRANS decided to conduct "with EEPGL activity" LOS modeling for the following scenarios:

- Conditions under the current road network in 2021—with assumed non-Project traffic growth—with the inclusion of additional EEPGL-related traffic (a.m. peak, p.m. peak); and
- Conditions under the current road network in 2023—with assumed non-Project traffic growth—with the inclusion of additional EEPGL-related traffic (a.m. peak, p.m. peak)

The full report containing the results of LOS modeling for these scenarios is included as Appendix U, Traffic Impact Assessment.

In summary, the LOS modeling for the various projected scenarios confirmed that the additional EEPGL-related vehicle trip counts in 2021 and 2023 (the latter of which is also considered to be conservatively representative of 2025) will not meaningfully change the base conditions (i.e., "without additional cumulative EEPGL vehicle movements") LOS ratings at any of the 2019 study intersections. On this basis, predicted cumulative impacts on ground transportation at the 2019 study intersections as a result of planned Project activities was determined to be negligible.

10.6.5. Summary of Cumulative Impact Assessment

Table 10.6-2 summarizes the CIA for the VECs identified as eligible for the CIA.

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Table 10.6-2: Summary of Cumulative Impact Assessment

VEC	Potential Impacts from Payara Development Project	Potential Impacts from EEPGL and Non-EEPGL Oil and Gas Exploration and EEPGL Development Projects [a]	Potential Impacts from Other EEPGL Projects		Potential Impacts from Other Projects		Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
			Gas to Shore Project	**FOC Project**	**Replacement of Demerara Harbour Bridge**	**Caribbean Mariculture**			
Air Quality and Climate	During all Project stages, the operation of drill ships and FPSO (power generation and engines), marine support and installation vessels, support aircraft, and temporary, non-routine flaring of gas when not re-injected, could cause the following key potential impacts: • **Air Quality**: Increased concentrations of pollutants in ambient air, potentially contributing to health impacts for onshore receptors (**Negligible**). • **Climate**: Increased GHG emissions, resulting in increases in Guyana´s national GHG emissions (**Moderate**).	Due to similarity in nature and magnitude, the offshore impacts from Other EEPGL Projects and other operators' exploration activities would be similar to those of the Payara Development Project (for activities that are similar to those of Payara): • **Air Quality**: During all project stages, the maximum predicted concentrations of the assessed pollutants at potential onshore receptor locations are **Negligible**. • **Climate**: Similar to the Payara Development Project, these Other Projects would generate GHG emissions, contributing to national GHG emissions.	**Power Plant** During the construction stage for the power plant, there would be a potential impact on air quality caused by emissions from diesel engine combustion from vehicles and heavy equipment. These effects would be temporary, with a peak at the height of construction activities. During the operation stage, gas-fired plant facilities would produce emissions of air pollutants. **Climate**: the Gas to Shore Project would generate GHG emissions during all project stages, further contributing to national GHG emissions.	During the construction stage, the operation of installation vessels, and other heavy equipment used to lay down the cables would be the main source of emissions. These activities are estimated to last a relatively short period of time (6 months approximately); therefore, no significant contributions of impacts on air quality and climate change are expected.	During the construction stage, earth movement activities and emissions from diesel engines from project vehicles and heavy equipment could potentially affect air quality in the area. During the operation stage, the key potential (indirect) impact could be decreased air quality, as the bridge would allow for higher volume of traffic, and consequently more vehicle emissions.	Based on the information available, the Consultants do not foresee impacts from the Mariculture Project on this VEC, or any impacts would be considered **Negligible**.	Air quality is not expected to be affected cumulatively by the external drivers identified for the purpose of this CIA. Global climate change contributions would be expected to contribute incrementally to those of the Project.	The Project, Other EEPGL Projects, other non-EEPGL oil and gas exploration, the Demerara Bridge Replacement Project, and the FOC Project would contribute to air quality impacts, but modeling indicates that—with the possible exception of the Gas to Shore Project, which has not yet been sited or designed, cumulative impacts would not result in significant onshore air quality impacts. The Project, Other EEPGL Projects, other non-EEPGL oil and gas exploration, the Demerara Bridge Replacement Project, and the global climate change external driver could contribute to the potential negative impact on climate change, measured in GHG emissions. The activities of the EEPGL Projects considered would result in cumulative GHG emissions causing a roughly three-fold increase of the overall emissions at a country level. Net removals would decrease only slightly from 58 million tonnes of CO_2e to approximately 52 million tonnes of CO_2e (i.e., an approximately 10 percent decrease). Actions should be implemented by EEPGL	**Low (Air Quality)** **Medium (Climate)**

VEC	Potential Impacts from Payara Development Project	Potential Impacts from EEPGL and Non-EEPGL Oil and Gas Exploration and EEPGL Development Projects [a]	Potential Impacts from Other EEPGL Projects		Potential Impacts from Other Projects		Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
			Gas to Shore Project	FOC Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture			
								to assess measures that can be taken to minimize GHG emissions during each of its projects and ensure that a Best Available Technology assessment process is undertaken	
Marine Water Quality	During all Project stages, key potential impacts caused by liquid effluent discharges from drill ships and marine support vessels could be changes in water quality and temperature, potentially contributing to health impacts on or avoidance of marine life (**Negligible**). During drilling/installation and decommissioning, key potential impacts caused by discharge of drill cuttings could be increased TSS concentrations in water column, potentially contributing to health impacts on marine life (**Minor**). During production operations, key potential impacts could include elevated temperature from cooling water discharge, and changes in water quality from routine effluent discharges (**Negligible**).	Due to similarity in nature and magnitude, the offshore impacts from Other EEPGL Projects, and other exploration activity, would be similar to those of the Payara Development Project (for planned activities shared with Payara): • During all Project stages, key potential impacts caused by liquid effluent discharges from drill ships and marine support vessels could be changes in water quality and temperature, potentially contributing to health impacts on or avoidance of marine life (**Negligible**). • During drilling and installation, key potential impacts caused by discharge of drill cuttings could be increased TSS concentrations in water column, potentially contributing to health impacts on marine fauna (**Minor**). • During production operations for development projects, key potential impacts could include elevated temperature from cooling water discharge, and changes in water quality from routine effluent discharges (**Negligible**).	**Power Plant** During operation, elevated temperature due to once-through cooling systems that use large quantities of water which are then discharged back to receiving surface water with elevated temperature. **Pipeline** During construction, changes to water quality as a result of permitted discharges from pipeline construction-related vessels. During operation, discharge of hydrotest waters could affect marine water quality. Hydrostatic testing of marine pipelines involves pressure testing with water to verify equipment and pipeline integrity. Chemical additives (corrosion inhibitors, oxygen scavengers, biocides, and dyes) may be added to the water to prevent internal corrosion or to identify leaks.	During cable laying, potential sources of impacts on marine water quality include treated wastewater and macerated food discharges from the installation vessels (similar to those considered for the development projects). Key potential impacts include: • Temporary increases in suspended solids concentration during periods where trenching or jetting are used to bury the fiber optic cable. • Conditions in the water column are expected to return to pre-disturbance conditions shortly after cessation of the activity.	Based on the information available, the Consultants do not foresee impacts from the project on this VEC, or they would be considered **Negligible**.	The main adverse potential impact in aquaculture are associated with the discharge of effluents, containing fish waste products, from farms into the environment, and potentially result in eutrophication. Due to the activities associated with the proposed culture of a significant biomass of fish, there could be changes in the baseline water parameters around the culture site. It is likely that in the immediate vicinity of the grow-out or culture area there be an increase of certain compounds, such as ammonia and nitrates, resulting from protein metabolism by the cultured species.	After severe flooding events, rivers might carry debris from inland areas, including agricultural fields, which could temporarily affect marine water quality in coastal areas.	The Project, Other EEPGL Projects, the Mariculture Project, and external drivers could contribute to the potential negative impacts on this VEC, including changes in water quality. However, the suite of embedded controls related to water quality management included in the Project's design, would appropriately mitigate the negative impacts and contribution. The Project is not expected to have an incremental contribution to the adverse effect. Therefore, no additional actions from EEPGL are required to mitigate potential adverse cumulative impacts on the VEC beyond Project mitigation measures, if any.	**Low**
Protected Areas and Special Status Species[5]	As discussed in more detail in the resource-specific impact assessment sections for marine fish (Section 7.8) and seabirds (Section 7.4), planned Project activities could result in a number of potential impacts, including: auditory impacts from vessel activity or pile driving, distribution and habitat changes from altered bottom habitats or water quality,	Due to similarity in nature and magnitude, similar impacts to those from other EEPGL Projects, and other exploration activity, would be similar to those of the Payara Development Project (for planned activities shared with Payara): • Offshore marine fish—EN (**Negligible** to **Moderate**), VU (**Negligible** to **Minor**), NT (**Negligible** to **Minor**).	**Power Plant** During construction, activities such as vegetation removal and earth movement may result in distribution and habitat changes for terrestrial fauna, death of fauna from collision with vehicles and elimination of terrestrial flora within the project´s layout including access roads and laydown area.	Based on the information available, the Consultants do not foresee impacts from the FOC Project on this VEC, or they would be considered **Negligible**.	Based on the information available, the Consultants do not foresee impacts from the New Demerara Harbour Bridge Project on this VEC, or they would be considered **Negligible**.	Based on the information available, the Consultants foresee potential impacts from the Mariculture Project on special status marine fish. This is in consideration of a potential impact related to the predation	The large-scale commercial trawl fishery mainly targets seabob, yet unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by	The Project and Other EEPGL Projects could have potential negative impacts on marine fish and seabird special status species. The Project embedded controls would mitigate its potential impacts to the extent reasonably practicable. External drivers such as	**Low**

[5] Excludes listed marine mammals and marine turtles, which are covered in the Marine Mammals and Marine Turtles resource categories

VEC	Potential Impacts from Payara Development Project	Potential Impacts from EEPGL and Non-EEPGL Oil and Gas Exploration and EEPGL Development Projects [a]	Potential Impacts from Other EEPGL Projects		Potential Impacts from Other Projects		Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
			Gas to Shore Project	FOC Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture			
	exposure to permitted discharges, entrainment in water intakes; and the attractive potential of lighting from the FPSO, drill ships, and major installation vessels. Based on the ranges of magnitudes for potential impacts and the receptor sensitivity ratings applicable for the various IUCN listing levels, the significance ratings for potential residual impacts on special status species are: • Offshore marine fish—EN (**Negligible** to **Moderate**), VU (**Negligible** to **Minor**), and NT (**Negligible** to **Minor**). • Coastal marine fish—CR (**Negligible**), EN (**Negligible**), VU (**Negligible**), NT (**Negligible**). • Seabirds—EN (**Negligible** to **Minor**), VU (**Negligible** to **Minor**), and NT (**Negligible** to **Minor**).	• Coastal marine fish—CR (**Negligible**), EN (**Negligible**), VU (**Negligible**), NT (**Negligible**). • Seabirds—EN (**Negligible** to **Minor**), VU (**Negligible** to **Minor**), and NT (**Negligible** to **Minor**).	During the operation stage, the once-through cooling system could cause the following potential impacts: • Elevated marine surface water temperature, may affect aquatic organisms within the affected area, including phytoplankton, zooplankton, fish, crustaceans, shellfish, and other forms of aquatic life. • Aquatic organisms drawn into cooling water intake structures can be impinged or entrained.			of fingerlings of various species of wild fish, as they can enter the cages, which are used as growing structures in mariculture. Once in the cages, it is likely that these fingerlings will be subject to predation. Four of the five species that would be grown are predaceous, and one is omnivorous.	catching juvenile fish and turtles, damaging the seafloor, and leading to overfishing. Bottom trawl nets can also harm coral reefs, sharks, and marine turtles. Rising temperatures associated with longer-term global climate change could potentially affect some special status species' ranges.	commercial trawl fishing and longer-term global climate change could also potentially negatively affect this VEC. However, it is not expected that the Project would have an incremental contribution to the negative effects. Therefore, no additional actions from EEPGL are required to mitigate potential adverse cumulative impacts on the VEC beyond the proposed Project embedded controls and mitigation measures.	
Marine Mammals	During all Project stages, key potential impacts on marine mammals are exposure to permitted discharges, potentially leading to toxicological or metabolic impacts (**Negligible**); and underwater sound disturbance from exposure to Project-induced non-impulsive underwater sound (**Negligible** to **Minor**). During drilling and installation, the key potential impacts are auditory injury from sound exposure (**Negligible**); and underwater sound disturbance from exposure to impulsive sound activities (**Moderate**). A potential **Positive** impact comes from offshore lighting; it is considered to be an attractant for fishes, and therefore as a secondary	Due to similarity in nature and magnitude, the offshore impacts from Other EEPGL Projects, and other exploration activity, would be similar to those of the Payara Development Project (for planned activities shared with Payara): • During all Project stages, key potential impacts on marine mammals are exposure to permitted discharges, potentially leading to toxicological or metabolic impacts (**Negligible**); and underwater sound disturbance from exposure to non-impulsive sound activities (**Negligible** to **Minor**). • During drilling and installation, the key potential impacts are injury from sound exposure (**Negligible**); and underwater sound disturbance from exposure to impulsive sound activities (**Moderate**). • A potential **Positive** impact comes from offshore lighting; it is	**Pipeline** During construction, marine mammal species may be affected by Project-related vessel traffic, and pipeline installation activities. The potential impacts would be underwater sound disturbance, toxicological and metabolic impacts from exposure to permitted discharges, and vessel strikes (unplanned). The impacts from this project would be expected to decrease to negligible levels during the operation stage.	During cable laying, potential sources of impacts on marine mammals include project-related vessel operations for trenching and undersea cable laying. Potential impacts could include: • Behavioral changes or displacement. • Potential vessel strikes. Cable laying activities are expected to a short-term duration (approximately six months); therefore, the potential impacts would be temporary.	Based on the information available, the Consultants do not foresee impacts from the Harbour Bridge Replacement Project on this VEC, or they would be considered **Negligible**.	Based on the information available, the Consultants do not foresee impacts from the Mariculture Project on this VEC, or they would be considered **Negligible**.	Rising temperatures (including sea temperatures) associated with longer-term global climate change could potentially affect some fish species distribution and, in consequence, alter the distribution of marine mammals that prey on them.	Balancing the conservation status of the more abundant marine mammal species that are known to be present in the Project AOI with that of the rarer species that could be present, the risk of a vessel collision with a marine mammal is considered to be **Moderate**. This is an expected risk from the Project as well as Other EEPGL Projects, which will also entail marine vessel movements within the Stabroek Block; therefore, the Project could incrementally contribute to adverse cumulative impacts from potential vessel strikes. Actions should be	**Medium**

VEC	Potential Impacts from Payara Development Project	Potential Impacts from EEPGL and Non-EEPGL Oil and Gas Exploration and EEPGL Development Projects [a]	Potential Impacts from Other EEPGL Projects		Potential Impacts from Other Projects		Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
			Gas to Shore Project	**FOC Project**	**Replacement of Demerara Harbour Bridge**	**Caribbean Mariculture**			
	attractant for some marine mammals. Vessel strikes (an unplanned event) are assessed as a risk (**Moderate**) to marine mammals.	considered to be an attractant for fishes, and therefore as a secondary attractant for some marine mammals. Vessel strikes (an unplanned event) are assessed as a risk (**Moderate**) to marine mammals. As additional EEPGL projects are undertaken, the amount of vessel traffic–and therefore the risk of vessel strikes–will increase.						implemented by EEPGL in the medium term to mitigate potential adverse cumulative impacts on the VEC.	
Riverine Mammals	During all Project stages, the operation of onshore infrastructure, and Project-related vessel operations, could cause the following key potential impacts on riverine mammals: • Behavioral changes or displacement as a result of increased vessel traffic within Georgetown Harbour (**Minor**). • Vessel strikes (an unplanned event) (Minor).	The potential impact on riverine mammals has not been assessed for the Other EEPGL Projects. However, due to similarity in nature and magnitude, the potential impacts from Other EEPGL Projects would be similar to those of the Payara Development Project (for planned activities shared with Payara). Therefore, these projects could also cause behavioral changes or displacement of riverine mammals as a result of increased vessel traffic within Georgetown Harbour, as well as contributing to risk of vessel strikes as a result of increased vessel traffic.	**Power Plant and Pipeline** During construction, riverine mammal species that occur in coastal waters may be affected by Project-related activities such as vessel traffic, earth movement, and pipeline installation. The potential impact would be behavioral changes or displacement from the area. The impacts from this project would be expected to decrease to negligible levels during the operation stage.	During cable laying, potential sources of impacts on riverine mammals include project-related vessel operations and trenching for undersea cable laying. Potential impacts could include: • Behavioral changes or displacement. • Potential vessel strikes. Cable laying activities are expected to a short-term duration (approximately 6 months); therefore, the potential impacts would be temporary.	According to the feasibility study, during construction, there could be damage or modification to mangroves in the east and west bank of the Demerara River. Based on the information available, the Consultants estimate that the West Indian Manatee (*Trichechus manatus*) (VU) could potentially be negatively impacted by bridge construction activities in or near the Demerara River; however, the level of significance of the potential impact cannot be assessed without further information on the nature of the planned project development.	During construction, there could be conversion of natural habitats (e.g., removal of mangroves), that would potentially affect riverine mammal species that occur in these habitats by causing changes in behavior or displacement. During operation, the main negative environmental effects are associated with discharge of effluent, containing fish waste products, from farms into the environment, and potentially result in water eutrophication, which in turn could cause potential impacts on riverine mammal species that occur in the affected areas.	Rising temperatures (including sea temperatures) associated with longer-term global climate change could potentially affect the distribution of riverine mammals. Marine fisheries and subsistence fishing occur throughout Guyana's coastal waters, and their vessels and fishing activities could potentially further displace riverine mammals species that occur in the brackish/intertidal waters of the Demerara Harbour	Riverine mammals likely to occur within the nearshore and riverine zone of the PDA are vulnerable to vessel collision and negative effects from disturbance of their habitats, such as changes in behavior and displacement. Of the five riverine mammal species known to occur in Guyana, only the West Indian manatee and river otter are known to occur in in the brackish/ intertidal waters of the Demerara Harbour and the lower Demerara River where the cumulative effects of Project-related vessel traffic would occur. While the Project could contribute incrementally to increased risk of vessel strikes, the level of habituation of manatees in Georgetown Harbour reduces the level of overall risk. No additional actions are required from EEPGL to mitigate potential adverse cumulative impacts on this VEC beyond the currently proposed Project embedded controls and mitigation measures.	**Low**

VEC	Potential Impacts from Payara Development Project	Potential Impacts from EEPGL and Non-EEPGL Oil and Gas Exploration and EEPGL Development Projects [a]	Potential Impacts from Other EEPGL Projects		Potential Impacts from Other Projects		Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
			Gas to Shore Project	FOC Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture			
Marine Turtles	During all Project stages, the key potential impacts on marine turtles are: impact on nesting turtles and immediate post-dispersal hatchlings from nearshore and coastal artificial lighting (**Negligible**); disturbance to turtles in the offshore environment from artificial lighting (**Negligible**); displacement from habitat to avoid disturbance from vessel activity (**Negligible**); acoustic injury from sound exposure (**Negligible**); exposures to permitted discharges, potentially leading to toxicological or metabolic impacts (**Negligible**); and habitat displacement as a result of avoidance behavior (**Negligible**). Vessel strikes (an unplanned event) are assessed as a risk (**Moderate**) to marine turtles.	Due to similarity in nature and magnitude, the offshore and nearshore impacts of Other EEPGL Projects, and other exploration activity, would be similar to those of the Payara Development Project (for planned activities shared with Payara): • During all Project stages, the key potential impacts on marine turtles are: impact on nesting turtles and immediate post-dispersal hatchlings from nearshore and coastal artificial lighting (**Negligible**); disturbance to turtles in the offshore environment from artificial lighting (**Negligible**); displacement from habitat to avoid disturbance from vessel activity (**Negligible**); acoustic injury from sound exposure (**Negligible**); exposures to permitted discharges, potentially leading to toxicological or metabolic impacts (**Negligible**); and habitat displacement as a result of avoidance behavior (**Negligible**).Vessel strikes (an unplanned event) are assessed as a risk (**Moderate**) to marine turtles. As additional EEPGL projects are undertaken, the amount of vessel traffic–and therefore the risk of vessel strikes–will increase.	**Power Plant** During the operation stage, the once-through cooling system could cause the following potential impacts: • Aquatic organisms drawn into cooling water intake structures can be impinged or entrained.	During construction, fiber optic cable installation activities could have potential impacts on marine turtles: • Auditory impacts—cable laying will not involve any activities that produce a level of sound equivalent to that of a VSP operation; accordingly, auditory impacts on marine turtles are expected to be Negligible. • Vessel strikes (unplanned)—cable laying activities for the FOC project will involve a relatively low number of vessel movements, and the limited number of marine turtles expected to be passing through the work area, as demonstrated by recent telemetry data, indicates that a collision with a marine turtle is unlikely.	Based on the information available, the Consultants do not foresee impacts from the New Demerara Harbour Bridge Project on this VEC, or they would be considered **Negligible**.	Based on the information available, the Consultants do not foresee impacts from the Mariculture Project on this VEC, or they would be considered **Negligible**.	The large-scale commercial trawl fishery mainly targets seabob, yet unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish and turtles, damaging the seafloor, and leading to overfishing. Bottom trawl nets can also harm coral reefs, sharks, and marine turtles.	All five species of marine turtles found in the region have IUCN Red List categories ranging from VU to CR. The Project and the other projects are expected to have negligible adverse impacts on marine turtles. Commercial trawl fisheries could cause harm to these species. However, it is not expected that the Project would have an incremental contribution to the negative effect due to the negligible significance of its impacts. No additional actions from EEPGL are required to mitigate potential adverse cumulative impacts on this VEC beyond the currently proposed Project embedded controls and mitigation measures.	**Low**
Marine Fish	During all Project stages, the key potential impacts are auditory impacts on fish (pelagic species) from vessel activity (**Negligible**); disturbance from or attraction to offshore lighting that would affect pelagic species (**Negligible**). During drilling and installation, the key potential impacts are auditory impacts on demersal species from pile driving and VSP **(Negligible);** exposure to permitted discharges, potentially leading to toxicological impacts (**Negligible**); and distribution impacts on offshore demersal fish from altered water quality (**Minor**).	Due to similarity in nature and magnitude, the offshore impacts from Other EEPGL Projects, and other exploration activity, would be similar to those of the Payara Development Project (for planned activities shared with Payara): • During all Project stages, the key potential impacts are auditory impacts on fish (pelagic species) from vessel activity **(Negligible)**; disturbance from or attraction to offshore lighting that would affect pelagic species **(Negligible**). • During drilling and installation, the key potential impacts are auditory disturbance on demersal species from pile driving and VSP **(Negligible);** exposure to permitted discharges,	**Power Plant** During the operation stage, the once-through cooling system could cause the following potential impacts: • Elevated marine surface water temperature, may affect aquatic organisms within the affected area, including phytoplankton, zooplankton, fish, crustaceans, shellfish, and other forms of aquatic life. • Aquatic organisms drawn into cooling water intake structures can be impinged or entrained.	During cable laying, the key potential impact on marine fish would come from temporary habitat alteration potentially caused by discharges of treated wastewater and macerated food from the installation vessels (similar to that considered for the development projects) could affect water quality and therefore, and temporary increases in suspended solids concentration during periods where trenching or jetting are used to bury the fiber optic cable. These changes in fish habitat may result in	Based on the information available, the Consultants do not foresee impacts from the New Demerara Harbour Bridge Project on this VEC, or they would be considered **Negligible**.	A potential adverse impact is the predation of fingerlings of various species of wild fish, as they can enter the cages, which are used as growing structures for the fish. Once in the cages, it is likely that these fingerlings will be subject to predation. Four of the five species that would be grown are predaceous, and one is omnivorous. Other potential adverse impacts on	The large-scale commercial trawl fishery mainly targets seabob, yet unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish and turtles, damaging the seafloor, and leading to overfishing. Bottom trawl nets can also harm coral reefs,	The Project and other projects could have potential negative impacts on marine fish species. The Project embedded controls would mitigate their impacts to an acceptable level. External drivers such as commercial trawl fishing and longer-term global climate change would also potentially negatively affect this VEC. However, it is not expected that the Project would have an incremental contribution to the negative effects. Therefore, no additional	**Low**

VEC	Potential Impacts from Payara Development Project	Potential Impacts from EEPGL and Non-EEPGL Oil and Gas Exploration and EEPGL Development Projects [a]	Potential Impacts from Other EEPGL Projects		Potential Impacts from Other Projects		Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
			Gas to Shore Project	FOC Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture			
	During production operations, the key potential impacts are pelagic species entrainment via water withdrawals (**Negligible**); pelagic species attraction to artificial light (Negligible); and distribution changes due to altered water quality for pelagic species (**Negligible**).	potentially leading to toxicological or metabolic impacts **(Negligible)**; and distribution impacts on offshore demersal fish from altered water quality **(Minor)**. • During production operations, the key potential impacts (**Negative**) are pelagic species entrainment via water withdrawals **(Negligible**); pelagic species attraction to artificial light (**Negligible**); and distribution changes due to altered water quality for pelagic species (**Negligible**).		marine fish avoidance of the altered areas. Conditions in the water column are expected to return to pre-disturbance conditions shortly after cessation of the activity.		marine fish identified for this industry are: • Potential release of artificially propagated seed into the wild; and • Risk of developing antibiotic resistance in pathogenic bacteria that could then spread from farms to wild stock.	sharks, and marine turtles. Rising temperatures associated with longer-term global climate change could potentially affect some marine fish species distribution ranges.	actions from EEPGL are required to mitigate potential adverse cumulative impacts on the VEC beyond Project mitigation measures, if any.	
Marine Benthos	During the construction stage, the key impacts are: • Smothering from deposition, filter fouling from elevated TSS concentrations caused by activities related to development well drilling (**Minor**). • Injury or disturbance by SURF/FPSO installation (**Negligible**). During the operation phase the key potential impact would be the creation of artificial substrate (**Positive**).	Due to similarity in nature and magnitude, the offshore and nearshore impacts for Other EEPGL Projects, and other exploration activity, would be similar to those of the Payara Development Project (for planned activities shared with Payara): • Smothering from deposition, filter fouling from elevated TSS concentrations caused by activities related to development well drilling (**Minor**). • Injury or disturbance by SURF/FPSO installation (**Negligible**). During the operation phase the key potential impact would be the creation of artificial substrate (**Positive**).	**Power Plant** During the operation stage, the once-through cooling system could cause the following potential impacts: • Elevated marine surface water temperature may affect nearshore benthic organisms. • Aquatic organisms drawn into cooling water intake structures can be impinged or entrained. **Pipeline** During the construction stage, it is estimated that potential impacts from offshore pipeline development would be similar to those associated with subsea infrastructure components of the Liza Phase 1, Liza Phase 2, Payara, and other FPSO Development Projects. However, the area of marine substrate that would be disturbed is different and would cover a larger area since it would be linear: • Smothering from deposition, filter fouling from elevated TSS concentrations, and injury or disturbance caused by excavation activities related.	During cable laying, potential sources of impacts on marine benthos include trenching for undersea cable laying. Potential impacts could include: • Smothering from deposition, filter fouling from elevated TSS concentrations. • Injury or disturbance. Cable laying activities are expected to last a period of approximately 6 months; therefore, the potential impacts would be temporary.	During construction, there could be damage or modification to mangroves, which provide benthic habitat. The mangroves that could be affected are those in the east and west banks of the Demerara River. According to the feasibility study, mangroves on the east bank are already impacted by anthropogenic activities, and are smaller than the mangrove fringe on the west bank.	During construction the main potential impact that could negatively affect marine benthos is the conversion of natural habitats (e.g., removal of mangroves, alteration of natural hydrology of lagoons). During the operation stage, the main negative environmental effects are associated with discharge of effluent, containing fish waste products, from farms into the environment, and potentially result in water eutrophication. Discharge from the hatchery and shore base components of the projects would be the only ones potentially having a negative effect on marine benthos given their location in shallow coastal waters.	The large-scale commercial trawl fishery mainly targets seabob, yet unselective fishing gear such as bottom trawls can cause harm on marine benthos by damaging the seafloor. Bottom trawl nets can also harm coral reefs, which may result in a shift of benthic communities.	The Project, Other EEPGL and non-EEPGL Projects, and external drivers would contribute to the potential negative impacts on this VEC. However, the embedded controls for the activities that could cause these effects would appropriately mitigate the adverse impacts. The Project is not expected to have an incremental contribution to the adverse effect. Therefore, no additional actions from EEPGL are required to mitigate potential adverse cumulative impacts on the VEC beyond Project mitigation measures, if any.	**Low**

VEC	Potential Impacts from Payara Development Project	Potential Impacts from EEPGL and Non-EEPGL Oil and Gas Exploration and EEPGL Development Projects [a]	Potential Impacts from Other EEPGL Projects		Potential Impacts from Other Projects		Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
			Gas to Shore Project	FOC Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture			
Ecological Balance and Ecosystems	During all Project stages, the key potential impacts are changes in the marine nutrient cycle, resulting in localized and temporary changes in phytoplankton species distribution (**Negligible**); and impacts on gene flow (**Negligible**). During production operations, the key potential impact is introduction of invasive species via ballast water (**Minor**).	Due to similarity in nature and magnitude, the offshore and nearshore impacts from Other EEPGL Projects, and other exploration projects, would be similar to those of the Payara Development Project (for planned activities shared with Payara): • During all Project stages, the key potential impacts are changes in marine nutrient cycle, resulting in localized and temporary changes in phytoplankton species distribution (**Negligible**); and impacts on gene flow (**Negligible**). • During production operations, the key potential impact is introduction of invasive species via ballast water (**Minor**).	**Power Plant** During construction, activities such as vegetation removal and earth movement may result in distribution and habitat changes for terrestrial fauna, death of fauna from collision with vehicles and elimination of terrestrial flora within the project´s layout including access roads and laydown area. During the operation stage, elevated temperature due to once-through cooling systems that use large quantities of water which are then discharged back to receiving surface water with elevated temperature, which may affect aquatic organisms, including phytoplankton, zooplankton, fish, crustaceans, shellfish, and many other forms of aquatic life. **Pipeline** It is estimated that potential impacts from offshore pipeline development would be similar to those associated with subsea infrastructure components of the Payara and other FPSO Development Projects. Based on the information available, the Consultants do not foresee impacts from the pipeline component of the Gas to Shore Project on this VEC, or they would be considered **Negligible**.	Based on the information available, and the short-term duration of any adverse effects that could potentially be caused by fiber optic cable laying, the Consultants do not foresee impacts from the project on this VEC, or they would be considered **Negligible**.	Based on the information available, the Consultants do not foresee impacts from the project on this VEC, or they would be considered **Negligible**.	Based on the information available, the Consultants anticipate localized changes in the marine nutrient cycle, and foresee the possibility of genetic changes over time in native species depending on the source of fingerlings and rates of escape from the facility, as well as introduction of non-native species. However, the Consultants predict the size of the North Brazil Large Marine Ecosystem, the strong currents in the vicinity, and the assimilative capacity of the ocean will prevent impacts from the Mariculture Project on this VEC from exceeding **Negligible**.	Unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish or turtles, and damaging the seafloor. These impacts would have a negative effect on the ecological balance of the coastal-marine ecosystem. Longer-term global climate change driven increases in the global mean temperatures could have a significant impact on ecosystems and ecological balance. Some ecosystems may become more vulnerable to invasive species.	The Project, Other EEPGL Projects, and external drivers would contribute to the potential negative impacts on this VEC: changes in nutrient cycle, gene flow, and introduction of invasive species. However, the mitigation measures proposed would appropriately mitigate the adverse impacts. The Project is not expected to have an incremental contribution to the adverse effect. Therefore, no additional actions from EEPGL are required to mitigate potential adverse cumulative impacts on the VEC beyond Project mitigation measures, if any.	**Low**
Employment/ Livelihoods	During all Project stages, a potential impact (**Positive**) is related to increased employment, local business activity, and household income for the population of Georgetown and vicinity. During all Project stages, key potential adverse impacts on fishing livelihoods (marine safety exclusion zones within the PDA for	Due to similarity in nature and magnitude, the offshore and nearshore impacts from Other EEPGL Projects, and other exploration activities, would be similar to those of the Payara Development Project (for planned activities shared with Payara): • During all Project stages, a potential impact (**Positive**) is related to increased employment, local business activity, and household	The effects on this VEC are expected to be similar to those generated by the Payara Development Project and other exploration activities: **Power Plant** During all Project stages, a potential impact (**Positive**) is related to increased employment, local business activity, and household income for the	During fiber optic cable laying, which requires vessel activity, key potential adverse impacts on fishing livelihoods are expected to be similar to those generated by the Payara Development Project and other exploration activities: marine safety exclusion zones; nearshore navigation and safety.	Some potential adverse impacts from the construction of the new bridge could be resettlement of some houses and potential impacts on commercial businesses adjacent to the bridge.	Based on the information available, the Consultants do not foresee impacts from the Mariculture Project on this VEC, or they would be considered **Negligible**.	The fishing industry is one of the most important direct and indirect economic drivers in Guyana, yet unselective fishing gear such as bottom trawls can cause harm to other fisheries.	The Project, Other EEPGL Projects, and external drivers would contribute to the potential negative impacts on this VEC: impacts on fishing livelihoods. The most vulnerable to these effects would be the artisanal fisherfolk. However, the embedded controls in the Project's design would	**Low**

VEC	Potential Impacts from Payara Development Project	Potential Impacts from EEPGL and Non-EEPGL Oil and Gas Exploration and EEPGL Development Projects [a]	Potential Impacts from Other EEPGL Projects		Potential Impacts from Other Projects		Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
			Gas to Shore Project	FOC Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture			
	commercial fishing operations; nearshore navigation and safety for subsistence fishing operations) are identified for industrial fisherfolk (**Negligible**); and artisanal fisherfolk (**Minor**).	income for the population of Georgetown and vicinity. • During all Project stages, key potential adverse impacts on fishing livelihoods (marine safety exclusion zones within the PDA for commercial fishing operations; nearshore navigation and safety for subsistence fishing operations) are identified for industrial fisherfolk (**Negligible**); and artisanal fisherfolk (Minor).	population of Georgetown and vicinity. **Pipeline** Depending on location of the project, during all Project stages, key potential adverse impacts on fishing livelihoods (construction or operational exclusion zones for commercial and artisanal fishing operations; nearshore navigation and safety for subsistence fishing operations) would be expected.	Given the short-term duration of the construction stage for this project, the Consultants do not foresee significant impacts on this VEC.			Changes in rainfall patterns and a predicted sea-level rise associated with longer term global climate change pose threats to the Guyanese population and its livelihoods during the Project life cycle (at least 20 years). In the recent past, floods have produced negative and significant health impacts, direct economic losses for agriculture, livestock, fisheries, and forestry industries, and significant damage to roads and other infrastructure. Longer-term global climate change driven increases in the global mean temperatures could have a significant impact on the coastal plain and on activities including the dominant agriculture sector in Guyana.	appropriately mitigate the negative impacts. The Project is not expected to have an incremental contribution to the adverse effect. Therefore, no additional actions from EEPGL are required to mitigate potential adverse cumulative impacts on the VEC beyond Project mitigation measures, if any.	

VEC	Potential Impacts from Payara Development Project	Potential Impacts from EEPGL and Non-EEPGL Oil and Gas Exploration and EEPGL Development Projects [a]	Potential Impacts from Other EEPGL Projects		Potential Impacts from Other Projects		Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
			Gas to Shore Project	FOC Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture			
Community Health and Wellbeing	During all Project stages, there will be increased worker presence and Project use of medical and health resources in the Georgetown area. Therefore, the key potential impacts could be increased risk of communicable disease transmission (**Negligible**); impacts on public safety (**Negligible**); public anxiety over oil and gas sector risks (**Minor**); and reduced access to emergency and health services (**Minor**). Vehicular traffic accidents and marine vessel collisions involving Project vehicles/vessels and non-Project vehicles/vessels (unplanned events), resulting in potential injuries, are assessed as a risk (**Minor** to **Moderate**, depending on severity of the incident) to community health and wellbeing.	Due to similarity in nature and magnitude, the impacts from Other EEPGL Projects, and other exploration activity, would be similar to those of the Payara Development Project (for planned activities shared with Payara): • During all Project stages, there will be increased worker presence and increased Project use of medical and health resources in the Georgetown area. Therefore, the key potential impacts could be increased risk of communicable disease transmission (**Negligible**); impacts on public safety (**Negligible**); public anxiety over oil and gas sector risks (**Minor**); and overburdening of medical and health services (**Minor**). • Vehicular traffic accidents and marine vessel collisions involving Project vehicles/vessels and non-Project vehicles/vessels (unplanned events), resulting in potential injuries, are assessed as a risk (**Minor** to **Moderate**, depending on severity of the incident) to community health and wellbeing. As additional EEPGL projects are undertaken, the amount of vessel traffic–and therefore the risk of vessel collisions–will increase. Additional EEPGL projects will also result in additional onshore vehicular traffic in/out of the shorebase facility; however, traffic impact modeling indicates a **Negligible** impact, even considering predicted cumulative EEPGL activities in Georgetown.	The effects on this VEC are expected to be similar to those generated by the Payara Development Project and other exploration activities. **Power Plant** During all project stages, potential negative impacts that could affect community health and wellbeing are: • Increased noise due to cleaning, earth movement, general construction activities, and construction-related traffic. • Noise and vibration generated by turbine generators; boilers; fans and ductwork; pumps; compressors; condensers; precipitators; piping and valves; motors; transformers; circuit breakers; and cooling towers. • Generation of low frequency noise (between 10 Hz to 200 Hz), which has been identified as a nuisance with potential health effects for the residents living near the source. • Vehicular traffic accidents and marine vessel collisions involving Project vehicles/vessels and non-Project vehicles/vessels (unplanned events),	Based on the information available, and the short-term duration of any adverse effects that could potentially be caused by fiber optic cable laying, the Consultants do not foresee impacts from the project on this VEC, or they would be considered **Negligible**.	As a result of the project, the feasibility study predicts some level of traffic growth, which would affect environmental components such as noise, air quality, public safety, nuisance, and health. To mitigate potential traffic-related impacts, the study suggests construction of bypasses on the west and east sides of the bridge. The feasibility study concludes that the overall social impact of the Project will be positive, especially if links and bypasses are constructed simultaneously with bridge construction. Shorter traffic time and economic development would benefit the communities.	A key negative potential impact would be noise pollution from the operation of diesel generators. These generators are expected to be operational between 8 to 12 hours per day, depending on the power requirements. This could have the potential to result in noise-related effects to community health and wellbeing.	Changes in rainfall patterns and a predicted sea-level rise associated with longer-term global climate change pose threats to the Guyanese population and its livelihoods. In the recent past, floods have produced negative and significant health impacts, direct economic losses for agriculture, livestock, fisheries, and forestry industries, and significant damage to roads and other infrastructure. In addition, floods can potentially increase the transmission of communicable diseases, such as water-borne diseases (e.g., typhoid fever, cholera). Also, receding flood waters and pooling water from heavy rainfall can provide perfect conditions for mosquito breeding increasing the incidence of	The Project, Other EEPGL Projects, and external drivers could contribute to the same types of negative impacts on this VEC: increased risk of communicable disease transmission, public safety, public anxiety, and reduced access to emergency and health services. The mitigation measures proposed for the Project would mitigate its potential adverse impacts. The potential adverse impacts identified for the Harbour Bridge replacement project could include public safety impacts associated with the construction phase. The Project is not expected to have an incremental contribution to the negative effect. Therefore, no additional actions from EEPGL are required to mitigate potential adverse cumulative impacts on the VEC beyond Project mitigation measures.	**Low**

VEC	Potential Impacts from Payara Development Project	Potential Impacts from EEPGL and Non-EEPGL Oil and Gas Exploration and EEPGL Development Projects [a]	Potential Impacts from Other EEPGL Projects		Potential Impacts from Other Projects		Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
			Gas to Shore Project	FOC Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture			
							mosquito-borne diseases (e.g., malaria, dengue).		
Marine Use and Transportation	During all Project stages, the key potential impacts caused by maritime transport of Project materials, supplies, and personnel are: • Increased vessel traffic in Georgetown Harbour, coastal waters between Georgetown and the PDA, along transit routes leading to Georgetown. • Reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around the FPSO, tankers, drill ships, and workover vessels. These potential impacts would have an effect on commercial cargo vessels (**Negligible**); commercial fishing vessels (**Minor**); and on subsistence fishing vessels (**Minor**). A marine vessel collision involving Project vessels and non-Project vessels (unplanned event), potentially resulting in a temporary obstruction to a marine navigation way, is assessed as a risk (**Minor**) to marine use and transportation.	Due to similarity in nature and magnitude, the offshore and nearshore impacts from Other EEPGL Projects, and other exploration activity, would be similar to those of the Payara Development Project (for planned activities shared with Payara): • During all Project stages, the key potential impacts caused by maritime transport of Project materials, supplies, and personnel are: increased vessel traffic in Georgetown Harbour, coastal waters between Georgetown and the PDA, along transit routes leading to Georgetown; and reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around the FPSO, tankers, drill ships, and workover vessels. The potential impacts will have an effect on commercial cargo vessels (**Negligible**); commercial fishing vessels **(Minor)**; and on subsistence fishing vessels **(Minor)**. • A marine vessel collision involving Project vessels and non-Project vessels (unplanned event), potentially resulting in a temporary obstruction to a marine navigation way, is assessed as a risk (**Minor**) to marine use and transportation.	The effects of construction of the pipeline component of the Gas to Shore Project on this VEC, are expected to be similar to those generated by the Payara Development Project and other exploration activities: • Increased vessel traffic in Georgetown Harbour, coastal waters, along transit routes leading to Georgetown; and reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around Project vessels. The potential impacts could have an effect on commercial cargo vessels; commercial fishing vessels; and on subsistence fishing vessels. • A marine vessel collision involving Project vessels and non-Project vessels (unplanned event), potentially resulting in a temporary obstruction to a marine navigation way.	During fiber optic cable laying, which requires vessel activity, key potential adverse impacts on marine use and transportation are expected to be similar to those generated by the Payara Development Project and other exploration activities: marine safety exclusion zones; nearshore navigation and safety. Given the short-term duration of the construction stage for this project, the Consultants do not foresee significant impacts on this VEC,	During the construction stage of the Project, some of the key adverse potential impacts could include impacts on the harbor and on river navigation. Procedures for river navigation would have to be reconsidered and new lead lines developed.	Based on the information available, the Consultants do not foresee impacts from the Mariculture Project on this VEC, or they would be considered **Negligible**.	To the extent the frequency or intensity of severe storms and flooding could be influenced by climate change, these could potentially damage some harbors and bridges during the Project life cycle (at least 20 years). Commercial fishing vessels contribute significantly to local marine traffic in the region.	The Project, Other EEPGL Projects, the Harbor Bridge replacement project, and external drivers could contribute to the potential negative impacts on this VEC: increased vessel traffic and reduced availability of ocean surface areas. The most vulnerable to these effects would likely be the subsistence fishing vessels with nearshore navigation. However, the mitigation measures proposed would appropriately mitigate the adverse impacts from the Project. The Project is not expected to have an incremental contribution to the negative effect. Therefore, no additional actions from EEPGL are required to mitigate potential adverse cumulative impacts on the VEC beyond Project mitigation measures, if any.	**Low**
Social Infrastructure and Services	During all Project stages, a key potential impact from Project workers and influx of job seekers to Georgetown area would be an increased demand or use of lodging, housing, and utilities, potentially leading to reduced availability and/or increased cost for the general population of Georgetown and vicinity (drilling and installation—**Minor**, and production operations/ decommissioning—**Negligible**).	Due to similarity in nature and magnitude, the onshore impacts from Other EEPGL Projects, and other exploration activity, would be similar to those of the Payara Development Project (for planned activities shared with Payara): • During all Project stages, a key potential impact from Project workers and influx of job seekers to Georgetown area would be an increased demand or use of lodging, housing, and utilities, potentially leading to reduced availability and/or increased cost for the general	The potential impacts on this VEC are expected to be similar to those generated by the Payara Development Project and other exploration activities. Project workers and influx of job seekers to Georgetown area would generate an increased demand or use of lodging, housing, and utilities, potentially leading to reduced availability and/or increased cost for the general population of Georgetown and vicinity. However, the significance of the	Based on the information available, and the short-term duration of any adverse effects that could potentially be caused by fiber optic cable laying, the Consultants do not foresee impacts from the project on this VEC, or they would be considered **Negligible**.	During the construction stage of the project, some of the key adverse potential impacts in the West Bank could include damage or modification of the current drainage channel and a timber company. Other potential impacts identified for the bridge relocation	Based on the information available, the Consultants do not foresee impacts from the Mariculture Project on this VEC, or it would be considered **Negligible**.	Changes in rainfall patterns and a predicted sea-level rise associated with longer term global climate change pose threats to the Guyanese population and its livelihoods. In the recent past, floods have produced	The Project, Other EEPGL Projects, the Harbour Bridge Project, and external drivers could contribute to the potential negative impacts on this VEC: increased demand or use of lodging, housing, and utilities. However, the Project is not expected to contribute to the negative effect or its contribution would be **Negligible**. Therefore, no additional actions from	**Low**

VEC	Potential Impacts from Payara Development Project	Potential Impacts from EEPGL and Non-EEPGL Oil and Gas Exploration and EEPGL Development Projects [a]	Potential Impacts from Other EEPGL Projects		Potential Impacts from Other Projects		Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
			Gas to Shore Project	FOC Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture			
	During all Project stages, a key potential impact from Project-related vehicle movements would be an increase in traffic congestion (**Negligible**). Vehicular traffic accidents collisions involving Project vehicles and non-Project vehicles (unplanned event), resulting in potential temporary contributors to traffic congestion, are assessed as a risk (**Minor**) to social infrastructure and services.	population of Georgetown and vicinity (drilling and installation—M**inor**, and production operations/decommissioning—**Negligible**). Although there will be temporally overlapping workforces for the respective EEPGL projects, the vast majority (expected to be on the order of 95 percent or more) of the workers during the drilling and installation phases will not require housing (as they will be accommodated offshore and will use hotels or dedicated company guest houses for one or two nights at a time between rotations in and out of country). • Vehicular traffic, resulting in potential contributors to traffic congestion, is assessed as a **Negligible** impact on social infrastructure and services. As additional EEPGL projects are undertaken, the amount of vessel traffic associated with combined EEPGL projects using the Guyana shorebase will increase; however, traffic impact modeling indicates a **Negligible** impact, even considering the cumulative EEPGL vehicle activity in Georgetown.	impacts driven by the power plant construction could potentially be higher due to a large number of workers during peak construction.		project are impacts on the harbor and on river navigation. Procedures for river navigation would have to be reconsidered and new lead lines developed.		negative and significant health impacts, direct economic losses for agriculture, livestock, fisheries, and forestry industries, and significant damage to roads and other infrastructure. Guyana is one of the most vulnerable countries to longer term global climate change due to the low-lying coastal areas, many below mean sea-level and with a high percentage of the population and critical infrastructure located along the coast.	EEPGL are required to mitigate potential adverse cumulative impacts on the VEC beyond Project mitigation measures, if any.	

VEC	Potential Impacts from Payara Development Project	Potential Impacts from EEPGL and Non-EEPGL Oil and Gas Exploration and EEPGL Development Projects [a]	Potential Impacts from Other EEPGL Projects		Potential Impacts from Other Projects		Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
			Gas to Shore Project	FOC Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture			
Waste Management Infrastructure Capacity	During all Project stages, a key potential impact from Project-related waste generation would be: • Contribution to overburdening of existing capacity of hazardous waste treatment facilities in Georgetown (**Negligible**). • Contribution to overburdening of local landfill existing capacity (**Minor**).	Due to similarity in nature and magnitude, the offshore and nearshore impacts for Other EEPGL Projects, and other exploration activity, would be similar to those of the Payara Development Project (for planned activities shared with Payara): • Contribution to overburdening of existing capacity of hazardous waste treatment facilities in Georgetown (**Minor**). • Contribution to overburdening of local landfill existing capacity (**Minor**).	During all project stages, hazardous materials stored and used at combustion facilities include solid, liquid, and gaseous fuels; air, water, and wastewater treatment chemicals; and equipment and facility maintenance chemicals (e.g., paint, lubricants, and cleaners). These waste streams will have to be disposed of in local hazardous waste treatment facilities, and will add pressure to the existing waste management infrastructure capacity.	During the construction stage, hazardous and non-hazardous waste would be generates. These waste streams will have to be disposed of in local landfills and hazardous waste treatment facilities, and will add pressure to the existing waste management infrastructure capacity.	Based on the information available, the Consultants do not foresee impacts from the Demerara Harbour Replacement Project on this VEC, or they would be considered **Negligible**.	During construction of the hatchery and shorebase area, the activities may involve the handling and use of hazardous materials (e.g. oil and other chemicals), which would have to be disposed of in local waste management facilities, adding pressure to the existing waste management infrastructure capacity.	The Consultants do not foresee impacts from the external drivers on this VEC.	Based on recent assessments of the currently available Georgetown-based hazardous waste treatment facilities and landfills in Georgetown, these facilities are nearing capacity (independently of EEPGL´s contributions in the case of landfill facilities). In this context, the Project, Other Projects (EEPGL and non-EEPGL) could incrementally contribute to the effects on this VEC, potentially accelerating the degree to which capacity constraints will manifest. Therefore, actions should be implemented in the medium-term to mitigate potential adverse cumulative impacts on the VEC.	**Medium**

CR = Critically Endangered; EN = Endangered; Hz = hertz; IUCN = International Union for Conservation of Nature; NT = Near Threatened; VSP = Vertical Seismic Profile; VU = Vulnerable
[a] Ongoing drilling and exploration – EEPGL, Repsol, Tullow, CGX; EEPGL Liza Phase 1 and Liza Phase 2; EEPGL FPSO #4 and FPSO #5

10.7. CUMULATIVE IMPACTS MANAGEMENT FRAMEWORK

Cumulative impacts often result from the successive, incremental, and/or combined impacts of multiple developments. Accordingly, responsibility for their prevention and management is shared among the various contributing developments. It is usually beyond the capability of any one party to implement all of the measures needed to reduce or eliminate cumulative impacts. In the following sections, recommendations are provided at the Project level, the EEPGL level (as EEPGL is the operator for several of the Other Projects assessed in the CIA), and the regional level.

10.7.1. Project Level

Effective application of the mitigation hierarchy (avoid, reduce, remedy) to manage individual contributions of cumulative impacts is recommended as best practice. EEPGL has incorporated a number of embedded controls (see Section 2.13, Embedded Controls, for a detailed list and description), which are physical or procedural controls that are planned as part of the Project design. These are considered from the very start of the impact assessment process as part of the Project, and are factored into the pre-mitigation impact significance ratings. In addition, a number of mitigation measures (see Chapters 6, 7, 8, and 13) have been proposed to address potential impacts from the Project. The EIA also includes an Environmental and Social Management Plan, which summarizes the embedded controls and mitigation and monitoring measures by VEC.

At the Project level, the above-referenced measures are considered sufficient to address the contributions of the Project to cumulative impacts.

10.7.2. EEPGL Level

Three medium priority cumulative impacts on VECs (i.e., for climate, marine mammals, and waste management infrastructure capacity) were identified, suggesting that additional consideration should be given in the medium-term to address potential cumulative impacts on these VECs. The medium priority ranking on marine mammals derives primarily from the potential cumulative impacts that could arise from additional vessel movements from simultaneous oil exploration and production operations (leading to the potential for an increased risk from vessel strikes). Accordingly, it is recommended that EEPGL, when designing and undertaking additional projects/activities, ensure that the same level of potential impact management (i.e., as in Payara) be implemented (e.g., embedded controls associated with minimization of the risk of marine mammal vessel strikes). In addition, with the intention of minimizing the potential interactions between effects of multiple projects, it is recommended that EEPGL take measures, where feasible and practicable, to share logistical resources between development projects—to reduce the number of additional vessel movements associated with additional projects. This approach would be expected to be sufficient to address contributions of the Project and Other EEPGL Projects to cumulative impacts on marine mammals.

Regarding climate, EEPGL has developed a flare minimization plan (see Section 6.1, Air Quality and Climate), and has committed to continue measuring and reporting its GHG contributions to national emissions. It is recommended that EEPGL continue to assess measures that can be taken to minimize GHG emissions during each Project's production operations stage, and ensure that a Best Available Technology assessment process (i.e., as conducted for the Payara Project) be undertaken to assess the feasible and appropriate embedded controls and mitigation measures that can be implemented to reduce GHG emissions.

In the case of waste management infrastructure capacity, the mitigation measures already initiated by EEPGL represent appropriate efforts to manage the cumulative impacts on this VEC. These include the following:

- Enable increases to existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facility or facilities, or identify suitable alternative solutions; and
- Monitor the Ministry of Communities' planned construction of Cell 2 at the Haags Bosch landfill, and/or identify suitable alternative (interim) local solutions for non-hazardous waste management.

10.7.3. Regional Level

The CIA did not identify any high priority cumulative impacts on VECs. Therefore, the Consultants do not deem necessary the development and implementation of a multi-stakeholder collaborative management framework. However, as cumulative impacts could vary in the future, with the addition of other projects or external drivers, it is recommended that EEPGL consider participation, to the extent feasible and practicable, in working groups and/or industry organizations aimed at addressing management of potential impacts on regional resources to which EEPGL's projects could incrementally contribute with respect to cumulative impacts.

11. ENVIRONMENTAL AND SOCIOECONOMIC MANAGEMENT PLAN FRAMEWORK

11.1. INTRODUCTION

This chapter provides a framework for the Project Environmental and Socioeconomic Management Plan (ESMP). The ESMP is the document that describes the measures EEPGL will implement to manage the Project's potential environmental and socioeconomic risks and reduce impacts on the environment and communities. The scope of this chapter includes the following:

- Overview of the policy framework underpinning the ESMP;
- Description of the ESMP structure;
- Description of the general ESMP guiding principles;
- Description of the general content of the management plans comprising the ESMP; and
- Description of how updates to the ESMP will be managed.

The Terms and Scope for this EIA require an ESMP, consisting of several affiliate-level, environmental media-specific or contingency-focused management plans, to be submitted concurrently with the EIA. The individual management plans that comprise the ESMP have been prepared consistent with the framework described herein. EEPGL will update the ESMP and its constituent plans to address the final conditions from the Environmental Authorisation, upon approval of the Project by the EPA.

11.2. REGULATORY AND POLICY FRAMEWORK

The Project is subject to various regulatory requirements as described in Chapter 3, Administrative Framework, the resource-specific laws and commitments described in each resource-specific discussion, the conditions established by the EPA upon issuance of the Environmental Authorisation, the conditions of the Petroleum Production Licence, and approval of the Project Development Plan. Other government agencies also have regulatory authority over aspects of the Project, including, but not limited to, the Fisheries Department of the Ministry of Agriculture, Guyana Revenue Authority, Civil Defense Commission, Guyana Geology and Mines Commission, Department of Energy, and Maritime Administration Department.

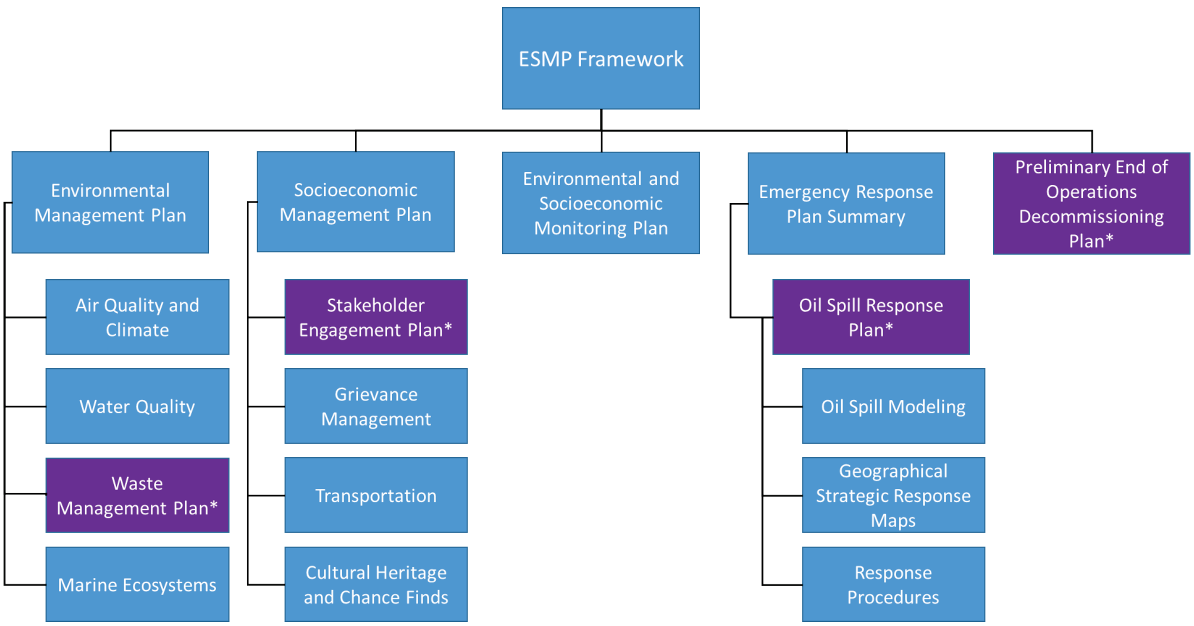
EEPGL is committed to ensuring its compliance with the laws and regulations of Guyana, and conducting business in a manner that is compatible with the environmental and economic needs of the communities in which it operates, and that protects the safety, security, and health of its employees, those involved with its operations, its customers, and the public. These commitments are documented in its Safety, Security, Health, Environmental, and Product Safety policies. These policies are put into practice through a disciplined management framework called the Operations Integrity Management System, which is further described in Section 3.5, EEPGL's Operations Integrity Management System.

11.3. ESMP Structure

Figure 11.3-1 depicts the overall structure of the Project ESMP. The specific management plans included in the ESMP are organized into five categories:

- Environmental Management
- Socioeconomic Management
- Environmental and Socioeconomic Monitoring
- Emergency Response Plan Summary (which serves as an umbrella document that includes a reference to the subordinate, stand-alone Oil Spill Response Plan)
- Preliminary End of Operations Decommissioning[1]

Each of these categories includes one or more specific management plans, which are included within the ESMP unless otherwise noted, as shown in Figure 11.3-1.



** Due to the size and/or complexity of these documents, these are stand-alone plans, and are provided as an appendix to the ESMP or as a separate attachment to the regulatory submittal for the Payara Development Project (e.g., Oil Spill Response Plan).*

Figure 11.3-1: ESMP Structure

[1] In alignment with the EPA's Initial Closure and Reclamation Plan

11.4. General ESMP Guiding Principles

EEPGL developed the overall ESMP, and each of the specific management plans it contains, consistent with the following guiding principles:

- Covers all Project stages (i.e., there are not separate management plans for each Project stage, except for a Preliminary End of Operations Decommissioning Plan);
- Contains a level of detail that is fit for purpose and varies among the individual management plans;
- Represents a "living document" that will be revised or amended as the Project progresses in response to changing circumstances, lessons learned, or other appropriate reasons;
- Develops some of the management plans as countrywide plans (e.g., Oil Spill Response Plan, Waste Management Plan, Stakeholder Engagement Plan), with asset-level details contained in an attachment as required, with the rest of the management plans (at this time) remaining asset-specific; and
- Reflects all regulatory commitments and obligations, including those from the EIA, supporting plans, and environmental authorizations.

11.5. Management Plan Contents

The ESMP contains an introduction and scope as well as a summary of the applicable regulations, standards, and guidelines. The environmental and socioeconomic management plans are fit for purpose, and therefore vary to some extent in content, but contain resource-specific management measures that include proposed mitigation measures developed from the impact assessment as well as embedded controls (see Chapter 13). The plans also include the following information for each measure:

- The source of potential impact;
- The likely affected receptor;
- The specific Project component(s) for which the control/measure will be implemented (e.g., Floating Production, Storage, and Offloading vessel, support vessels, shorebases, etc.) and/or the specific stage or stages of the Project during which each measure will be implemented (e.g., drilling, installation, production operations);
- A description of the management measure; and
- Monitoring requirements, where applicable.

11.6. MANAGEMENT OF CHANGE

During Project implementation, changes may be required to address unanticipated conditions or situations. Managing change is an integral part of the Operations Integrity Management System. Risk assessments, audits, inspections, and/or observations may identify the need for amendments to the ESMP. In these cases, the ESMP will be updated to reflect the change. In addition, the ESMP will be updated when applicable environmental laws, regulations, standards, and/or company processes, systems, and/or technologies that are being applied to the Project change. EEPGL will notify the EPA of any significant updates to the ESMP and will provide an updated version of the document for their records and use. The ESMP is also envisioned to be a living document that will be updated to reflect continuous learning and improvements, and will be shared with the Government of Guyana.

12. CONCLUSIONS AND SUMMARY OF IMPACTS

This section summarizes the potential environmental and socioeconomic impacts of the Project resulting from planned Project activities and the risks from potential unplanned events, as well the Project's potential contributions to cumulative impacts on resources and receptors.

12.1. PLANNED PROJECT ACTIVITIES

The planned Project activities are predicted to have **Negligible** to **Moderate** impacts on physical resources (i.e., air quality and climate, marine geology and sediments, marine water quality), no impacts on coastal biological resources, **Negligible** to **Moderate** impacts on marine biological resources, and **Negligible** to **Minor** impacts on socioeconomic resources—with largely positive impacts on socioeconomic conditions. These predictions result from the fact that the bulk of the Project will occur approximately 207 kilometers (128 miles) northeast of the coastline of Georgetown, and that the Project will:

- Capture and re-inject recovered natural gas (the portion that is not used as fuel on the Floating Production, Storage, and Offloading [FPSO] vessel) back into the reservoirs;
- Treat all wastewater streams as required prior to discharge to the sea;
- Have a very small physical footprint (e.g., installation of infrastructure will only physically disturb up to 0.8 square kilometers [0.3 square miles] of benthic habitat); and
- Use Marine Mammal Observers and "soft starts" during vertical seismic profile and pile driving operations to reduce the potential for auditory injury or disturbance to marine animals.

The Project will generate benefits for the citizens of Guyana through revenue sharing with the Government of Guyana, a minor increase in employment, and select Project purchasing from Guyanese businesses.

12.2. UNPLANNED EVENTS

Unplanned events, such as a potential oil spill, are considered unlikely to occur due to the extensive preventive measures employed by EEPGL; nevertheless, an oil spill is considered possible. The types of resources that would potentially be impacted and the extent of the impacts on those resources would depend on the volume and duration of the release, as well as the time of year, but impacts would tend to be most significant for a well-control event with loss of containment during the drilling stage. EEPGL has conducted oil spill modeling to evaluate the range of possible spill trajectories and rates of travel. The location of the Project 207 kilometers (128 miles) offshore, prevailing northwest currents, the nature of the Payara field crude oil, and the region's warm waters would all help reduce the severity of a spill. Accounting for these factors, modeling of an unmitigated subsea release of crude oil from a loss-of-well-control event indicates only a 5 to 20 percent probability of oil reaching the Guyana coast, without taking into consideration the effectiveness of any oil spill response, and in the unlikely event that a spill were even to occur.

Although the probability of an oil spill reaching the Guyana coast is very small, a subsea release of crude oil from a loss-of-well-control event at a Project well would likely impact any marine resources near the well, which could include marine turtles and certain marine mammals (especially baleen whales) that may transit or inhabit the area impacted by the spill, as well as marine water quality. Other physical and biological resources such as air quality, seabirds, marine fish, and marine benthos could also be impacted, although likely to a lesser extent because the duration of acute impacts would not be long and the impacts are reversible.

A coastal oil spill (i.e., of marine diesel) could occur as a result of another unplanned event (e.g., Project vessel collision or grounding, release during bunkering of a supply vessel). Depending on the scale of a coastal oil spill, the types of physical or biological resources that could be impacted would be generally similar to those potentially impacted by a marine oil spill.

Either a marine oil spill or a coastal oil spill could potentially impact Guyanese fisherfolk if commercial fish and shrimp resources were impacted. The magnitude of this impact would depend on the volume and duration of the release as well as the time of year at which the release were to occur (e.g., whether a spill would coincide with the time of year when these resources are more abundant in the Project Development Area). Effective implementation of EEPGL's Oil Spill Response Plan would reduce this risk by reducing the ocean surface area impacted by a spill and thereby reducing the exposure of these resources to oil.

Additional unplanned events, which are also considered unlikely to occur due to the preventive measures employed by EEPGL, could include collisions between Project vessels and non-Project vessels; Project vessel strikes of marine mammals, marine turtles, riverine mammals, or rafting seabirds; collisions between Project vehicles and non-Project vehicles; and a release of untreated wastewater from the FPSO. The impact extent from these types of events would depend on the exact nature of the event. However, in addition to reducing the likelihood of occurrence, the embedded controls that EEPGL will put in place if such an event were to occur (e.g., training of vessel operators to recognize and avoid marine mammals, riverine mammals, and marine turtles; adherence to international and local marine navigation procedures; adherence to Road Safety Management Procedure) would also serve to reduce the likely extent of impact.

12.3. Cumulative Impacts

The Project's expected contribution to cumulative impacts will be limited by its distance offshore, by the distance between the Project and other EEPGL projects/activities, and by the small number of non-EEPGL projects or activities either operating or currently planned to be operating offshore of Guyana. EEPGL is planning other offshore Guyana oil and gas exploration and development activities, including the approved Liza Phase 1 Development Project and Liza Phase 2 Development Project, continued exploration drilling, future planned offshore development projects (assumed for the purpose of this assessment to also be in the Stabroek Block), and the potential Gas to Shore Project, which would transport gas from the Liza Phase 1 Project Development Area to shore to remove natural gas liquids and provide gas for a possible natural gas-fired power plant. Additionally, a limited number of non-oil and gas-related projects are proposed by others that could potentially impact the same types of resources that could be impacted by the Project.

The Project activities, other planned EEPGL activities, and non-EEPGL activities together could cumulatively impact some resources such as:

- Climate (via increased emissions of greenhouse gases);
- Marine mammals (via vessel strikes or potential acoustic injury or disturbance from underwater sound);
- Marine turtles (via vessel strikes);
- Marine fish (via degraded water quality and entrainment of fish from cooling and ballast water intakes);
- Community health and wellbeing (via increased demand on limited medical treatment capacity);
- Marine use and transportation (via additional marine congestion, especially near Georgetown Harbour);
- Social infrastructure and services (via increased demand for limited housing, utilities, and services; or via increased traffic congestion); and
- Waste management infrastructure capacity (via demand on hazardous waste treatment facilities and landfills).

Many of the above potential impacts that require offshore interaction between the Project and others have a limited chance of occurring, given the size of the Stabroek Block.

The Project will adopt a number of embedded controls, mitigation measures, and management plans. These are considered sufficient to address the contributions of the Project to cumulative impacts. With respect to the contributions of multiple EEPGL projects to cumulative impacts, it is recommended that EEPGL, when designing and undertaking these additional projects and activities, ensure that the same level of potential impact management (i.e., as for the Payara Project) be implemented. In addition, with the intention of minimizing the potential interactions between effects of multiple projects, it is recommended that EEPGL actively manage, where feasible and practicable, the spatial and temporal overlap of their additional projects activities. These measures are expected to be sufficient to address contributions of the Project and other EEPGL projects to cumulative impacts.

12.4. Degree of Irreversible Damage

The planned Project would not cause irreversible damage to any onshore areas of Guyana. There would be a very minor (approximately 0.8 square kilometers [0.3 square miles]) permanent loss of benthic habitat offshore as a result of the installation of wells, flowlines, and other subsea equipment, which may be proposed to be left in place upon decommissioning. However, this equipment can ultimately provide the substrate for recolonization of the impacted areas. Even in the unlikely event of a large marine oil spill, little irreversible damage would be expected, although it could take a decade or more for all resources to fully recover, depending on the volume and duration of the release, as well as the time of year.

12.5. PROJECT BENEFITS

The Project will generate benefits for the citizens of Guyana in several ways:

- Through revenue sharing with the Government of Guyana, as detailed in the Petroleum Agreement (PA) between the Government of Guyana and EEPGL et al., which was made available to the public in December 2017. The type and extent of benefits associated with revenue sharing will depend on how decision makers in government decide to prioritize and allocate funding for future programs, which is unknown to EEPGL and outside the scope of the EIA.
- By procuring select Project goods and services from Guyanese businesses in alignment with the PA and the EEPGL Local Content Plan approved by the Ministry of Natural Resources on 6 April 2018.
- By hiring Guyanese nationals in alignment with the PA and the EEPGL Local Content Plan.

In addition to direct revenue sharing, expenditures, and employment, the Project will also likely generate induced economic benefits. These induced benefits could result from the re-investment, hiring, and spending by Project-related businesses and/or workers, which in turn benefits other non-Project-related businesses and generates more local tax for the government. These beneficial "multiplier" impacts are expected to occur throughout the Project life (at least 20 years).

12.6. SUMMARY

Table 12.6-1 provides a summary of the predicted residual impact significance ratings (taking into consideration proposed mitigation measures) for impacts on each of the resources that may potentially result from the planned Project activities in each Project stage (i.e., development well drilling/Subsea, Umbilicals, Risers, and Flowlines/FPSO installation, production operations, and decommissioning). For each resource, the table shows the highest residual impact significance rating among the potential impacts relevant to each Project stage. For each resource, the table also summarizes the highest residual risk rating for potential risks to resources from unplanned events (e.g., oil spill, vessel strike, etc.) and the priority rating for potential cumulative impacts on each resource, as determined by the cumulative impact assessment.

Table 12.6-1: Summary of Residual Impact Significance Ratings, Residual Risk Ratings, and Cumulative Impact Priority Ratings

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Drilling and Installation	Production Operations	Decommissioning		
Air Quality	Negligible	Negligible	Negligible	Minor	NA
Climate	Negligible	Moderate	Negligible	Minor	Medium
Sound [a]	None	None	None	None	None
Marine Geology and Sediments	Negligible	None	None	Minor	NA
Marine Water Quality	Minor	Negligible	Negligible	Moderate	Low
Protected Areas	None	None	None	Minor	NA
Special Status Species: [b]					
• Critically Endangered and terrestrial species	Negligible	Negligible	Negligible	Minor	Low
• Vulnerable/Near Threatened fish species	Minor	Minor	Negligible	Minor	Low
• Endangered fish and Endangered Black-capped Petrel (*Pterodroma hasitata*)	Negligible	Minor [d]	Negligible	Minor	Low
• Vulnerable Leach's Storm-Petrel (*Oceanodroma leucorhoa*)	Negligible	Minor [d]	Negligible	Moderate [e]	Low
Coastal Habitats	None	None	None	Minor	NA
Coastal Wildlife	None	None	None	Minor	NA
Seabirds [c]	Negligible	Minor	Negligible	Minor	NA
Marine Mammals	Moderate	Minor	Negligible	Moderate	Medium
Riverine Mammals	Minor	Minor	Minor	Minor	Low
Marine Turtles	Negligible	Negligible	Negligible	Moderate	Low
Marine Fish [f]	Minor	Negligible	Negligible	Minor	Low
Marine Benthos	Minor	Positive	Positive	Minor	Low
Ecological Balance and Ecosystems	Negligible	Minor	Negligible	Minor	Low
Socioeconomic Conditions	Positive	Positive	Positive	Minor	NA
Employment and Livelihoods	Positive	Positive	Positive	Minor	Low
Community Health and Wellbeing	Minor	Minor	Minor	Minor to Moderate	Low
Marine Use and Transportation:					
• Commercial cargo	Negligible	Negligible	Negligible	Minor	Low
• Commercial fishing	Minor	Minor	Minor	Minor	Low
• Subsistence fishing	Minor	Minor	Minor	Minor	Low

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Drilling and Installation	Production Operations	Decommissioning		
Social Infrastructure and Services:					
• Lodging	Minor	Negligible	Negligible	Minor	Low
• Housing and utilities	Minor	Negligible	Negligible	Minor	Low
• Ground and air transportation	Negligible	Negligible	Negligible	Minor	Low
Waste Management Infrastructure Capacity	Minor	Minor	Minor	Minor	Medium
Cultural Heritage	Negligible	None	None	Minor	NA
Land Use	Negligible	Negligible	Negligible	Minor	NA
Ecosystem Services	None	None	None	Minor	NA
Indigenous Peoples	None	None	None	Minor	NA

NA = Not assessed in cumulative impact assessment; scoped out as potentially eligible (see Chapter 10, Cumulative Impact Assessment)

[a] Potential underwater sound-related impacts on marine mammals, marine turtles, and marine fish are assessed in the resource-specific sections for those resources.

[b] Excludes listed marine turtles, which are covered in the Marine Turtles resource category.

[c] Excludes listed seabirds, which are covered in the Special Status Species resource category.

[d] Based on the 20-year presence of the FPSO (as a lighted attractant), the potential impact significance to special status marine birds during the production operations stage is considered Minor.

[e] The residual risk rating for Leach's Storm-Petrel is considered Moderate based on the results of marine bird surveys in 2017, 2018, and 2019, which documented the importance of the offshore zone as a migratory corridor for this special status marine bird.

[f] Excludes listed marine fish, which are covered in the Special Status Species resource category

13. RECOMMENDATIONS

The Consultants recommend the following measures be considered by the EPA, the Environmental Assessment Board, and other relevant Government of Guyana agencies as conditions of issuance of an Environmental Authorisation for the Project:

- Embedded Controls—incorporate all of the proposed embedded controls (see Table 13-1).
- Mitigation Measures—adopt the recommended mitigation measures (see Table 13-2).
- Management Plans—implement the proposed Environmental and Socioeconomic Management Plan (ESMP) to manage and mitigate the potential impacts identified in the EIA. The ESMP includes the following:
  - ESMP Framework (Chapter 11)
  - Environmental Management Plan, including:
    - Air Quality Management
    - Water Quality Management
    - Waste Management
    - Marine Ecosystems Management
  - Socioeconomic Management Plan, including:
    - Stakeholder Engagement
    - Grievance Management
    - Transportation Management
    - Cultural Heritage Management, including Chance Finds
  - Emergency Response Plan Summary
  - Oil Spill Response Plan (OSRP), including oil spill modeling, Net Environmental Benefit Analysis, emergency preparedness and response procedures, Wildlife Response Plan, and geographic strategic response maps
  - Preliminary End of Operations Decommissioning Plan
  - Environmental and Socioeconomic Monitoring Plan
- Oil Spill Preparedness—EEPGL has proactively embedded multiple controls into the Project design to prevent a spill from occurring, and we agree that a large spill that affects the Guyana coastline and/or other regional coastlines is unlikely. But given the sensitivity of many of the resources that could potentially be impacted by a spill (e.g., Shell Beach Protected Area; marine mammals; critically endangered, endangered, and vulnerable marine turtles; and Amerindian, fishing, and other communities reliant on ecosystem services for sustenance and their livelihood), we believe it is critical that EEPGL commit to regular oil spill response drills, simulations, and exercises—and involve appropriate Guyanese authorities and stakeholders in these activities, document the availability of appropriate response equipment on board the Floating Production, Storage, and Offloading (FPSO) vessel, and demonstrate that offsite equipment could be mobilized for a timely response.

With the adoption of such controls, mitigation measures, and management plans, and requirements for emergency response preparedness, the Payara Development Project is expected to pose only minor risks to the environmental and socioeconomic resources of Guyana, while potentially offering significant economic benefits to the residents of Guyana.

Table 13-1: List of Proposed Embedded Controls

Embedded Controls	Resources/Receptors Benefited
Development Well Drilling and Subsea, Umbilicals, Risers, and Flowlines (SURF)/FPSO Installation and Commissioning	
Use water-based drilling fluids to the extent reasonably practicable (upper sections of the wells). For well sections requiring non-aqueous drill fluid (NADF), use only low-toxicity International Oil and Gas Producers Group III base fluid.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
When NADF is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Install a blowout preventer (BOP) system that can be closed rapidly in the event of an uncontrolled influx of formation fluids and that allows the well to be circulated to safety by venting the gas at surface and routing oil so that it may be contained.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Test BOP equipment at installation, after disconnection or repair of any pressure containment seal, and at regular intervals (at least every 14 days or as operations allow).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Employ trained Marine Mammal Observers during the conduct of seismic-related activities.	Marine mammals, marine turtles
Conduct a continuous observation of a mitigation zone (500 meters [1,640 feet] around the sound source) to verify whether it is clear of marine mammals and marine turtles before commencing sound producing seismic operations. Do not commence sound-producing seismic operations (including soft starts) if marine mammals or turtles are sighted within the mitigation zone during the 30 minutes prior to commencing sound-producing operations in water depths less than 200 meters [656 feet], or 60 minutes prior to commencing sound-producing operations in water depths greater than 200 meters [656 feet].	Marine mammals, marine turtles
Where reasonably practicable, ensure that sound-making devices or equipment are equipped with silencers or mufflers and are enclosed, and/or use soft-start procedures (e.g., for pile driving, vertical seismic profiling, etc.) to reduce noise to levels that do not cause material harm or injury to marine species.	Marine mammals, marine fish, marine turtles
Adhere to the Joint Nature Conservation Committee guidelines (JNCC 2017) during the conduct of seismic-related activities.	Marine mammals, marine turtles
If well testing is performed, implement the following measures: • Flow only the minimum volume of hydrocarbons required for the test and reduce the test duration to the extent practical;	Air quality and climate

Embedded Controls	Resources/Receptors Benefited
• Use an efficient test-flare burner head equipped with an appropriate combustion enhancement system to minimize incomplete combustion, black smoke, and hydrocarbon fallout[1] to the sea; • Record volumes of hydrocarbons flared and make available to the EPA upon request; • Provide adequate gas sensors that are appropriately located during testing operations, to ensure all sources of gas can be detected; • Monitor pipes and joints on a daily basis for leakages and fugitive emissions. Burn all collected gaseous streams in high-efficiency flares, and implement and maintain a leak detection and repair program; • Keep the well test to the minimum practical time, in keeping with a pre-approved schedule with the EPA. Notify the EPA immediately in case of any deviation/variation to the well test; and • Provide sufficient compressed to the oil burner for efficient flaring assignment.	
With respect to prevention of spills of hydrocarbons and chemicals during the drilling stage: • Change liquid hydrocarbon transfer hoses periodically; • Use dry-break connections on liquid hydrocarbon bulk transfer hoses; • Use a liquid hydrocarbon checklist before every bulk transfer; • Perform required inspections and testing of all equipment prior to deployment/installation; • Use overbalanced drilling fluids to control wells while drilling; • Perform operational training certification (including well-control training) for drill ship supervisors and engineers; • Regularly audit field operations on the drill ships to ensure application of designed safeguards; and • Use controls for mitigating a failure of the Dynamic Positioning (DP) system on the drill ships and maintaining station-keeping, which include: – Use of a Class 3 DP system, which includes numerous redundancies; – Rigorous personnel qualifications and training; – Sea trials and acceptance criteria; – DP proving trials; – System Failure Mode and Effects Analysis; – DP failure consequence analysis; and – Establishment of well-specific operations guidelines.	Marine geology and sediments, marine water quality, protected areas and special status species, coastal habitats, coastal wildlife, marine mammals, marine turtles, marine fish, marine benthos, ecological balance and ecosystems
During pile-driving activities, gradually increase the intensity of hammer energy to allow sensitive marine organisms to vacate the area before injury occurs (i.e., soft starts).	Marine mammals, marine turtles, marine fish
Maintain marine safety exclusion zones to be issued through the Maritime Administration Department with a 500-meter (approximately 1,640-foot) radius around drill ships and major installation vessels, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Marine use and transportation

[1] Hydrocarbons that are deposited on the ocean surface due to both wet and dry deposition processes

Embedded Controls	Resources/Receptors Benefited
Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with International Maritime Organization (IMO)/International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Ensure leak detection systems are in place for equipment, treatment, and storage facilities (fuel, chemical, etc.) on drill ships in accordance with international offshore petroleum industry standards.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use leak detection controls during installation and operation of SURF equipment (e.g., pigging and pressure testing of lines, periodic remotely operated vehicle surveys of subsea trees, manifolds, flowlines, and risers).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Production Operations	
Use aero-derivative turbines instead of industrial turbines on the FPSO.	Air quality and climate
Install waste heat recovery units (WHRUs) on turbine generators to reduce the demand of more power generation or fired heaters, thus decreasing fuel gas consumption. Two WHRUs provide sufficient heat for the entire FPSO, but the Project is designed to use WHRUs on three of the four turbine generators, which adds spare capacity to ensure achieving maximum uptime and reducing flaring.	Air quality and climate
Use a crude–crude exchanger to recover heat from the dead crude to heat up live crude, instead of using a fired heater.	Air quality and climate
Use a large power plant and maximize the use of mechanical driven equipment that is more energy efficient. Use a gas turbine to drive the compressor directly, allowing savings in fuel versus using a gas turbine to generate electricity, and then using an electric motor to drive the compressor - reducing motor losses and power generation losses.	Air quality and climate
Use large, high-voltage motors, which are more efficient than industry standard machines.	Air quality and climate
Use the same gas turbines for the main generators, designed slightly larger than the need for the compressor such that when one compressor trips, the second unit still can meet 60% of production and thus reduce flaring.	Air quality and climate
Implement an FPSO topsides leak detection and repair program to reduce fugitive emissions.	Air quality and climate
Implement a flare minimization plan	Air quality and climate
Instead of continuous flaring, re-inject produced gas that is not used as fuel gas on the FPSO into the reservoir, to avoid routine flaring.	Air quality and climate
Adopt highly efficient combustion equipment using recovery heat systems as part of the heat and power production.	Air quality and climate
With respect to non-routine flaring, the following measures will be implemented: • Ensure flare equipment is properly inspected, well maintained, monitored, certified, and function-tested prior to and throughout operations; • Install the flare at a safe distance from storage tanks containing flammable liquids or vapors and accommodation units; • Ensure combustion equipment is designed and built to appropriate engineering codes and standards; • Do not operate the flare outside design operating ranges;	Air quality and climate

Embedded Controls	Resources/Receptors Benefited
• Use efficient flare tips and optimize the size and number of burning nozzles; • Minimize risk of pilot blowout by ensuring sufficient exit velocity and provision of wind guards; • Use a reliable pilot ignition system; • Install high-reliability instrument pressure protection systems, as appropriate, to reduce overpressure events and avoid or reduce flaring situations; • Operate the flare to control odor and visible smoke emissions; • Record volumes of hydrocarbons flared and submit a copy of the record to the EPA annually; • Maximize efficiency of flaring through flare tip design to ensure correct ratio of fuel and air are present to support efficient combustion • Implement burner maintenance and replacement programs to ensure continuous maximum flare efficiency; • Minimize liquid carryover and entrainment in the gas flare stream with a suitable liquid separation system, with sufficient holding capacity for liquids that may accumulate, and which is designed in accordance with good engineering practice; • Equip liquid separation system (e.g., knockout drum) with high-level facility shutdown or high-level alarms and empty as needed to increase flare combustion efficiency; • Implement source gas reduction measures (i.e., gas re-injection into reservoir) to the extent possible to avoid or reduce flaring from FPSO; • Minimize flaring from purges and pilots without compromising safety through measures such as installation of purge gas reduction devices, vapor recovery units, inert purge gas, and soft seat-valve technology where appropriate, and installation of pilot flares; and • Minimize flame lift off and/or flame lick.	
Develop equipment strategies and execute a maintenance program to minimize equipment breakdowns and plant upsets that could result in flaring, and make provisions for equipment sparing and plant turn-down protocols where practical.	Air quality and climate
Implement inspection, maintenance, and surveillance programs to identify and prevent unplanned emissions to atmosphere onboard the FPSO.	Air quality and climate
In the event of an emergency or equipment breakdown on the FPSO, or when facility upset conditions arise, excess gas should not be vented but rather should be sent to an efficient flare gas system, where practical and operationally safe.	Air quality and climate
Notify the EPA via email, correspondence, and/or telephone within 24 hours after process upset events or unplanned maintenance occur that result in a flaring event on the FPSO sustaining a volume of at least 10 million standard cubic feet per day. Capture volumes from minor flaring events not requiring notification in aggregate in annual emissions reporting.	Air quality and climate
Avoid routine venting (excludes tank flashing emissions, standing/ working/breathing losses) except during safety and emergency conditions.	Air quality and climate
Avoid use of chlorofluorocarbons and polychlorinated biphenyls on the FPSO.	Air quality and climate

Embedded Controls	Resources/Receptors Benefited
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 milligrams per liter (mg/L) on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored and the discharge meets the noted specification.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C at 100 meters (approximately 328 feet) from discharge point.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Measure residual chlorine concentration of sewage discharges from the FPSO monthly to ensure it is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Perform daily visual inspections on the FPSO of discharge points to ensure that there are no floating solids or discoloration of the surrounding waters.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Maintain marine safety exclusion zones to be issued through the Maritime Administration Department with a 2-nautical-mile (approximately 12,150-foot) radius around FPSO during offloading operations, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Ensure offloading activities are supervised by a designated Mooring Master, according to the conditions of the sea. The conditions and characteristics of the export tankers will be assessed by the Mooring Master and reported to the Offshore Field Manager prior to commencing offloading operations. Use only properly registered and well-maintained double-hull vessels.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use support tugs to aid tankers in maintaining station during approach/departure from FPSO and during offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use a hawser with a quick release mechanism to moor the FPSO to the tanker at a safe separation distance during offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Ensure FPSO offloading to tankers occurs within an environmental operating limit that is established to ensure safe operations. In the event that adverse weather occurs during offloading operations that is beyond the environmental operating limit, the tanker will cease offloading operations, and may disconnect and safely maneuver away from the FPSO as appropriate.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use a certified marine-bonded, double-carcass floating hose system that complies with the recommendations of Oil Companies International Marine Forum Guide to Manufacturing and Purchasing Hoses for Offshore Moorings 2009 Edition (OCIMF 2009) or later.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds

Embedded Controls	Resources/Receptors Benefited
Use breakaway couplers on offloading hose that would stop the flow of oil from FPSO during an emergency disconnect scenario.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use a load-monitoring system in the FPSO control room to support FPSO offloading.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use leak detection controls during FPSO offloading (e.g., for breach of floating hose, instrumentation/procedures to perform volumetric checks).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Inspect and maintain onboard equipment (engines, compressors, generators, sewage treatment plant, and oil-water separators) in accordance with manufacturers' guidelines, in order to maximize efficiency and minimize malfunctions, and unnecessary discharges into the environment.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use low-sulfur fuels for major Project vessels, where available and commercially viable.	Air quality and climate
Use dust-suppression measures at the shorebases to reduce impacts on air quality.	Air quality and climate
Abide with IMO (2004) guidelines including the International Convention for the Control and Management of Ship's Ballast Water and Sediments, with the exception of Regulation D-2 (Ballast Water Performance Standard) while the FPSO is on station, and abide with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78).	Ecological balance and ecosystems
General Measures	
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' specifications and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.	Air quality and climate, sound, marine water quality, marine mammals, marine turtles, riverine mammals
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Equip Project vessels with radar systems and communication mechanisms to communicate with third-party mariners.	Marine use and transportation
Regularly inspect and service shorebase cranes and construction equipment to mitigate the potential for spills and to reduce air emissions to the extent reasonably practicable.	Air quality and climate, marine water quality
Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.	Air quality and climate
Implement a chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets;	Air quality and climate, marine water quality, marine geology and sediments, marine mammals, marine turtles, riverine mammals, marine fish, marine benthos, seabirds

Embedded Controls	Resources/Receptors Benefited
• Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment;	
Use secondary containment for storage of bulk fuel, drilling fluids, and hazardous materials, where reasonably practicable.	Marine water quality
Regularly check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks.	Marine water quality
Ensure wastewater released from the onboard sewage treatment plant complies with aquatic discharge standards in accordance with MARPOL 73/78 regulations.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
For transport of hazardous wastes offsite for treatment or disposal, ensure the waste is accompanied by a manifest signed by the hazardous waste generator and transporter.	Waste management infrastructure capacity
Provide for adequate onshore waste-management equipment and facilities for the proper management of waste in accordance with local regulation and good international oil field practice	Waste management infrastructure capacity
For wastes that cannot be reused, treated, or discharged/disposed on the drill ships or FPSO, ensure they are manifested and safely transferred to appropriate onshore facilities for management.	Waste management infrastructure capacity
Periodically audit waste contractors to verify appropriate waste management practices are being used.	Waste management infrastructure capacity
Avoid, reduce, and reuse/recycle wastes preferentially prior to disposal in accordance with waste management hierarchy.	Waste management infrastructure capacity
Perform onshore waste treatment for certain categories of waste, thereby reducing demand on landfill capacity.	Waste management infrastructure capacity
Operate incinerators in accordance with the manufacturers' operating manuals and Waste Management Plan. Ensure that the incinerators are operated only by trained personnel.	Waste management infrastructure capacity, air quality and climate
Ensure there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Treat bilge water in accordance with MARPOL 73/78 to ensure compliance with an oil-in-water content of less than 15 parts per million, as applicable.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and riverine mammals at the sea surface. Provide standing instruction to Project-dedicated vessel masters to avoid marine mammals, riverine mammals, and marine turtles while underway and reduce speed or deviate from course, when possible, to reduce probability of collisions.	Marine mammals, marine turtles, riverine mammals

Embedded Controls	Resources/Receptors Benefited
Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from Project Development Area.	Seabirds
Provide standing instructions to Project-dedicated vessel masters to reduce their speed within 300 meters (984 feet) of observed marine mammals and marine turtles, and to not approach the animals closer than 100 meters (328 feet).	Marine turtles
Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.	Marine use and transportation
Provide health screening procedures to Project workers to reduce risks of transmitting communicable diseases.	Community health and wellbeing
Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practicable. Partner with select local institutions and agencies to support workforce development programs and proactively message Project-related employment opportunities.	Socioeconomic conditions, employment and livelihoods
Procure Project goods and services locally when available on a timely basis and when they meet minimum standards and are commercially competitive.	Socioeconomic conditions, employment and livelihoods
Develop and implement a Stakeholder Engagement Plan.	Community health and wellbeing
Implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) early on, prior to onset of Project activities. Ensure CGM is well publicized and understood by the public.	Community health and wellbeing
Monitor grievances received and resolved by the CGM; adjust CGM and other management measures, as appropriate	Community health and wellbeing
Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to vehicle incidents.	Social infrastructure and services, community health and wellbeing
Implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The procedure will include, at a minimum, the following components: • Definition of typical, primary travel routes for ground transportation in Georgetown area; • Development of an onshore logistics/journey management plan to reduce potential conflicts with local road traffic when transporting goods to/from onshore support facilities; • Definition of required driver training for Project-dedicated drivers, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as applicable; • Designation and enforcement of speed limits through speed governors, global positioning system, or other monitoring systems for Project-dedicated vehicles; • Avoidance of deliveries during typical peak-traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; • Monitoring and management of driver fatigue; • Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment for Project-dedicated vehicles; and	Social infrastructure and services, community health and wellbeing

Embedded Controls	Resources/Receptors Benefited
• Community outreach to communicate information relating to major delivery events or periods.	
Coordinate with relevant aviation authorities and stakeholders to understand peak Project-related utilization rates.	Social infrastructure and services
Use an established Safety, Security, Health, and Environment program to which all Project workers and contractors will be required to adhere to mitigate against risk of occupational hazards. Ensure all workers and contractors receive training on implementation of these principles and are required to adhere to them in the daily execution of their duties.	Occupational health and safety
Maintain an OSRP to ensure an effective response to an oil spill, including maintaining the equipment and other resources specified in the OSRP and conducting periodic training and drills.	All resources and receptors potentially impacted by an oil spill
Where reasonably practicable, direct lighting on FPSO and major Project vessels to required operational areas rather than at the sea surface or skyward. Ensure lighting on vessels adheres to maritime safety regulations/standards.	Seabirds, marine turtles
Provide screening for seawater intakes, if safe and practical, to avoid entrainment and impingement of marine flora and fauna.	Marine fish

Table 13-2: List of Proposed Mitigation Measures

Proposed Mitigation Measure	Resources/Receptors Benefited
Use an increased inlet pressure to decrease the overall compression requirements, which leads to a reduction in power demand and fuel consumption.	Air quality and climate
Install volatile organic compound recovery on the FPSO cargo tanks, which results in a reduction in FPSO cargo tank emissions.	Air quality and climate
Optimize gas turbine maintenance to ensure that gas turbines are not overhauled more often than needed, and also to ensure overhauls are completed at the right time, in alignment with other FPSO maintenance activities to reduce the need to flare.	Air quality and climate
Implement trip-reduction initiatives for the gas turbines to improve reliability/ availability to reduce flaring.	Air quality and climate
Quantify and report direct greenhouse gas emissions from Project offshore facilities and offshore and onshore Project activities and its dedicated contractors on an annual basis in accordance with internationally recognized methodologies.	Air quality and climate
Issue Notices to Mariners via the Maritime Administration Department, the Trawler's Association, and fishing co-ops for movements of major marine vessels (including the FPSO, drill ship, and installation vessels) to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.	Employment and livelihoods, marine use and transportation
Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.	Employment and livelihoods, marine use and transportation
Promptly remove damaged Project vessels (associated with any vessel incidents) to minimize impacts on marine use, transportation, and safety.	Marine use and transportation
Proactively communicate the Project's limited staffing requirements as a measure to reduce the magnitude of potential population influx to Georgetown from job seekers.	Social infrastructure and services
Adopt and implement as needed a Chance Find Procedure that describes the requirements in the event of a potential chance find of heritage or cultural resources.	Cultural heritage

Proposed Mitigation Measure	Resources/Receptors Benefited
Require Project workers to adhere to a Worker Code of Conduct, which will address shore-leave considerations.	Community health and wellbeing
Use a dedicated medical provider to complement the services of the local private medical clinic used by the Project, and procure a dedicated ambulance to avoid overwhelming the local medical infrastructure.	Community health and wellbeing
Implement the OSRP in the unlikely event of an oil spill, including: • Conducting air quality monitoring during emergency response; • Requiring use of appropriate PPE by response workers; and • Implementing a Wildlife Oil Response Program, as needed.	All resources potentially affected by an oil spill
Implement a claims process and, as applicable, a livelihood remediation program to address economic losses or impacts on livelihood as a result of an oil spill.	Socioeconomic conditions, employment and livelihoods, indigenous peoples, ecosystem services
Communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners.	Social infrastructure and services
In case of a collision involving a Project vessel and a non-Project vessel that may result in a claim arising from such type of incident, provide appropriate restitution, consistent with governing contracts and applicable laws.	Employment and livelihoods
To address future waste capacity constraints in Georgetown relative to Project's predicted waste management needs: • Enable increases to existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facility or facilities, or identify suitable alternative solutions; and • Monitor the Ministry of Communities' planned construction of Cell 2 at the Haags Bosch landfill, and/or identify suitable alternative (interim) local solutions for non-hazardous waste management.	Waste management infrastructure and capacity

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14. PROJECT TEAM

Table 14-1 identifies the core members of the Consultant team and their roles in preparing the Project EIA.

Table 14-1: Core Project Team Members

Member	Company and Position	Role
Todd Hall	ERM: Partner-in-Charge	Overall lead for regulatory engagement, EIA process execution, and deliverable production
Jason Willey	ERM: Project Manager, Biological Resource Specialist	Overall day-to-day management of technical execution for EIA process; technical lead for marine mammals, riverine mammals, marine turtles, marine fish, and marine benthos
Neil Henry	ERM: Local Coordinator	Logistics and other local support for field studies and stakeholder engagement
Karin Nunan	ERM: Socioeconomic, Stakeholder Engagement, and Ecosystems Services Specialist	Overall lead for socioeconomic impact assessment and stakeholder engagement; technical lead for ecosystem services
Julia Tims	ERM: Biological Resource Specialist	Technical lead for coastal wildlife and marine birds
Rick Osa	ERM: Air Quality and Noise Monitoring Specialist	Technical lead for ambient air quality monitoring and ambient noise monitoring
Shwet Prakash	ERM: Water Quality Specialist	Technical lead for marine water quality modeling and impact assessment; technical lead for marine geology and sediments
Mark Garrison	ERM: Air Quality Modeling Specialist	Technical lead for air quality dispersion modeling and air quality and climate impact assessment
Charles Ceres	GSEC: Senior Technical Advisor	Strategic input for regulatory and stakeholder engagement; senior technical review of physical resource components
Hance Thompson	GSEC: Senior Environmental Specialist	Technical lead for protected areas and special status species, and ecological balance and ecosystem; senior technical review of biological resource components
Raeburn Jones	GSEC: Forest Resource Specialist	Technical lead for coastal mangrove habitats
Shyam Nokta	EMC: Strategic Oversight and Coordination—Socioeconomic and Stakeholder Engagement	Strategic input for regulatory and stakeholder engagement; senior review of socioeconomic components
Khalid Alladin	EMC: Technical Lead of Stakeholder Engagement and Technical Inputs into Socioeconomic Component	Technical lead for Regional Democratic Council (RDC)/Neighbourhood Democratic Council (NDC) stakeholder engagement, socioeconomic conditions, employment and livelihoods, waste management, and community health and wellbeing
Andrew Bishop	EMC: Technical Lead for Socioeconomic Component	Technical lead for land use; senior review of socioeconomic components, in particular marine use and transportation, and social infrastructure and services/
Richard Persaud	EMC: Technical Lead for Stakeholder Engagement	RDC/NDC stakeholder engagement support; ecosystem services support
Romeo De Freitas	EMC: Technical Lead for Stakeholder Engagement	RDC/NDC stakeholder engagement support; marine turtles and ecosystem services support

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Chapter 8 Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources

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