

Environmental Assessment and Management Plan

Stabroek Block 25-Well Exploration Drilling Campaign

Esso Exploration and Production Guyana Limited

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/g	micrograms per gram
µg/m^3	micrograms per cubic meter
µmol/kg	micromoles per kilogram
2D	two dimensional
3D	three dimensional
4D	four dimensional
AOI	Area of Influence
ARRT	Americas Regional Response Team
BTEX	benzene, toluene, ethylbenzene, and xylenes
BOP	blowout preventer
BOPE	Blowout Prevention Equipment
CGM	Community Grievance Mechanism
CI	Conservation International
CIA	cumulative impact assessment
CMI	Caribbean Mariculture Inc.
CO	carbon monoxide
CR	Critically Endangered
DD	Data Deficient
DE	Guyana Department of Energy
DP	dynamic positioning
EA&MP	Environmental Assessment and Management Plan
EBS	environmental baseline survey
EEPGL	Esso Exploration and Production Guyana Limited
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EITI	Extractive Industries Transparency Initiative
EMC	Environmental Management Consultants
EMP	Environmental Management Plan
EN	Endangered
EPA	Guyana Environmental Protection Agency
ERM	Environmental Resources Management
ERP	Emergency Response Plan
ERT	Emergency Response Team
ESG	Emergency Support Group

ESMP	Environmental and Socioeconomic Management Plan
FPSO	Floating Production, Storage, and Offloading (vessel)
GDP	gross domestic product
GGMC	Guyana Geology and Mines Commission
GHG	greenhouse gas
GIS	Geographical Information System
GMCS	Guyana Marine Conservation Society
GMRP	Guyana Mangrove Restoration Project
GSDS	Green State Development Strategy
GSEC	Ground Structures Engineering Consultants Ltd.
GYD	Guyanese dollars
H_2S	hydrogen sulfide
HSE	Health, Safety, and Environment
IC	Incident Commander
ICS	Incident Command System
ICZM	Integrated Coastal Zone Management
IFC	International Finance Corporation
ILO	International Labour Organization
IMO	International Maritime Organization
IMT	Incident Management Team
IUCN	International Union for Conservation of Nature
ITD	Intent to Drill
km^2	square kilometer
JNCC	Joint Nature Conservation Committee
LADCP	Lowered Acoustic Doppler Current Profiler
LCDS	Low Carbon Development Strategy
LME	Large Marine Ecosystem
LWD	Logging While Drilling
m	meter
m^2	square meter
m^3	cubic 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
mg/L	milligrams per liter
mi^2	square mile
MMO	Marine Mammal Observer
MOC	Meridional Overturning Circulation
MPN	most probable number
NABF	non-aqueous base fluid
NADF	non-aqueous drilling fluid
NAREI	National Agriculture Research and Extension Institute
NBC	North Brazil Current
NBSAP	National Biodiversity Strategy and Action Plan
NDC	Neighbourhood Democratic Council
NDS	National Development Strategy
NEAP	National Environmental Action Plan
NEBA	Net Environment Benefit Analysis
NGL	natural gas liquid
NO_2	nitrogen dioxide
NOAA	U.S. National Oceanic and Atmospheric Administration
NO_x	nitrogen oxides
NT	Near Threatened

OIMS	Operations Integrity Management System
OSRP	Oil Spill Response Plan
P&GA	Public and Government Affairs
PA	Petroleum Agreement
PAC	Project-Affected Community
PAH	polycyclic aromatic hydrocarbon
PBPA	Portland Bight Protected Area
PDA	Project Development Area
PM	particulate matter
$PM_{2.5}$	particulate matter with an 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
ppm	parts per million
ppb(v)	parts per billion by volume
PS	Performance Standards
PSO	Protected Species Observer
PWD	Pressure While Drilling
ROV	remotely operated vehicle
SBPA	Shell Beach Protected Area
SEA	Strategic Environmental Assessment
SEDAC	Socioeconomic Data and Applications Center
SIMOP	Simultaneous Operations
SO_2	sulfur dioxide
SSHE	Safety, Security, Health, and Environment
SURF	Subsea, Umbilicals, Risers, and Flowlines
TBD	to be determined
TED	turtle excluder device
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSS	total suspended solids
UOG	Upstream Oil & Gas
USD	U.S. dollars
USEPA	U.S. Environmental Protection Agency
VEC	Valued Environmental Component
VOC	volatile organic compound
VSP	vertical seismic profiling
VU	Vulnerable
WBDF	water-based drilling fluids
WCD	Worst Case Discharge
WMP	Waste Management Plan
WWF	World Wildlife Fund

1 INTRODUCTION

Esso Exploration and Production Guyana Limited (EEPGL) is seeking environmental authorization for an extension of its ongoing exploration drilling campaign in the Stabroek Block involving completion of up to 25 additional exploration/appraisal wells (hereafter referred to as "the Project"). The Stabroek Block is located approximately 200 kilometers offshore of Guyana, and encompasses an area of roughly 2.7 million hectares. In response to EEPGL's October 2019 Application for Environmental Authorisation for the Project, the Guyana Environmental Protection Agency (EPA) has required EEPGL to submit an Environmental Assessment and Management Plan (EA&MP) before an Environmental Authorisation can be granted for the Project.

1.1 BACKGROUND

EEPGL is the designated Operator of the Stabroek Block, acting on behalf of itself and the parties comprising the other participants in the Petroleum Agreement (PA) and Prospecting License granted for the Stabroek Block by the Government of Guyana dated 27 June 2016 (i.e., CNOOC Petroleum Guyana Limited and Hess Guyana Exploration Limited, collectively called "Contractor"). Unless otherwise expressly stated, all references in this EA&MP refer to EEPGL acting in its capacity as Operator (as defined in the PA) on behalf of Contractor.

EEPGL has drilled 23 exploration/appraisal wells to date in the Stabroek Block and is in the process of drilling additional exploration/appraisal wells within the Stabroek Block as part of existing approvals, as indicated in Table 1.1-1.

Table 1.1-1: EEPGL Stabroek Block Exploration/Appraisal 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

Well Name	Year Drilled	Result
Pacora-1	2018	Successful
Sorubim-1	2018	Dry well
Liza-5	2018	Successful
Longtail-1	2018	Successful
Hammerhead-1	2018	Successful
Ranger-2	2018	Successful
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	Successful
Mako-1	2019	Successful
Uaru-1	2020	Successful

TBD = to be determined

1.2 SUMMARY OF ENVIRONMENTAL STUDIES AND ASSESSMENTS COMPLETED TO DATE

A series of exploration activities have been completed to date for offshore Guyana including the following:

- 2008/2009—Licensing of two-dimensional (2D) seismic survey data (7,500 kilometers)
- 2010/2011—Licensing of 2D seismic survey data (4,640 kilometers)
- 2012/2013—Licensing of three-dimensional (3D) seismic survey data over Sorubim and Liza areas of interest (1,250 square kilometers [km^2] and 1,100 km^2, respectively)
- 2015—First Exploration Well (Liza-1) and first major hydrocarbon discovery
- 2015—Acquisition of 3D seismic survey over two-thirds of Stabroek Block (17,050 km^2)
- 2015/2016—Acquisition of 3D seismic survey over 7,693 km^2, across the Canje Block
- 2016/2017—Multiwell Exploratory Drilling Program over several prospective leads with drilling of Liza-2, Skipjack-1, Liza-3, and additional discoveries, Payara-1, Snoek-1, Turbot-1, and Ranger-1

- 2017—Acquisition of 3D seismic survey over 5,739 km^2, across the Kaieteur Block
- 2017—Acquisition of 3D/four-dimensional (4D) seismic survey over 1,100 km^2 of the Liza Area of Interest and future development
- 2018/2019—3D/4D seismic survey initially over the northwest Stabroek Block area, and then redeployed to the southeast Stabroek Block area
- 2018-ongoing—Continued Multiwell Exploration and Appraisal Drilling Program over additional prospective leads in the Stabroek Block

In the course of these exploration activities, a number of baseline field surveys and impact assessments have been completed, and these are described in the remainder of this report. Based on this work, EEPGL has, at this stage, comprehensively documented baseline environmental conditions over approximately 46,225 km^2 in the Stabroek, Canje, and Kaieteur blocks, as well as in additional regions of the continental shelf and slope of Guyana's Exclusive Economic Zone (EEZ). The objectives of this section are:

- To clearly document the relevant field work, studies, and impact assessments completed as of the time of writing; and
- To discuss the associated body of knowledge that is now available to facilitate informed decision-making by the EPA with respect to EEPGL's request for authorization to initiate exploration/appraisal drilling of up to 25 additional wells in the Stabroek Block.

1.2.1 Environmental Studies

The exploration, appraisal, and development activities commissioned by EEPGL to date have been supported by numerous baseline surveys and studies to characterize the physical, environmental, and biological conditions in current and future operational regions offshore, as well as additional areas of the Guyana shield shelf and slope.

The breadth and depth of EEPGL's commissioned studies has grown substantially with the increasing work scope. Also, in preparation for ongoing exploration and development activities in the region, EEPGL has proactively conducted multi-year studies, as well as broader baseline surveys that cover the Guyana nearshore and areas of the shelf and slope.

1.2.1.1 *Environmental Studies in the Stabroek Block and Adjacent Areas*

EEPGL commissioned its first Environmental Baseline Studies (EBS) in the Stabroek Block in 2014. Since then, numerous EBS and other environmental studies have been conducted in the Stabroek, Kaieteur, and Canje blocks, and along the Guyana continental shelf. These studies have been leveraged for the EA&MP assessment, as appropriate. Table 1.2-1 summarizes the environmental studies that have been completed and their relevance to the Project.

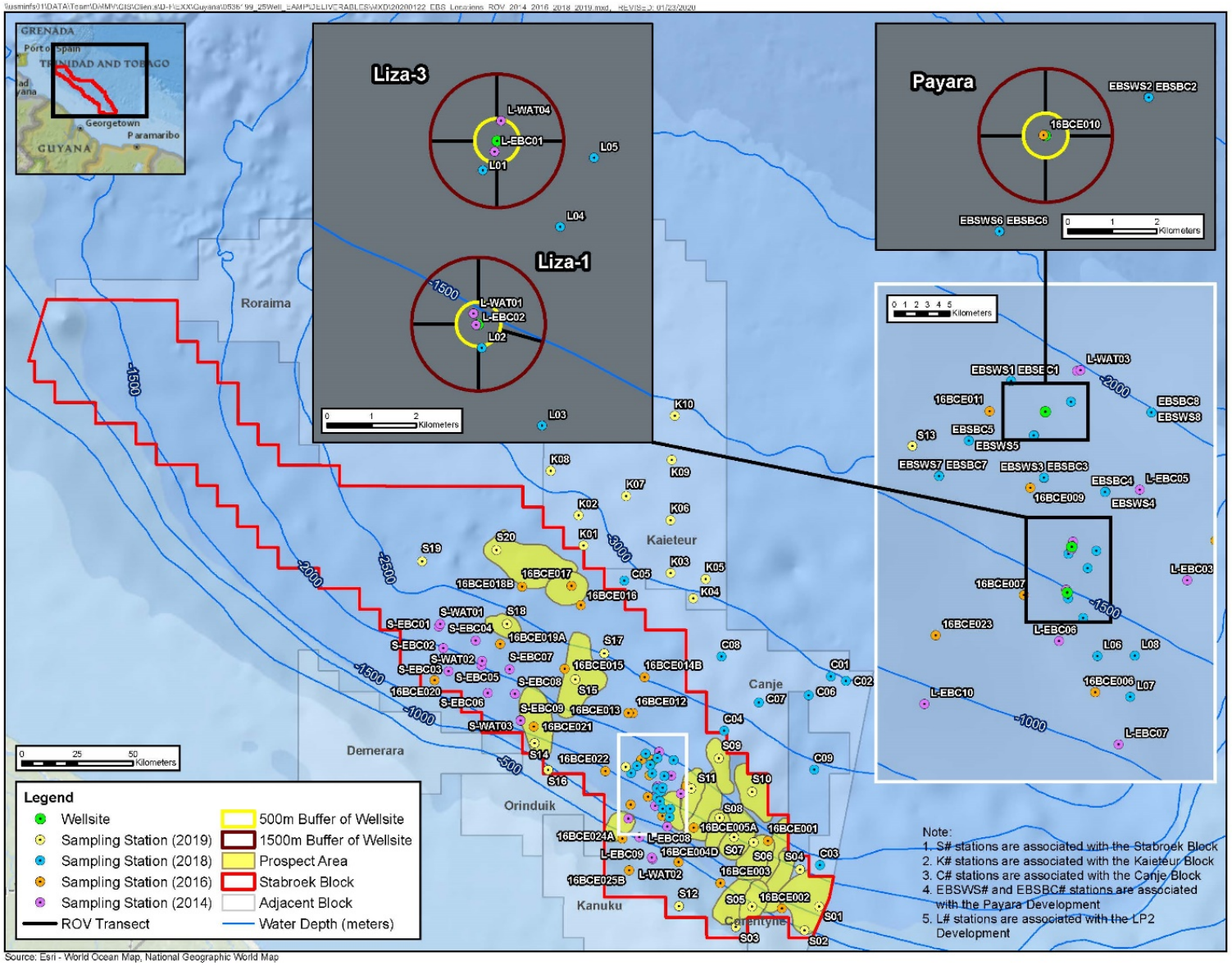
Table 1.2-1: Environmental Studies Completed to Date in the Stabroek Block, Adjacent Blocks, and along the Guyana Coast

Study	Scope of Studies	Relevance to the Project
2014 Stabroek Block EBS	First EBS in the Stabroek Block, which collected water and seabed sediment samples and profiled currents to describe their physical, chemical, and biological characteristics in the Liza and Sorubim Areas of Interest	Indicative of water quality, sedimentology, and benthic communities on the outer continental shelf and slope
2016 Liza-1 EBS	EBS of the Liza-1 Deepwater Field, which collected water and seabed sediment samples to describe their physical, chemical, and biological characteristics within the vicinity of the Liza-1 exploration well	Indicative of water quality, sedimentology, and benthic communities on the outer continental shelf and slope
2015–2019 Protected Species Observations	Monitored and recorded marine mammal and marine turtle observations and detections. Geographical Information System (GIS) data has been collected for the last 5 years offshore Guyana and continues to be collected.	Characterizes species and abundance of marine mammals and turtles in Guyana's offshore marine waters
2016–2019 Metocean Survey Data	Three-year metocean survey data program in the Stabroek Block	Indicative of broad meteorological and oceanographic conditions on the outer continental shelf and slope
2017 Drop Camera and Remotely Operated Vehicle transect imagery	Collected transect imagery to characterize the benthic community on the continental shelf and slope	Indicative of benthic communities on the continental shelf and slope, as influenced by the Guiana Current
2017 Continental Shelf EBS	Collected water and seabed sediment samples to describe their physical, chemical, and biological characteristics on the continental shelf between the Stabroek Block and Guyana coast	Indicative of water quality, sedimentology, and benthic communities on the outer continental shelf

Study	Scope of Studies	Relevance to the Project
2017–2019 Marine and Coastal Fish and Bird Studies	Fish and bird surveys conducted in the Stabroek Block and in the area between the Stabroek Block and Guyana coast	Characterizes fish and bird species in Guyana's coastal and offshore marine waters
2017–2019 Liza Phase 1 Ecosystem Services and Coastal Sensitivity Mapping Study	Desktop and field verification of shoreline and coastal types, ecosystem services, and important habitat types along the Guyana coast	Characterizes coastal habitats and sensitive resources that could be impacted by an unplanned event (i.e., oil spill) associated with the Project
2018–2019 Turtle Telemetry Study	Tagged and tracked turtles nesting on the Guyana coast to characterize their inter-nesting and migratory movements	Indicative of marine turtle movements in Guyana's coastal and offshore marine waters
2018 Liza Phase 2 Development EBS	Collected water and sediment samples at eight locations to identify the physical, chemical, and biological characteristics in the Liza Phase 2 Project Development Area	Indicative of water quality, sediment quality, and benthic communities on the outer continental shelf and slope
2019 Payara Development EBS and Habitat Assessment	Collected water and sediment samples at 13 locations to identify the physical, chemical, and biological characteristics in the Payara Project Development Area	Indicative of water quality, sediment quality, and benthic communities on the outer continental shelf and slope
2018 Canje Block EBS	Collected sediment and water samples at nine locations to identify the physical, chemical, and biological characteristics within targeted areas of the Canje Block	Indicative of water quality, sediment quality, and benthic communities on the outer continental shelf and slope
2019 Kaieteur Block EBS	Collected sediment and water samples at ten locations to identify the physical, chemical, and biological characteristics within targeted areas of the Kaieteur Block	Indicative of water quality, sediment quality, and benthic communities on the outer continental shelf and slope
2019 Stabroek Block EBS	Collected sediment and water samples at 20 locations to identify the physical, chemical, and biological characteristics within the Southern Stabroek Block	Indicative of water quality, sediment quality, and benthic communities on the outer continental shelf and slope

Given the large extent of data collected over the last 6 years, which spans multiple seasons, EEPGL's baseline data set represents a valuable database that will continue to grow with contributions from the EPA, Protected Areas Commission, Ministry of Agriculture Fisheries Department, and other third-party operators in adjacent blocks. Figure 1.2-1 shows the sampling stations for the EBS campaigns occurring in the Stabroek and adjacent blocks for the past 6 years.

Figure 1.2-1: 2014–2019 Environmental Baseline Survey Locations – Stabroek, Canje, and Kaieteur Blocks



1.2.2 Environmental Assessments

The primary data collected as part of the above-referenced multi-year surveys and studies have been incorporated into a number of formal impact assessments and environmental management plans including the following:

- 2014—Strategic Environmental Assessment (SEA), assessing exploration drilling impacts and mitigations in Liza and Sorubim areas of interest
- 2015—SEA Addendum, continuing to assess exploration drilling impacts and mitigations following the Liza Discovery and enable the drilling of the Liza-2 well
- 2015—Environmental Management Plan (EMP), assessing multiwell exploration drilling impacts and mitigations across several areas of interest (Liza area plus four additional priority areas)
- 2016—EMP Addendum, assessing multiwell exploration drilling impacts, including cumulative impacts, within the Stabroek Block, and defining management and mitigation measures
- 2016/2017—Liza Phase 1 Environmental Impact Assessment (EIA) and Environmental and Socioeconomic Management Plan (ESMP), assessing impacts, including cumulative impacts, of the Liza Phase 1 Development Project, and defining management and mitigation measures
- 2018—EMP Addendum Update, assessing additional multiwell exploration drilling impacts, including cumulative impacts, within the Stabroek Block, and defining management and mitigation measures
- 2017/2018—Liza Phase 2 EIA and ESMP, assessing impacts, including cumulative impacts, of the Liza Phase 2 Development Project, and defining management and mitigation measures
- 2019—Stabroek Revised EMP, assessing impacts from 12 wells within the Stabroek Block, including cumulative impacts and management and mitigation measures
- 2019—Payara EIA and ESMP, assessing impacts of the proposed Payara Development Project
- 2019—Canje EA&MP, assessing impacts of the proposed 3-well exploratory drilling campaign within the Canje Block, including cumulative impacts and management and mitigation measures

- 2020—Kaieteur EA&MP, assessing impacts of a proposed 1-well exploratory drilling campaign within the Kaieteur Block, including cumulative impacts and management and mitigation measures.

The collective knowledge amassed by these multi-year and multi-seasonal surveys, studies, and assessments now represents the largest environmental data set for Guyana's marine and coastal territory, including the Stabroek, Canje, and Kaieteur blocks, and shallow continental shelf. Primary sampling stations have been distributed across these areas and span waters as shallow as 30 to 50 meters in the south, to the very deep waters near the northern boundary of the EEZ, as well as onshore, nearshore, and intertidal areas across six coastal regions. Moreover, as EEPGL's exploration and development activities progress, this knowledge will continue to grow with new field observations collected and reported as part of routine operations.

The assessment presented in this EA&MP was built on the knowledge and baseline data gathered from earlier surveys, studies, and assessments, which included the 2014 SEA; the 2015 SEA Addendum, 2015 EMP, 2016 EMP Addendum, 2018 EMP Addendum Update, and the 2019 Stabroek Revised EMP; the Liza Phase 1, Liza Phase 2, and Payara EIAs; and the recent Canje Block EA&MP and Kaieteur Block EA&MP. With the preparation and completion of the EIAs, EMPs, and EA&MPs, and the supporting EBSs and studies that have been conducted, the overall knowledge and understanding of the Guyana coastal habitats and marine environment has increased.

Taken together, the desktop studies, multi-year field surveys, coastal ecosystem services, biodiversity field verification and validation studies, and impact assessments conducted to date have rendered a detailed characterization of the existing physical, biological, and socioeconomic conditions across Guyana's six coastal regions, the Stabroek Block, adjacent Kaieteur and Canje blocks, and a portion of the nearshore and shelf and slope areas of the Guyana EEZ.

1.3 PURPOSE OF THE STABROEK BLOCK 25-WELL EA&MP

The purpose of the Stabroek Block 25-well EA&MP is to support EEPGL's application to the EPA for an Environmental Authorisation to drill up to an additional 25 exploration/appraisal wells in the Stabroek Block. The designs and final locations of these wells are still in the planning stages. Preliminary locations for each are described in Section 2.1, Project Location.

1.4 SCOPE AND OBJECTIVES OF THE EA&MP

The EA&MP identifies and assesses the potential environmental and socioeconomic impacts associated with the Project. The specific objectives of the EA&MP are to:

- Describe the components, activities, processes, and best available technologies for all phases of the Project, including:
  - Exploration/appraisal drilling, including well design and mobilization and operation of drill ships
  - Onshore support, including shorebases
  - Marine and aviation support vessels and equipment
  - End of well drilling operations (plugging and abandonment)
- Describe the existing conditions within the Stabroek Block. The evaluation of existing conditions in the Stabroek Block has leveraged the scientific body of knowledge that has been acquired through the various prior and ongoing studies listed in Table 1.2-1.
- Identify and assess the potential direct, indirect, and cumulative environmental and socioeconomic impacts that could credibly result from the Project during the drilling, well plugging and abandonment, and ancillary activities using an assessment process described in Chapter 4, Methodology for Preparing the Environmental Assessment and Management Plan.
- Describe a strategy to manage any potentially significant adverse impacts of the Project.
- Provide the factual and analytical basis required by the EPA to make an informed decision on EEPGL's request to permit the Project.

1.5 ENVIRONMENTAL ASSESSMENT AND MANAGEMENT PLAN STUDY TEAM

The EA&MP was prepared with the assistance of Environmental Resources Management (ERM). Table 1.5-1 identifies the primary core members of the ERM team and their primary roles in preparing the document.

Table 1.5-1: EA&MP Core Team

Member	Role	Role
Todd Hall	Partner in Charge	Quality assurance and control, final document review
Amberly Moon	Project Manager and Physical and Biological Resources Specialist	Team leader, coordinator of document preparation, physical and biological components of the environmental baseline, and impact assessment
Jason Willey	Senior Technical Advisor	Ecological components of the environmental baseline and impact assessment
Kris Hiatt	Document Manager	Technical editor, document management and production
Karin Nunan	Socioeconomic Resources Lead	Socioeconomic components of the environmental baseline and impact assessment
Mark Garrison	Air Quality Lead	Senior subject matter expert on air emissions and associated environmental management strategy
Allison Ronan	Air Quality Specialist	Air emission components of the environmental baseline and impact assessment
Shwet Prakash	Water Quality Lead	Senior subject matter expert on water quality and associated environmental management strategy
Desik Somasundaram	Water Quality Specialist	Water quality components of the environmental baseline and impact assessment
Morriah Fickes	Biological Resources Specialist	Biological components of the environmental baseline and impact assessment
Patrick del Pizzo	GIS Lead	GIS subject matter expert for all geospatial and graphic components of the environmental baseline and impact assessment

2 PROJECT DESCRIPTION

2.1 PROJECT LOCATION

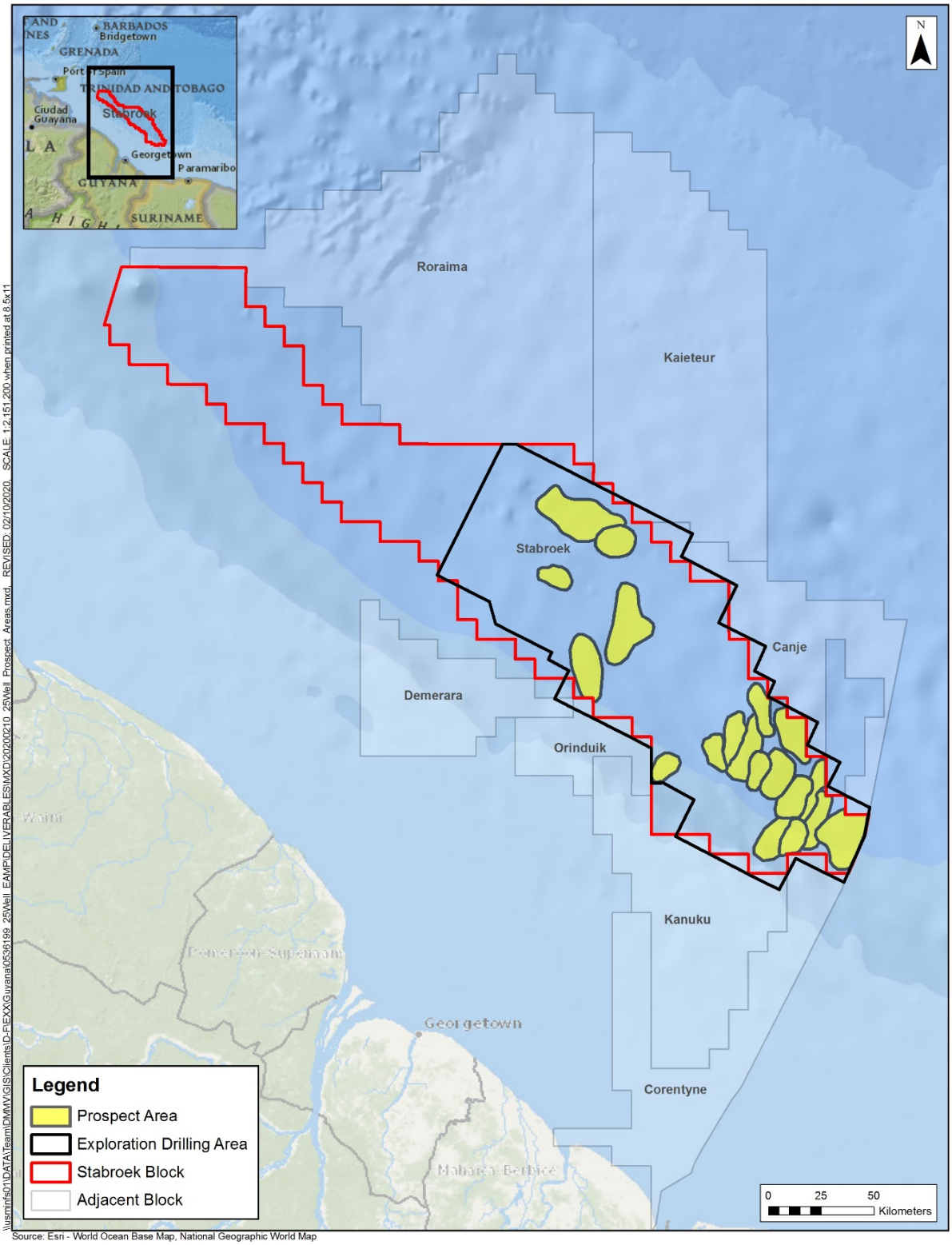
Guyana is located between 1˚ 10′ and 8˚ 33′ north latitude and 56˚ 20′ and 61˚ 22′ west longitude. It is bordered on the north by the Atlantic Ocean, on the east by Suriname, on the west and northwest by Venezuela, and on the south and southwest by Brazil.

The Stabroek Block is located along the continental shelf and in deep waters approximately 200 kilometers off the coast of Georgetown, Guyana. EEPGL has conducted substantial exploration and development activities to date, including the drilling of multiple exploration, appraisal, and development wells. Based on data from these exploration and development activities, several areas of interest (referred to herein as "Prospect Areas") have been identified. These Prospect Areas (which represent the areas within which the Project exploration/appraisal wells may be drilled) are shown on Figure 2.1-1. The Prospect Areas are collectively referred to herein as the "Project area."

The exact locations of the 25 wells comprising the Project have not yet been finalized. While some of the 25 wells will be drilled for exploration purposes, it is also possible that some of the wells may be drilled as appraisal wells within the proximity of previously drilled exploration areas.

If discoveries are found at particular locations, subsequent wells could be drilled in the vicinity of such locations to further assess the commerciality of the discoveries. Priorities and schedules could therefore change. Therefore, EEPGL will continue to submit the well information necessary to obtain approval for an Operations Permit from the EPA prior to the respective spud dates.

Figure 2.1-1: Prospect Areas for Proposed Stabroek Block 25-Well Exploration Drilling Campaign



2.2 *DESCRIPTION OF THE PROJECT AND ALTERNATIVES*

The process of drilling these wells will be very similar to the process followed during prior EEPGL exploration drilling campaigns and may include mobilization, drilling, ancillary processes (possibly including sidetracks[1], well tests, and/or vertical seismic profiling [VSP]), and demobilization. The wells will be drilled in a yet-to-be-determined order, with timing of the initial well and between the wells dependent on well results and prioritization with other EEPGL activities offshore Guyana. The specific features and activities for each well are still being finalized and will be provided to the EPA in advance of spudding.

The wells will be drilled by one of the four drill ships currently operating offshore Guyana (the *Stena Carron, Noble Tom Madden, Noble Bob Douglas, and Noble Don Taylor*) or by one of up to three additional drill ships (as of yet selected), which are expected to begin work in 2020 or 2021.

All drill ships are fully equipped for such drilling operations. However, of the four drill ships currently operating offshore Guyana, only the *Stena Carron* and *Noble Don Taylor* drill ships have the equipment required to perform a well test. If such a well test is determined to be warranted for the Project, the well would be temporarily abandoned in place to schedule the return of a suitable drill ship in order to re-enter the well and complete the well test at a later date, if applicable.

2.3 *PROJECT SCHEDULE*

Pending receipt of approval, it is anticipated that the Stabroek Block 25-well exploration/appraisal drilling campaign will begin in 2021 and continue into 2022. This schedule is preliminary and could be influenced by new discoveries, determination of the need for sidetracks, and/or well tests that would extend the drilling period for such exploration/appraisal wells. The same factors could also influence the locations and sequence of subsequent wells.

The drilling of exploration/appraisal well(s) in the Stabroek Block will potentially be conducted simultaneously with other drilling activities, including:

[1] A secondary wellbore drilled away from the original hole (e.g., to further explore a geologic feature)

- The Liza Phase 2 Development Project well drilling program (authorized under Environmental Permit Ref. No. 20171204-ESSLP)
- Ongoing exploration/appraisal well drilling operations in the Stabroek Block covered under a 12-well extension approved on 26 July 2019—together with the individual environmental permits issued by the EPA for individual wells; and
- Pending approval, a proposed three-well exploration drilling campaign in the Canje Block.

It is possible that drilling in the Stabroek Block could also potentially overlap (temporally) with development-well drilling for the Payara Development Project—for which an Environmental Authorisation process is ongoing and with development-well drilling for the Hammerhead Development Project—for which an Application for Environmental Authorisation has recently been submitted to the EPA.

EEPGL manages Simultaneous Operations (SIMOPs) through a structured process that includes weekly planning meetings to verify that simultaneous activities between different offshore teams (Drilling, Installation, Production, Logistics) are managed safely. SIMOPs have been considered in the cumulative impact assessment (CIA) in this EA&MP.

A detailed schedule including any sidetracking, well tests, or VSP for each well will be provided as it becomes available and presented with the Intent to Drill (ITD) prior to the start of any well-specific activities.

2.4 DRILLING PROCESS DESCRIPTION

The details of the proposed drilling operations are provided below, including descriptions of the drill ship selection and mobilization process, well planning, drilling procedures, ancillary processes, discharges, plugging and abandonment, and demobilization procedures. EEPGL is using the most appropriate industry-proven technologies in developing the Project, in terms of well drilling, drilling fluids, equipment selection, and environmental management. Each description of the drilling process includes the fundamental basis of decision making for key equipment and environmental performance criteria by EEPGL considering technical and commercial considerations. When making such best available technology design and operational decisions, EEPGL considers technology options, feasibility, economics, regulatory requirements and benchmarks, and environmental aspects and impacts.

2.4.1 *Well Planning*

Well planning incorporates all of the preparations required to design and complete the wells. This stage typically involves geotechnical site investigations, pressure predictions, choosing casing points, designing a drilling fluid program, designing well data collection and well logging programs, designing casing and wellhead equipment, and designing Blowout Prevention Equipment (BOPE).

2.4.2 *Drill Ship Selection, Procurement, and Mobilization*

As stated in Section 2.2, Description of the Project and Alternatives, the *Stena Carron*, *Noble Tom Madden*, *Noble Bob Douglas*, *Noble Don Taylor*, or any of up to three additional to-be-determined drill ships could be used for the Project. Of the four drill ships currently operating offshore Guyana, only the *Stena Carron* and *Noble Don Taylor* have the equipment required to perform a well test. All drill ships will be equipped to comply with the water pollution control standards required by the International Maritime Organization (IMO) International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78).

Before a drill ship is accepted, a thorough drill ship acceptance test process is conducted to locate and correct any issues that could affect the integrity of the operations. This includes inspection of BOPE, fluid handling equipment, drill string components, hoisting equipment, and station-keeping equipment. Prior to drilling, inspections of the safety systems, marine systems, and structural components of the drill ship are also conducted as part of the pre-mobilization review and internal safety checks required by ExxonMobil's (and its affiliate EEPGL's) Operations Integrity Management System (OIMS)[2]. This allows for review team members to communicate with the drill ship operator regarding EEPGL's expectations, spill prevention requirements, waste management standards, and environmental initiatives. The team also ensures that the contractor's environmental procedures are consistent with EEPGL standards, especially around operations, valves, and hoses that could be at risk for spills and leaks. Other equipment such as the cuttings dryer and oil water separator that are elaborated on in other sections of this EA&MP are also examined. Upon completion of the visit, action items are followed-up on to closure in preparation for mobilization.

[2] 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.

The *Stena Carron*, *Noble Tom Madden*, *Noble Bob Douglas*, and *Noble Don Taylor* have already undergone this drill ship acceptance test process, and any new drill ships will undergo the same process.

2.4.3 The Drilling Process

The process of drilling a well is multifaceted and involves deploying the drill ship to the site, spudding the well, advancing the drill string into the well, managing drilling fluids using a dedicated fluid handling system, solids control, and fluid recovery (to enable removal of solids and/or gas entrained in the fluid during the drilling phase and to recycle the drilling fluid).

This section describes the major pieces of equipment and the processes required to develop a subsea exploration well. Further drilling details and information on materials to be used, anticipated timeline, and duration of activities and safety measures to be employed will be provided as part of the ITD prepared prior to commencement of drilling for submittal to the Guyana Geology and Mines Commission (GGMC) and Department of Energy (DE) in accordance with the Guyana Petroleum Exploration and Production Act of 1986.

2.4.3.1 Drill Ship, Drill String, and Casing Program

The drill ship provides the operational base and power needed to conduct the drilling operation. Together, the bits, tubulars[3], and various 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 tubing. The drill ship advances the drill string into the well, and provides the torque to turn the bit in the borehole. All of the equipment used to assemble and manipulate the drill string, such as the travelling equipment and rotating system, will be housed on the drill ship.

Much of the following information provided in this section is based on typical information for the types of drill ships customarily used for offshore deepwater exploration drilling programs. The planned drilling program and its cuttings management approach are consistent with industry practices, have previously been the basis for exploration wells in the Stabroek Block, and are also the basis for the development wells for the approved Liza Phase 1 and Liza Phase 2 Development Projects. The actual equipment to be used may change dictated by the criteria mentioned in Section 2.4.1, Well Planning.

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

The drilling process uses drill bits of different sizes to drill a series of telescoping holes from the seabed to the planned well total depth. Drill pipe is continuously added to the top of the string from the drill ship as the string advances into the borehole. 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 (for the conductor casing and deeper casings) is installed, pressure and integrity testing is performed according to standard industry practices.

Cements, produced in a combustion process using a specialized blend of limestone and clay, are used to support the casing and isolate formations. With increasing depth, temperature, and pressure, additives are required to ensure that the cement slurry maintains its required properties. Additives can be subdivided into six functional groups: (1) density control additives, (2) setting time control additives, (3) lost circulation additives, (4) filtration control additives, (5) viscosity control additives, and (6) specialty additives. Casing is run into the borehole and cemented in place after each successive well section is drilled. The Safety Data Sheets for any additives are compiled in advance of any operations.

After each cementing operation, the cement unit must be thoroughly cleaned to ensure that it is fit for use when needed. Effluent from the cleaning operation may be discharged to prevent cement setting in the system. Any discharges are subject to protocols outlined in the Waste Management Plan (WMP)[4] (see Appendix A).

2.4.3.2 Drilling Fluids and Handling System

A drilling fluid is circulated through the inside of the drill string to the bit. The primary function of the drilling fluid system is the removal of cuttings[5] from the well and the control of formation pressures. Other functions of the drilling fluid system include:

- Sealing permeable formations
- Maintaining wellbore stability
- Cooling, lubricating, and supporting the drill bit and assembly
- Transmitting hydraulic energy to tools and bit

[4] EEPGL maintains an affiliate-level WMP, which was most recently updated as part of the updated Payara Development Project EIA prepared in February 2020. This plan currently covers waste management aspects of all affiliate activities in Guyana.
[5] Drill cuttings are the broken bits of solid material produced as the drill bit advances through the borehole in the rock or soil.

Another important function of the drilling fluids system is related to the control of fluid volume during the well drilling. The comparison of the volume of fluid pumped into the well with the volume that returns to the drill ship allows for the monitoring of fluid losses or fluid gains inside the well, respectively indicating either a loss of drilling fluids to the formation or an inflow of formation fluids into the well.

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[6] and fracture gradient[7]; and
- Longer drilling risers requiring larger volumes of drilling fluid.

The drilling fluid is designed to have specific properties and is prepared by mixing solid additives and chemicals to specified concentrations. 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 Procedures 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 will be required to maintain borehole stability while drilling all well sections below the conductor casing.

WBDF returns and drill cuttings are discharged at the seabed. This is consistent with industry practices used globally to drill the top-hole sections of exploration wells. WBDF contains no hydrocarbons; accordingly, no treatment of WBDF-based cuttings is required. Drilling fluids are selected to be suitable for deepwater operations and the temperatures and pressures that will be encountered, to facilitate safety and integrity of the drilling operations, including well control and borehole stability.

WBDF contain the following commonly used types of products: salt water, polymers, and stabilizers. More specifically, they include the following:

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

- Sodium chloride brine—this is salt water made from table salt; it is largely the same salt as seawater, but a little more concentrated.
- Xanthan gum—this is a polysaccharide with many industrial uses, including as a common food additive. It is an effective thickening agent and stabilizer to prevent ingredients from separating. It can be produced from simple sugars using a fermentation process, and derives its name from the species of bacteria used (*Xanthomonas campestris*). Xanthan gum can be found as an ingredient in many foods such as ketchup, yogurt, and salad dressing, among others. It is not harmful to humans or the marine environment.
- Caustic soda—this is used in low concentrations to stabilize the fluid to a pH of 7.5–9.0.
- Bactericide—this is used in a very low concentration (5 gallons per 1,000 barrels); it is similar to caustic soda in that it helps as a stabilizer for xanthan gum.
- Barite—this is a natural occurring mineral (barium sulfate, an inert solid).

This is a standard formulation for WBDF and is also used for drilling top-hole sections in the Gulf of Mexico. All these products disperse quickly in the seawater and degrade readily with the exception of barite—an inert mineral used to increase the density of the fluids critical for safety.

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.

Solids control and cuttings drying equipment, as described below, 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.

2.4.3.3 Solids Control and Fluid Recovery

Drilling fluids recovered from the well will be treated to remove solids and/or gas entrained in the fluid during the drilling phase. A solids

control system will separate drill cuttings and particles of solids from the circulating drilling fluid system. Once the marine riser is installed, the flow of drilling fluid returning from the well will be directed to the solids control system. The removal of solids from the returning flow enables reuse of the base fluid. Thus, the solid removal system performs an important role in the drilling operation by maintaining optimal drilling fluid properties, reducing the volume of base fluid required, and reducing fluid properties of drilling waste generated.

Additionally, immeasurable amounts of gas may be encountered while drilling and will be released. Gas will be removed from the drilling fluid by means of a degasser and will be vented to the top of the drill ship.

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 options for disposal include offshore discharge or transport of cuttings to shore for treatment and onshore disposal. While transport to shore may limit the impact offshore, transportation, emissions from transportation, treatment, and disposal onshore also have an impact on the environment.

The offshore discharge option reduces the oil retained on cuttings prior to discharge. The NADF and base oil are selected such that the remaining base oil and additives have minimal impact on the environment. The total suspended solids (TSS) plume from the cuttings discharge and the cuttings deposition footprint on the seabed were modeled as part of this EA&MP to inform the assessment of potential impacts. Water depth and currents are considered in such studies. As discussed in Chapter 6, these studies verify that cuttings beds that are deposited in the vicinity of the drilling location have a negligible impact on the benthic community in a localized area around the well.

Various techniques exist to treat cuttings and reduce the non-aqueous base oil on cuttings. Of these techniques, two offshore applications are noteworthy for their ability to reduce base oil retained on cuttings: thermo-mechanical desorption and cuttings dryers.

Thermo-mechanical desorption treatment generates 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 percent by weight. This technically proven method requires a large space for installation on the drill ship, and may not be suitable for many drill ships 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 larger boreholes. The reported rate of cuttings

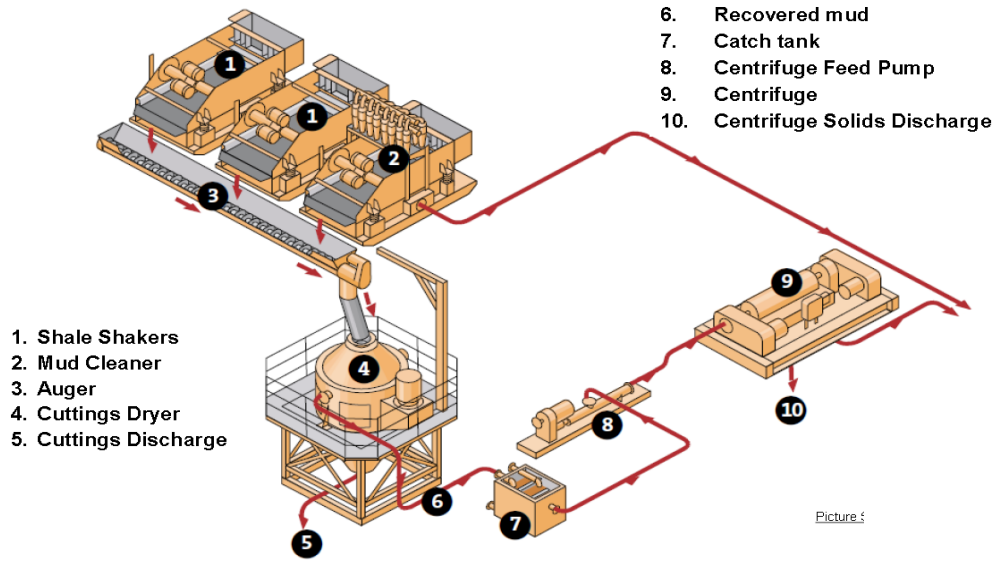
treatment is 3.5 to 5 tonnes per hour. The significant energy consumption to generate the heat may also generate atmospheric emissions.

Another more commonly used technique is the use of so-called cuttings dryers. A view of a typical solid control/fluid recovery system is shown on Figure 2.4-1. Using this method, the base oil retained on cuttings can be reduced to less than 6.9 percent by weight, an international best practice standard for offshore discharge. Cuttings dryers can be readily installed on most drill ships; the hourly processing rate is from 45 to 65 tonnes per hour (depending on model). Emissions and energy consumption are moderate to low. The use of solids control and cuttings dryer systems such as those on the drills ships currently being used in Guyana are consistently achieving an average by wet weight residual NADF on cuttings of 3.5 percent, with a range of approximately 2.4 percent to 3.8 percent per well; this is consistent with the treatment commitments of the approved Liza Phase 1 and Liza Phase 2 Development Projects.

Regular testing is conducted to monitor the percent of drilling fluid retained on cuttings and to check that the solids control equipment is functioning correctly. The solids control system has multiple levels of redundancy including multiple shakers, cuttings dryers, and centrifuges that work together as an integrated system to achieve the percent drilling fluid retained on cuttings requirement. An additional layer of redundancy exists in the form of specialized storage containers that can be utilized to capture drill cuttings for additional treatment to ensure compliance if the end-of-well percent drilling fluid retained on cuttings is projected to exceed 6.9 percent; however, there is a low probability of this occurring.

If there is a failure of the cuttings dryers, drilling operations would be adjusted to cease generation of cuttings until the cuttings dryers were returned to operational status. However, the mud pumps would continue pumping to circulate the cuttings out of the well. Auger systems are in place for circulated cuttings not processed through the cuttings dryer. The auger system would transport the cuttings to skips on board the drill ship. The cuttings collected in the skips would be processed (so as to be below specifications) once the cuttings dryers were repaired.

Figure 2.4-1: Typical Solid Control/Fluid Recovery System



Source: MI-Swaco

2.4.3.4 *Well Control*

ExxonMobil's well-control philosophy (and those of its affiliate EEPGL's) is focused on blowout prevention using safety and risk management systems, management of change procedures, international standards, and trained experienced personnel. ExxonMobil's OIMS emphasizes attention to Safety, Well Control, and Environmental Protection (see Section 2.4.2, Drill Ship Selection, Procurement, and Mobilization). This includes proper preparation for wells (well design, well control equipment inspection, and testing), detecting the influx early, closing-in the well efficiently (personnel training and proficiency drills), and circulating-out kicks with weighted drilling fluid in a controlled manner.

2.4.3.5 *Integrated Well Control System*

The following key aspects of well control are common to all ExxonMobil drilling projects, and will be implemented during the Project drilling campaign:

- Designing wells and drilling procedures based on site-specific data and integrated pore pressure prediction (described below in Section 2.4.3.6, Planning Fluid Densities to Control Reservoir Pressure);
- Planning fluid densities to control reservoir pressure;
- Installing BOPE as a secondary well-control mechanism and frequently inspecting and testing the BOPE and control system;

- Specialized training, equipment, and procedures that meet or exceed regulatory requirements; and
- Installing redundant well-flow monitoring devices, and implementing strict well monitoring practices to maximize the likelihood of detecting and shutting in a hydrocarbon influx prior to surface release.

Should an influx occur, standard well-control procedures will be employed; these could include closing-in the well efficiently and circulating-out kicks with kill weight fluids in a controlled manner.

Effective well control begins at the well planning stage, which is described above in Section 2.4.3.4, Well Control. Each of the subsequent aspects of EEPGL's integrated well control program listed above is described in further detail below.

2.4.3.6 Planning Fluid Densities to Control Reservoir Pressure

Blowout prevention while drilling and operating wells relies on a number of interrelated processes and procedures. Drilling will be performed using an overbalanced drilling fluid weight[8] to control the well. Drilling fluids will provide primary well control during execution operations, as they are designed to exert enough hydrostatic pressure on the wellbore to exceed pore pressures, thereby preventing undesired fluid flow into the wellbore. Insufficient drilling fluid weight could lead to an underbalanced condition, and may, in turn, result in an influx of formation fluids. Excessive drilling fluid weight may result in lost circulation, which could in turn lead to a drop in fluid level and an underbalanced condition. A range of drilling fluid weights will be used as the well is drilled to provide the proper well control for the formation conditions encountered.

2.4.3.7 Using Blowout Prevention Equipment

The blowout preventer (BOP) will provide secondary well control during drilling operations once the riser has been installed. Constant monitoring of the total fluid circulating volume and other drilling parameters (as described below) will ensure that an influx of formation fluid into the well is quickly detected. If an influx of formation fluid occurs, secondary well control methods will be applied. The drill pipe will be shut-in by a downhole check valve near the bit and a surface-mounted safety valve, and the well annulus will be shut-in using the BOP. In the event primary well control is lost, actuation of the BOP will contain the influx of

[8] In overbalanced drilling, the pressure exerted by the drilling fluid column exceeds formation pressure, preventing formation fluids from entering the well.

formation fluid and then allow safe circulation of the influx out of the wellbore. Specifically, the BOP's main functions include:

- Closing around the drill string, casing, or liner and allowing circulation;
- Closing and sealing open holes and allowing volumetric well control operations;
- Stripping the drill pipe using the annular preventers;
- Hanging-off drill pipe and controlling the wellbore; and
- Shearing cable or drill pipe.

BOPs are hydraulically activated closing devices. They are typically installed in series, and BOPs installed on a well are often referred to collectively as the "BOP stack." BOPs consist of both ram- and annular-type preventers.

The BOP stack provides capability to shut-in the well. With the well shut-in and with controlled back-pressure, kill-weight drilling fluid can be circulated through the well via the drill stem, annulus, and the choke and/or kill lines to achieve the necessary bottom hole pressure and stop the flow of fluids from the reservoir into the well. Figure 2.4-2 shows the components of a BOP system configuration.

Figure 2.4-2: Typical Blowout Preventer System



2.4.3.8 *Well Control during Riserless Hole Drilling*

EEPGL will conduct a shallow drilling hazards evaluation to identify and characterize shallow drilling hazards at proposed well locations from the drilling fluid line down to the surface casing setting depth. Seafloor, shallow subsurface geologic, and constructed features that may impact proposed oil and gas operations include:

- Seafloor geologic hazards such as fault scarps, gas vents, unstable slopes, and reefs;
- Shallow subsurface geologic hazards such as faults, gas charged sediments, buried channels, and abnormal pressure zones; and
- Synthetic hazards such as pipelines, wellheads, shipwrecks, and debris.

Surface locations are chosen to avoid potential seafloor and subsurface drilling hazards, including shallow hydrocarbon bearing intervals and shallow water flow zones. Shallow hazard assessments include thorough analysis of seismic data (seismic facies identification, amplitude analysis, and geological structure mapping) and the integration of relevant offset well information. EEPGL can adapt drilling plans in place to address shallow flows while drilling the riserless sections of any well.

2.4.3.9 Well Control While Drilling Below the Surface Hole

During drilling operations below the surface hole (after conductor casing has been set), the primary well control barrier will be the hydrostatic pressure of the drilling fluid, but the full BOP stack will be used due to potential for an influx from hydrocarbon zones. Should an influx occur, the BOP will be used to close in the well.

2.4.4 Ancillary Processes

The Project may entail one or more ancillary processes such as VSP, sidetracking, or well testing. None of these activities are currently confirmed for a specific Project well at this stage, but they are all critical diagnostic tools that may be required to help determine the physical properties, productive capacity, pressure, permeability, or extent (or a combination of these) of a hydrocarbon reservoir. These activities have been previously assessed on multiple occasions in support of the ongoing Stabroek exploration drilling campaigns. ERM has also taken a conservative approach in assuming such operations for the purposes of the assessment of potential impacts. It is currently conservatively anticipated that up to 4 well tests per drill ship per year could occur during the Project, as described further in this EA&MP.

2.4.4.1 Sidetracking

One or more of the wells included in the Project may include a sidetrack, which is a secondary wellbore drilled at an angle to the main wellbore and drilled toward the total depth of the well. This procedure may be implemented for mechanical reasons when it becomes impractical to continue drilling the initial wellbore, or it may be implemented to gather additional samples or information not gathered in the initial wellbore. The

drilling program has not been finalized and additional information on sidetracking is not available at this time.

2.4.4.2 *Well Testing*

A well test is a temporary completion of a well to acquire dynamic rate through time, pressure, and fluid property data. The well test often indicates how the well will perform when it is subjected to various flow conditions. An analysis is usually performed on the data to determine reservoir parameters and characteristics including pressure, volume, and temperature. Current testing practices are carried out using modern testing equipment and high-resolution pressure data acquisition systems. The reservoir evaluation objectives depend on the behavior of the formation fluid properties. Well completion and flow assurance situations are only known when testing is carried out.

A production well test is performed by isolating the zone of interest with temporary packers. One or more valves are opened to produce the reservoir fluids through the drill pipe and allow the well to flow for a time. Following testing, hydrocarbons are sent to a flare boom with a burner to ensure as complete of a destruction of fluids (including hydrocarbons) as possible. Flaring may be initiated using diesel or similar fuel to ignite the mixture. More than one flare boom can be used to ensure that burning can be done downwind of the drill ship, and water misters may be used to mitigate heat exposure on the drill ship.

At the end of a production well test, the operator stops the well's flow, closes the valves, removes the packers, and extracts the tools from the hole. Depending on the requirements and goals for the test, it may be of short (1 hour or less) or long (several days or weeks) duration. Downhole sampling normally consists of recovering reservoir fluids via wireline. Wireline testing involves running instruments into the borehole on a cable to measure formation pressures and obtain fluid samples. Formation fluids are brought to the surface where the composition can be analyzed.

It is currently conservatively anticipated that up to 4 well tests per drill ship per year could occur during this campaign.

2.4.4.3 *Vertical Seismic Profiling*

In some reservoir applications, seismic data are acquired with downhole sources (commonly air guns) and receivers. If the receiver is stationed at various depth levels in a well and the source remains on the surface, the measurement is called VSP. This technique produces a high-resolution, 2D image that profiles the vertical plane.

Because the receiver stations are aligned vertically, the data-recording procedure is called VSP to distinguish the technique from conventional

horizontal seismic profiling, in which seismic receivers are deployed across the surface of the Earth. In VSP, a seismic sensor is lowered to a sequence of targeted depths in a well by wireline. The vertical spacing between successive stations is a few tens of feet. A common receiver spacing is 50 feet or 15 meters.

In horizontal seismic profiling along the Earth's surface, only upgoing seismic wavefields are recorded. The crucial information of the downgoing wavefields is not available to assist seismic data processors and interpreters. In VSP, the receiver records the total seismic wavefield, including both downgoing and upgoing events.

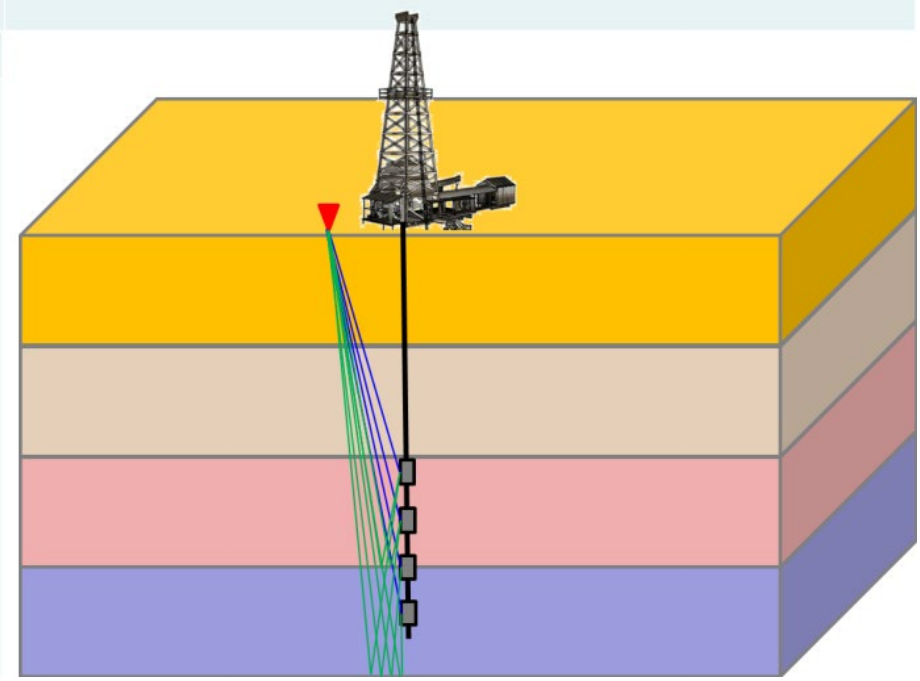
VSP data may be collected to improve velocity modeling and reduce uncertainty in reservoir mapping. VSP surveys can be used to correlate the surface-seismic data to the information on the physical properties and characteristics of the hydrocarbons gained from drilling the well. VSP data, along with check shots and well logs, provide further time/depth information from which to improve knowledge and understanding of the structure and stratigraphy of the reservoir. VSP programs typically last fewer than 20 to 30 hours.

Data are acquired by the receiver, which is installed within the wellbore. The source may be located with zero offset from the well (directly above the wellbore), at a fixed offset (a defined lateral distance from the well), in a walk-away arrangement (at a range of offsets), or at a walk-above arrangement (at zero offset to the downhole well location). The final scope of such a survey and specific geophysical tools to be used are still under review.

While there are no guidelines or regulations specific to VSP currently, EEPGL has and will continue to follow the Joint Nature Conservation Committee (JNCC) guidelines for all of its seismic activities in Guyana. Therefore, appropriate marine mammal protective measures will be taken to ensure that resulting marine sound generated during the survey does not adversely impact marine mammals through the use of Marine Mammal Observers (MMOs) to monitor for the presence of such species and the maintenance of an offset or buffer zone from such sources.

A sample image of an (onshore) zero-offset VSP is provided on Figure 2.4-3. Offshore, as would be the case in the Project, the sound source would be lowered from the drill ship (i.e., zero offset from the wellbore).

Figure 2.4-3: Illustrative Diagram of a Zero-Offset VSP



2.4.5 *Well Plugging and Abandonment*

Once exploration drilling activity is completed, the well will be plugged and abandoned. Several measures will be put in place to ensure that the exploration wells drilled during the Project are properly and securely plugged and abandoned at the end of the proposed exploration activities. Plugged and abandoned wells will be secured with two barriers between any hydrocarbon-bearing formation and the wellbore, consistent with industry standards. Cement will be used to secure the well casing and isolate the wellbore from the formation. A cement plug will also be set near the seabed surface to cap the well. These barriers are integrity tested prior to removal of the BOP at the conclusion of the well operations. The barriers installed are designed to restore the same integrity as the original reservoir caprock that was in place prior to the well construction activities. The barriers are designed on a rock-to-rock basis to provide isolation across the borehole geometry. The two-barrier standard provides redundancy and in the unlikely event of the failure of a single barrier, each barrier is designed to have the integrity required to contain the reservoir formation fluid. The wellhead may be left on the seafloor.

While specific information is unlikely to be available until closer to the time of the well's abandonment, notice of the intent to abandon each well and the specific techniques to be used will, as may be required, be provided to the EPA, Guyana Ministry of the Presidency, Minister Responsible for Petroleum, DE, and GGMC initially in the presentation of the ITD, with receipt of prior consent in the form of no-objection, and then in greater detail in the Well-Specific Drilling Program for each exploration

well in accordance with the Guyana Petroleum Exploration and Production Act (1986) requirements.

2.4.6 *Discharges*

The potential discharges of drilling and well-completion discharges are listed in Table 2.4-1. Potential discharges include drill cuttings and fluids and well completion and treatment fluids, 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 2.4-1, 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 2.4-1, is described in Section 2.4.3.2, Drilling Fluids and Handling System.
- **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.

Table 2.4-1: Summary of Drilling and Completion-Related Discharges

Fluid Type	Estimated Discharge Per Well (bbl) [a]
Drill Cuttings Discharges	7,300
WBDF Discharges	18,900
NABF Retained on Cuttings	1,200 [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

In addition to the above discharges, ballast water discharges from the drill ships will occur. 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. The drill ships used for the Project will have periodic exchanges of ballast water that occur on a daily basis depending on operations at hand and vessel stability.

Ballast Control Officers (role filled by Dynamic Positioning Officers) will pump seawater in or out of various compartments on the drill ships to counteract changes in vessel weights (e.g., as a result of changes in drill

supplies on deck) and locations. All ballast water exchanges that occur during the Project will comply with IMO MARPOL 73/78 and will be recorded in a log book per the Ballast Water Management Plan for each vessel.

2.5 SUPPORT INFRASTRUCTURE AND OPERATIONS

Shorebase activities required to support the continued exploration and development drilling campaign will be consistent with the activities associated with prior exploration and development drilling operations to date. EEPGL plans to use the existing Guyana shorebases located on the east side of the Demerara River as the primary shorebases supporting the Project. Additional onshore facilities may be used by other companies supporting the Project. All onshore support 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 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 assessment presented herein.

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 shorebases; 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 utilized.

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 drilling fluid plant to support offshore drilling operations; and
- Secure handling, storage, and treatment of wastes pending final recycling, treatment, or disposal.

Emergency preparedness and oil spill response supplies will be staged at the shorebases as needed along with those to be maintained on the drill

ships and support vessels. Additional pipe yards or further offsite storage/warehousing facilities may be necessary depending on holding times for long-lead items, and space restrictions or security considerations for select goods and materials may be needed in advance of drilling.

The same or similar support vessels that are being used to support current exploration and development drilling activities in the Stabroek Block will be used to support the Project drilling activities. Table 2.5-1 identifies the current support vessels being used and their primary roles, taking into consideration that all support vessels will be shared across the exploration and development activities in the Stabroek, Canje, and Kaieteur blocks.

Table 2.5-1: Support Vessels and Functions

	Vessel Name	**Type of Vessel/Primary Function**
1	*Cat Island*	Offshore Supply
2	*Horn Island*	Offshore Supply
3	*Eland*	Offshore Supply
4	*Paradise Island*	Offshore Supply
5	*Sanibel Island*	Offshore Supply
6	*Oryx*	Offshore Supply
7	*Clarence Triche*	Offshore Supply
8	*Jack Edwards*	Offshore Supply
9	*Robert Adams*	Offshore Supply
10	*Springbok*	Offshore Supply
11	*Gary Rook*	Offshore Supply
12	*Russell Adams*	Offshore Supply
13	TBD	Offshore Supply
14	TBD	Offshore Supply
15	TBD	Offshore Supply
16	*Amazon*	Offshore Supply
17	TBD	Offshore Supply
18	*Michael Crombie McCall*	Fast Supply
19	*John G McCall*	Fast Supply
20	*Emily D McCall*	Fast Supply
21	TBD	Fast Supply
22	*C-Installer*	Multi-purpose
23	*Kirt Chouest*	Multi-purpose
24	*Guyana Hero*	Offshore Supply
25	*O'Rourke Tide*	Support Tug
26	*Liberty-308*	Support Tug
27	*Seaways 20*	Support Tug

TBD = to be determined

Note: Frequent substitutions of one or more vessels may commonly occur as a result of scheduled maintenance and other scheduling and contracting changes. However, the associated air emissions, wastewater discharges, and waste generation by individual vessels have been conservatively based

on the maximum number of vessels and associated crew members per such vessel types and classes.

In terms of aviation assets, there currently are six helicopters supporting the concurrent operation of four drill ships currently operating offshore Guyana. A seventh helicopter is being added to the fleet to support the addition of a fifth ship in the 2020 timeframe. Additional crews also have been added in order to have the ability to fly simultaneous crew change flights.

Support and supply vessels will require sufficient water depths to transit between the well sites and the shorebases. Although EEPGL currently has no plans to dredge as part of the Project, any such activity, as well as associated permitting and safety measures, would be the responsibility of the facility operator. The transit time between the Project area and the shorebases is approximately 8 hours by support vessel.

2.6 WELL CONTROL TRAINING

2.6.1 Specialized Training, Equipment, and Procedures

EEPGL requires certified well-control training for drilling supervisors, operations superintendents, drilling engineers, contractor drill ship drillers, tool pushers, and other appropriate personnel through an operations training program with a professional organization. The curriculum consists of training in blowout prevention technology and well control. Successful completion results in participant certification.

All EEPGL drill ship supervisors and engineers are certified in well control. All drill ship supervisors, the operations superintendent, engineering manager, and field drilling manager will be experienced professionals. Drill ship crews will be trained to identify warning signs of hazards and to avoid escalation. On-the-job proficiency drills are routinely conducted to ensure an influx can be detected.

EEPGL is committed to providing employment opportunities to the local workforce where possible. Any qualified employee who will be deployed offshore will be provided with health and safety training (including emergency preparedness and response) appropriate for the role they would assume. EEPGL will mobilize internal experts to train any local contractors that may be used to this end, with additional support from Oil Spill Response Ltd. as needed.

Specialized tools will be available to the drilling crews during drilling operations. Logging While Drilling (LWD) is a technique of gathering downhole data while drilling a well through a tool that is installed as part of the bottom hole assembly. Pressure While Drilling (PWD) systems

measure downhole pressure through a tool similarly installed as part of the bottom hole assembly. LWD and PWD tools will provide real-time data on conditions within the well to the drilling crew. Engineers and geologists will monitor drilling data to identify and react to escalating trends. For example, on the *Stena Carron*, Schlumberger's TeleScope tool can be used to obtain real time updates on downhole vibrations and flow (where applicable). These PWD and LWD technologies are used primarily for drilling optimization and formation evaluation.

Prior to drill ship acceptance, comprehensive inspection and testing programs are performed on the drill ship. Routine functional and pressure testing during drilling operations is conducted in compliance with ExxonMobil requirements. BOP drills will be performed on a frequent basis to ensure the well can be shut in quickly and properly. Certified training of personnel will include hands-on simulator practice for recognizing an influx, well shut-in, and circulating the influx out of the wellbore. Certification of BOP inspections, a test schedule, and the names of designated employees to perform the tests can be provided as required.

Well-specific shut-in procedures will be posted on the drill ship. Table 2.6-1 summarizes key features of some training drills that are commonly performed during drilling operations.

Table 2.6-1: Key Aspects of Training Drills

Type of Drill	Key Aspects
Trip drills and pit drills	• Unannounced • Purpose is to reduce time for driller, drill crew and drilling fluid loggers to detect and react to trip tank or pit level changes
Power choke drills	• Performed after setting casing • Conduct crew training using the power choke and manual back-up (i.e., practice bringing on pumps and adjusting choke to control backpressure)
Drill ship gas detector test	• Test gas detectors in areas around the drill ship • Ensure detectors are functioning properly
Fire/gas drills	• Drills include mustering as if fire/gas alarms were sounded
Casing test	• Pressurize casing in wellbore to ensure stability
Well control readiness checklist	• Daily reviews of well control procedures

2.6.2 Monitoring the Well

Monitoring the rate of cuttings production from the drilling fluid returns indicates whether a problem situation is developing, allowing the drilling team to implement corrective measures before an incident can occur. Watching for an increase in cuttings return rate can flag conditions that call for an adjustment of drilling fluid density or other factors. To this end,

the drilling fluid weight (the primary well control mechanism) will be monitored and adjusted based on actual wellbore requirements. Automatic and manual monitoring equipment will be installed to detect abnormal variation in drilling fluid system volumes and properties, and drilling parameters. Systems and processes in place for early detection of formation fluids will include:

- Setting the drill ship and drilling fluid logger Pit Volume Totalizer and Flo-Sho alarms to the lowest practical limits;
- Close monitoring of the standpipe pressure and PWD equipment while drilling;
- Use of trip tanks for monitoring of fluid displacements during trips; and
- Gas monitoring systems.

If an influx of formation fluid into the wellbore occurs, the BOP will be used to immediately shut in the well.

If these monitoring processes flag an irregularity, the well and solids control systems described above can be used to correct/mitigate any issues. The systems noted above, for example, can be displayed to the primary operator via monitoring visualization software (e.g., graphs of pressure, weight on bit, cuttings production) that allows the driller(s) to make operational decisions.

2.6.3 Oil Spill Prevention, Control, and Emergency Response Measures

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 (OIMS; see Section 3.4, ExxonMobil's Operations Integrity Management System) 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.

In addition to the established spill prevention controls, EEPGL also has developed a detailed Oil Spill Response Plan (OSRP)[9], which is used together with the Project's ESMP (Chapter 8, Environmental and Socioeconomic Management Plan), 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 in Section 2.9.1, Oil Spill or Release, 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 draft National Oil Spill Contingency Plan outlines how the Civil Defense Commission will coordinate the responses of other agencies, including Maritime Administration Department (MARAD).

2.7 WASTE GENERATION

The Project will generate hazardous and non-hazardous wastes in a "per linear well-foot" volume similar to exploration campaigns conducted to date. Table 2.7-1 presents estimates of the quantities for major categories of wastes that would be generated based on the class of drill ships that would be used; anticipated number of support vessels and typical crew sizes normally used for deepwater well drilling of this type; planned duration of the drilling campaign, as described above; and experience gained on previous exploration wells drilled in the Stabroek Block. Waste will begin to be generated when drilling commences in 2021 and extend through the life of the exploration drilling campaign.

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. The Project is planning to use similar facilities in Guyana or the region during the exploration drilling. To the extent that solid wastes are

[9] EEPGL maintains an affiliate-level OSRP, which was most recently updated as part of the updated Payara Development Project EIA in February 2020. This plan currently covers oil spill response-related aspects of all affiliate activities in Guyana.

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 EA&MP. All Project waste streams will be managed in accordance with the WMP (Appendix A).

Table 2.7-1: Preliminary Estimates of Per-Well Waste Volumes to be Generated by the Project

Waste Type	Quantity
Hazardous waste [a]	≤100 tonnes
Cardboard	≤2 tonnes
Aluminum cans	≤1 tonnes
Scrap wood	≤15 tonnes
Plastic	≤4 tonnes
Scrap metal	≤16 tonnes
Food waste	≤10 tonnes
Sanitary and domestic wastes	2,500–4,500 m^3

m^3 = cubic meter

[a] Includes oily residues

2.8 AIR EMISSIONS

Air emissions for the Project have been calculated and estimated from actual experience to date. These estimates account for the potential of up to 4 well tests per drill ship per year, and with up to 8 support vessel trips per month per drill ship, as well as 15 helicopter trips per month per drill ship. These preliminary estimates of monthly and annual emissions are presented in Table 2.8-1, and the predicted onshore concentration impacts are discussed further in the impact assessment section.

Table 2.8-1: Preliminary Estimates of Air Emissions

Emissions Source	NO_x	SO_2	PM	CO	H_2S
Emissions in tonnes/month					
Drill Ships [a]	321	11	23	67	<0.01
Flaring	32	50	<0.5	171	0.6
Support Vessels	16	<0.5	<0.5	3	<0.01
Helicopter Flights	1	<0.1	<0.1	<0.5	<0.01
Incineration	<0.1	<0.01	<0.01	<0.01	<0.01
Total Monthly Emissions	370	62	25	242	0.6
Emissions in tonnes/year					
Drill Ships [a]	3,856	129	271	803	<0.1
Flaring	378	605	11	2,056	7
Support Vessels	193	6	14	40	<0.1
Helicopter Flights	8	1	1	2	<0.1
Incineration	1	<0.1	<0.1	<0.1	<0.1
Total Annual Emissions	4,436	742	296	2,902	7

CO = carbon monoxide; H_2S = hydrogen sulfide; PM = particulate matter; SO_2 = sulfur dioxide

[a] Based on 5,044 kilogallons of diesel per year per drill ship / 12 months per year = 420 kilogallons/month

Notes:

1. The annual estimated totals generally reflect the current preliminary Project schedule and remain subject to adjustment. The totals shown here reflect ***four*** drill ships conducting Project exploration drilling activities (the number of ships modeled for 2022).
2. PM emissions represent total PM; for the purpose of the assessment, the results from modeling of total PM values were used for comparison to both PM_{10} (particulate matter with an aerodynamic diameter less than 10 microns) standards and $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5 microns) standards (a conservative assumption).

2.9 *UNPLANNED EVENTS*

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. For the purposes of this EA&MP, the following unplanned events are considered as having the potential to occur during the Project life, should a combination of standard and Project-specific safety controls fail concurrently:

- Marine oil spill (potentially resulting from a loss-of-well-control event);
- NADF release as a result of a drill ship losing station and releasing the contents of some or all of the drilling riser pipe;
- Coastal oil spill (potentially resulting from a loss of diesel fuel from a Project support vessel near a shorebase);
- Marine vessel collision (focused on potential physical damage to other vessels or structures, and/or injuries to marine animals); and
- Onshore vehicular accident.

Unplanned events, such as a potential oil spill, are considered unlikely to occur because of the extensive preventative measures employed by EEPGL. As described in prior submittals to the EPA, a loss-of-well-control event is a rare event in the oil and gas industry. This applies to active as well as plugged-and-abandoned wells, so the potential for a properly plugged-and-abandoned well to "blow out" is also remote. 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 EA&MP. These other unplanned events could occur on the drill ships, marine and aviation support vessels, and equipment, 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.

2.9.1 Oil Spill or Release

Exploratory drilling for crude oil is the core Project activity. Additionally, the Project will use marine vessels, helicopters, and equipment that use petroleum products for fuel and lubrication. There are multiple layers of controls in place with respect to these activities; however, if multiple controls fail, there is the potential for a hydrocarbon spill to occur. EEPGL categorizes hydrocarbon spills into three tiers:

- Tier I—Spill is small, the source of the 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.

Effective implementation of the OSRP would reduce risks posed by a spill by reducing the ocean surface area impacted by a spill and thereby reducing potential exposure of the environment to oil. In the event of a loss-of-well-control scenario, EEPGL's affiliate-level OSRP would be immediately activated and measures would be implemented to mitigate the effects of the spill. In the unlikely event that an uncontrolled release occurred from an abandoned wellbore, options for intervention would be similar to those for an active deepwater well undergoing drilling and would include installation of a BOP or capping stack or drilling of a relief well.

Due to the precautionary measures utilized by EEPGL to prevent and control an oil spill, as described herein and in Section 2.6.3, Oil Spill Prevention, Control, and Emergency Response, the likelihood of a Tier II or III oil spill occurring is considered to be **Unlikely**.

Hydrocarbons that could potentially be released include crude oil, marine diesel, fuel oil, aviation fuel, lubricating oil, and NADF. Releases of hydrocarbons could result from a number of different unplanned events. Discussions of the unplanned events considered are provided below.

2.9.1.1 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 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.

2.9.1.2 *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 development-drilling activities—inclusive of well planning, drilling, ancillary processes, and well plugging and abandonment activities. These vessels will transit between the Guyana shorebase(s) and the Project area. 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 Georgetown Harbour or other coastal areas will be required to observe standard international and local navigation procedures (e.g., adhere to speed restrictions and navigation aids), as well as best ship-keeping and navigation practices while at sea.

2.9.1.3 *Offshore Collision between Project Vessels or between a Project Vessel and Another (Third-Party) Vessel*

Other vessel collisions (e.g., collisions between drill ships and other vessels) are not considered reasonably foreseeable scenarios given the following safety measures that will be put in place:

- Notices to Mariners will be issued via MARAD, the Trawler's Association, and fishing co-ops to inform of drill ship movements to aid marine users in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.
- Ongoing stakeholder engagement processes will be augmented (along with those for relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notice to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.
- 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.
- EEPGL will utilize a SIMOPs 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., dynamic position systems on drill ships) to maintain station in the offshore environment.

2.9.1.4 *Helicopter Ditching*

The Project will involve the use of helicopters to support drilling activities. It is estimated that during exploration/appraisal drilling, approximately 15 helicopter trips per month per drill ship will support the operations. 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 EA&MP. However, a ditching event could potentially result in a spill of aviation

fuel or lubricating oils from the helicopter and related potential localized environmental impacts.

2.9.1.5 Other Shorebase-Related Events

Spills of hydrocarbons at the shorebase(s) 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.

2.9.1.6 Oil Spill Scenarios Considered in the Risk Assessment

Releases of hydrocarbons could result from a number of different unplanned events. Based on the considerations of unplanned events discussed above, a range of potential spill scenarios were considered that are applicable to this Project. These include:

- Spills during exploration drilling operations (loss-of-well-control or spills of NADF);
- Spills of fuel offshore (release of fuel from drill ship, supply vessel, project vessel, or helicopter ditching); and
- Spills of fuel at the Guyana shorebase(s).

An oil spill from a loss-of-well-control event, NADF spill, offshore vessel, or offshore helicopter ditching are collectively referred to herein as a "marine oil spill." An oil spill from nearshore vessels or helicopters and from vessels at the shorebase(s) are collectively referred to herein as a "coastal oil spill."

EEPGL has previously conducted oil spill modeling to evaluate the range of likely spill trajectories and rates of travel in the unlikely event of a marine oil spill in the Stabroek Block. The results of these analyses were provided to the EPA as part of the Liza Phase 1, Liza Phase 2, and Payara Development Project regulatory submittals.

While several coastal and marine oil spill scenarios are described in the oil spill modeling, a higher-volume marine oil spill (30-day duration at 202,000 barrels per day) and coastal oil spill (up to 500 barrels) scenarios were the focus of the resource-specific assessments, to provide a conservative assessment of potential risk. The most recent results of spill modeling for the Stabroek Block are described in the Payara Development Project EIA (ERM et al. 2019).

Modeling for the Liza Phase 1, Liza Phase 2, and Payara Development Projects indicates that for a loss-of-well-control event (i.e., a blowout), the

location of the Stabroek Block (200 kilometers offshore), prevailing northwest currents, the anticipated light to medium nature of the crude oil, and the region's warm waters would all help reduce the severity of a spill. As such, the modeling results from the Liza Phase 1, Liza Phase 2, and Payara EIAs would be expected to be representative of a spill from the Project area.

2.9.2 Vessel Collisions

This section includes a description of possible vessel collisions with a third-party vessel, structure, or animal for non-spill related impacts.

2.9.2.1 Vessel Collision with a Third-Party Vessel or Structure

This section addresses the potential non-spill related aspect of a vessel collision with a third-party vessel or structure.

As discussed in Section 2.5, Support Infrastructure and Operations, a variety of Project vessels will supply and support well planning, drilling, ancillary processes, and well plugging and abandonment activities, and these vessels will transit between the Guyana shorebase(s) and the Project area. 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 shorebase(s) are downstream of the Demerara Harbour Bridge, which reduces the probability of a Project-related vessel colliding with this structure.

2.9.2.2 Vessel Collision with Marine Mammals, Turtles, or Seabirds

This section addresses the potential for a Project vessel to collide with a marine animal, specifically focusing on marine mammals, turtles, and seabirds.

Collisions with vessels can injure or kill marine mammals. Marine mammals possess an acute sense 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 Project area will

be low, reducing the potential for collisions. The only planned nearshore activities will be supply vessels entering/ exiting shorebase(s), but even at the peak of drilling, the incremental increase in traffic near shorebase(s) will represent a small increase in overall risk to marine mammals.

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 5.2.4.1, 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.

There is very little potential for collisions to occur within the Project area, but the potential remains for individual marine mammals or turtles to collide with vessels transiting between the Project area and shorebase(s). The greatest potential for collisions to occur will be during drilling, when vessel traffic is at its peak; accordingly, the risk of injury or mortality from vessel collisions will be higher during drilling 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:

- Provision of awareness training to Project-dedicated marine personnel to recognize signs of marine mammals at the sea surface and marine turtles in shallow nearshore areas; and
- Standing instruction to Project-dedicated vessel masters to avoid marine mammals and marine turtles while underway and reduce their speed or deviate from course, as needed, to reduce probability of collisions.

Given the relatively low number of vessel movements, limited number of marine turtles expected to be passing through the Project area or transit corridor, and the tendency of concentrations of inter-nesting turtles to remain generally near the nesting beaches in the far western portion of Guyana's EEZ (far removed from Project-related vessel traffic) as demonstrated by recent telemetry data, a collision with a marine turtle is considered **Unlikely**.

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, such an event is **Possible**.

Rafting seabirds may suffer injury or mortality from vessels colliding with them when transiting to and from the Project area. However, rafters are not likely to be present in large aggregations in the Project area 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. On the rare occasions that suitable conditions for rafting occur in the Project area and seabirds presence is high enough in 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.

Given the low likelihood of vessels encountering rafting seabirds and EEGPL's embedded control of providing standing instruction to Project dedicated vessel masters to avoid any identified rafting seabirds (that do not move out of the vessel's path on their own) when transiting to and from the Project area, the likelihood of a vessel collision with a seabird is considered **Unlikely**.

2.9.3 Onshore Vehicular Accident

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 shorebase(s) operations have been designed to minimize road movement of freight. Although the Project-related traffic volume is incrementally insignificant with respect to existing traffic volumes in the vicinity of the shorebases (for example), the potential for a vehicular accident involving a Project-related vehicle is considered **Possible**.

2.10 UPDATES TO THE PROJECT DESCRIPTION

To allow flexibility to respond to new information gained during drilling operations and geological interpretation, this Project Description is written to describe a range of drilling and testing options, some of which may not be executed. EEPGL is seeking permits to cover all the activities described and assessed under this EA&MP; however, it also recognizes that the EPA, GGMC, and DE would benefit from additional information on the proposed activities as and when such information becomes available. EEPGL proposes to submit the following information as part of the ITD for each well, prior to the start of drilling activities at each well site:

- Locations of proposed wells;
- Description of anticipated well design;

- Identification of any ancillary activities to be undertaken for each well (e.g., VSP, well test, sidetrack);
- Anticipated drilling schedule; and
- Any anticipated differences between the specific activities planned for the well and the general descriptions provided in this Project Description.

EEPGL plans to submit the above information in a form or template that will be consistent across all the wells to be drilled as part of the Project. Additionally, a Well-Specific Drilling Program will be submitted to the EPA prior to spud.

3 ADMINISTRATIVE FRAMEWORK

The Project will be regulated under several Guyanese statutes establishing the requirements of the applicable laws and regulations of Guyana. This chapter reviews the relevant laws and regulations in Guyana applicable to the Project, together with certain relevant Government of Guyana policies and strategies. The chapter is separated into four 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 the Co-operative Republic of Guyana, as well as specific 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, 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 3.3, 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 3.4, ExxonMobil'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, environmental, and socioeconomic performance.

3.1 NATIONAL LEGAL FRAMEWORK

This section provides an overview of the key pieces of legislation currently in force in Guyana that could pertain 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 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 impact the environment, and the penalties for environmental infractions. It also provides for the establishment of an environmental trust fund. Most importantly, the Act authorizes 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 GGMC, which is within the Ministry of Natural Resources. The GGMC promotes and regulates the exploration and development of the country's mineral 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 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, including the territorial sea, continental shelf, and EEZ. This act identifies persons allowed to hold prospecting licenses, establishes the process for obtaining prospecting licenses, and specifies requirements for further resource development in the event petroleum resources are discovered.

3.1.6 Amerindian Act

The Amerindian Act of 2006 provides for the recognition of the collective rights of Amerindian communities and villages as well as the granting of lands and promotion of good governance within all Amerindian communities and villages.

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 that could be affected in the event of an oil spill from the Project.

3.1.7 Other Applicable Legislation

Several Guyanese environmental laws with more narrowly defined scopes pertain to specific biological or physical natural resources. Other laws, which primarily have a public-health-related focus, are also 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. Table 3.1-1 identifies these laws and summarizes their relevance to the Project.

Table 3.1-1: Resource-Specific Environmental and Social Laws with Relevance to the Project

Title	Objective	Relevance to the Project
Biological Resources		
Fisheries Act, 2002	Regulates fishing and related activities in Guyana territorial waters.	Section 33(1) of the Fisheries Act authorizes the prohibition and/or regulation of deposition or discharge of substances harmful to fish.
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013; the Wild Birds Protection Act, 1987; and the Species Protection Regulations, 1999)	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 support mechanism cognizant of national goals for wildlife protection, conservation, management, sustainable use, and external trade.
Physical Resources		
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.
Environmental Protection Air Quality Regulations, 2000	Sets ambient air quality standards, reporting requirements, penalties for violations of standards, and permitting requirements for stationary and mobile sources of air emissions.	Regulates emissions that could be part of the Project.
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.
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.	Regulated facilities include any offshore installation and any other installation, whether floating or resting on the seabed.

Title	Objective	Relevance to the Project
Pesticides and Toxic Chemicals Control Act No. 13 of 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 chemicals listed as toxic may be used.
Pesticides and Toxic Chemicals Regulations, 2003	Deems pesticides or toxic chemicals as prohibited if they are a contravention of any known requirement of the laws of the country in which they were manufactured or produced or banned by the United Nations. Restricts manufacturing, importing, advertising, selling, using, storing, or transporting any controlled substance unless they are registered and a license is obtained for the manufacturing and importing.	Requires all toxic chemicals to be registered with the Pesticides and Toxic Chemicals Control Board before being used in Project-related applications. Requires an import license to be obtained for importation of any toxic materials.
Draft Guyana Standard, Requirements for Industrial Effluent Discharge into the Environment, 2015	Compulsory standard used for monitoring effluents discharged into freshwater, estuarine, and marine water resources.	Sets limits for key parameters in discharges of industrial effluent, including Project-related discharges.
Public Health		
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.
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.
Socioeconomic Resources		
National Trust Act, 1972	Stewardship of historic resources and places of cultural significance.	Governs the management of any building, structure, object, or other man-made or natural feature that is of historic or national cultural significance that could be impacted by the Project (e.g., shipwrecks and other such marine features).

Title	Objective	Relevance to the Project
Local Content Policy (released in February 2020)	Provides for first consideration and fair and adequate opportunity of Guyanese where capability exists. The objectives are to: be fit-for-purpose; promote education, inclusion, and advancements; localize supply chains; align with good industry standards; grow supplier competencies to become world-class and develop export potential; retain value in the Guyanese economy; enhance other sectors of the economy; build and enhance institutional capacity; invest in physical utilities, infrastructure, and facilities; invite partnering; and develop world-class capacity in key state institutions to implement the policy.	Includes government guidance on Guyanese participation in the petroleum sector. Expected to directly influence Guyanese service provision and employment in the sector. Includes prescriptive development of plans and reporting.

3.2 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 possibly applicable to the Project.

3.2.1 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, and 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.

3.2.2 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 the forests in an effort to reduce global carbon emissions and at the same time attract payments from 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. The LCDS identifies Reducing Deforestation and Forest Degradation Plus as a primary mechanism for achieving the goals of the strategy.

3.2.3 National Development Strategy

The National Development Strategy (NDS) sets priorities for Guyana's economic and social development policies for the next decade. The NDS 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, with Volumes 3 and 5 being the most relevant to the Project. Volume 3 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 into the future (NDS 1997).

3.2.4 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.

3.2.5 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 the government is currently undertaking 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 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).

3.2.6 *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 use, 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.

3.3 *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. Table 3.3-1 lists the key agreements relevant to the Project to which Guyana has acceded or is a signatory.

Table 3.3-1: Guyana-Signed/Acceded International Agreements Relevant to Environmental or Socioeconomic Issues

Agreement/ Convention	Objective	Guyana Status	Relevance to Project
Climate Change/Air Quality			
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.	Acceded and ratified in 1994	Provides the framework for possible future controls on greenhouse gases (GHG) emissions within Guyana's territory (maritime and land), and the framework for establishing national policy regarding adaptation to climate change.
Kyoto Protocol	Extends the United Nations Framework Convention on Climate Change and commits countries to reduce GHG emissions.	Acceded in 2003	Establishes national GHG emission reduction targets. The Kyoto Protocol has been superseded by the Paris Agreement.

Agreement/ Convention	Objective	Guyana Status	Relevance to Project
Vienna Convention on the Protection of the Ozone Layer	Provides a framework for the protection of the ozone layer.	Acceded in 1993	Establishes measures for protecting the ozone layer.
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.	Acceded in 1993	Prohibits the use of several groups of halogenated hydrocarbons that may deplete the ozone layer.
Pollution Prevention			
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.	Acceded in 1997	Impacts the handling and disposition of controlled substances from the drill ships, and support vessels.
International Convention for Safe Containers	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.	Acceded in 1997	Regulates the manufacture, use, and integrity of containers used on board the drill ships and support vessels.
International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties	Confirms the right of coastal member states to take specific actions when necessary to prevent pollution from oil following a maritime casualty.	Acceded in 1997	Would protect Guyana's rights to respond to an oil spill if such an event were to occur.
Basel Convention on the Transboundary Movement of Hazardous Wastes and Their Disposal	Reduces and controls the movements of hazardous waste between nations and discourages transfer of hazardous waste from developed to less-developed countries.	Acceded in 2001	Would apply to the Project only if hazardous waste generated in Guyana is disposed outside Guyana.

Agreement/ Convention	Objective	Guyana Status	Relevance to Project
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	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.	Acceded June 2007	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.
Stockholm Convention on Persistent Organic Pollutants, as amended	Requires party nations to take measures to eliminate or reduce the release of persistent organic pollutants.	Acceded September 2007	Would apply to the Project only if persistent organic pollutants are released to the environment during the course of Project-related activities.
International Convention on Oil Pollution Preparedness, Response and Cooperation	Establishes measures for dealing with marine oil pollution incidents.	Ratified in 1997	Requires ships and operators of offshore units to have oil spill emergency plans and to report any discharge or probable discharge of oil.
Oil Spills Protocol – Cartagena Convention	The Protocol Concerning Co-operation and Development in Combating Oil Spills in the Wider Caribbean Region calls for strengthened national and regional preparedness, and response capacity of the nations and territories of the region.	Acceded and Ratified in 2010	The Protocol facilitates cooperation and mutual assistance in cases of emergency to prevent and control major oil spill incidents.
International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage	Provides financial compensation for oil pollution damage that occurs in member states, resulting from spills of persistent oil from tankers.	Guyana is not currently a formal party, but participates as an observer nation	The Convention would provide supplementary funds to member states for remediation of oil spilled from export tankers.
Ecological/Environmental Quality			
The Cartagena Convention for the Protection and Development of the Marine Environment in the	Provides a framework for international protection and development of the marine environment	Acceded and Ratified in 2010	Sets general goals for protection of the marine environment, especially from possible pollution.

Agreement/ Convention	Objective	Guyana Status	Relevance to Project
Wider Caribbean Region	across the Caribbean region.		
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.	Acceded and Ratified in 2010	Elaborates on the wildlife goals established in the Cartagena Convention and Convention on Biological Diversity.
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.	Signed in 1992, ratified in 1994	Discourages activities that would negatively impact biodiversity.
United Nations Convention on the Law of the Sea	Defines nations' rights and responsibilities in terms of their use of oceans and provides guidance on environmental and natural resource management.	Concluded in 1982 and ratified in 1994	Encourages resource development be done in a way that supports healthy global economic growth and trade balance, and mandates that states take measures to prevent, control, and reduce pollution of the oceans.
Convention on International Trade in Endangered Species of Wild Flora and Fauna	Protects endangered plants and animals from international trade.	Acceded in 1977	Restricts collection and trade of endangered species.
United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage	Protects "all traces of human existence having a cultural, historical, or archaeological character" that have been underwater for over 100 years.	Ratified in 2014	Would apply to any shipwrecks or other submerged cultural heritage in the Project area.

Agreement/ Convention	Objective	Guyana Status	Relevance to Project
Labor/Health/Safety			
International Convention for the Safety of Life at Sea	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.	Acceded in 1997	Affects construction, operation, and equipment on board the drill ships and support vessels.
Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation	Promotes safety at sea by criminalizing actions that would endanger a vessel or its cargo, or that contribute to activities that would do so.	Acceded in 2003	Would apply to any activity intended to endanger vessels while conducting Project-related activities.
Dock Work Convention	Regulates activities associated with the loading and unloading of cargo onto/from oceangoing vessels when at port.	Acceded 1983	Applies to loading and offloading activities at Project shorebases.
Repatriation of Seafarers Convention (Revised)	Requires vessel owners/ operators to repatriate (at the operator's expense) seafarers that have successfully concluded a minimum period of service on board a vessel (minimum time to qualify for this benefit to be determined by the member state but not to exceed 12 months).	Acceded 1996	Would apply to workers on board both EEPGL-owned/ operated vessels, and those of their contractors.
Seafarer's Identify Documents Convention	Requires signatory states to issue identity cards to seafarers and for other signatory states to allow holders of these cards entry to their territories for the purposes of shore leave, joining a crew, or repatriation after completing a voyage.	Acceded 1966	Applies to seafarers entering or egressing Guyana prior to or following employment on vessels operated by EEPGL or those of its contractors, and to seafarers on shore leave while employed by EEPGL or its contractors.

Agreement/ Convention	Objective	Guyana Status	Relevance to Project
Convention on the International Regulations for Preventing Collisions at Sea	Officially recognizes the importance of traffic separation in the marine environment and codifies basic measures to accommodate traffic separation, including safe speed, signaling conventions, and general vessel conduct.	Acceded in 1997	Governs maritime operation of drill ships and support vessels.
International Convention on Standards of Training, Certification and Watchkeeping	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 IMO concerning administrative measures taken to ensure compliance with the convention.	Acceded in 1997	Impacts required capabilities of crew on board the drill ships and support vessels, and provides for inspection by authorities to ensure compliance.
Convention on Facilitation of International Maritime Traffic	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.	Acceded in 1998	Facilitates entry of drill ships and support vessels into Guyana.

Guyana is a member state of two organizations that administer multiple international treaties and conventions: the International Labour Organization (ILO) and the 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 would govern certain specific aspects of the Project as they relate to labor.

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 Minister of Public Infrastructure's MARAD 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.

Guyana also belongs to other international organizations such as the Organization of American State, 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 the 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.[10]

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.

3.4 EXXONMOBIL'S OPERATIONS INTEGRITY MANAGEMENT SYSTEM

EEPGL is committed to 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 Safety, Security, Health, Environmental, and Product Safety policies and in ExxonMobil's Standards of Business Conduct (Appendix B). These policies are put into practice through a disciplined management framework called 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 will be consistent with the risks associated with the business activities being planned and performed. Figure 3.4-1 provides a high-level description of the OIMS Framework and its 11 essential elements.

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

Figure 3.4-1: Operations Integrity Management System



4 METHODOLOGY FOR PREPARING THE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT PLAN

The objectives of the impact assessment and management and monitoring strategy components of the EA&MP are fundamentally different, and require different methodologies. Both are predictive in the sense that they relate to future conditions, but the impact assessment is descriptive while the management and monitoring strategy is more action-oriented. The following subsections describe the methodological approaches for each of these components.

4.1 EA&MP METHODOLOGY

The impact assessment process is essentially a comparative process that identifies differences between existing physical, biological, and socioeconomic conditions and the projected conditions that are directly or indirectly attributable to the Project, as well as potential cumulative impacts that may result from the Project in combination with other past, present, and reasonably foreseeable future activities. The EA&MP focuses primarily on the resources potentially impacted in Guyana, but also identifies any potential transboundary effects (i.e., effects on other countries or their territorial waters). Information on potential impacts, including potential cumulative impacts generated from the activities required to develop the Project in Guyana, was obtained from various sources, including consultation with governmental and non-governmental stakeholders; impact assessments for similar projects worldwide; scientific research and literature; and Project-specific analyses.

The impact assessment process involves rating impacts from planned Project activities and rating risks from unplanned events (e.g., oil spills, vessel strikes, or other events with a low probability of occurrence) that could be associated with the Project. The impact assessment of planned Project activities consists of three primary steps: identifying the potential sources of Project-generated impacts, describing the characteristics of each impact, and rating the significance of each impact. Potential impacts from planned Project activities were rated according to the magnitude of the potential impact, and the sensitivity/vulnerability/importance of a given resource or receptor. The risks for unplanned events were rated according to the likelihood of occurrence of the unplanned event, and the consequence/severity of the impact on the affected resource if it were to occur.

4.1.1 Criteria for Rating Impacts

Impacts will be rated according to (1) the magnitude of the potential impact and (2) the sensitivity/vulnerability/importance of the impacted resource or receptor. These elements are described in greater detail below.

4.1.1.1 Magnitude

Magnitude essentially describes the degree of change that the identified potential impact is likely to impart upon the resource or receptor.

Magnitude is a function of some or all of the following impact characteristics:

- Geographical Extent
- Intensity
- Frequency
- Duration
- Degree of reversibility

The magnitude of impacts 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 that may be immeasurable or undetectable. Such changes will be 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

Not all impacts can be assessed according to the same criteria, so the magnitude ratings for specific impacts may be determined differently according to the resource/receptor (or the type of impact) being assessed.

4.1.1.2 Sensitivity/Vulnerability/Importance

A range of 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 assessment 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 assessment:

- Low
- Medium
- High

4.1.1.3 *Determining Impact Significance*

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 of the resource/receptor. The matrix depicted on Figure 4.1-1 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.

Figure 4.1-1: Impact Significance Rating Matrix for Planned Activities

		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

Mitigation measures or management measures are proposed commensurate with the impact significance ratings. Management measures are generally not developed for potential adverse impacts that are deemed to be of **Negligible** significance.

Magnitudes are generally not assigned in the case of positive impacts. It is usually sufficient to indicate that the Project will result in a positive impact without characterizing the exact degree of positive change likely to occur.

Following identification of mitigation measures or management measures, the residual significance of each potential impact (i.e., considering the implementation of the identified mitigation or management measures) is characterized.

Where appropriate, the spatial and temporal extent of potential adverse impacts will be described to provide context to the impact assessment. In addition, the concept of reversibility is addressed, as appropriate.

4.1.2 Rating Risk 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 assessment 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 4.1-2) is used to rate the risk to resources associated with these events.

Figure 4.1-2: Unplanned Events Risk Matrix

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

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 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.

4.1.3 Cumulative Impacts

Potential cumulative impacts on environmental and socioeconomic resources as potential receptors of impacts from the Project and other non-Project activities are discussed in Chapter 7, Cumulative Impact Assessment.

4.1.4 Resources/Receptors Assessed in the EA&MP

Table 4.1-1 identifies the resources/receptors that could potentially be impacted by the Project, and describes the potential impacts that will be assessed in the EA&MP.

Table 4.1-1: Resources/Receptors and Potential Impacts Assessed in the EA&MP

Resource or Receptor	Potential Impact
Marine Water Quality	The Project will have localized impacts on marine water quality in the Project area from discharge of drill cuttings and from routine operational and hydrotesting discharges. The Project also could potentially impact marine water quality in the Project Area of Influence (AOI) as a result of non-routine, unplanned events (i.e., oil spill or release).

Resource or Receptor	Potential Impact
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. Project activities will also generate greenhouse gas (GHG) emissions, which may increase the concentrations of GHGs in the atmosphere.
Coastal and Marine Geology and Stratigraphy	The Project will disturb marine geology and sediments on a localized basis in the Project area and could impact sediment quality from deposition of NABF adhered to discharged drill cuttings.
Bathymetry	The Project may have localized impacts on bathymetry in the Project area from discharge of drill cuttings directly on the seafloor.
Natural Hazards	Indirect impacts on seismicity and other natural hazards are not expected as a result of the Project, but this is discussed in the EA&MP.
Coastal Habitats	The Project is not expected to impact beaches, mangroves, mudbanks, coastal or marine habitats, coastal bird habitats, coastal fish habitats, or wetlands in the Project AOI as a result of routine, planned activities. The Project could potentially impact beaches, mangroves, mudbanks, coastal or marine habitats, coastal bird habitats, coastal fish habitats, and coastal wetland habitats in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).
Benthic Resources	The Project could potentially disturb some benthic habitat and organisms in a localized manner in the Project area.
Fishery Resources	The Project could potentially impact marine fish as a result of underwater sound, light, changes to seafloor habitat, and changes in marine water quality in the Project area. 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).
Marine Turtles and Mammals	The Project could potentially impact marine turtle and mammal 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 and mammal individuals in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release, vessel strikes).
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).
Special Status Species	The Project could potentially impact some special status species individuals (e.g., listed endangered or threatened species) in the Project area as a result of underwater sound, light, and/or changes in marine water quality. The Project could potentially impact special status species in the Project

Resource or Receptor	Potential Impact
	AOI as a result of non-routine, unplanned events (e.g., oil spill or release, vessel strike).
Protected Areas	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).
Coastal Demographics	The Project is not expected to directly cause any changes to population or demographics. 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).
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).
Cultural and Archaeological Resources	The Project has the potential to adversely affect cultural heritage through localized disturbance of any archaeological or historical resources present in the subsea Project area. 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 area as a result of non-routine, unplanned events (i.e., oil spill or release).
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). 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.
Tourism and Recreation	The Project is not expected to impact tourism and recreation in the Project AOI as a result of routine, planned activities, as the bulk of Project-related activities will occur offshore, and activities at the shorebase will occur within an industrial zone. Potential adverse impacts on tourism and recreation could occur as a result of non-routine, unplanned events (i.e., oil spill or release).

4.2 ENVIRONMENTAL AND SOCIOECONOMIC MANAGEMENT AND MONITORING STRATEGY METHODOLOGY

The management and monitoring strategy component (Chapter 8) of the EA&MP builds on the findings of the assessment (Chapter 6 and 7) and identifies measures that EEPGL might implement to reduce the significance of potential environmental and socioeconomic impacts described in the assessment.

In accordance with international best practice, the management and monitoring strategy reflects a hierarchical approach to impact management, which reduces impacts through a staged process as follows:

- Anticipate and avoid impacts when and where possible;
- Minimize impacts in cases where avoidance is not possible; and
- Mitigate residual impacts that remain, following application of avoidance and minimization strategies.

At each stage in the hierarchy, options have been evaluated to reduce the magnitude and/or sensitivity that underpin the significance rating for each potential impact from planned Project activities and each risk associated with an unplanned event. The management and monitoring strategy is adaptive in nature, allowing sufficient flexibility to address unanticipated impacts resulting from operational or schedule changes. To the extent possible, the EA&MP has identified protocols for documentation, record keeping, reporting, and quality control during the monitoring phase.

5 DESCRIPTION OF THE EXISTING ENVIRONMENT

5.1 PHYSICAL RESOURCES

5.1.1 Marine Water Quality

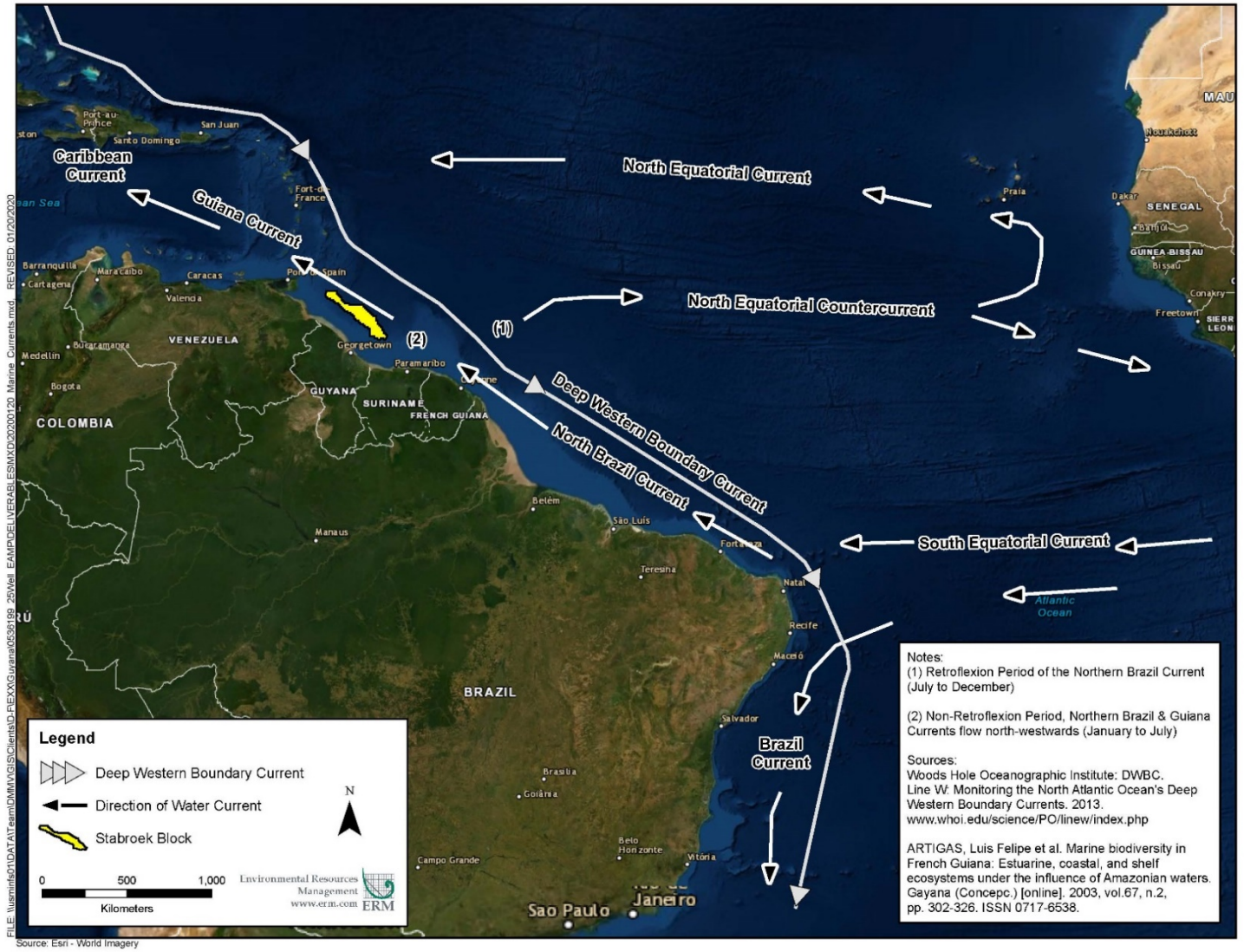
5.1.1.1 Currents

Guyana's marine environment is 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 fresh water discharges from these major rivers, as well as Guyana's own Essequibo, Demerara, and Berbice rivers (FAO 2005). The large amount of freshwater discharge affects the flow, temperature, and salinity offshore of Guyana. Oceanic water is relatively heavy, cold, and saline compared to the lighter, warmer, and fresher waters of the Amazon and Orinoco rivers. Convergences between continental and oceanic water masses form oceanic fronts offshore Guyana. Freshwater lenses generated by the Amazon and Orinoco rivers are transported across Guyana's continental shelf to points north and west. These freshwater lenses can persist for months, and have been detected as far away as Barbados and Trinidad (Sherman and Hempel 2009).

The offshore region of Guyana is considered part of the North Brazil Shelf Large Marine Ecosystem (LME). The North Brazil Shelf LME has alternately warmed and cooled over the last few decades with a period of cooling occurring between the mid-1970s through the mid-1990s. Since the mid-1990s, the North Brazil Shelf LME has consistently warmed (Sherman and Hempel 2009). The net change in water temperature of the North Brazil Shelf LME equates to an increase of 0.22˚C over 50 years (Sherman and Hempel 2009).

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 regions. 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 while the rest continues flowing northwest to form the Guiana Current. Figure 5.1-1 illustrates the proximity of the Guiana Current, NBC, and North Equatorial Counter Current to the Stabroek Block.

Figure 5.1-1: Marine Currents in the Vicinity of the Stabroek Block



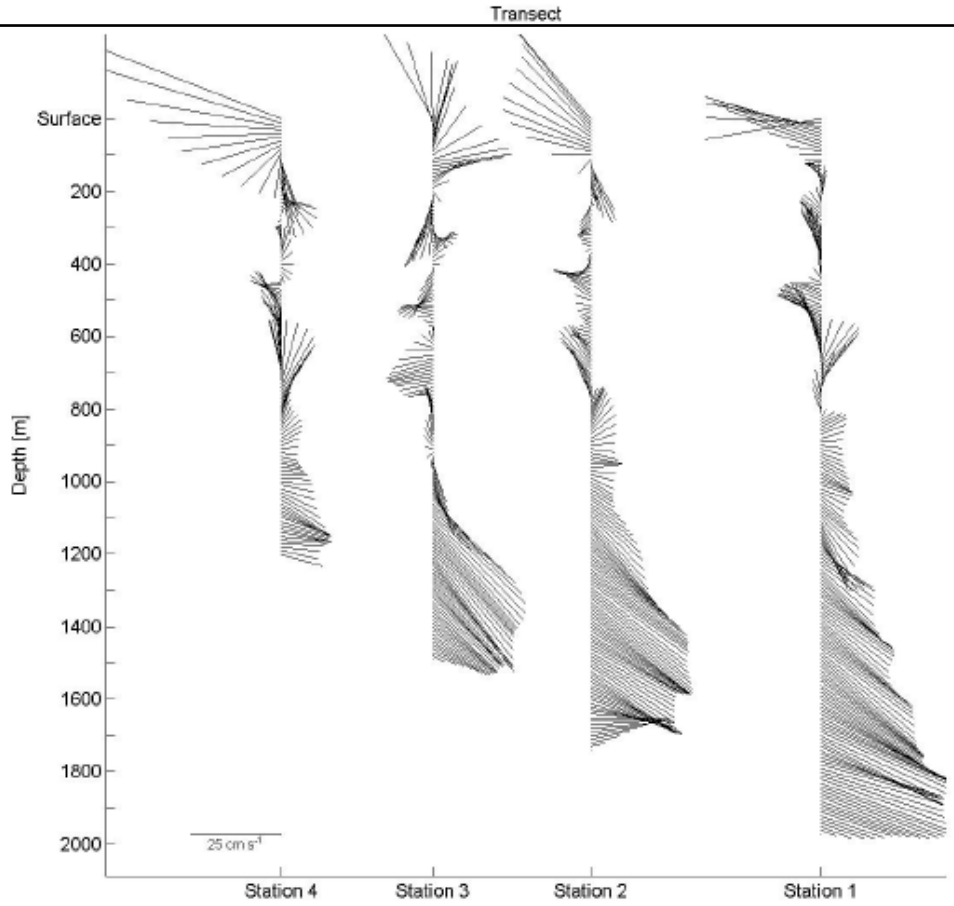
During spring tide, the Guiana Current can extend as far as 300 nautical miles offshore along Guyana's entire continental shelf. The current's highest velocities tend to occur along the edge of the continental shelf, which is located near the southern boundary of the Stabroek Block. Fluctuations in the Inter-Tropical Convergence Zone and the trade winds lead to significant variation in the strength of the Guiana Current and the extent of its influence offshore. Maximum speeds generally occur from April to May, while minimum speeds commonly occur in September (Gyory et al. 2013).

The Guiana Current is primarily a surface current, while the deeper portion of the water column in the Stabroek Block is strongly influenced by the North Atlantic Deep Western Boundary Current. The North Atlantic Deep Western Boundary Current is the southward limb of the North Atlantic MOC and returns colder, denser water from polar regions to the subtropics at intermediate and deep levels.

As described in Section 1.2.1, Environmental Studies, environmental baseline surveys have been conducted in the Stabroek Block and adjacent Canje and Kaieteur blocks for the past 6 years. Most of the studies conducted to date have occurred in the Stabroek Block.

In May 2014, EEPGL commissioned an Lowered Acoustic Doppler Current Profiler (LADCP) survey along a transect located in the central portion of the Stabroek Block. The LADCPs were placed at depths ranging from approximately 970 to 1,100 meters. The survey indicated the presence of both the Guiana Current and the Deep Western Boundary Current. Figure 5.1-2 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- a north-westward surface flow influenced by the Guiana Current and a deeper south-eastward flow due to the Deep Western Boundary Current. Station 4 reported similar results; however, the speed of the north-westward surface current was significantly greater at this station than at the others (TDI-Brooks 2014).

Figure 5.1-2: Vector Stick Plot for All Four Stations on the Stabroek LADCP Transect



Each "stick" (also called a vector) describes the direction, speed, and depth of a discreet measurement. The length of the vector is directly proportional to its speed. The depth of each measurement is provided on the y-axis. The direction of the vector points from the LADCP's position toward the compass heading the current is flowing toward. The horizontal distance between stations on the x-axis is to scale.

Source: TDI-Brooks 2014

In March 2016, an EEPGL contractor deployed and maintained a series of four deepwater current profile mooring buoys and one surface buoy (RPS 2016; 2017a, b, c). The buoys were deployed in the western portion of the Stabroek Block. Processed datasets from the mooring buoys recorded from March 2016 to March 2018 confirmed the overall circulation patterns off the coast of Guyana and indicated regional current occurrences. For example, data reported a higher-magnitude northwest/north-northwest current in February 2017, indicative of the irregular NBC at this location.

5.1.1.2 *Marine Water Quality of the Stabroek Block*

In 2014, EEPGL embarked on a multi-year EBS program to assess the physiochemical attributes of marine water quality and seafloor sediments in the offshore region of Guyana. In 2019, the EBS campaign characterized water column profiles at 20 sampling stations that were similar for salinity/conductivity, temperature, and density (Maxon and TDI Brooks 2019a). The water column temperature was consistent from the surface to approximately 40 meters, where the density structure was driven by salinity. Most stations showed relatively low salinity above 5 meters, a seasonal mixed layer down to 40 meters, and then a steep halocline at a depth of 80 meters. The low salinity in the surface waters was more pronounced in the southeast stations of the Stabroek Block. These results are consistent with EBS campaigns conducted in 2014, 2016, 2017, and 2018 (Maxon and TDI Brooks 2014; Fugro 2016; ESL 2018; Fugro 2019; Maxon and TDI Brooks 2019b). The lower salinity in the surface waters is likely maintained by consistent river flow from the Amazon River (1,000 kilometers downstream) carried by the fast-moving Guiana Current (Maxon and TDI Brooks 2019a).

The Stabroek Block has a highly stratified water column, which suggests limited nutrient influx into surface waters from below the mixed layer. Overall, extremely low turbidities above the pynocline (at approximately 60 meters) were identified across sampling sites, which may be due to accumulation of settling particles or phytoplankton growth. These data are consistent with open ocean environments removed from impacts such as surface water runoff and hydrodynamic transport of suspended materials, and with data collected during other surveys conducted in the Stabroek Block (Maxon and TDI Brooks 2019a).

Total organic carbon (TOC) concentrations were low at all sampling stations. The TOC concentrations in the surface and mid-depth samples were significantly higher than TOC concentrations in the near-bottom samples. These results are typical since phytoplankton density is typically highest in the mixed layer. The mean pH recorded at the sampling stations was 8.72, which is above the range expected for normal seawater (7.9 to 8.4). This is likely due to a systematic error or a calibration issue with the pH sensor (Maxon and TDI Brooks 2019a).

Analysis of hydrocarbon profiles across sampling sites indicated no detectable concentrations of total petroleum hydrocarbons (TPH) and extremely low concentrations of polycyclic aromatic hydrocarbons (PAHs), including naphthalene and phenanthrene. Naphthalene is a known laboratory contaminant and was detected across all depths (Maxon and TDI Brooks 2019a). Phenanthrene is commonly associated with petroleum and its products; however, it can also be found in degraded

plant material. Ultra-trace phenanthrene was detected at only one station. Both naphthalene and phenanthrene were detected in the corresponding procedural blanks indicating laboratory contamination as the most likely source (Maxon and TDI Brooks 2019a). As described above, the marine environment offshore Guyana is affected by several coastal rivers, but the Amazon River, with its average discharge of 180,000 cubic meters (m^3) per second (Nittrouer and De Master 1987 in Charlier 2001), is the most prominent influence on marine water quality in the region. Analyses of the nutrient content of the Amazonian plume have shown that there is little seasonal variation of the plume's nutrient content (silicates, 144 micromoles per kilogram [µmol/kg]; phosphates, 0.7 µmol/kg; nitrates, 16 µmol/kg, etc.) (De Master and Pope 1996 in Charlier 2001). It has been estimated that 40 to 50 percent of the annual Amazon run-off transits along the coast of the Guianas.

Mercury-contaminated runoff from gold mining areas in the interior has infiltrated the marine environment via the coastal rivers and affected coastal marine water quality offshore Guyana. In 2012, concerns over environmental degradation from uncontrolled contaminated mine runoff led the GGMC to temporarily suspend applications for new mining permits (Guyana Gold and Diamond Miners Association 2012). Potential downstream impacts on marine environments were one of the concerns cited in the GGMC's announcement. Mol et al. (2001) found mining-related mercury contamination in some marine fish species in Surinamese marine waters; this phenomenon is likely to occur in Guyana as well although no direct empirical evidence exists to support it. Mercury was found in water samples taken by EEPGL from the Stabroek Block and outer continental shelf in 2014, 2016, and 2018 along with several other metals including copper, zinc, cadmium, chromium, lead, barium, nickel, and arsenic (Maxon and TDI Brooks 2014; Fugro 2016; ESL 2018; Fugro 2019; Maxon and TDI Brooks 2019b). Not all metals were detected in all samples or in all years.

Each of the 60 water samples analyzed in 2019 contained heavy metals. Ten of the 12 heavy metals for which the analysis was run were detected in several of the samples. Aluminum, arsenic, barium, copper, lead, and nickel were detected in each sample. Mercury and selenium were not detected in any of the samples. All detected concentrations were within the natural range for seawater and varied little across stations, with the exception of highly enriched barium at one station (S07) (Maxon and TDI Brooks 2019a).

Potential impacts on water quality and sediment from planned discharge of drill cuttings was also evaluated. This analysis was conducted by 3D modeling examining effects of drilling on TSS concentrations in the water

column and seabed accumulation of adhered muds and drill cuttings on the seafloor with drilling occurring at two representative depths (Appendix C, Drill Cuttings Deposition and Total Suspended Solids Modeling Report).

5.1.1.3 Marine Water Quality of the Adjacent Canje and Kaieteur Blocks

EBS campaigns were conducted in the adjacent Canje and Kaieteur blocks in 2018 and 2019 respectively. Results from the sampling in these two blocks characterized water column profiles that were similar for salinity/conductivity, temperature, and density (Maxon and TDI Brooks 2019c and 2019d). The presence of a prominent thermocline and steep halocline were observed at all stations in the Canje and Kaieteur blocks. Both of these blocks have a highly stratified water column, which suggests little nutrient influx occurs between surface waters and the mixed layer. Lower salinities were observed in the surface layers of the Canje Block, which is likely a result of rainfall rather than river input due to the distance of the Canje Block from Guyana's rivers (Maxon and TDI Brooks 2019c). The lower salinity observed only in the southeastern sampling stations in the Kaieteur Block is likely maintained by consistent river flow from the Amazon River (1,000 kilometers downstream) carried by the fast-moving Guiana Current (Maxon and TDI Brooks 2019d), which would be consistent with the interpretations of salinity data from prior EBS campaigns in the Stabroek Block. Overall, extremely low turbidities were identified across sampling sites in both the Canje and Kaieteur blocks, which is expected for open ocean environments removed from impacts such as surface water runoff and hydrodynamic transport of suspended materials (Maxon and TDI Brooks 2019c and 2019d), and is also consistent with prior findings from the Stabroek Block.

TOC concentrations were highest at the surface and decreased with increasing depth in the Canje and Kaieteur blocks, which is typical of low nutrient, tropical Atlantic Ocean water as phytoplankton density is typically highest in the mixed layer (Maxon and TDI Brooks 2019c and Maxon and TDI Brooks 2019d). The pH levels in the Canje Block were within the expected ranges for tropical, offshore ocean water (7.9 to 8.4) (Maxon and TDI Brooks 2019c); however, the pH recorded at most of the sampling stations in the Kaieteur Block was 8.6, which was above the expected range. This was likely due to a systematic error or a calibration issue with the pH sensor (Maxon and TDI Brooks 2019d). The depth-dependent TOC trend and elevated pH readings were consistent with prior findings from the Stabroek Block.

Analysis of hydrocarbon profiles across sampling sites indicated no detectable concentrations of TPH and very low concentrations of PAHs in the Canje and Kaieteur blocks. The PAHs detected were present in specific forms most likely associated with laboratory analytical equipment and airborne combustion sources (Maxon and TDI Brooks 2019a and 2019d).

Each of the water samples analyzed contained heavy metals in the Canje and Kaieteur blocks. Mercury was only detected in the Canje Block. Barium, nickel, and cadmium had significantly higher concentrations in near bottom water, and zinc had significantly higher concentrations in surface samples in the Canje Block (Maxon and TDI Brooks, 2019c). Aluminum and iron were elevated in the bottom water at one station of the Kaieteur Block. Increased concentrations of these metals may be due to resuspension of sediments (Maxon and TDI Brooks 2019d). The results of the PAH and metals analyses from the Canje and Kaieteur blocks were consistent with prior findings from the Stabroek Block.

5.1.2 Air Quality and Climate

5.1.2.1 Offshore Air Quality

There are no permanent air quality stations in the vicinity of the Stabroek Block from which data can be derived to assess offshore air quality, so long-term air quality within the block must be inferred from its proximity to likely sources of pollution. The Stabroek Block is well offshore and far removed from any permanent sources of airborne pollution and prevalent wind direction is from the northeast (an open ocean area); therefore, ambient air quality within the Stabroek Block is expected to be good.

Four offshore monitoring campaigns were conducted between 2016 and 2019 to assess existing offshore air quality conditions within the Stabroek Block. The first offshore monitoring campaign was conducted from 3 October through 23 October 2016. The second campaign was conducted from 9 April through 16 April 2018. The third campaign was conducted from 2 May through 13 May 2018. The fourth campaign was conducted from 22 April through 26 April 2019. Pollutants sampled in the first two campaigns included inhalable particulate matter with an 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). Pollutants sampled in the third campaign included particulate matter with an aerodynamic diameter of less than 2.5 micrometers ($PM_{2.5}$), SO_2, H_2S, NO_2, and VOCs. Pollutants sampled in the fourth campaign included PM_{10}, $PM_{2.5}$, CO, SO_2, H_2S, NO_2, and VOCs.

All four offshore monitoring campaigns indicated that ambient concentrations of constituents were generally below laboratory reporting limits, with the exception of PM_{10} (measured 24-hour average concentrations ranging from non-detectable to 32 micrograms per cubic meter [$\mu g/m^3$]), $PM_{2.5}$ (measured 24-hour average 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)), which is very low compared to typical ambient air concentrations in urban environments, and consistent with measurements documented in the literature for remote, offshore marine environments (National Research Council 1991). For the 2019 monitoring program, reported non-methane VOC 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 the specific VOC species for which health guidelines have been established were all below their corresponding guideline concentrations.

Chemical analysis of the particulate matter samples found that the most abundant elements in the collected particulate mass were sodium and chloride—the most likely source of which is sea salt. Laboratory-reported concentrations of CO, SO_2, H_2S, and NO_2 were all below reporting limits (i.e., non-detectable) for all four monitoring campaigns. The lack of detectable CO in any of the samples suggests that the monitoring campaigns were not significantly biased by the vessels' engine emissions. These findings corroborate the assumption that air quality is generally good in the Stabroek Block.

5.1.2.2 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 5.1-3).

Figure 5.1-3: Onshore Ambient Air Quality Monitoring Sites



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 more 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 was performed at this site from 12 April 2019 through 27 August 2019. This EA&MP 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.

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 5.1-1 through 5.1-10. 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).

Table 5.1-1: 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 5.1-2: Summary of $PM_{2.5}$ 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	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 5.1-3: 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)	–		

ppm = parts per million

Table 5.1-4: 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)		

ppb = parts per billion

[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 5.1-5: Summary of SO_2 Monitoring Results

Location	Maximum 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)	–		

ppb = parts per billion

[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 5.1-6: 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)	–		

ppb = parts per billion

[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 5.1-7: 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; ppb = parts per billion

[a] Data from integrated 24-hour Summa samples [11]

Table 5.1-8: 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; ppb = parts per billion

[a] Data from integrated 24-hour Summa samples

[11] 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 5.1-9: 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 (v); ppb = parts per billion

[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 5.1-10: 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; ppb = parts per billion

[a] Data from integrated 24-hour Summa samples

As illustrated in the above summary tables, PM concentrations (both PM_{10} and $PM_{2.5}$) were near or exceeded WHO criteria at all three onshore monitoring sites. The only exceedance of a gaseous pollutant criterion was the 24-hour average benzene levels at the Carifesta monitoring site.

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.

The comparison between the full monitoring period average and the annual WHO Guideline Values at the three onshore sites should be considered indicative rather than directly comparable, as the WHO Guideline Values are for an 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 from Carifesta Road and 69 meters 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 USEPA has set 9.4 ppb(v) as its reference concentration.

At sufficient concentration, CO can be an asphyxiant or, over longer time periods, stress the cardio-vascular system. The onshore monitoring program found that current ambient CO concentrations 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 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 indicate that current onshore 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 onshore monitoring results demonstrate that the H_2S concentrations at the New Amsterdam and Carifesta sites were less than 2 percent of the WHO criterion. New Guyana School H_2S measurements were significantly higher, but still less than 20 percent of the health 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.

5.1.3 Coastal and Marine Geology and Stratigraphy

5.1.3.1 Coastal Morphology

Guyana's continental shelf occupies an area of 48,666 km^2. The average width of the continental shelf is approximately 113 kilometers (NDS 1997). The shelf is widest near the borders of Suriname and Venezuela, and slightly narrower near the center. Guyana's coastline is 431 kilometers 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 Guiana Current. These coastal/submarine ridges present a minor impediment to shipping because they require continuous dredging of a shipping channel to allow ships to reach the docks.

5.1.3.2 Marine Stratigraphy

The Guyana basin has been described as a passive margin basin[12] associated with the rifting and opening of the equatorial Atlantic Ocean. Part of the Guyana Basin is onshore but most of it occurs offshore.

[12] 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 5.1-11 summarizes the age and composition of the major geologic formations that comprise the Guyana basin (Workman 2000; CGX 2009).

Table 5.1-11: 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
Kaieteur and Cenonian	Santonian to Turonian	Organic shale, non-organic shale, and sandstone
Canje	Cenomanian to Turonian	Organic shale
Potoco Formation	Aptian	Carbonates
Stabroek Formation	Cretaceous–Barremian	Basal shales and sandstones of continental origin
Precambrian Basement	Proterozoic-Hadean	Igneous/metamorphic rock

5.1.3.3 Marine Sedimentology

Fine clay and mud sediment are transported from the mouth of the Amazon River and are deposited approximately 21 to 60 kilometers offshore, to an average thickness of 20 meters across Guyana's continental shelf (CGX 2009). Fine-grained and ultra-fine grained sediments move down the shelf edge towards the seaward basins, including the southern Stabroek Block (Maxon and TDI Brooks 2019a). Fine grained particles have a higher chemical adsorptive capacity, and as such, there is a potential for accumulation of contaminants in deep waters as the fine grained sediments move seaward to the continental slope and Stabroek Block.

Although the Amazon, Essequibo, Orinoco, and several other smaller rivers discharge large quantities of fine sediment that are subsequently transported across the continental shelf, analysis of the humic content, nutrient composition, and ratio of surface area to mass of Guyanese marine sediments indicate 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 lies in a transitional zone containing terrestrial muds from the Amazon and marine calcarenite substrates.

Sediment samples were collected at 20 sampling stations in the Stabroek Block offshore Guyana in 2019 as part of the EBS program mentioned in Sections 1.2, Summary of Environmental Studies and Assessments Completed to Date, and 5.1.1, Marine Water Quality. Samples were analyzed for TOC, grain size, metals, and hydrocarbons. The samples were typical of the transitional zone between terrestrial muds and marine calcarenites, consisting of a patchy distribution of a relatively wide range of class sizes. Most of the stations were categorized as poorly sorted, fine-grained material comprised mainly of silts and clay, except at five stations where sand was dominant (>43 percent) (Maxon and TDI Brooks 2019a). Coarse-grained foraminifera and shell fragments were also observed at several sampling stations. Concentrations of TOC were low to moderate (0.29 to 1.31 percent) and fairly homogenous across all stations, which is typical of slope sediments in oligotrophic waters (Maxon and TDI Brooks 2019a). The TOC maximum (2.65 percent) was observed at one station located in the productive waters of the continental shelf at a depth of 125 meters (Maxon and TDI Brooks 2019a).

Twelve metals were analyzed, ten of which are commonly associated with anthropogenic sources (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc) and two to provide geological source information (aluminum and iron). Concentrations of metals were within previously reported background ranges and similar to reported concentrations for the Atlantic lower slope and basin depth sediments. Chromium, copper, iron, nickel, lead, and zinc were within the normal range of those reported for sediments originating from the Amazon River, with the exception of one station (S07) containing highly enriched barium at an overall average concentration 100 times higher (17,600 micrograms per gram [µg/g]) than the other 19 stations (less than 172 µg/g) (Maxon and TDI Brooks 2019a). The highest concentration of lead and mercury were also recorded at station S07; however, the concentrations of these metals were within normal ranges and consistent with background concentrations previously recorded in the Stabroek Block. Concentrations of barium greater than 5,000 µg/g typically indicate an anthropogenic source (Maxon and TDI Brooks 2019a). Most likely the source of the barium is associated with discharged drill cuttings as there was also a relatively high concentration of aliphatic hydrocarbons at station S07. Station S07 is located within a cluster of five recently drilled exploration wells to the southeast, suggesting hydrodynamic transport by the Guiana Current if drill cuttings were released above 150 meters and the Deep Western Boundary Current if cuttings were discharged below 150 meters (Maxon and TDI Brooks 2019a). The data suggest this is a localized occurrence as the two stations nearest to station S07 (9.3 and 10.7 kilometers away, respectively) had barium concentrations of 171 and 125 µg/g respectively (Maxon and TDI Brooks 2019a).

Six of the 10 indicator metals had strong positive correlations with aluminum and/or iron, indicating that geological minerals are the likely source of the observed metals. Copper, mercury, and nickel had the strongest correlation with aluminum, indicative of natural aluminosilicate minerals as the metal-bearing phase. Relatively high concentrations of iron at one station in the southeastern Stabroek Block indicate different sources of marine sediment between shelf-depth and deeper sediments (Maxon and TDI Brooks 2019a).

Low concentrations of PAH and TPH were measured in all 20 sediment samples. PAH and TPH concentrations were slightly higher in 2019 than the 2014 EBS campaign, but were generally lower than concentrations reported for coastal and shelf sediments elsewhere. A significant, positive correlation between total PAH and sediment size of clay was found, likely due to the high results for both parameters measured in sediments. There were no additional significant correlations between PAH or TPH with sediment grain size of sand and silt, TOC, or water depth. There was also no significant correlation between total PAH and total TPH, indicating non-petroleum related sources of southern Stabroek Block sediment for these hydrocarbon classes (Maxon and TDI Brooks 2019a).

Sediment samples were also collected from the eastern Stabroek Block offshore Guyana in 2014, 2016, 2017, and 2018 and analyzed for TOC, metals, and hydrocarbons. Similar to the samples collected in 2019, TOC concentrations were generally low (<1 percent), and tended to be negatively correlated with distance to shore and particle grain size. Metal concentrations in 2017 and 2018 were similar to background concentrations in 2014, but were significantly higher in 2016; however, differences in sample size and extraction laboratory procedures make direct comparison between the 2014 and 2016 samples challenging. Metal concentrations for samples collected in 2014 and 2018 were generally consistent, with the exception of barium, arsenic, and nickel (Fugro 2019; Maxon and TDI Brooks 2019b). Average arsenic and nickel concentrations, which were selected as indicators of anthropogenic effects, exceeded their respective U.S. National Oceanic and Atmospheric Administration (NOAA) Effects Range Low values in 2016, 2017, and 2018 (arsenic); and 2016 and 2018 (nickel). These effects indicated a low level of anthropogenic impacts on marine sediments at some but not all locations within the Stabroek Block in 2016 through 2018. The results of the hydrocarbon analysis indicated low concentrations of hydrocarbons in seafloor sediments and that these hydrocarbons had primarily biogenic origins in some locations and a mix of biogenic/anthropogenic origins in other locations. This result was consistent with the low-level and uneven distribution of anthropogenic sedimentary effects suggested by the metals analysis and is similar to the results at all stations except for station S07 in

the 2019 EBS (Maxon and TDI Brooks 2019a; Maxon and TDI Brooks 2019b).

Sediment samples were also collected in 2018 and 2019 from the adjacent Canje and Kaieteur blocks respectively, and analyzed for TOC, grain size, metals, and hydrocarbons. Sediment in the Canje and Kaieteur blocks consisted almost entirely of fine-grained material comprised mainly of clay, with sand and silt occurring in the remaining minor fractions. Concentrations of TOC were very low (<1 percent) and fairly homogenous across all stations in both blocks (Maxon and TDI Brooks 2019c and 2019d). There were no statistically significant relationships between sediment grain size, TOC, and/or water depth in the Canje Block (Maxon and TDI Brooks 2019c), unlike the results in the Stabroek and Kaieteur blocks. Concentrations of metals were similar to those reported for clean coastal environments at all stations in the Kaieteur Block (K02 in the southwest corner of the Kaieteur Block), which had elevated levels of aluminum (343 µg/g) and iron (455 µg/g) in the bottom water (Maxon and TDI Brooks 2019d). Enriched concentrations of aluminum and iron could be due to resuspended sediment where erosion and turbulence are a common occurrence (Maxon and TDI Brooks 2019d). Concentrations of metals in the Canje Block were also similar to those reported for clean coastal environments at all but one station (carbon dioxide in the northeast corner of the Canje Block), which had elevated levels of barium (1,660 µg/g; approximately 8 times), but lower concentrations of heavy metals (Maxon and TDI Brooks 2019c). Enriched barium is typically associated with barite from drilling in the absence of other anthropogenic sources as discussed previously for the 2019 Stabroek EBS; however, concentrations up to 2,000 µg/g have been reported for offshore sediment in the absence of drilling (Maxon and TDI Brooks 2019c). Concentrations of nickel, lead, and zinc were also slightly elevated (<2 times) at this station in the Canje Block when compared to background concentrations, but are in the normal reported range for offshore sediment (Maxon and TDI Brooks 2019c).

5.1.4 Bathymetry

The width of the continental shelf offshore Guyana ranges from 150 to 165 kilometers between the Guyana-Suriname border and the mouth of the Essequibo River, to about 75 kilometers west of the Essequibo River (Guyana Department of Fisheries and GTA Consultants 1995). 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 offshore. These submarine ridges migrate along the coast at a rate of approximately 1 kilometer per year. The continental slope begins at depths from 90 to

100 meters (Repsol 2009) and descends to depths of several thousand meters. The Stabroek Block is located over the continental slope. Depths gradually increase from approximately 100 to 500 meters in the southeastern corner of the Stabroek Block to nearly 3,000 meters along its north-central boundary. Exploration/appraisal wells to be drilled as part of the Project would be distributed between depths of approximately 500 to 3,000 meters.

5.1.5 Natural Hazards

For the purposes of this assessment, natural hazards include environmental phenomena that, because of their location, severity, and frequency, have the potential to adversely affect the lives, health, property, or general well-being of humans. The only Project-related activities that will occur on the coast are at the shorebase(s). Thus, the information provided in this section is most relevant to the Project shorebase(s).

5.1.5.1 The United Nations International Strategy for Disaster Reduction Risk Ratings for Guyana

The United Nations International Strategy for Disaster Reduction indicates that over the last century the most common natural disasters to affect people in Guyana are droughts and floods (UNISDR 2014; EM-DAT 2010) (see Table 5.1-12).

Guyana's topography and population distribution causes its population to be vulnerable to floods. Guyana's coastline elevation is low and flat, and most of the country's population and infrastructure (including the capital city of Georgetown) are located along the coast. Uncontrolled breaches of sea defenses due to unanticipated high tides and deterioration of the sea defense system adversely affect transportation, safety, and agricultural production.

Table 5.1-12: Top Five Years for Natural Disasters in Guyana from 1900-2014

Type of Disaster	Year	Persons Affected
Drought	1997	607,200
Flood	2005	274,774
Flood	2008	100,000
Flood	1996	38,000
Flood	2006	35,000

Source: EM-DAT 2010

5.1.5.2 *Socioeconomic Data Applications Center Risk Ratings*

The United States National Aeronautics and Space Administration Socioeconomic Data and Applications Center (SEDAC)[13], has estimated global risk levels for six major categories of natural hazards: earthquakes, volcanoes, landslides, floods, drought, and cyclones/ hurricanes. The SEDAC model divides Earth into a 2D gridded surface and estimates the relative risk that each of the six types of hazard event will occur within each grid cell based on historical records. The SEDAC methodology only rates risks on land, so it is not directly applicable to risks within the Exploration Drilling Area. However, SEDAC's approach estimates risk levels for each of the six hazard types at sub-national scales rather than for countries as a whole, and so yields region-specific risk profiles.

SEDAC divided the total number of land grid cells across the earth into deciles and then grouped the ten deciles into qualitative risk categories as follows:

- Deciles 1 through 4 (Low Risk)
- Deciles 5 through 7 (Medium/Moderate Risk)
- Deciles 8 through 10 (High Risk)

Cells with values of zero (essentially zero risk of incidence) were excluded from the analysis (Dilley et al. 2005). Table 5.1-13 provides the SEDAC risk rating for the shorebase area for each of the six major hazard categories.

Table 5.1-13: Risk of Occurrence for Natural Hazards in the Shorebase Area

Hazard Category	**Risk of Occurrence (Decile Rating)**
Earthquakes	Excluded (minimal risk)
Volcanoes	Excluded (minimal risk)
Landslides	Excluded (minimal risk)
Floods	Low Risk
Drought	Low Risk
Cyclones/ Hurricanes	Excluded (minimal risk)

[13] SEDAC is one of the Distributed Active Archive Centers in the Earth Observing System Data and Information System of the U.S. National Aeronautics and Space Administration. SEDAC develops and operates applications that support the integration of socioeconomic and Earth science data.

Regional Flood Hazards

ThinkHazard! is a web-based tool designed by the World Bank Global Facility for Disaster Reduction and Recovery that allows users to consider the impacts of natural disasters (e.g., coastal flooding) for project planning and disaster risk management purposes (GFDRR 2017). ThinkHazard! translates technical hazard data describing hazard intensity, frequency, and susceptibility—in scientific parameters—into four categories of hazard: very low, low, medium, and high. ThinkHazard! ranks coastal flood hazard level as Very Low to High, depending on location. Specifically, Regions 3, 4, and 6 have high coastal flood risk ratings, while Regions 2, and 5 have medium coastal flood risk ratings. The extreme western coast of Region 1 has a very low coastal flood risk rating, but most of the Region 1 coast has a medium coastal flood rating. Interior Guyana (Regions 7, 8, 9, 10, and the western interior of Region 1) has very low hazard levels for coastal flooding. A high hazard level means that potentially damaging waves are expected to flood the coast at least once in the next 10 years. Figure 5.1-4 depicts the ThinkHazard! risk ratings for coastal flooding across Guyana's regions.

Regional Drought Hazards

The SEDAC model describes the local risk that a drought could occur in coastal Guyana (including the shorebase) as low, while interior regions of Guyana are mapped as minimal, low, or medium depending on location, as depicted on Figure 5.1-5.

The SEDAC model also computes the proportional economic risk associated with a drought. The proportional economic risk associated with a coastal drought in the vicinity of the shorebase is moderate, while the corresponding risk in southern Guyana is high. The proportional economic risk associated with a drought receives a higher rating in SEDAC's model than the risk that a drought could occur. This is fairly typical of developing countries globally, because these countries often have limited capacity to respond effectively to natural disasters. In other developing areas where the chance that a disaster will occur is relatively low, the risk to life, property, and economic activity if a disaster does occur is often higher than in developed countries due to this effect.

Figure 5.1-4: Regional Flood Hazard in Guyana

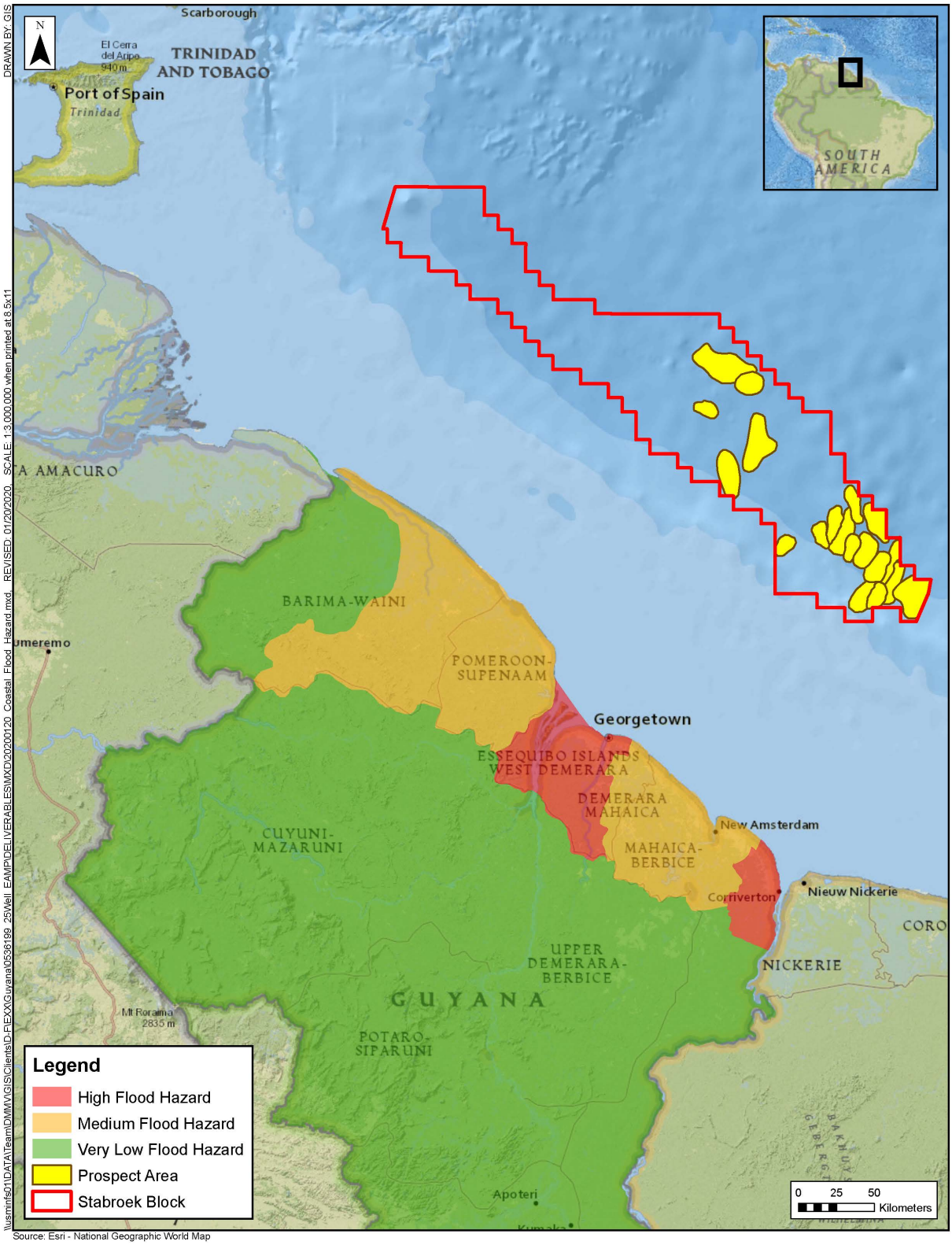
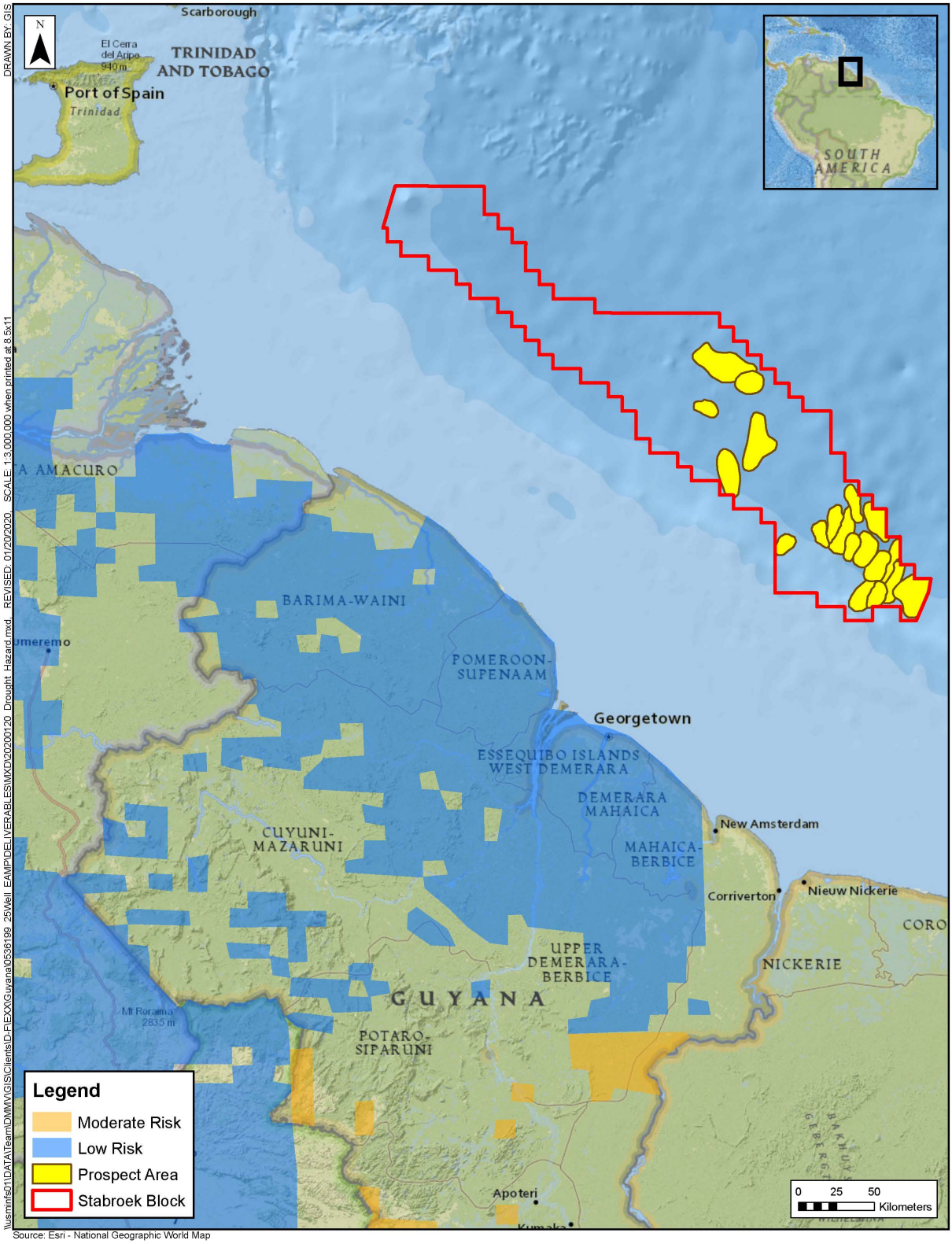


Figure 5.1-5: Regional Drought Hazard in Guyana



Other Potential Natural Hazards

The SEDAC database indicates minimal risk of natural hazards not included above at the potential shorebase location. Of the numerous major hazard types generally tracked by the United Nations International Strategy for Disaster Reduction and SEDAC, cyclones/ hurricanes, earthquakes, and submarine landslides have the potential to occur offshore Guyana. The Guyanese coastline is south of the region most frequently affected by North Atlantic hurricanes. The area surrounding the Stabroek Block is generally considered to be at low risk for cyclonic activity (IRICS undated). There are no readily available seismic hazard maps for the area offshore Guyana, but the Kaieteur Block is not located in an area known for high levels of seismic activity. Additionally, there are no available assessments of mass movement hazards offshore Guyana, however a bathymetric study of the Demerara plateau, the Guiana slope and rise, and the Demerara abyssal plain offshore French Guiana and Suriname identified physical indicators of past landslides along the continental slope across the survey area (Gaullier et al. 2010).

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 5.1-6):

- The Septentrional Fault Zone, located north of the Dominican Republic;
- The Hispaniola Trench, also located 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 into the western Atlantic Ocean.

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).

Figure 5.1-6: Areas of Potential Seismic Risk



WHOI 2005

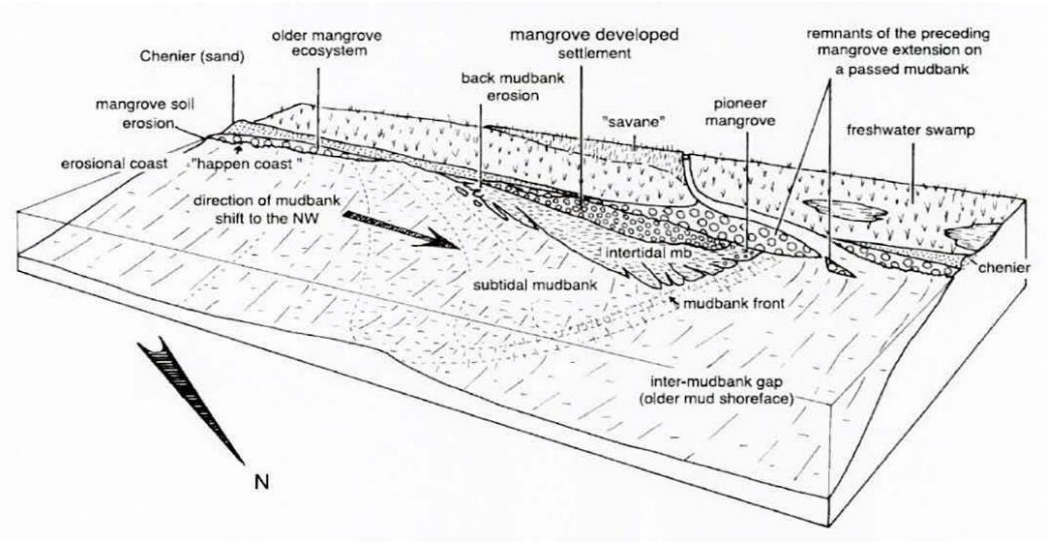
5.1.5.3 *Sea Defenses*

Guyana's coastal plain is situated from 1 meter below sea level up to sea level, which renders the coastal plain highly vulnerable to erosion and salinization especially during spring tides (GMRP 2010a). Approximately 90 percent of the population, infrastructure, and economic activities are concentrated in the coastal plain, so protection from sea level rise and coastal flooding is a national priority. As a result, Guyana's national government has established a network of coastal protection measures that consist of a combination of hardscapes and natural buffers. This network is known collectively in Guyana as the "Sea Defense."

Hardscaped defenses generally consist of an earthen embankment protected on the seaward side by a concrete slab and/or a (coping) wave wall or rock armoring (rip-rap) (Royal Haskoning, Delft Hydraulics 2004). Most of the existing hard structures are between 30 and 70 years old, and many are in need of repair (Royal Haskoning, Delft Hydraulics 2004).

Natural defenses include a combination of mudbanks and mangrove forests along the Guyana coastline (see Figure 5.1-7). The mudbanks are comprised of fine sediments that originate from the Amazon, and are carried by the NBC along the northern coast of South America (see Section 5.1.1, Marine Water Quality). Waves from the Atlantic Ocean (swell) break on the mudbanks, protecting part of the coastline from wave attack (Royal Haskoning, Delft Hydraulics 2004). The mudbanks also promote further sediment accretion and mangrove growth, thereby enhancing the resilience of these natural sea defense network.

Figure 5.1-7: Typical Distribution of Mudbanks and Mangroves on Guyana's Coast



Source: Royal Haskoning, Delft Hydraulics 2004

Mangrove forests along coastal Guyana also contribute to sea defense by dampening wave action and protecting the coastal bank from shoreline erosion. The 2010 National Mangrove Management Action Plan identifies mangroves as the most effective protection from coastal flooding in Guyana. Many government and non-profit groups, such as the Government of Guyana's Ministry of Agriculture and the Guyana Mangrove Restoration Project (GMRP) have been working together to restore mangroves along the Guyanese coast. GMRP has been operating since May 2010, with mangrove planting and protection initiatives at ten locations along the Guyanese coast (GMRP 2010a). An important aspect of the GMRP is promotion of the sustainable management of Guyana's mangrove forests. Eight of the ten mangrove restoration areas are located adjacent to Georgetown, and the other two are near New Amsterdam, Guyana (Figure 5.1-8). See Section 5.2.1, Coastal Habitats for a biological description of mangroves in Guyana.

5.2 BIOLOGICAL RESOURCES

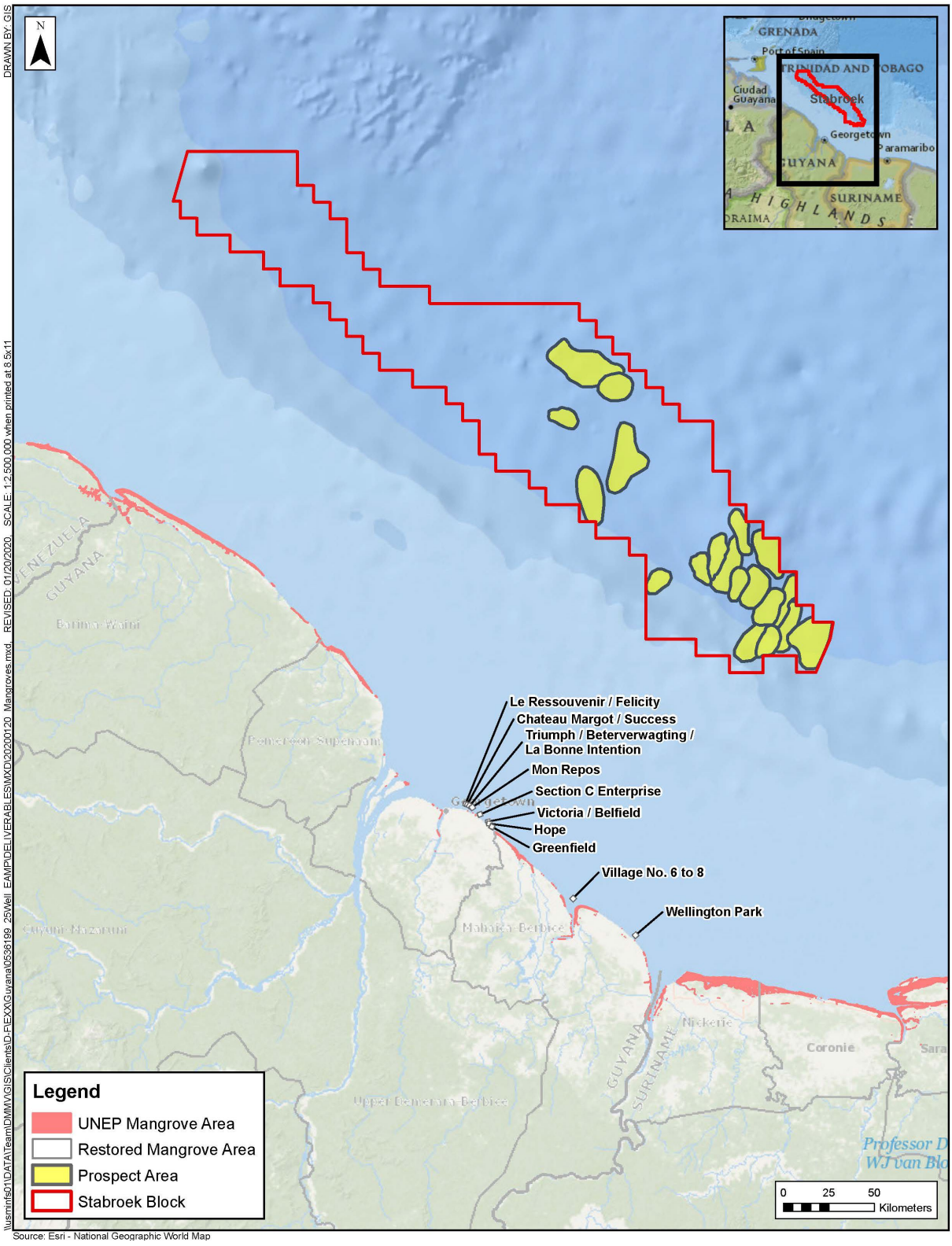
5.2.1 Coastal Habitats

There are four distinct terrestrial ecoregions in Guyana including coastal plain, interior savannas, hilly sand and clay, and forest highlands (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, and forested highlands; 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]).

The entire Guyanese coastline is designated as coastal plain and encompasses a narrow belt of riverine and marine clay and silt sediments. This ecoregion occupies about 7 percent of Guyana's total area and varies in elevation from sea level to approximately 3 meters above sea level. The coastal plain is influenced by both marine and terrestrial environments ecological processes.

Several habitat types are present in the coastal plain, including mangroves, salt to brackish lagoons, brackish herbaceous swamps, swamp forests, beaches, mudbanks, and mudflats. The swamps are an important source of freshwater for mangrove vegetation and other flora and fauna (WWF 2016). The ecosystems that make up Guyana's coastal plains are some of the most productive, biodiverse, and vulnerable in the world. Additionally, Guyana has relatively few beaches, but the beaches that do occur are critically important nesting habitats for marine turtles.

Figure 5.1-8: Distribution of Mangroves along Guyana's Coast



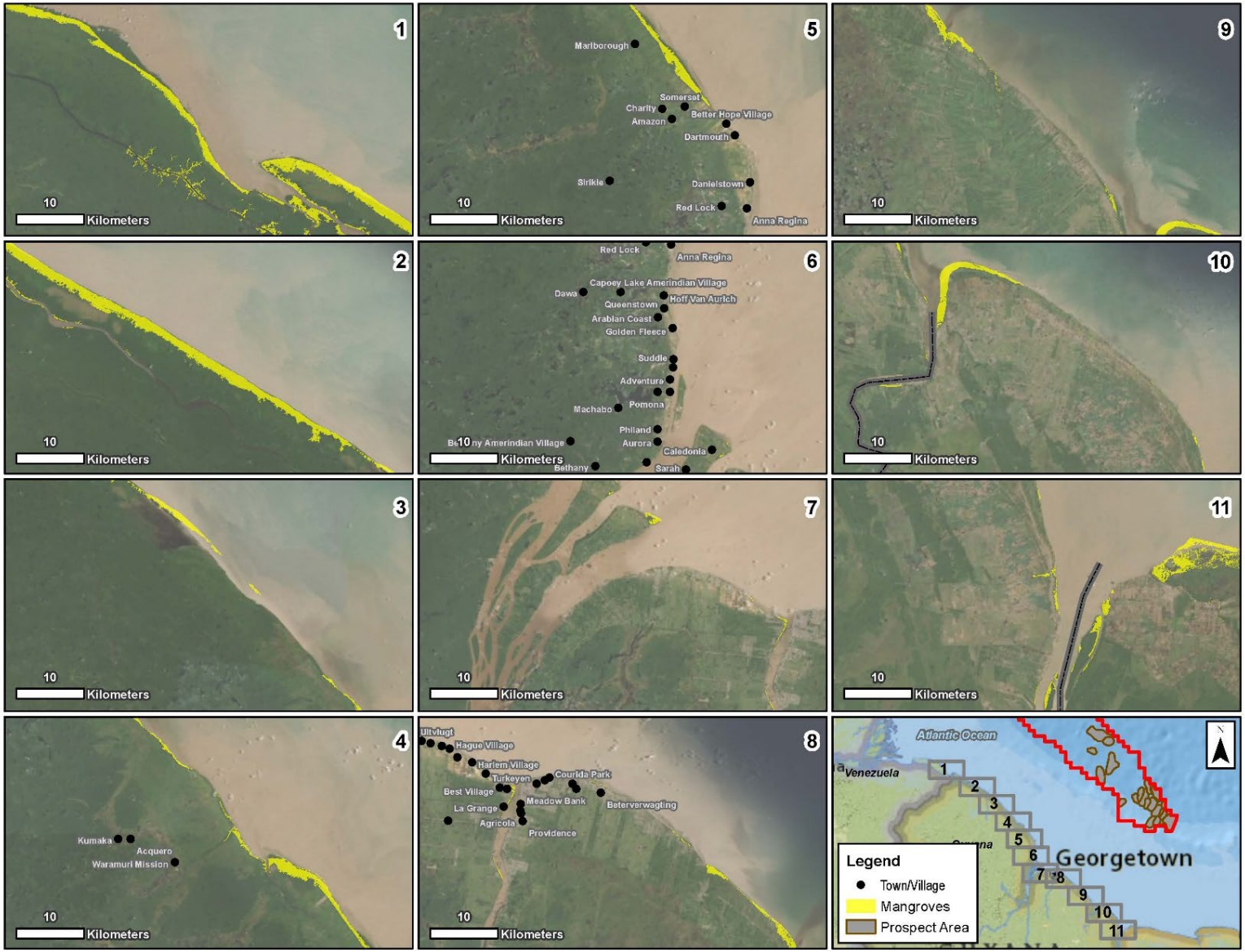
Guyana's continental shelf is located near the southern boundary of the Stabroek Block and occupies an area of 48,665 km^2. The average width of the continental shelf is 112.6 kilometers (NDS 1997). The shelf is widest near the Suriname and Venezuela borders, and slightly narrower near the center, north of Georgetown. The entire continental shelf, continental slope, and the adjoining portion of the abyssal plain are part of the North Brazil LME. The North Brazil LME is an oceanic habitat unit that extends from the Caribbean Sea south to the Parnaiba River in Brazil (Ekau and Knoppers 2003, in Sherman and Hempel 2009). Although the North Brazil LME is considered a highly productive zone in comparison to other large marine areas, nearshore primary productivity potential is limited by turbidity, which reduces light penetration. The highest primary productivity in the LME is generally found at the oceanic fronts between nutrient-rich freshwater lenses from the Amazon, Essequibo, and other large rivers, and comparatively warm clear water of oceanic origins (Sherman and Hempel 2009). The substrate is generally composed almost entirely of mud and silt deposited by the NBC (MOA 2013).

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 coastal habitats are mangroves, beaches, mudbanks, mudflats, and sandflats which are described below.

5.2.1.1 Mangroves

Coastal mangroves have been identified by numerous national and international stakeholders as vital to Guyana's biodiversity, coastline protection, and economy (WWF 2016; GMRP 2010a; Ilieva undated). In October 2017 to April 2018, a multi-disciplinary team consisting of geospatial analysts, ecologists, marine biologists, and bird specialists from the Consultant Team (ERM and its subcontractors) conducted extensive field work and subsequent desk-top analysis in order to field verify (i.e., ground truth) selected shoreline and coastal habitat types along the Guyana coastline (ERM/EMC 2018). The team used internationally recognized methodologies (i.e., Environmental Sensitivity Index), combined with Guyana-specific methodologies (i.e., National Agricultural Research and Extension Institute mangrove data collection procedures), to achieve robust scientific results. The biodiversity aspects studied included mangroves, shoreline classifications, coastal bird habitats, and coastal fish habitats. Figure 5.2-1 is a composite of 11 individual map tiles showing the distribution of mangroves across this portion of Guyana's coastline. These maps were incorporated into EEPGL's Geographic Strategic Response Maps, which EPA has previously reviewed and approved.

Figure 5.2-1: Mosaic of Guyana's Coastal Mangroves



Mangroves are regarded as one of the most important ecosystems to security of the biodiversity of the entire Guyana coast, as they protect coastlines from wave action and shoreline erosion. Distribution of mangroves along the coast of Guyana is highly dynamic, subject to rapid and dramatic change, and sound geo-referenced baseline datasets and updated images are lacking. This makes it difficult to ascertain the location and extent of mangrove forests in the country today. A 2008 Smithsonian report stated that mangroves occupied over 81,000 hectares of Guyana's coast in six of Guyana's ten geopolitical regions (ERM/EMC 2018). An assessment in 2018 by ERM identified 52,379 hectares of mangroves in Regions 1-4 (ERM/EMC 2018). The GMRP publication estimates 75 percent of the country's mangroves are concentrated in the Barima-Waini and Pomeroon-Supenaam regions (GMRP 2010b). Although ERM's 2018 study did not include riverine mangroves, the study did support the conclusion that coastal mangroves are heavily concentrated in the northern portion of the coastline within Regions 1 and 2.

The modern Guyana coast is the result of a net accretive trend over the last millennium; however, in recent decades this trend has tended to be more erosive than accretive and the coast is undergoing a general recession. One of the causal factors in coastal recession can be the decline of mangrove areas (which serve as a natural sea defense). In cases where mangroves provide a natural buffer between coastal plain uplands and the ocean, once the mangroves disappear the coast is no longer protected and often starts to erode.

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. Black mangroves are known to colonize the coastal shorelines and red mangroves establish themselves further inland along the rivers. 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 (NAREI 2014).

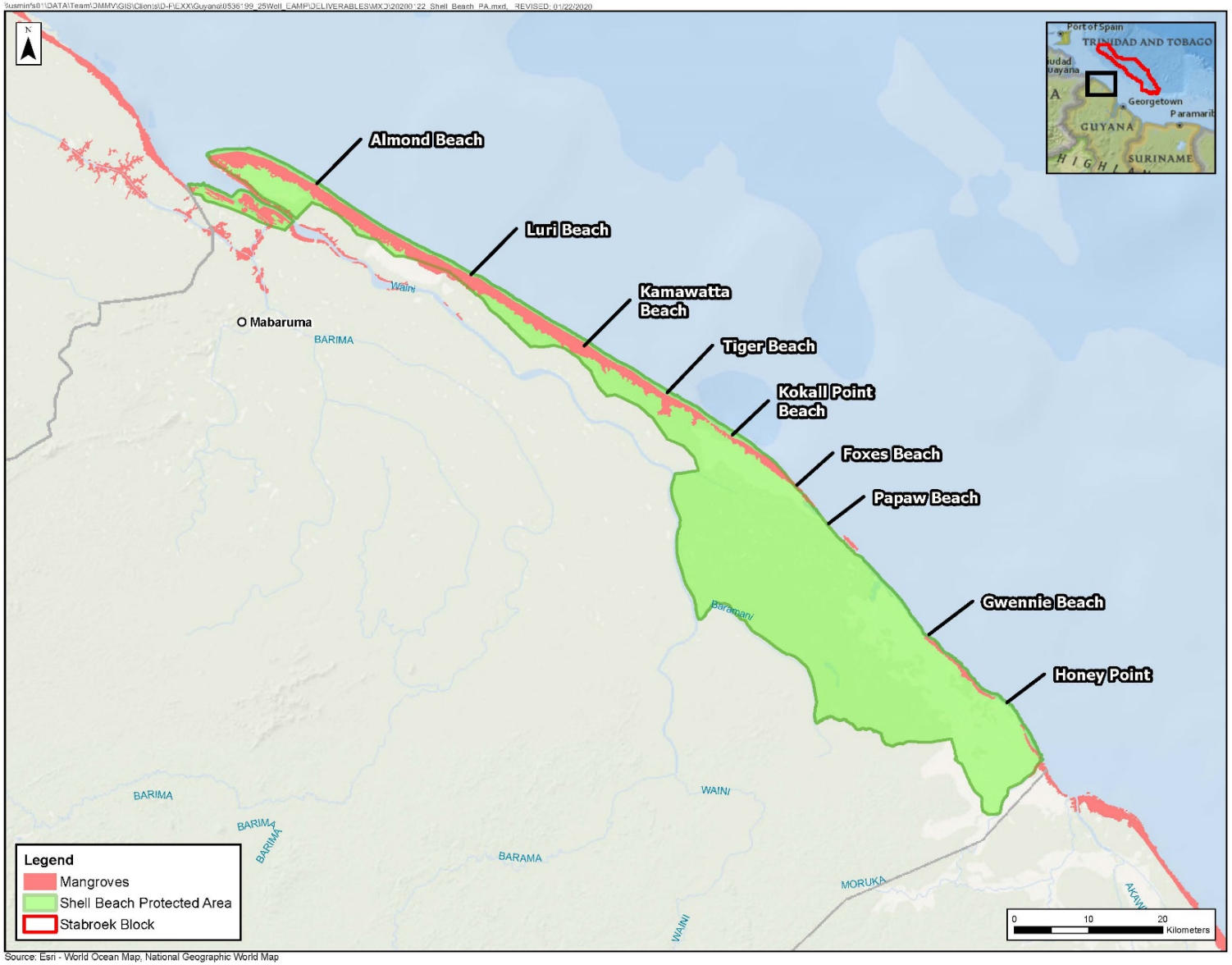
Like most coastal habitats, mangroves are dynamic habitats that are capable of rapid changes over time. As part of the coastal sensitivity verification study, historical imagery was analyzed to identify areas where mangroves have been lost along the coast (ERM/EMC 2018). The analysis documented the loss of approximately 1,460 hectares 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 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), providing shelter and feeding sites for many faunal species (Mestre et al. 2007). Coastal mangroves have been identified by numerous national and international stakeholders as vital to Guyana's biodiversity, physical security, and economy (WWF 2016; GMRP 2010b; Ilieva undated). Many invertebrate inhabitants of mangrove ecosystems in Guyana live either on or in close proximity to mangrove roots and/or the bottom substrate, including snails, barnacles, tunicates, mollusks, polychaete worms, oligochaete worms, shrimp, crabs, sponges, jellyfish, amphipods, and isopods. 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).

5.2.1.2 Beaches

Guyana has relatively few beaches and the largest expanse of beaches in the country lies within the Shell Beach Protected Area (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 5.2-2 for the locations of beaches in the SBPA). Beaches are discussed in detail in Section 5.2.7, Protected Areas.

Figure 5.2-2: Beaches in the Shell Beach Protected Area



5.2.1.3 Mudbanks, Mudflats, and Sandflats

The 1,500-kilometer-long coast of South America between the Amazon and Orinoco River mouths has been described as the "world's muddiest coastline" (Anthony et al. 2010). "Mudbanks" generally refer to the submerged mud features below the low tide line as distinct from "mudflats" within the intertidal zone. "Sandflats" are similar to mudflats except they are composed of sand rather than mud.

The mudbanks along the Guyana coast are dynamic features that have a significant influence on the coastal environment. The highest parts of the mudbanks occur at an average interval of about 40 kilometers. The mudbanks move along the coast at a rate of about 1.5 kilometers per year (Anthony et al. 2010). The passage of a mudbank crest coincides with accretion, while the passage of mudbank trough tends to result in erosion. The period of this cyclic pattern of erosion and accretion varies between 20 and 40 years. Mudbanks extend approximately 20 to 40 kilometers offshore to a depth of 20 meters (CGX 2009), and are located seaward of the mangrove swamps that fringe much of the coastline as depicted on Figure 5.1-7. The mudbanks are rich in invertebrate fauna, including plankton and micro-plankton assemblages, algae mats (diatoms), and benthic communities of Nematodes (worms), Tanaidacea (crustaceans), and Foraminifera (amoeboid protists) (Artigas et al. 2003). These small organisms provide habitat for fish species, post-larval and juvenile shrimps, and crabs (Artigas et al. 2003), and numerous resident and migratory shore birds (CGX 2009).

Coastal mudflats, also referred to as tidal flats, are habitats along Guyana's coastline that have been formed by the deposition of mud as a result of tides. Mudflats occur within the intertidal zone so they are submerged under water and exposed twice daily with the tides. Mudflats are usually barren (without any vegetation) and the mud can range from very soft (almost liquid form) 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. Mudflats (some with adjacent mangrove habitats) can be Important Bird Habitat (IBH) sites due to their importance for migratory shorebirds and resident coastal birds.

Sandflats are another coastal habitat type that occurs in the intertidal zone. 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. 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.

5.2.2 Benthic Resources

The EBSs conducted to date in the Stabroek, Canje, and Kaieteur blocks emphasized water and sediment analyses, 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 physical and chemical sediment conditions. Benthic resources in Guyana waters can be separated into continental shelf and deepwater communities. This section discusses each community separately.

5.2.2.1 Stabroek, Canje, and Kaieteur Block Benthic Resources

The benthic community in Guyana's deepwaters is known on the basis of a series of EBS samples taken in 2014, 2016, 2018, and 2019 in the Stabroek Block, 2019 in the Kaieteur Block, and 2018 in the Canje Block; benthic bycatch from fish traps deployed in 2017 and 2018; and ROV footage taken in 2017. The ROV footage found scattered trash, pieces of discarded cable, and a discarded fishing net on the seafloor, but no evidence of oil and gas activities (such as drill cuttings or debris). The 2014, 2016, 2018, and 2019 EBS sample locations in the Stabroek Block, 2018 EBS sample locations in the Canje Block, 2019 EBS sample locations in the Kaieteur Block, and ROV transects are depicted on Figure 5.2-3. Several Payara and Liza well sites are also shown on Figure 5.2-3 to illustrate the survey transects extending in the four cardinal directions from the 500-meter buffer from the well sites outwardly to the 1,500-meter buffer. The EBS sample locations in the Stabroek Block in 2019 are shown on Figure 5.2-4. The fish trap locations are depicted in Figure 5.2-5. EBS samples are most effective at sampling small, common infaunal organisms because they cover a small area and penetrate into the sub-seafloor strata

Figure 5.2-3: EBS Sampling Locations and ROV Transects in the Stabroek, Canje, and Kaieteur Blocks

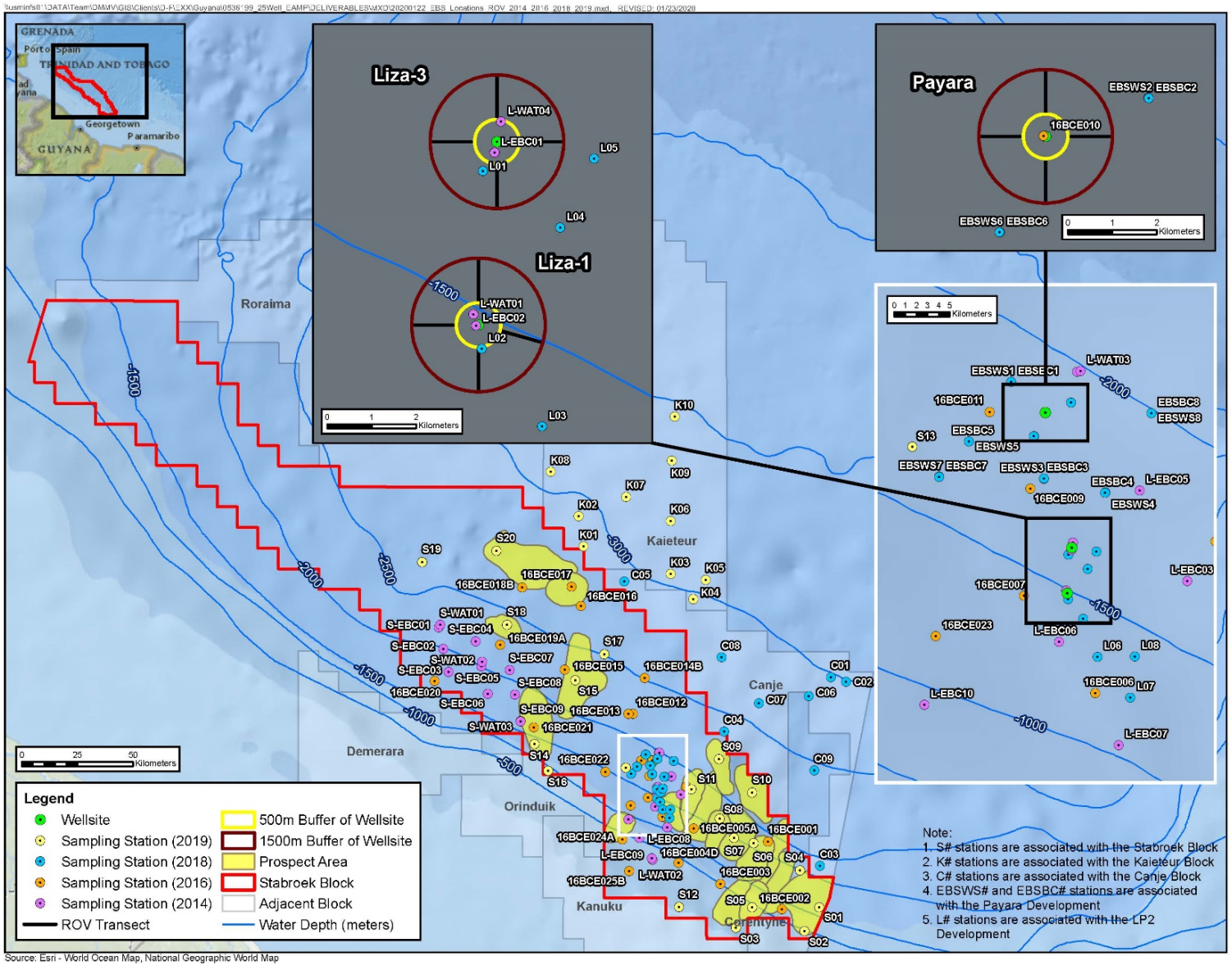


Figure 5.2-4: 2019 EBS Sampling Locations in the Stabroek Block

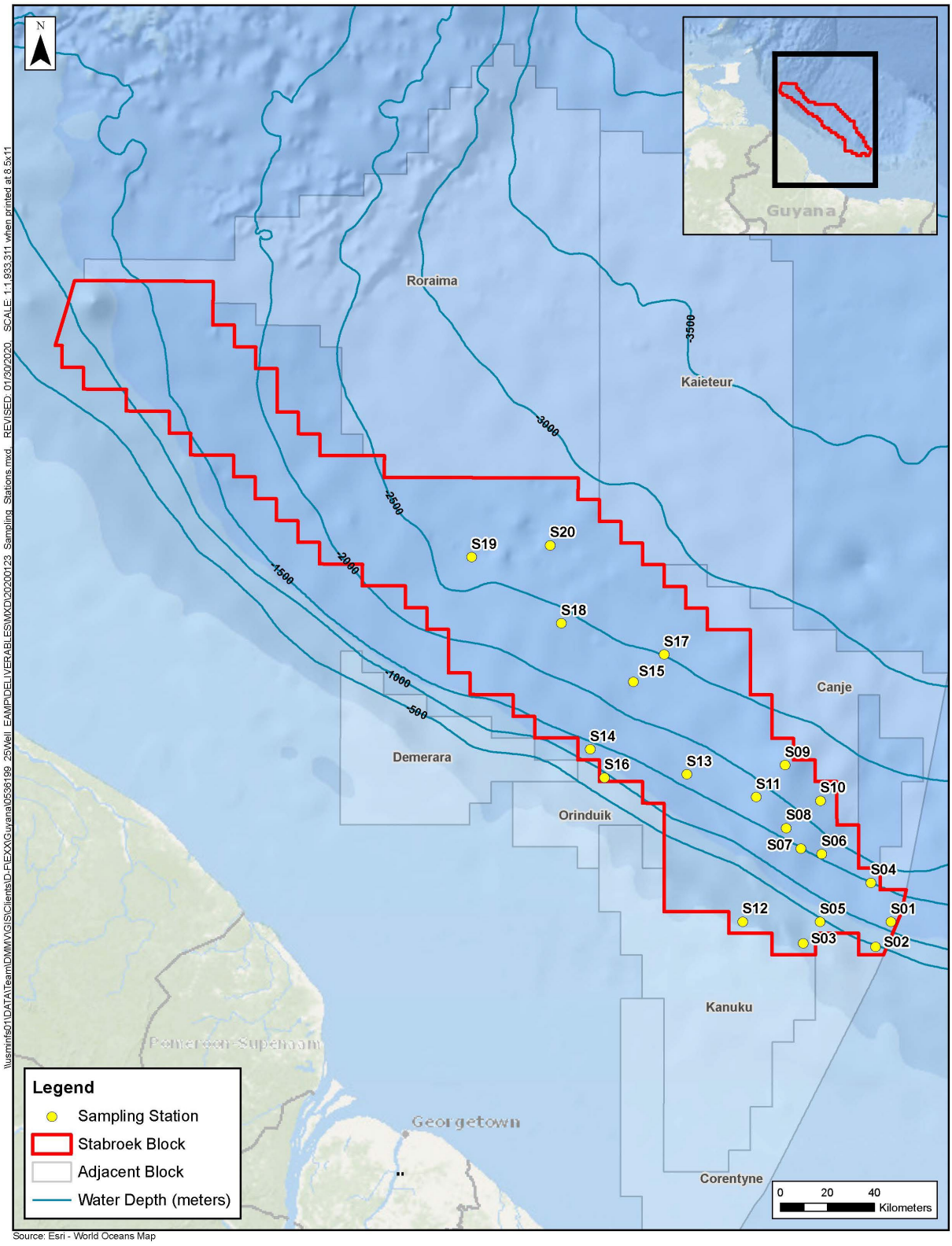
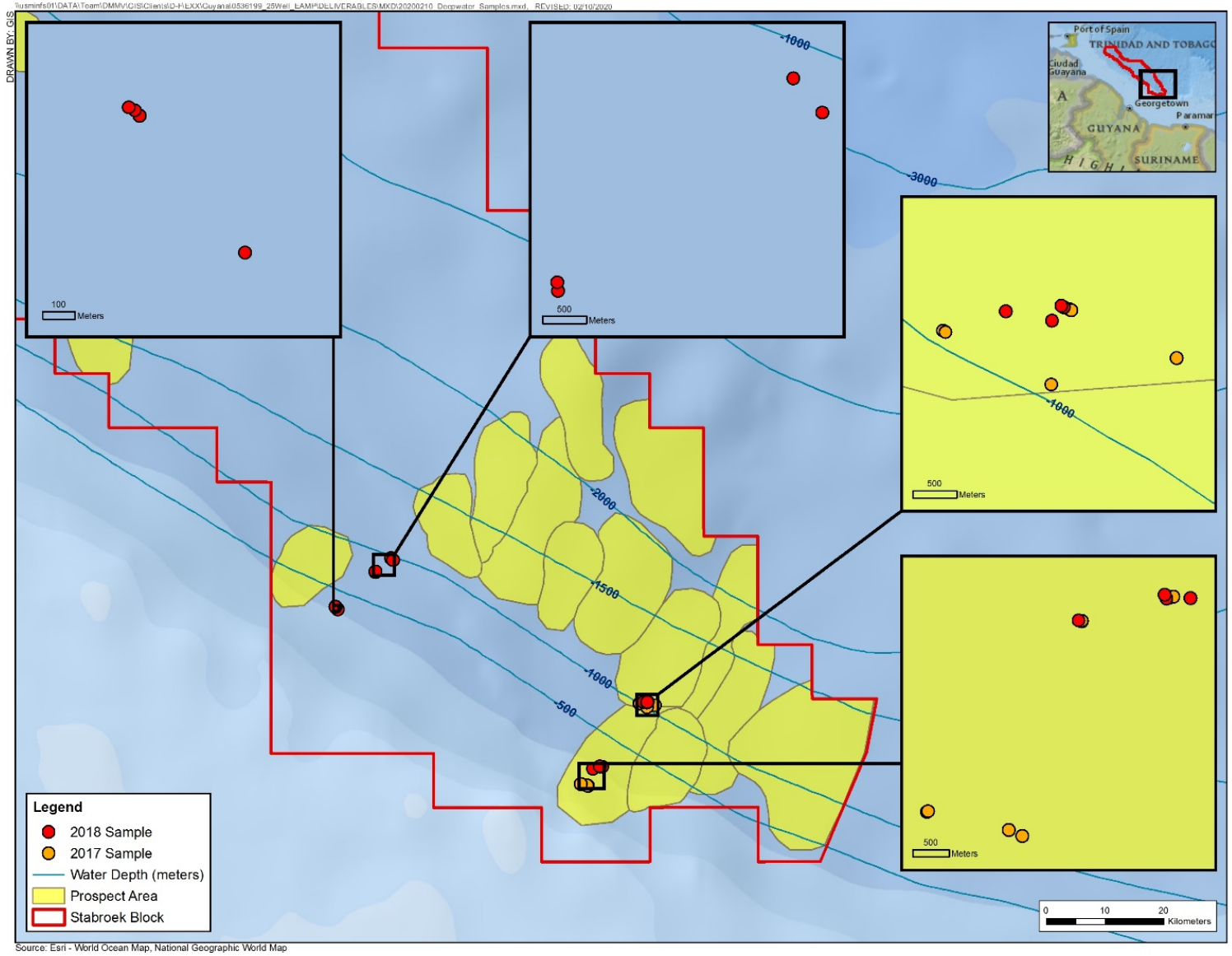


Figure 5.2-5: 2017 and 2018 Deepwater Fish Trap Locations in the Stabroek Block



Benthic Resources in the Stabroek Block

The benthic community was sampled at 20 stations in the southern Stabroek Block in April 2019. The EBS data identified 1,259 organisms, with an average abundance of 629 organisms per m^2 (Maxon and TDI Brooks 2019a). This abundance is low compared to values reported from various continental slope and basin habitats worldwide, but is likely a result of the limited TOC present in the sediments of the southern Stabroek Block. However, total macrofauna abundance in 2019 was six times higher than reported in the 2014 EBS campaign in the southern Stabroek Block (Maxon and TDI Brooks 2019a). There were higher densities of crustaceans and mollusks in the 2019 EBS, indicating a variable macrofaunal community over the past 6 years. Sediment grain size, TOC, and bottom-water oxygen concentrations remained relatively unchanged since 2014, indicating the increase in macrofaunal abundance is unrelated to these physical characteristics (Maxon and TDI Brooks 2019a).

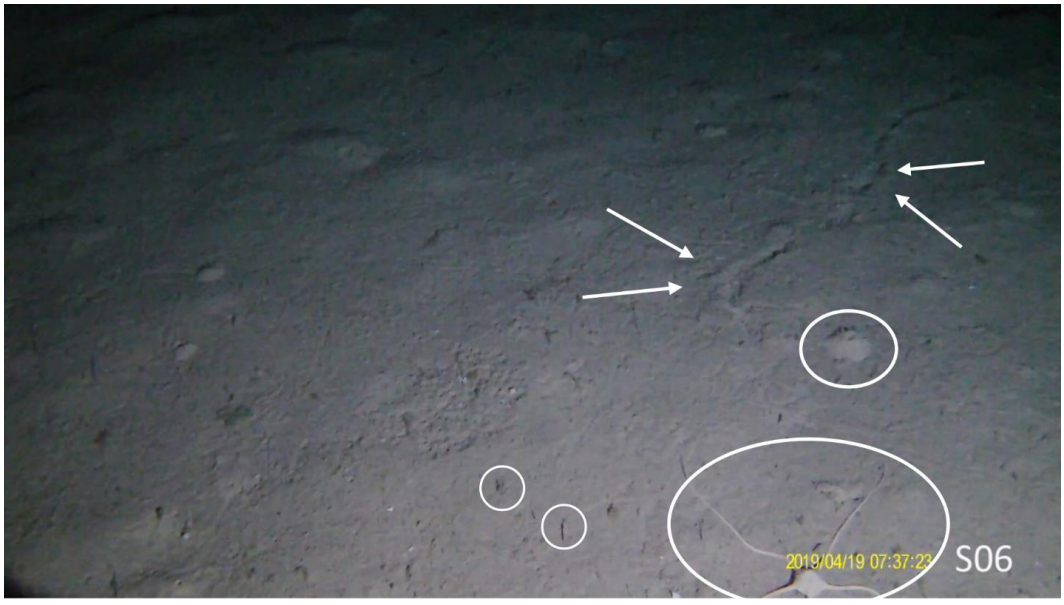
There was a significant negative relationship between total abundance and depth. This relationship (i.e., decreasing macrofaunal abundance with increasing depth) is typical of the continental slope as food availability also declines with depth. Station S03 was the most shallow sampling station and had the highest density with an abundance of 2,430 organisms per m^2, dominated by polychaete worms (82 percent) (Maxon and TDI Brooks 2019a). A significant positive correlation was found for total macrofaunal abundance with sand content and TOC, each of which were higher at shallower depths (Maxon and TDI Brooks 2019a).

A total of 219 distinct taxa were identified from 108 families, of which 19 collectively made up 51.05 percent of total abundance, belonging to the polychaetes, nematodes, crustaceans, mollusks, and sipunculan subgroups. Eleven of the 19 taxa belonged to polychaetes. Polychaetes typically comprise about half of the numbers and a third of the macrofaunal species from deep-water marine habitats worldwide. No taxa exceeded 5 percent of the total abundance, which indicates an even distribution of species and low numerical dominance by a single or few species, suggesting an unstressed habitat (Maxon and TDI Brooks 2019a). The lowest abundance of species was found at Station S07, which as previously discussed in Section 5.1.3, Coastal and Marine Geology and Stratigraphy, had highly enriched barium in the sediment and evidence of drilling-related hydrocarbons. Species such as polychaetes are less sensitive to anthropogenic contamination compared to other taxa such as amphipods, which are often the dominant macrofauna group on the continental shelf and are strong environmental indicators due to their sensitivity. The abundance of polychaetes at Station S07 was substantially

decreased and amphipods were completely absent, suggesting an effect on these species from drilling-related discharges (Maxon and TDI Brooks 2019a).

Video images of the seafloor were collected at 19 of the 20 EBS stations. Burrows, feeding depressions, biogenic mounds, fecal casts, and numerous tracks and trails were observed at nearly all video stations, indicating presence of active infaunal and epifaunal organisms. Species residing on the seafloor surface were also observed, particularly at Station S06, where a brittle star (family Ophiuroidea), potential sea anemone, sedentary polychaetes, and a potential sea cucumber or sea urchin track were observed, as shown on Figure 5.2-6 (Maxon and TDI Brooks 2019a).

Figure 5.2-6: Video Image of Brittle Star, Sedentary Polychaete, and Long Sinuous Track in the Stabroek Block



The results of the 2014 environmental survey in the Stabroek Block revealed that the total abundance of benthic infauna was low, averaging 116 organisms per m^2. This organism density is below the range of typical abundances reported from other continental slopes (Maxon and TDI Brooks 2014) and six times lower than observed in the 2019 EBS (Maxon and TDI Brooks 2019a). The low number of individuals in the Stabroek Block 2014 was likely due to limited organic food sources, indicated by the extremely low organic carbon content in the sediment. The most abundant major taxonomic groups were polychaete worms, mollusks, and crustaceans. No other individual major taxa were abundant, and collectively comprised less than 14 percent of total abundance. A total of 50 distinct families were identified during the 2014 environmental survey, with approximately half represented by either one or two individuals (Maxon and TDI Brooks 2014). This is a relatively high level of diversity

considering the low abundance of the 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.

Similar to the 2014 and 2019 data, the 2016 data for the Stabroek Block documented low densities of annelids (including polychaetes), crustaceans, and mollusks typical for marine sediments. The 2016 sample density averaged 20 organisms per 0.1 m^2, which can be extrapolated to 200 organisms per m^2 for the purposes of comparison to the 2014 data (Fugro 2016). While the 2014 survey did not categorize the macrofauna organisms beyond the family level, the 2016 survey 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 species of crustaceans, 8 species of mollusks, and 3 species of 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) (Fugro 2016).

The 2018 EBS data for the Liza Phase 2 area in the Stabroek Block represents eight 0.1 m^2 subsamples from box core samples and contained 287 organisms, represented by 52 families and 76 distinct taxa. The average total macrofaunal abundance (359 organisms per m^2) was at the lower end of population densities reported from continental slope sediments around the world (Maxon and TDI Brooks 2019b) but approximately three times higher than the average total abundance for the EBS samples collected in 2014. The most abundant major taxonomic group was polychaete worms followed by neatodes and crustaceans, together comprising approximately 92 percent of the total macrofauna sampled (Maxon and TDI Brooks 2019b).

In the Payara area of the Stabroek Block, the faunal community within the 2018 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 was recorded and classified as *Aspidoniscus* sp. A and three arthropod individuals were recorded and

classified as *Heteromesus*. These are considered likely to be new records of these species (Fugro 2019).

Benthic Resources in the Canje and Kaieteur Block

In the adjacent Canje Block, results of the 2018 environmental survey identified a total of 441 organisms and exhibited an average abundance of 490 organisms per m^2 (Maxon and TDI Brooks 2019a). This abundance is low compared to values reported from various continental slope and basin habitats worldwide (Maxon and TDI Brooks 2019c) but higher than the 2014, 2016, and 2018 average total abundance in the Stabroek Block. Abundances were significantly and negatively correlated with TOC. The most abundant major taxonomic group was nematodes (> 50 percent), followed by polychaetes, crustaceans, and cnidarians. The macrofaunal community was comprised of 73 taxa and 45 families (Maxon and TDI Brooks 2019c). This diversity is relatively high considering the low abundance of the macrofauna collected. Dominant families were typical cosmopolitan inhabitants of shelf and slope sediments worldwide.

EBS sampling of the benthic community in the adjacent Kaieteur Block identified an average abundance of 332 organisms per m^2, which is low compared to values reported from various continental slope and basin habitats worldwide (Maxon and TDI Brooks 2019d) and consistent with results from the other EBS events in the Stabroek and Canje blocks. Abundances exhibited a significant positive correlation with TOC; however, there was no significant correlation with grain size or depth. The most abundant major taxonomic group was polychaetes (37 percent), followed by crustaceans (27 percent), and mollusks (17 percent). Nematodes, which are often found in high numbers in unconsolidated marine sediments, were relatively rare compared to the other taxanomic groups. The macrofaunal community was moderately diverse, comprised of 76 taxa from 43 families (Maxon and TDI Brooks 2019d). The dominant families were typical inhabitants of slope habitats over wide geographic ranges in oceans worldwide.

Video images of the seafloor were also collected at each of the 10 EBS stations in the adjacent Kaieteur Block using a pressure-controlled camera. The video images showed evidence of active infaunal and epifaunal organisms through the observance of a number of burrows, feeding depressions, fecal coils and casts, and numerous surface tracks and trails (Maxon and TDI Brooks 2019d). Brittle stars were observed in the video images, as shown on Figure 5.2-7. Other images included probable sea urchins, sea cucumbers, sedentary polychaetes, and potentially a sea-pen, but these could not be identified conclusively (Maxon and TDI Brooks 2019d).

Figure 5.2-7: Video Image of Brittle Stars in the Kaieteur Block



Overall, the macrofaunal abundances surveyed within the Stabroek, Canje, and Kaieteur blocks 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 2019b). Additionally, the macrofaunal communities within these areas are commonly found within the wider South Atlantic Ocean region.

Similar to trawls in shallow water, deepwater fish traps complement EBS samples in deep water by targeting benthic organisms that are not highly susceptible to being sampled by the types of sampling equipment that is typically used for EBS sampling. To date, three macrobenthic species, the giant isopod (*Bathynomus giganteus*), red deepsea crab (*Chaceon quinquedens*), and flatback lobster (*Stereomastis sculpta*) have been documented to occur in the Stabroek Block. All of these species are widespread in deep Western Atlantic Basin waters, but the records from the Stabroek Block represent the first (and to date, only) record of *B. giganteus* or *C. quinquedens* from Guyana's waters.

ROV surveys conducted to date in the Stabroek Block indicate that deepwater habitat on the continental slope is more varied than shallower habitats on the continental shelf. The dominant seafloor type is soft, fine sediment, but areas of heterogeneous seafloor but including rocky outcrops, boulders, patches of gravel, and cobbles also occur. In terms of readily visible epibenthos, the echinoderms (sea cucumbers, brittle stars, and sea stars) are the most prevalent identifiable deep sea epibenthos. It is noteworthy that the radial symmetry of the asteroid echinoderms renders them recognizable even in poor quality images. In view of their easily recognizable gross morphology, it is not surprising that they comprise the

most diverse taxon in the study area and account for most of the recognizable still images extracted from the digital footage from the ROV surveys. Therefore, any conclusions about the apparent dominance of Asteroidae taxa in the deepwater epibenthic community must be considered provisional. The "lumpy" appearance of the epibenthic surface and the numerous tunnel entrances in the deepwater footage show an active but largely infaunal benthic community. Figure 5.2-8 depicts some of the benthic fauna detected in the Stabroek Block.

Cnidarians (corals) and poriferans (sponges) were more prolific on the shallow continental shelf transects than in the ROV images taken from within the Stabroek Block. Two "deepwater" or "black" coral species (*Madrepora oculata* and *Solenosmilia variabilis*) are known to occur offshore Guyana. Neither *M. oculata* nor *S. variabilis* have been documented to date inhabiting the Stabroek Block, although ROV surveys have demonstrated that soft corals can be locally common in some locations within the Stabroek Block, especially in areas with hard substrate. Figure 5.2-9 shows one of the rocky areas that are scattered throughout the area with encrusting soft corals and gorgonians.

5.2.2.2 Continental Shelf Benthic Resources

The benthic community on the continental shelf has been characterized on the basis of a series of EBS samples taken in 2017, trawl bycatch from fish surveys conducted in 2017 and 2018, and ROV footage taken in 2017. The 2017 continental shelf EBS samples and ROV transects are depicted in Figure 5.2-10; the trawl transects are depicted in Figure 5.2-11.

Figure 5.2-8: Representative ROV Photographs of Macrobenthos from the Stabroek Block

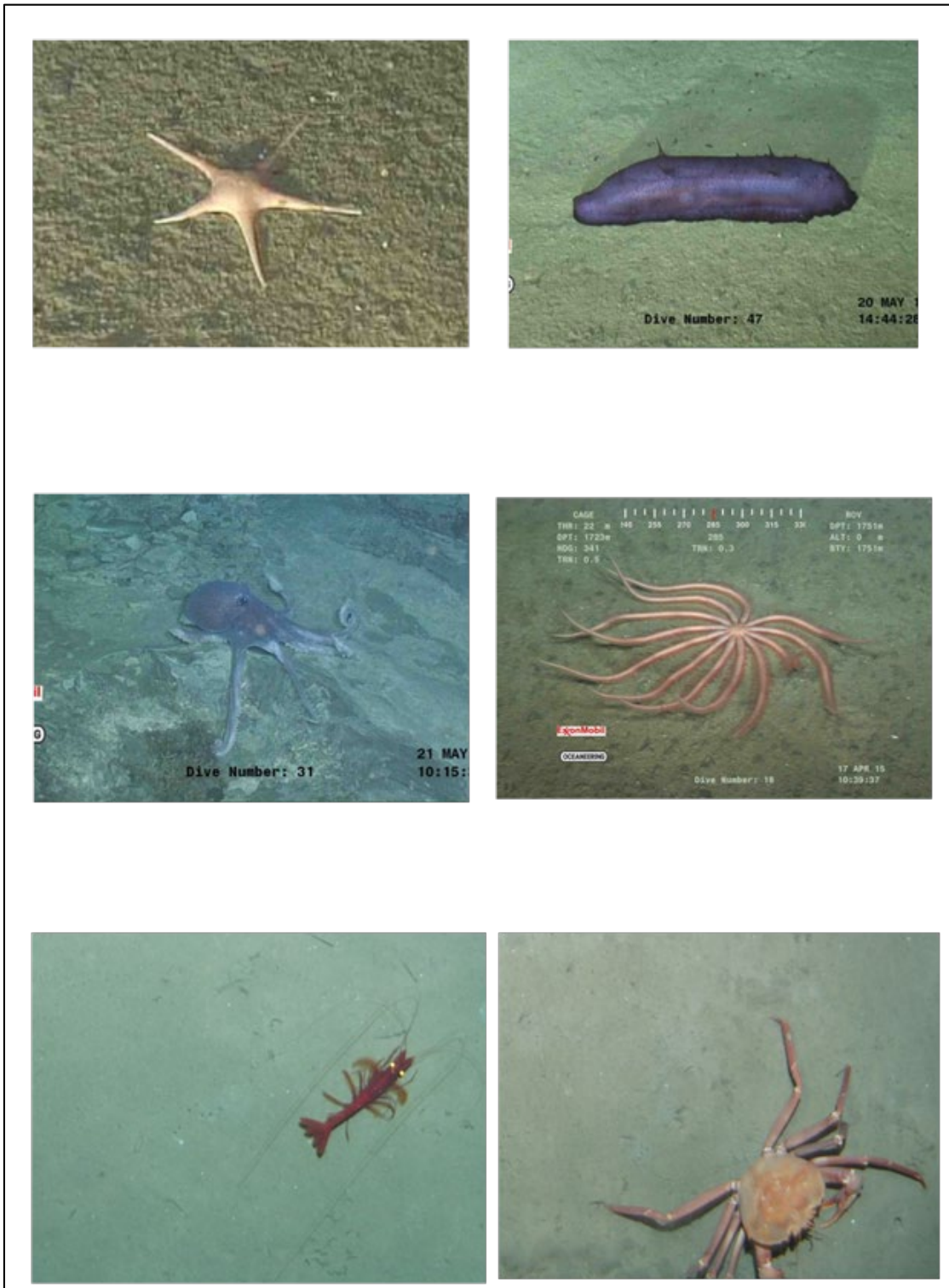


Figure 5.2-9: Rocky Outcrop Community in the Stabroek Block

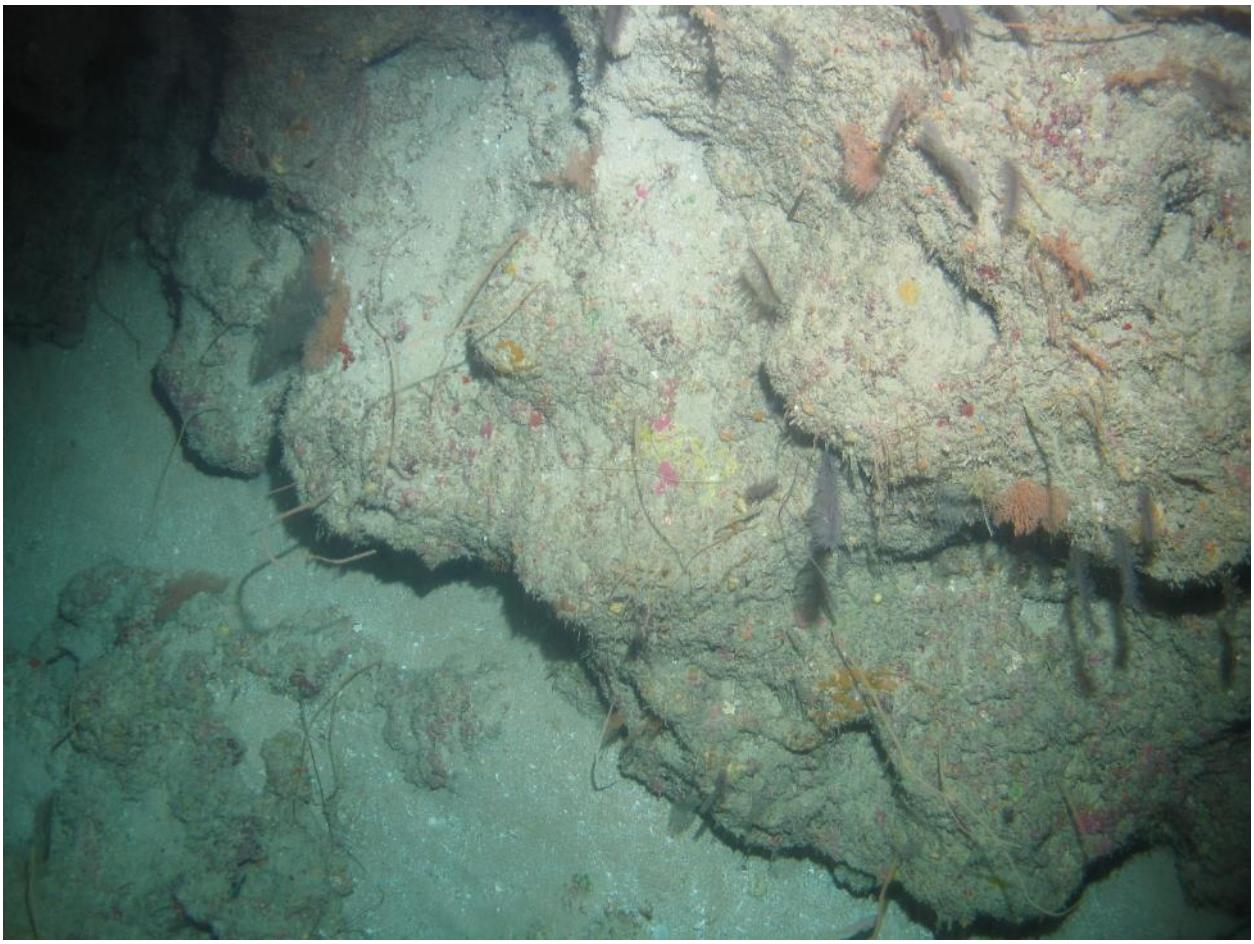


Figure 5.2-10: EBS Sampling Stations and ROV Transects in the Stabroek Block and on Guyana's Continental Shelf

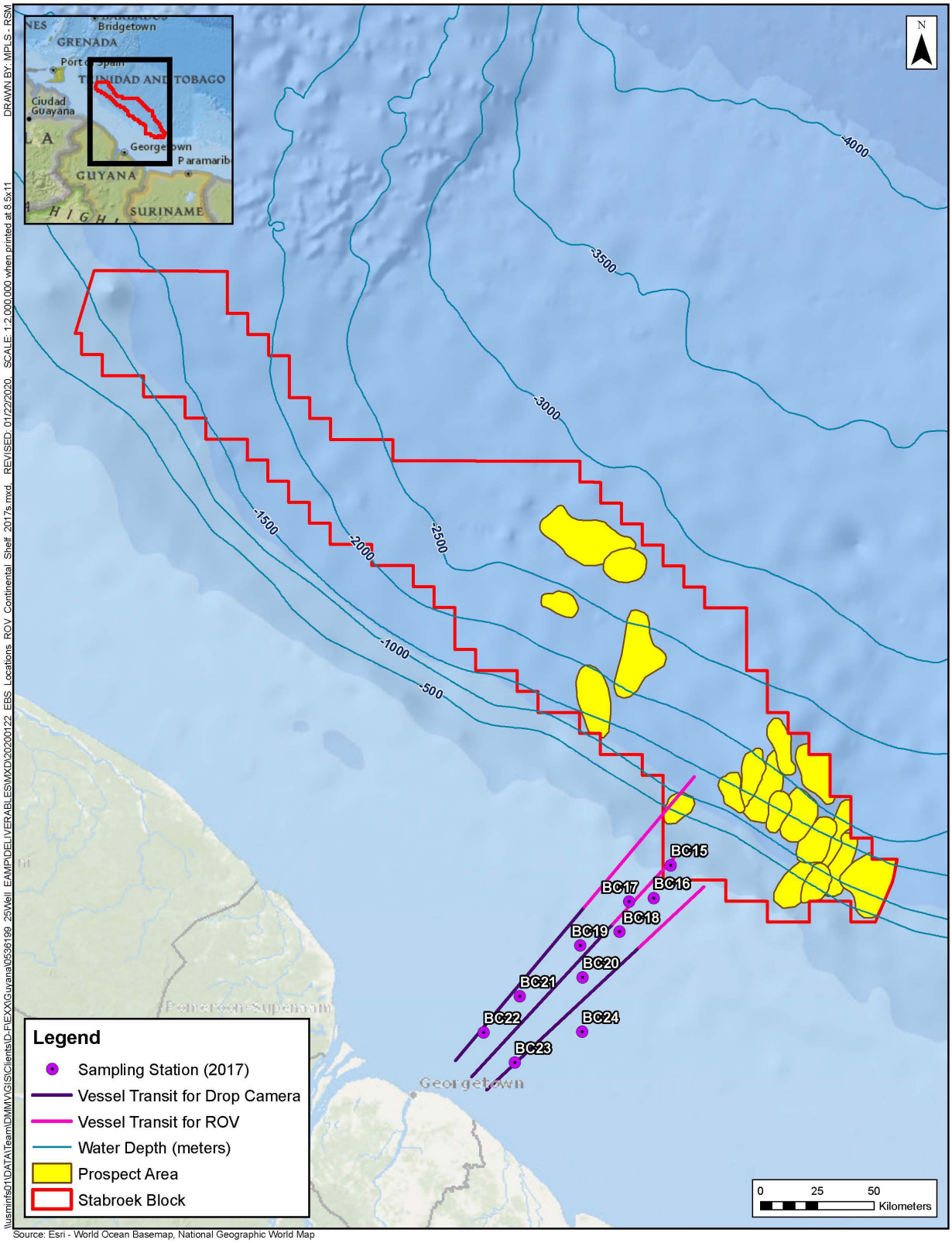
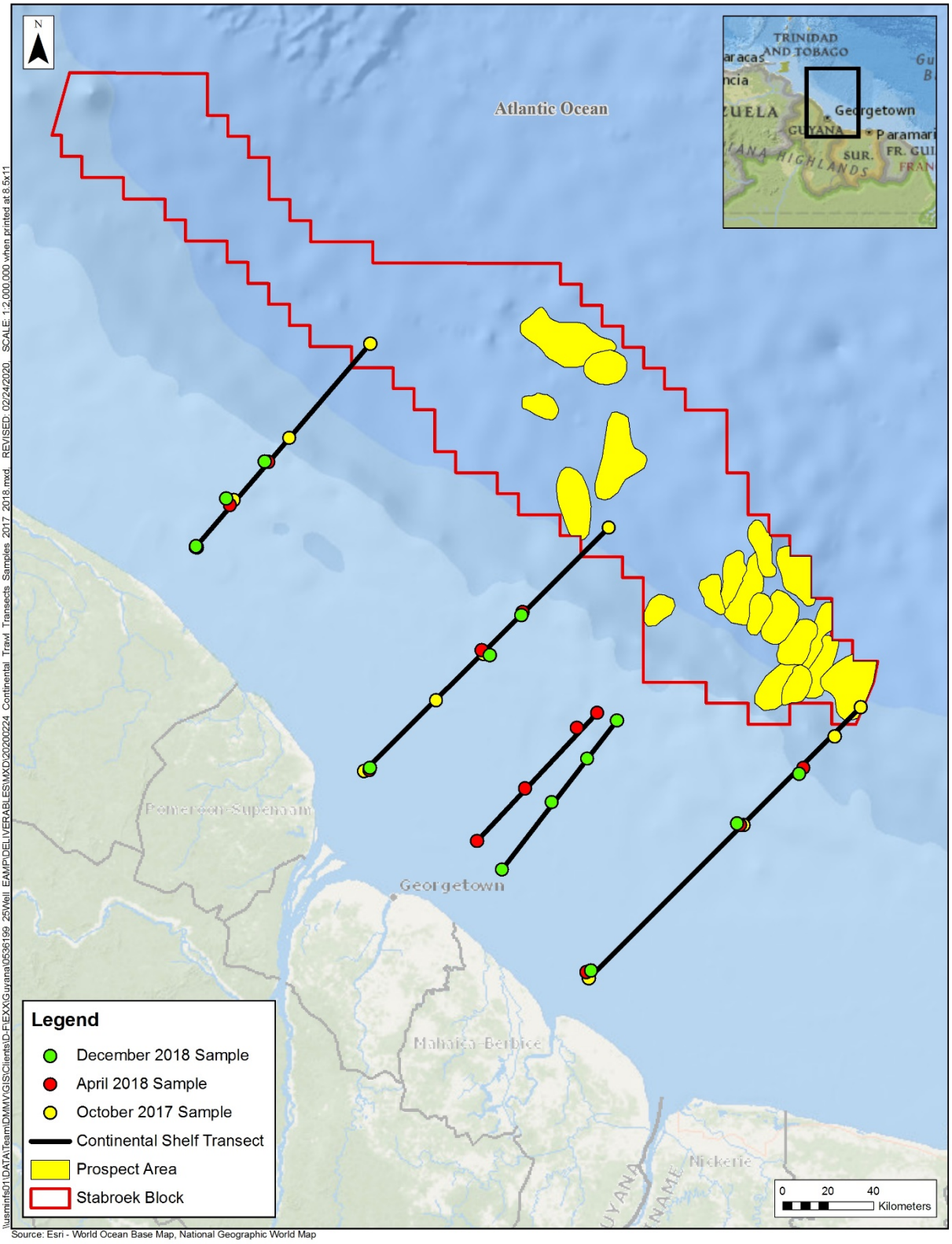


Figure 5.2-11: Trawl Transects on Guyana's Continental Shelf



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 compared to the area in the Stabroek Block that was sampled in 2014, 2016, 2018, and 2019. 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 species were identified.

Unlike the EBS samples, trawls sample a relatively large area but only at the seafloor surface. The continental shelf trawl surveys captured numerous species which are not actively targeted by fisheries in Guyana and therefore may not have been reported from Guyana's territorial waters to date. During the 2017 continental shelf survey, the trawl samples included numerous species of sea cucumbers (Holothuroidea sp.), brittle stars (*Ophioderma* spp.), sea urchins (*Clypeaster euclastus, Eucidaris tribuloides*, *Hygrosoma* sp., and *Lytechinus variegatus*), sea stars (*Astropecten americanus*, *Astopecten marginatus*, *Anthenoides guyanensis*, *Goniaster tesselatus*, *Luidia senegalensis Luidia clathrata*), mantis shrimp (*Squilla empusa),* crabs (*Hepatus gronovii*, *Dromia erytrophus*, *Mithrax* sp., *Callinectes* sp.), shrimp (*Xiphopenaeus kroyeri*, *Penaeus subtilis* and *Penaeus schmitti),* sea snails (*Distorcio clathrata*, *Turritela variegata*, *Tonna galea),* bivalves (*Euvola chazaliei*, *Arcinella* sp.), squid (*Loligo pelaei*), and sponges (Porifera).

Benthic incidental take was widespread across the continental shelf sample stations. Figure 5.2-12 depicts some of the benthos documented from the continental shelf in trawl samples.

Figure 5.2-12: Representative Benthos from Guyana's Continental Shelf



Benthic biological resources offshore Guyana do not include the shallow coral reefs and seagrass meadows that are characteristic of coastal tropical Atlantic environments elsewhere. This is due to the highly turbid conditions offshore Guyana, which do not permit the growth of warm water corals that rely on symbiotic photosynthetic algae for nourishment. However, both *M. oculata* and *S. variabilis* have been documented on the shallow continental shelf. Based on fragments of live coral found at several locations in the 2017-2018 EEPGL-commissioned fish surveys (Figure 5.2-13), these corals appear to be sparse but widespread across the continental shelf. Both *M. oculata* and *S. variabilis* are technically considered reef-building corals but *M. oculata* is particularly fragile and does not often form reefs. It more frequently occurs as a commensal[14] species living within or on reefs that were originally constructed by more robust species such as *S. variabilis*. No coral reefs have been found to date in Guyana's waters.

[14] Living in close association, such that one species benefits without harming the other

Figure 5.2-13: Live Black Coral Fragments from Guyana's Continental Shelf



5.2.3 *Fishery Resources*

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 NBC 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 from studies of similar locales. Beginning in 2015, EEPGL commissioned a program of collecting incidental observations of marine fish from Protected Species Observers (PSOs) engaged in marine mammal-focused surveys offshore Guyana. EEPGL subsequently commissioned a series of surveys targeted at fish in the Stabroek Block and south of the Stabroek Block from 2017 to 2019. Surveys were conducted in separate zones within this area by teams of international and Guyanese fish experts, as follows:

- Stabroek Block: October 2017, April 2018;
- Continental Shelf: September–October 2017, April 2018, 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:

- Deepwater, 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 included in the December 2018 survey event 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.

5.2.3.1 Deepwater and Offshore Pelagic Fish Community

Compared to the shallower environments, Guyana's deepwater environment appears to be lacking in numbers or variety of species. The deepwater fish survey conducted as part of the 2017–2018 fish study sampled demersal fish at several locations on the continental slope (shown above on Figure 5.2-10) between depths of 800 and 1,500 meters and documented three deepwater species: Robinson's hagfish (*Myxine c.f. robinsorum*), sharp-tailed eel (*Coloconger meadi*), and lanternfish (family Myctophidae) (ERM 2018a). According to Guyana's Centre for the Study of Biodiversity, Robinson's hagfish and short-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. Robinson's hagfish was most common near the 1,000-meter isobath. No fish were captured deeper than 1,000 meters. These are the only species of deepwater 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:

- A study of deepwater habitats using ROVs and drop cameras produced images of putative grenadiers (family Macrouridae), skates/rays, and tripodfish (*Bathypterois* sp.) within the Stabroek Block, although none were identifiable to species (ERM 2018a).
- In 2019, Fugro published an investigation of hard seafloor features (HSFs) in the Stabroek Block that captured a photo of an eelpout that was provisionally identified as possibly a member of the genus *Lycodonus*.

Population studies for demersal fish are scarce, but the low productivity of deep sea environments compared to more shallow water environments is thought to limit the numbers of deepwater organisms in general, so the low numbers of fish in the samples are expected. This conclusion is supported by nutrient analysis conducted as part of the Stabroek, Kaieteur, and Canje blocks' EBSs (see discussion in Section 5.1.1, Marine Water Quality) which identified a haloclinic barrier to nutrient inputs to deep water from shallower portions of the water column.

Pelagic sampling of the top 50 meters of the water column within the Stabroek Block in 2017 documented only one species of fish, dolphinfish (*Coryphaena hippurus*); however, 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 Stabroek Block (ERM 2018a). 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 within the Stabroek Block.

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 episodes of the phenomenon. 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 (family 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*).

5.2.3.2 Targeted Surveys of Continental Shelf Fish Community

The discussion of continental shelf fish community data is derived from sampling conducted across the continental shelf in 2017 and 2018. The stations sampled as part of these continental shelf survey events were located in water from 11 to 2,340 meters deep, although most sites were less than 100 meters deep. The continental shelf sampling also included demersal sampling in depths from 10 to 85 meters. The continental shelf was the most diverse environment sampled during this assessment (compared to nearshore and deepwater environments), accounting for 109 fish species. The largest catch in biomass (39.9 percent) was obtained along the easternmost continental shelf transect, which is located offshore of the SBPA in Region 1. The remoteness of this area from commercial fishing harbors and its proximity to the SBPA are both likely playing a role in conserving the fishery resource on the far northwestern Guyanese continental shelf. The relatively high biomass documented on this transect was related more to abundance than to size of individual fish, indicating this area may be playing an important role as nursery habitat (ERM 2018a). Unpublished preliminary data from subsequent dry season surveys in 2019 show similar results.

The most complete historical data on marine fish in Guyana's territorial waters come from a 2-year trawl survey conducted 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 parkerii*), curass (*Sciades proops*), highwater catfish (*Hypophthalmus edentatus*), and several croakers/seatrouts, including bangamary (*Macrodon ancylodon*), bashaw (*Cynoscion acoupa*), and seatrout (*Cynoscion virescens*), were all prevalent at depths of 10 to 15 meters. The snappers and grunts, represented chiefly by barred grunt (*Conodon nobilis*), Caesar grunt (*Haemulon carbonarium*), mutton snapper (*Lutjanus analis*), lane snapper (*Lutjanus synagris*), and southern red snapper (*Lutjanus purpureus*) occurred deeper, primarily between 45 and 60 meters, although they likely extend deeper based on their known depth ranges elsewhere.

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 remaining were habitat generalists that are found in a wide variety of marine settings. 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 fish study 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. The 2017–2018 fish study 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 (ERM 2018a). Lowe-McConnell

noted the presence of some typically reef-associated fishes in her samples, including butterflyfishes, angelfishes, wrasses, and parrotfishes. The study also documented a few reef-associated species, including ocellated moray (*Gymnothorax ocellatus*), French angelfish (*Pomacanthus paru*), and spotfin butterfly fish (*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 2017-2018 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 described above (ERM 2018a). 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).

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. 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* species 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 (ERM 2018a). Unpublished preliminary data from subsequent dry season surveys in 2019 show similar results. 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 Cadel 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.

5.2.3.3 *Additional Surveys of Deepwater and Offshore Pelagic Fish Community*

Additional information on pelagic species of the deepwaters offshore of Guyana is available from visual observations made during EEPGL-commissioned activities in the Stabroek, Kaieteur, and Canje blocks, and surrounding offshore and continental shelf region since 2015. Figure 5.2-14 illustrates the locations of these and other biological observations made since 2015 relative to the location of the Project area. Based on the combination of the surveys and opportunistic observations made since 2015, a total of 32 fish taxa were assessed to be present in the Stabroek, Kaieteur, and Canje blocks at least on an occasional basis (Table 5.2-1).

Table 5.2-1: Fish Species Observed in the Offshore Blocks, and between the Offshore Blocks and the Guyana Shore during EEPGL-Commissioned Activities Since 2015

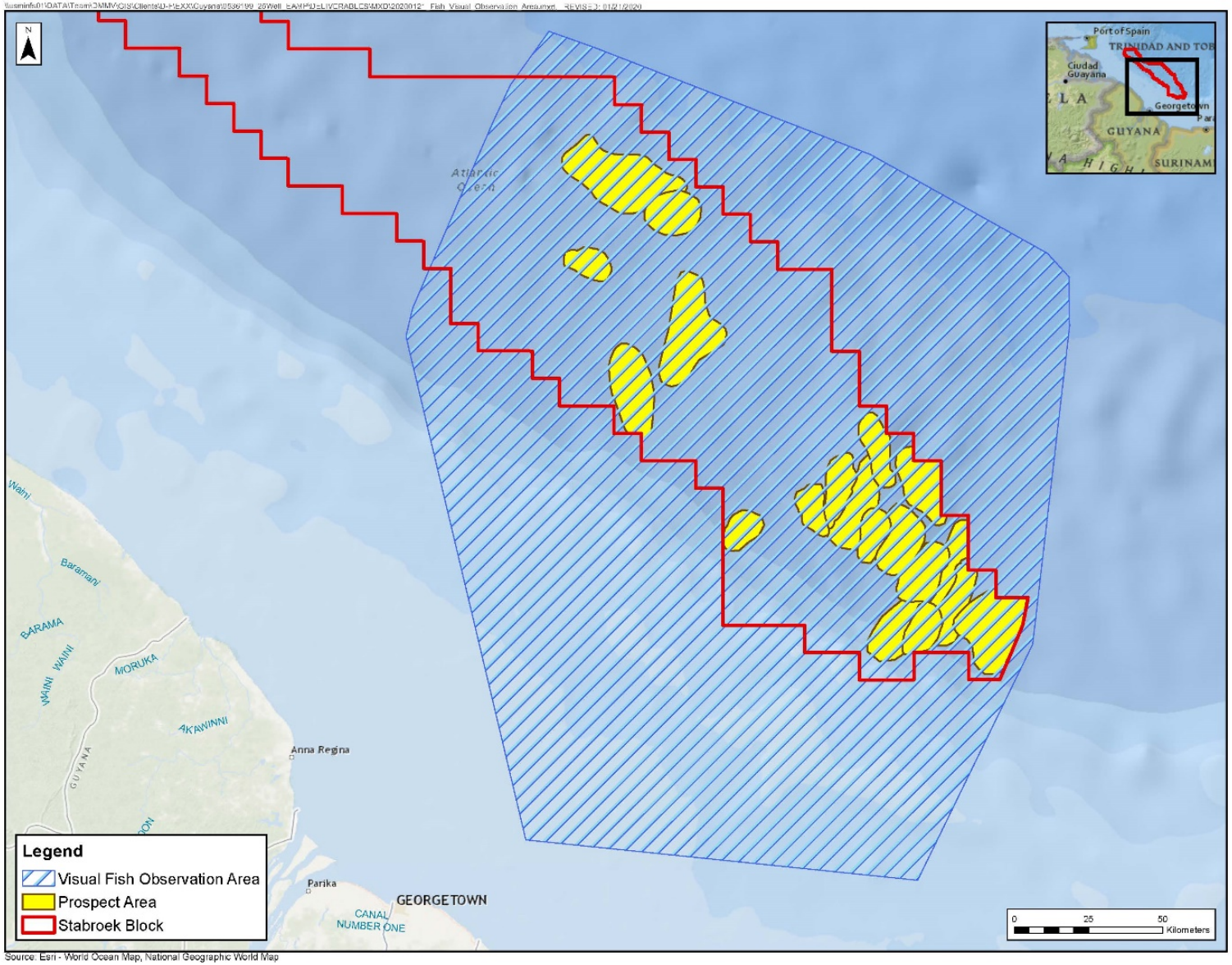
Common Name	Scientific Name	IUCN Status [a]
Atlantic bonito	*Sarda sarda*	LC
Atlantic flying fish	*Chellopogon melanurus*	LC
Atlantic tripletail	*Lobotes surinamensis*	LC
bar jack	*Caranx ruber*	LC
blackfin tuna	*Thunnus atlanticus*	LC
blackwing flying fish	*Hirundichthys rondeletii*	LC
blue marlin	*Makaira 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
largehead hairtail	*Trichiurus lepturus*	LC
little tunny	*Euthynnus alletteratus*	LC
dolphinfish/mahi-mahi	*Coryphaena hippurus*	LC
manta ray	*Mobula* sp.	–

Common Name	Scientific Name	IUCN Status [a]
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
white marlin	*Kajikia albida*	VU

DD-LC = Data Deficient-Least Concern; IUCN = International Union for Conservation of Nature; LC = Least 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.

Figure 5.2-14: Approximate Area of Visual Fish Observations from EEPGL-Commissioned Surveys Since 2015



5.2.3.4 *Nearshore and Estuarine Fish Community*

The nearshore and estuarine surveys conducted as part of the 2017–2019 fish study 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 through January 2019. The estuarine fish community accounted for 20 species sampled at five estuarine stations in 2018 and 2019 (ERM 2018a and unpublished data).

Based on the data from the 2017-2018 fish study (the only years 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 highwater 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/oligohaline 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 dry season nearshore and estuarine surveys in early 2019 were conducted in the early dry season as rainfall was tapering off and yielded 46 species and 13 species, respectively—the most species of any of the nearshore or estuarine surveys to date. This was likely a period of moderate salinity that supported the moderately tolerant species of both the wet-season and dry-season communities. Such transitional conditions would support a short-term increase in the total number of species in both locations.

A noteworthy aspect of the estuarine surveys was the prevalence of leptocephalus larvae in the samples. Leptocephali are slim, transparent larvae of eels and other more distantly related species including tarpon, known as "cuffum" in Guyana, and ladyfish (*Elops saurus*) known as "silverfish" in Guyana. 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 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.

5.2.3.5 *Ichthyoplankton Community*

The ichthyoplankton community was sampled across 17 stations distributed across all four zones in December 2018–January 2019. A total of 8,107 marine organisms representing 152 taxa (including unidentified eggs) were identified in the samples. Fourteen percent more marine organisms were collected at the nearshore sites than at the offshore sites. Overall, 13 taxa (including unidentified eggs) dominated (90 percent) the catch. Sixty-one percent of the catch consisted of marine organisms in the Engraulidae (anchovy) and Sciaenidae (drum or croaker) families. In terms of the species able to be identified to a specific genus species, broadband anchovy (*Anchoviella lepidentostole*), red-eye round herring (*Etrumeus teres*), and acoupa weakfish (*Cynoscion acoupa*) were the most abundant taxa, representing around 9 percent of the catch.

The distribution of marine organisms varied not only by the total number collected per sampling station, but it 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 the yolk-sac larvae (43 percent) followed by the post-yolk sac larvae (30.5 percent) and eggs (18.7 percent). The least abundant life-stages were juvenile (1.6 percent), leptocephalus (0.45 percent), and adult (0.01 percent). The most common life-stages in the nearshore stations were the yolk-sac larvae followed by the post yolk-sac larvae and juveniles. At the offshore stations, the most common life-stages were post yolk-sac larvae, egg, and leptocephalus. The relative abundance of leptocephali in the offshore samples in the December 2018–January 2019 (transitional between wet and dry conditions) 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 migrated 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 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, 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 other nearby regions.

Ichthyoplankton sampling of the nearshore and continental shelf suggest the waters off Guyana provide habitat for the early life-stages of a variety of taxa. As expected, taxa and life-stages 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 nearby regions, such as Brazil indicating this region is as important as others for providing habitat for both nearshore and offshore species.

5.2.4 Marine Turtles and Mammals

5.2.4.1 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 area were described using observational data collected during exploration activities from 2015 to 2019, marine turtle telemetry studies conducted at Shell Beach, data from Reichart et al. (2003), and more recent compilations from Project GloBAL (2007).

Five marine turtle species are found in the greater Caribbean region, all of which occur in Guyanese waters. Four of these species (green turtle [*Chelonia mydas*], leatherback [*Dermochelys coriacea*], hawksbill [*Eretmochelys imbricata*], and olive ridley turtle [*Lepidochelys olivacea*]) nest on Guyana's beaches. A fifth species, loggerhead turtle (*Caretta caretta*) also occur offshore Guyana but rarely come ashore to nest in Guyana. In addition to sandy beaches for egg-laying, as a group, marine turtles require 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 life stages are associated with clearer offshore waters or coral reefs environments where they prey on a variety of items (Piniak and Eckert 2011).

The Guianas region is known for supporting important leatherback, olive ridley, and green turtle colonies. Large nesting aggregations of green and leatherback turtles are located in the eastern Guianas (Suriname and French Guiana), while smaller nesting areas are located from northwestern Guyana (Shell Beach) to Costa Rica. They forage and nest in the Caribbean islands (Leeward, Lesser, and Greater Antilles); the Gulf of Mexico (Central America); and Atlantic Ocean (the Bahamas, mostly for

foraging); and large nesting areas are found along the southern coast of the United States; green marine turtles and loggerhead marine turtles nest in Florida (Dow Piniak and Eckert 2011). Within the Project area, the hawksbill turtle's range is primarily in the Caribbean Sea, with small nesting areas in the Guianas and in eastern Brazil. Similarly, 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 (Dow Piniak and Eckert 2011).

The primary marine turtle (green, hawksbill, leatherback, and olive ridley) nesting site in Guyana is Shell Beach, which is located on the northwestern coast of Guyana. The exact location of secondary nesting sites change with coastal erosion, which either creates or destroys nesting areas, but they are generally distributed along the northwest coast between the Pomeroon and Waini river estuaries. Historically, leatherback turtles were the most common species that nested on Guyana's beaches (e.g., Almond Beach); however, green turtles now commonly nest on Guyana's beaches along with leatherbacks, 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).

Similar to other regions, the primary threats to marine turtles in Guyana are poaching; intentional and incidental take in fishing activities; habitat disturbance and degradation; coastal zone development; shore 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., Tavares et al. 2017) and sometimes intentionally (e.g., Lagueux et al. 2014) taken in commercial fisheries around the world, which has negatively affected their populations. Commercial fisheries are one of the biggest threats to the conservation and recovery of marine turtles (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., USA and Costa Rica), turtle excluder devices (TED), which are specialized devices installed in trawl gear that allow a marine turtle to escape, are required to be installed in trawls. This measure has benefited 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 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 the highest bycatch of olive ridley coincides with the peak shrimp fishery (February-March), which is also when the nesting arribadas in Suriname takes place (January-March).

Information about the behavior and distribution of juvenile marine turtles is extremely limited, but recent research has documented the early life-history of marine turtle activities and movements. 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 marine 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 small-juvenile turtles drifted with oceanic currents during their surface-pelagic stage. Putman and Mansfield (2015) reported hatchling green 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).

EEPGL-Commissioned Marine Turtle Data

Protected Species Observer Data

The EEPGL commissioned the collection of protected species data during various survey activities related to oil and gas activities off Guyana (2015-2019). Data on marine mammals and turtles was collected using visual and auditory detection methods. Together, these survey efforts represented more than 18,000 hours of survey time and generated the most comprehensive dataset available on protected species activity off the coast of Guyana (RPS 2018b; RPS 2019).

During the over 18,000 hours of survey time in the Stabroek, Kaieteur, and Canje blocks, and between the blocks and the Guyana coast from May 2015 through April 2019, a total of 15 marine turtles were detected, including green, hawksbill, loggerhead, and olive ridley turtles. No leatherback turtles were detected during the surveys. Unidentified hard-shelled marine turtles represented 5 of the 15 observations, followed by 4 detections of loggerhead turtles and 2 detections each of green, hawksbill, and olive ridley turtles (RPS 2018b; RPS 2019). Leatherback turtles are

known to occur in the Stabroek Block, but have not been detected at sea by EEPGL staff or its contractors to date.

Conservation Group Marine Turtle Satellite Tracking Studies

Some research groups have documented the movements of adult marine turtles off Guyana. For example, the Sea Turtle Conservancy Society[15] (STC) actively maps marine turtle movements by placing satellite transmitter tags on individual turtles after they finish nesting. In May 2012, STC tracked three leatherback turtles from their nesting site at SBPA and discovered that each turtle remained offshore of SBPA 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 in Guyanese waters until the third week of July and eventually transited to Honduran waters. It should be noted that one individual swam through the Stabroek Block before moving northward. These movements are consistent with other researchers (Pritchard 1973; Fossette et al. 2010) that have reported most turtles migrate away (a few hundred kilometers) from nesting beaches during post-nesting periods. Most turtles remain relatively close to nesting beaches during the nest season (Shillinger et al. 2010; Bond and James 2017) because they often return to lay additional eggs (multiple clutches). Although habitat use by juvenile turtles is generally poorly understood, green turtles and hawksbills are known to have a pelagic juvenile stages which lasts several years (NOAA Fisheries 2014; NOAA Fisheries 2016). 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.

Participatory Fish Study (January-April 2019)

During the EEPGL-commissioned participatory fish study that was initiated in January 2019, additional anecdotal information on marine turtles was collected from fisherfolk through interviews. 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 program in those regions. Many fisherfolk in Region 2 indicated they have seen 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

[15] www.conserveturtles.org

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 SBPA. Similarly, fisherfolk from Smith's Creek (Region 1) report encountering many juvenile marine turtles (ERM/EMC 2019b).

EEPGL-Commissioned Tracking Studies

To study turtle movements, EEPGL's environmental consultant enlisted the assistance of the Chelonian Research Institute and Environmental Management Consultants in 2018 and 2019 to develop and a study on marine turtle movements. Overall, the program included three mobilizations to the SBPA, two in 2018 and one in 2019.

2018 Telemetry Analysis

The first deployment 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. The second deployment 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. The field teams worked in close collaboration with Protected Areas Commission Rangers and local community members during field activities in the SBPA.

In March 2018, the scientists tagged four green turtles (designated as Sibille, Becky, Violet, and Karin for the purpose of tracking) at Shell Beach with satellite tags during the first component of a satellite tagging study being conducted to satisfy the conditions of the Environmental Permit for the Liza Phase 1 Development Project. In June 2018 during the second field component, the scientists placed satellite tags on three leatherback turtles (designated as Julie, Denise, and Arleen, for the purposes of tracking).

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 and three different inter-nesting movement behaviors were identified:

1. Individual remained in the immediate vicinity of Almond Beach, making small near-shore loops;
2. Individual moved moderate distances up and down the Guyana-Venezuela coastline, making small near-shore loops; and
3. Individual moved large distances, making off-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, with the exception of one green turtle which also nested across the Barima-Waini river mouth and nested at longer time intervals than the other turtles. All turtles demonstrated remarkable nesting-site fidelity irrespective of their maximum displacements among nests. With respect to the size of the area used by the turtles during the inter-nesting period, there were no significant differences among species or individuals; however, the leatherback turtles occupied waters at a farther distance from shore than the green turtles.

Generally, the turtles' inter-nesting habitat-use was concentrated within the territorial seas of Guyana in the immediate vicinity of Almond Beach, but it also included the territorial seas of Venezuela and Trinidad. The three leatherback marine turtles and one of the green marine turtles demonstrated more itinerant movement behaviors. Karin, a green turtle, moved the farthest during the inter-nesting period, traveling 261.7 kilometers along the coast, and 50 kilometers 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, the only leatherback with a flipper tag scar, displayed the most moderate offshore movements (54 kilometers) among the leatherback turtles during the nesting season, traveling 104.9 kilometers along the coasts of Guyana and Venezuela and staying around the 50 meter depth contour. Denise, a leatherback turtle, moved the farthest distance from shore (111 kilometers), crossing the 100 meter depth contour during three inter-nesting loops that spanned 120.4 kilometers of shoreline, which included Guyana and Venezuela (ERM 2018b).

As highlighted above, three inter-nesting movement behaviors were reported. Despite these differences, the center of inter-nesting activity for all turtles was immediately adjacent to the nesting beach. Generally, inter-nesting habitat was concentrated within the territorial seas of Guyana - in the vicinity of Almond Beach, but also included the territorial seas of Venezuela and Trinidad. Sibille and Becky remained near their capture locations, spanning 16.7 kilometers and 17.8 kilometers of coastline,

respectively. The turtles circled the 10-meter depth contour, and never traveled more than 11 kilometers from shore.

The two green turtles that exhibited the widest inter-nesting travels (Karin and Violet), dove 16.7 meters, but spent most of their time within the upper 5 meters of the water column. The two comparatively far-ranging turtles traveled into Venezuelan waters, venturing 30 to 40 kilometers off the coast near the Orinoco Delta, and traveling approximately 60 kilometers southeast of Almond Beach. These two turtles very likely remained near the surface more than the others did because the metabolic demands were greater given their extended movement behavior, which forced them to use more energy breathing than the other turtles. These findings 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 (ERM 2018b).

Leatherback turtles occupied deeper water than green turtles in the inter-nesting period. Green turtles spent most of their time in less than 5 meters of water while leatherback turtles spent of their time in less than 10 meters of water. Leatherback turtles are known to dive deep. The one leatherback turtle with a depth sensor tag, Denise, dove to 134.5 meters during the inter-nesting period. Most of the time, Denise made dives within the upper 10 meters. 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) was the day before her last transmission when she was in water depths exceeding 5,000 meters. Details on the vertical habitat use of turtles during their entire tracking period are summarized in Table 5.2-2 (ERM 2018b).

Table 5.2-2: Turtle Daily Vertical Habitat Use

	Water Depth (m)		Turtle Depth (m)		Maximum Dive Depth (m)[16]	
Turtle ID	**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	-	-	-	-

[16] Note: 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 10–13 meters for green turtles. Maximum dives of 30–40 meters were rare but are captured in the range column of the table. The same logic applies to leatherbacks.

Turtle ID	Water Depth (m)		Turtle Depth (m)		Maximum Dive Depth (m)[16]	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
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	-	-	-	-

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.
m = meters

In summary, the 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; 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) 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. Neither the fourth green turtle nor any of the leatherbacks were tracked to their foraging grounds.

The first leatherback migrated 4,634 kilometers 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 offshore.

The 2018 study findings provided a wealth of new information about Guyana's nesting marine turtles. Although the sample size was small, the results provide the at-sea behaviors of green and leatherback turtles in this region. The results showed that Shell Beach is an important nesting area for green and leatherback marine turtles. It also showed the turtles remained in the inter-nesting zone for one to more than three months, before migrating northwest to Venezuela and Trinidad. Turtles laid multiple clutches of eggs and displayed strong site fidelity. During this period, turtles remained primarily in the upper 10 meters near shore, but occasionally migrated to the continental shelf between nesting. Interestingly, green turtles followed a narrow migration corridor along the coastline after nesting, avoiding the opposing Guiana and North Brazil western boundary currents. Leatherback turtles dispersed into the high seas after nesting, taking an initial northeasterly course.

2019 Telemetry Initial Data

In May 2019, the team conducted a third and final tagging event during 7 through 17 May 2019. The fieldwork 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 2 May 2019. 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 also present during tagging. At the time this document was prepared, 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 EA&MP, or any other similar analysis.

5.2.4.2 *Marine Mammals*

A basic understanding of the existing species composition and distribution of the marine mammal community in the Project area is provided by various sources, including regional compilations (Ward et al. 2001; Ward and Moscrop 1999), MMO data collected during EEPGL's exploration activities from 2015 to 2019, 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 Project area (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 in the Stabroek Block and/or adjacent Canje Block—3D/4D surface seismic; field geotechnical; automated underwater vehicle (AUV); VSP; and environmental baseline/metocean.

Historical Data from the Guianas Region

Historical data from the region consists of several separate studies. In 2015 the Dutch Institute for Marine Resources and Ecosystem Studies published a peer-reviewed account of marine mammal data collected in a targeted survey in 2012 offshore Suriname, and incidental observations from 2008-2012 from Surinamese and adjacent waters (de Boer 2015). The data from this study were collected at similar depths and distances offshore as the Project area. The survey data from de Boer (2015) contain mostly odontocetes (toothed whales, including sperm whales, beaked whales, killer whales, and dolphins). These are more common offshore of Suriname than the baleen whales, which de Boer found were limited to Bryde's (*Balaenoptera brydei*) and sei (*Balaenoptera borealis*) whales.

De Boer (2015) recorded Bryde's and sei whales only during June, July, and October. De Boer (2015) notes that the most abundant species documented offshore Suriname were the sperm whale (*Physeter macrocephalus*) and melon-headed whale (*Peponocephala electra*). Spinner dolphins (*Stenella longirostris*) and pantropical spotted dolphins (*Stenella attenuata*) were also frequently encountered in large groups. The relative abundance index for all cetaceans was relatively low in de Boer (2015).

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), both of which have similar offshore environments to Guyana and are therefore relevant to this analysis. According to these reports, bottlenose dolphins are incidentally captured in both gillnet and trawl fisheries in these countries. Tucuxi or grey dolphin (*Sotalia fluviatilis*) are known to suffer incidental capture in gillnets and seines throughout their 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, but is known to occur in the Demerara River where Project-related marine support vessels are expected to transit.

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 EEZ. Project GLoBAL data indicate the potential for up to 26 species of marine mammals to occur offshore Guyana. Consistent with the above-mentioned sources, most of the species in the Project GloBAL profile for Guyana are small to medium sized species including dolphins, porpoises, and beaked whales, but the report includes eight species of large whales (baleen whales plus sperm whales) as well.

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 2018b; RPS 2019).

Over the approximate 5-year study period (2015-2019), there have been 1,322 marine mammal detections. To date, in the Stabroek Block, there have been confirmed observations of 15 cetacean species, four cetacean species in the Canje Block, and four cetacean species observed incidentally at the southern boundary of the adjacent Kaieteur Block (RPS 2018a; RPS 2019).

From May 2018 through April 2019, dolphins (72 percent) were the most commonly detected species group, followed by whales (1.5 percent) (RPS 2019). This resembles the results from the 2015 through April 2018 surveys, during which dolphins accounted for 82.5 percent of all detections (RPS 2018b). The May 2018 through April 2019 surveys

identified three new species not previously recorded during the 2015 through April 2018 surveys: pygmy killer whale (*Feresa attenuata*), long-beaked common dolphin (*Delphinus capensis*), and clymene dolphin (*Stenella clymene*) (RPS 2019). The most common identified dolphins in the May 2018 through April 2019 surveys were spinner dolphins, followed by pantropical spotted dolphins, and clymene dolphins. The most common identified whales were Bryde's whales and sperm whales; there were a few other whales detected, but their identification was unable to be confirmed (RPS 2019).

Table 5.2-3 summarizes the species visually documented during the 2015 through 2019 surveys. Most of the species identified are listed as Least Concern (LC) by the International Union for Conservation of Nature (IUCN), indicating that they are relatively common and are not currently assigned an elevated conservation status.

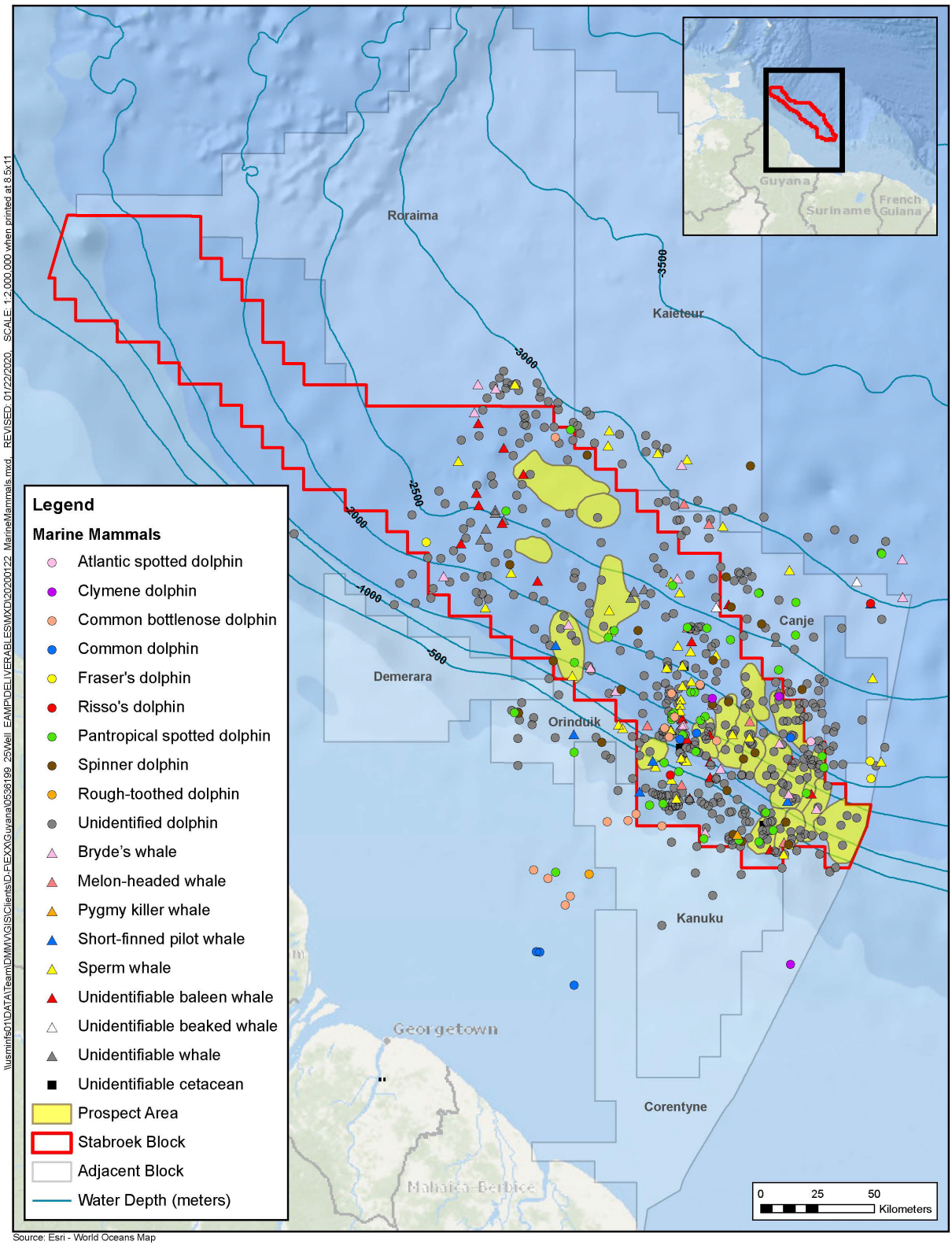
Table 5.2-3: Marine Mammal Species Visually Observed during EEPGL Activities (2015-2019)

Common Name	**Scientific Name**
Bryde's whale	*Balaenoptera brydei*
Sperm whale	*Physeter microcephalus*
Melon-headed whale	*Peponocephala electra*
Short-finned pilot whale	*Globicephala macrorhynchus*
Pygmy killer whale	*Feresa attenuate*
Atlantic spotted dolphin	*Stenella frontalis*
Common bottlenose dolphin	*Tursiops truncates*
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*

Sources: RPS 2019

Overall, 674 of the 1,322 detections from 2015 through April 2019 were identifiable to species (Figure 5.2-15). Sperm whales (3.1 percent) were the most commonly identified species of whale during the entire study period followed by the Bryde's whale (1.6 percent) (Figure 5.2-15). 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.

Figure 5.2-15: Marine Mammal Sightings (2015–2019)



RPS graphed detections per hour of observation effort by month for the survey period from 2015 through April 2018 (RPS 2018b). Toothed whale detections showed seasonal variability, with an increase in autumn and winter and a decrease in spring and summer. 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.

A survey of nearshore Guyanese fisherfolk (n = 125) 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 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. These findings also suggest that dolphins may be present throughout the Project area and at all times of the year; however, they are likely to be more abundant in the Project area in the autumn and winter months.

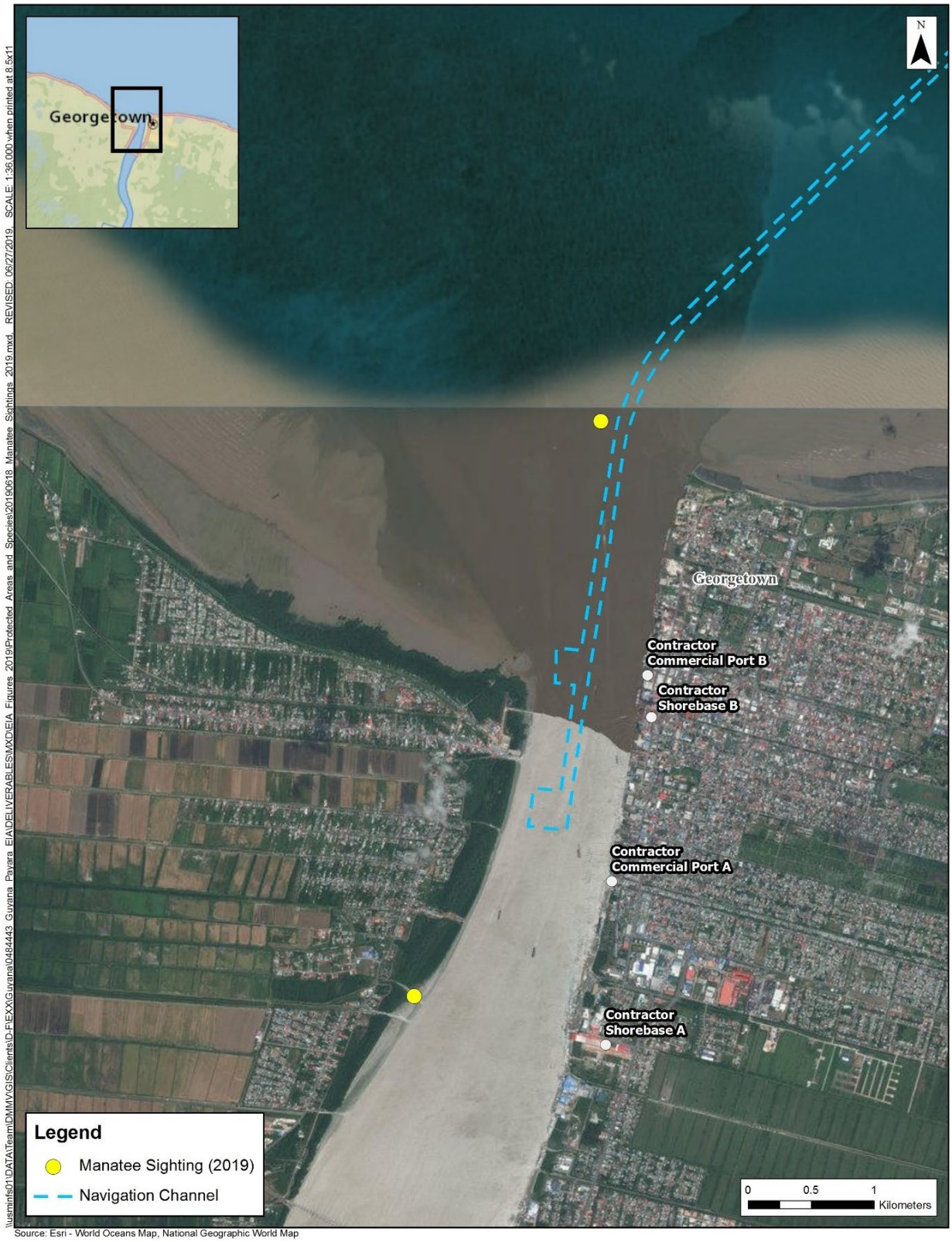
Shorebase facilities where Project-related vessel traffic and onshore infrastructure operations will occur are located in potential habitat for five other aquatic mammals that live in inland and coastal riverine and

wetland environments, as well as nearshore marine environments in Guyana. These species include the West Indian manatee, giant otter (*Pteronura brasiliensis*), neotropical otter (*Lontra longicaudis*), Amazon river dolphin (also locally referred to as boto; *Inia geoffrensis*), and gray river dolphin.

The distribution and composition of these species in Guyana is largely unknown and no known systematic survey has been conducted in the country. EEPGL commissioned a targeted survey in early 2019 to document the species assemblage and abundance of aquatic 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 location of the shorebase facilities and onshore infrastructure operations. 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, the data from two survey events have been reviewed—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 Demerara 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 5.2-16). No other aquatic mammals were observed during the April and May 2019 survey events.

Figure 5.2-16: Location of West Indian Manatee Sightings Recorded in April and May 2019



5.2.5 Seabirds

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 that have been observed 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 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 potentially occurring in the Project area are likely to be transients, moving opportunistically with schools of fish, oceanic arthropods, plankton, and other prey. The marine environment within the Project area 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 Project area (see Section 5.1.1.1, Currents). Further, no islands or near-surface submarine ridges that would be an attractant to foraging seabirds occur in the Project area. While a variety of fish likely occur in the Project area, 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 Project area to the extent that they would promote regular use by foraging seabirds. The turbid conditions in the Project area further reduce the likelihood that the area has significant importance for foraging seabirds.

Well 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 Kaieteur, Canje, and Stabroek blocks, 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).

5.2.5.1 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[17] 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.

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 Project area 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 region, 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 undoubtedly higher than 28, as documented through EEPGL-commissioned marine bird survey work conducted in the Stabroek Block between 2017 and 2019 (Section 5.2.5.2, EEPGL-Commissioned Marine Bird Surveys).

[17] 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.

5.2.5.2 *EEPGL-Commissioned Marine Bird Surveys*

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. Figure 5.2-17 depicts the locations of the surveys and bird sightings near the Kaieteur Block that took place in the Stabroek Block and the area between the Stabroek Block and Guyana coast.

The nine EEPGL-commissioned marine bird surveys conducted to date yielded 1,837 bird observations representing 69[18] bird species within the Stabroek Block and the area between Georgetown and the Stabroek Block (Table 5.2-4). Fewer than half of the species observed during the surveys are classified as seabirds[19] (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*). 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.

[18] The species count includes only individuals confirmed to species; it does not include species identified to only genus (i.e., unknown tern).
[19] Includes species categorized as Pelagic or Nearshore Marine in Table 7.4-4.

Figure 5.2-17: Marine Bird Survey Locations (2017-2019)

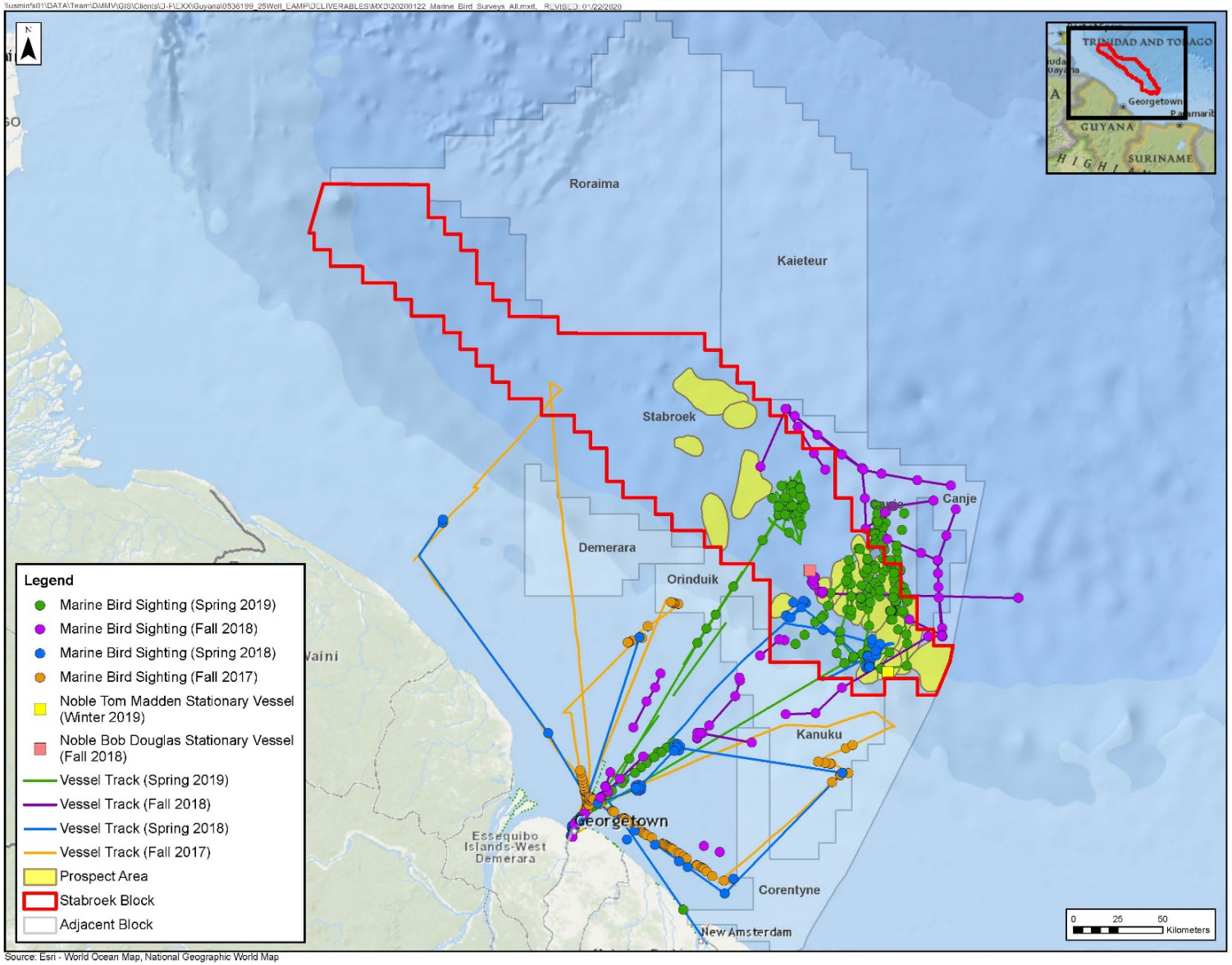


Table 5.2-4: Bird Species Observed during EEPGL-Commissioned Marine Bird Surveys Conducted in the Stabroek Block and between the Stabroek Block and Georgetown, 2017–2019

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 Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring
Common Tern	*Sterna hirundo*	Nearshore Marine	X	X	X		X
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		

Common Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring
Whimbrel	*Numenius phaeopus*	Shorebird	X				X
Barn Swallow	*Hirundo rustica*	Migratory Landbird	X		X		
Purple Martin	*Progne subis*	Migratory Landbird			X		
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		

The EEPGL-commissioned marine bird surveys have yielded nine new records for Guyana to date (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*), Arctic Tern (*Sterna paradisea*), White-tailed Tropicbird (*Phaethon lepturus*), 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.

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. 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 from shore and steadily decreased with increased distance to shore, with the fewest number of birds in areas more than 100 kilometers 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). The Fall 2017, Fall 2018 Survey 1b, and Fall 2018 Survey 1a events also had the greatest abundance per survey effort.

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 5.2-4). 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 (i),

Common Tern (*Sterna hirundo*), Rock Pigeon—Feral (*Columba livia*)[20], Laughing Gull (*Leucophaeus atricilla*), and Masked Booby (*Sula dactylatra*).

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. 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).

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), 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.

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).

Species richness documented during the Spring 2018 and Spring 2019 surveys were very 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.

[20] 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.

The seasonal variations described above indicate that the Stabroek Block and surrounding offshore area, including the Kaieteur and Canje blocks, 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[21] 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 offshore area of Guyana 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 Important Bird Areas (IBAs) in Tobago and St. Vincent and the Grenadines 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.

Incidental Seabird Observations

Incidental observations within and en route to the offshore areas of Guyana have been recorded by PSOs during various EEPGL-commissioned environmental and geophysical sampling and survey activities offshore Guyana from 2015 through 2019 (RPS 2018b; 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 2018a; 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

[21] Staging areas are areas along bird migration corridors that are consistently used by migrating birds for foraging and resting.

documented during EEPGL's targeted marine bird surveys, include Black-capped Petrel (*Pterodroma hasitata*), Great Skua, South Polar Skua (*Stercorarius maccormicki*), and Northern Gannet[22]. Of these four 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 (36 percent), Magnificent Frigatebird (15 percent), Barn Swallow (*Hirundo rustica*) (5 percent), and Brown Booby (*Sula leucogaster*) (4 percent).

Summary of Available Seabird Data

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, including two species of conservation importance (Leach's Storm-Petrel and Black-capped Petrel, see Section 5.2.5.3, Conservation Status of Seabirds Confirmed for Offshore Guyana), occur in Guyana's offshore areas; (2) Guyana's 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 Guyana's offshore areas; (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 terms 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 seasonal migrations in the Stabroek Block by a wide range of bird species and nine new species records for Guyana generated during the EEPGL-commissioned marine bird surveys.

[22] 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.

5.2.5.3 *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 LC, which means that the population status of the species does not meet the IUCN criteria for a Threatened or Near Threatened (NT) designation (IUCN 2019). 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 (VU); and Black-capped Petrel is classified as Endangered (EN).

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. Also, this species was previously reported in Guyana in eBird and during prior EEPGL surveys (RPS 2018a; RPS 2019). It nests in cold, northern ocean waters, so these individuals were likely undergoing their seasonal migration when observed during the surveys. Based on the number of sightings during spring over two consecutive years, the Stabroek and Canje blocks, and likely the Kaieteur Block, can be considered to contain an appreciable population of this species seasonally.

The Black-capped Petrel, classified by IUCN as EN, has been reported in eBird for offshore Guyana and has been recorded during incidental observations collected by PSOs during various sampling activities, 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[23] (Simons et al. 2013), of which myctophids (lanternfishes, a group of fish species that exhibit bioluminescence) are common to abundant in Guyana's offshore waters. 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).

5.2.5.4 Important Bird Areas for Seabirds

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 5.2-5). Figure 5.2-18 depicts the location of these IBAs relative to the Stabroek Block.

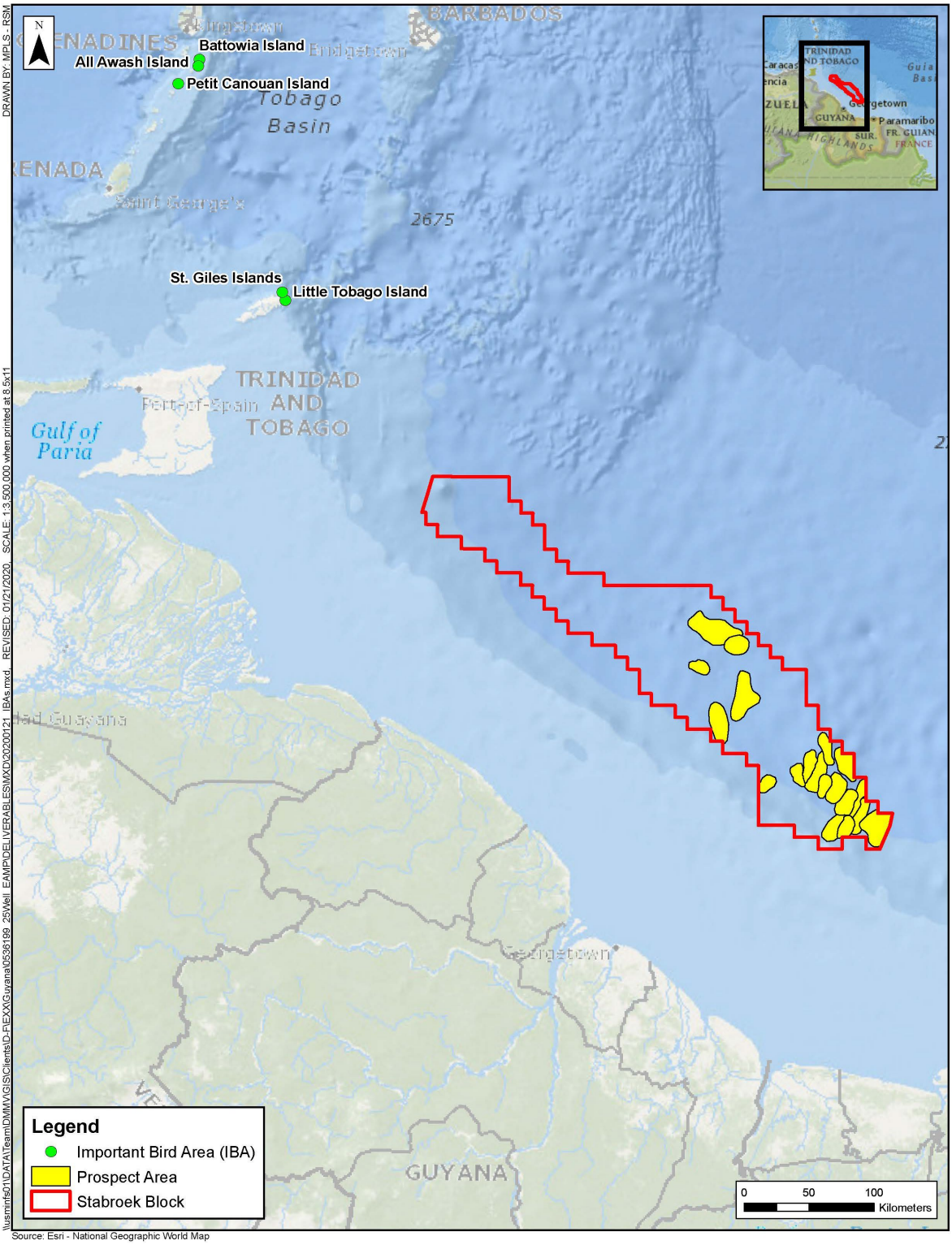
[23] Actively swimming aquatic organisms in a body of water that can move independently from water currents

Table 5.2-5: Marine IBAs with Importance to Seabirds that Transit near 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

Figure 5.2-18: Marine IBAs of Importance to Seabirds that Transit near the Stabroek Block



5.2.6 *Special Status Species*

The IUCN maintains the IUCN Red List, which provides taxonomic, conservation status and distribution information on plants and animals that have been globally evaluated to determine the relative risk of extinction (IUCN 2019). The IUCN Red List is globally recognized as a source of information on the conservation status of specific species. There are 296 IUCN Red Listed species known to occur in the coastal and marine habitats in Guyana. Seventy-four (74) of these coastal or marine species have been ranked NT or higher (i.e., VU, EN, or Critically Endangered [CR]). An additional 37 species known to occur in the coastal or marine habitats in Guyana are listed by IUCN as Data Deficient (DD). These species are listed in Appendix D, IUCN-Listed Coastal and Marine Species Known From Guyana.

According to the IUCN's classification scheme, these 74 species currently face a credible threat of extinction, are expected to face such risks soon, or cannot be objectively assessed with the currently available data. The vast majority of the species ranked NT or higher are fish (54 species), 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 5.2.2, Benthic Resources, many of these listed finfish species are also targeted by the Guyanese commercial fishing industry. The remaining IUCN-listed marine and coastal species in Appendix D are comprised of marine and terrestrial turtles (5), marine/mammals (4), and birds (11).

Table 5.2-6 lists the 74 species with elevated conservation status, their current IUCN Red List status, and their primary habitat association.

Table 5.2-6: 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	Detected in EEPGL-Commissioned Studies
Birds				
Agamia agami	Agami Heron	VU	Coastal lowland forest and marsh	
Buteogallus aequinoctialis	Rufous Crab Hawk	NT	Coastal mangrove	X
Calidris canutus	Red Knot	NT	Coastal mudflat and beach; marine during migration	X

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana	Detected in EEPGL-Commissioned Studies
Calidris pusilla	Semipalmated Sandpiper	NT	Coastal mudflat and beach; marine during migration	X
Conirostrum bicolor	Bicolored Conebill	NT	Coastal mangrove	X
Harpia harpyja	Harpy Eagle	NT	Coastal mangrove	X
Oceanodroma leucorhoa	Leach's Storm-Petrel	VU	Marine	X
Patagioenas subvinacea	Ruddy Pigeon	VU	Coastal and inland forest	X
Picumnus spilogaster	White-bellied Piculet	VU	Coastal mangrove	X
Pterodroma hasitata	Black-capped Petrel	EN	Marine	X
Ramphastos tucanus	White-throated Toucan	VU	Coastal and riverine forest	X
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	X
Trichechus manatus	West Indian manatee	VU	Coastal and riverine	X
Marine and Terrestrial Turtles				
Chelonia mydas	Green turtle	EN	Marine and coastal	X
Dermochelys coriacea	Leatherback turtle	VU	Marine and coastal	X
Eretmochelys imbricata	Hawksbill turtle	CR	Marine and coastal	X
Geochelone denticulata	Yellow-footed tortoise	VU	Riverine and interior forest	X
Lepidochelys olivacea	Olive ridley turtle	VU	Marine and coastal	
Fishes				
Aetobatus narinari	Spotted eagle ray	NT	Offshore and coastal pelagic	
Albula vulpes	Bonefish	NT	Coastal demersal	X
Alopias vulpinus	Common thresher shark	VU	Offshore and coastal pelagic	
Balistes capriscus	Gray triggerfish	VU	Coastal demersal	X

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana	Detected in EEPGL-Commissioned Studies
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	
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	X
Galeocerdo cuvier	Tiger shark	NT	Offshore and coastal pelagic	X
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	X
Lachnolaimus maximus	Hogfish	VU	Coastal demersal	

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana	Detected in EEPGL-Commissioned Studies
Lopholatilus chamaeleonticeps	Golden tilefish	EN	Offshore and coastal demersal	
Lutjanus analis	Mutton snapper	NT	Coastal demersal	X
Lutjanus cyanopterus	Cubera snapper	VU	Coastal demersal	
Lutjanus synagris	Lane snapper	NT	Coastal demersal	X
Makaira nigricans [a]	Blue marlin	VU	Offshore pelagic	X
Manta birostris	Giant manta ray	VU	Offshore and coastal pelagic	
Megalops atlanticus	Tarpon	VU	Coastal pelagic	
Mola mola	Ocean sunfish	VU	Offshore pelagic	X
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	X
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	X
Sciades parkeri	Gillbacker sea catfish	VU	Coastal demersal	X
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	

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana	Detected in EEPGL-Commissioned Studies
Thunnus alalunga	Albacore tuna	NT	Offshore pelagic	
Thunnus albacares	Yellowfin tuna	NT	Offshore pelagic	X
Thunnus obesus	Bigeye tuna	VU	Offshore pelagic	
Thunnus thynnus	Atlantic bluefin tuna	EN	Offshore pelagic	

Source: IUCN 2019

[a] Blue marlin is not listed by the IUCN as occurring in Guyanese waters; however, blue marlin have been reported in Guyanese waters from EEGPL-commissioned vessels operating offshore Guyana.

5.2.7 *Protected Areas*

In 2011, Guyana enacted protected areas legislation which established a Protected Areas Commission to oversee and manage protected areas. The legislation also established Shell Beach and the Kanuku Mountains as Guyana's newest nationally protected areas, which 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 nine percent of Guyana's land area, as summarized in Table 5.2-7. Figure 5.2-19 illustrates the locations of Guyana's protected areas.

Table 5.2-7: Protected Areas in Guyana

Protected Area	Approximate Size (hectares)
Kaieteur National Park	63,000
Iwokrama Forest	371,00
Kanashen (Community Owned Conservation Area)	625,000
Moraballi Forest Reserve	11,000
Kanuku Mountains	611,000
Shell Beach Nature Reserve	200,000
Maruba Hill Forest Reserve	2,000

Figure 5.2-19: Protected Areas of Guyana

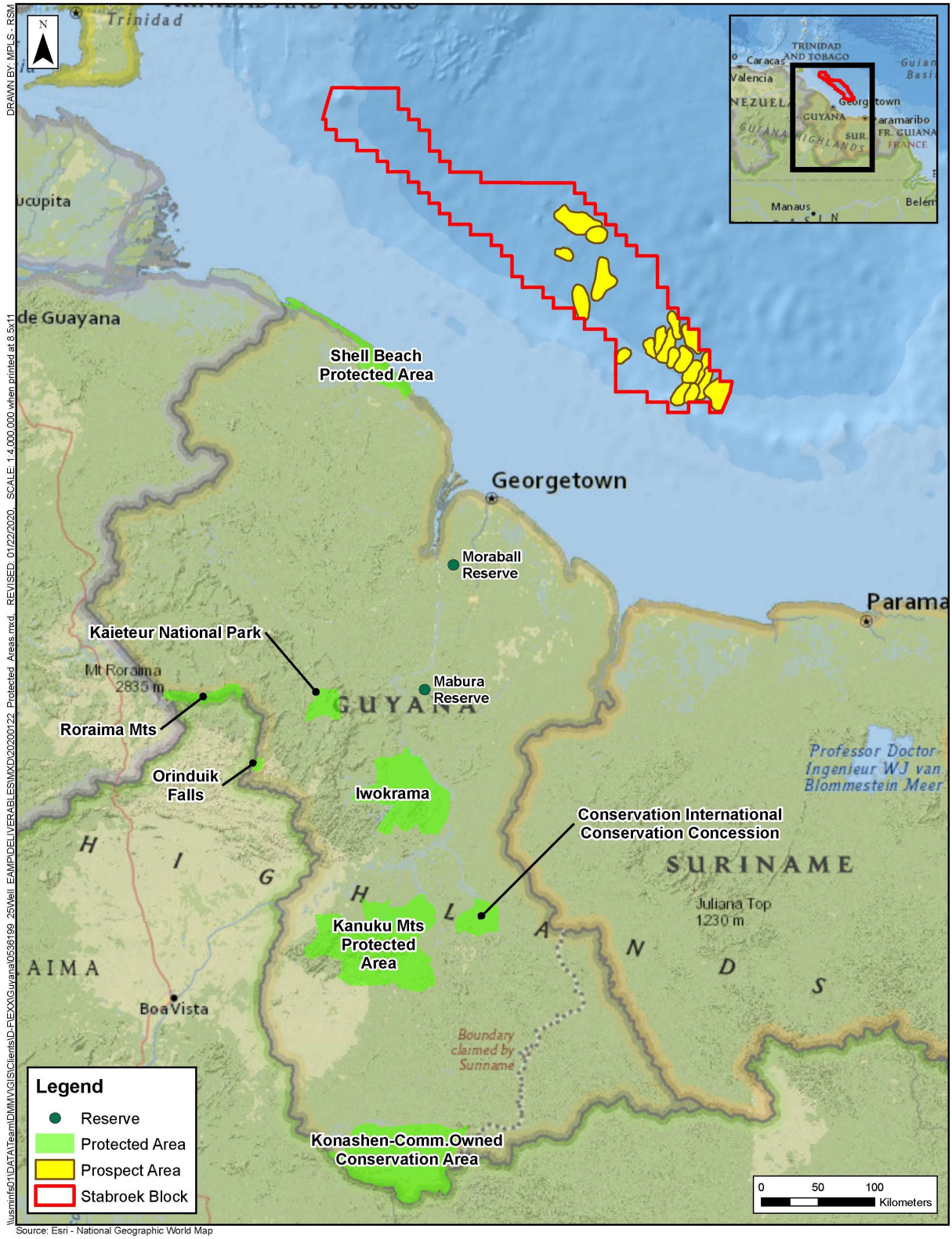
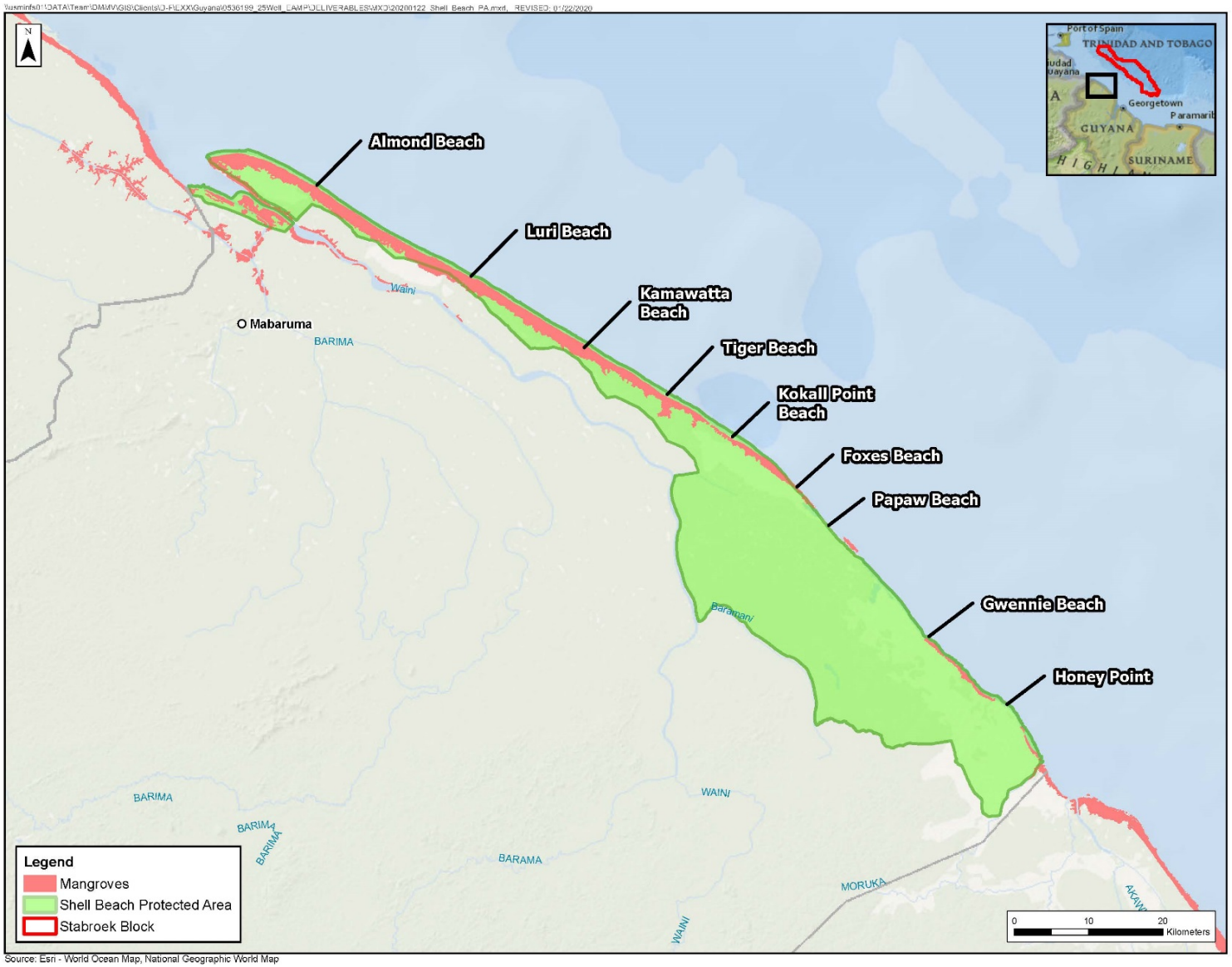


Figure 5.2-20: Shell Beach Protected Area



The SBPA is the only protected area on Guyana's coast, and is most pertinent to the assessment of potential impacts from the Project. Figure 5.2-20 provides a detailed map of Shell Beach and the surrounding area. It is located in northwestern Guyana and extends for almost 140 kilometers between the Waini, Baramani, and Moruka Rivers and the Atlantic Ocean. The shortest distance between the SBPA and the Project area is more than 225 kilometers. Shell Beach is a dynamic area and its landscape constantly changes due to the competing effects of erosion and accretion along the shorefront. Seventy percent of the area is forested; the rest is made up of mostly swamp (28.8 percent), and sandy beaches (1.2 percent) (Kandaswamy 2014). Shell Beach supports numerous plant species including coconut, papaya, and palm trees (GMTCS 2011; Bovell 2011). Shell beach supports rich bird, herpetofauna (reptiles and amphibians), and mammal communities, as described below.

There are currently no designated marine protected areas in Guyana. However, the ecology of the coastal zone and Shell Beach are inextricably connected to the coastal marine ecosystem. The SBPA includes riparian area along the coast, but does not extend into the Atlantic Ocean. The vegetation within the coastal zone area of Guyana is comprised of lowland swamp forests, palm savannas, and the largest stretch of mangrove forests in the country. 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 protected area 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.

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 impact makes it an ideal nesting site for marine turtles. Most nesting beaches in Guyana are used by only one or two species of marine turtle but four species of marine turtle (leatherback [*Dermochelys coriacea*], hawksbill [*Eretmochelys imbricata*], olive ridley [*Lepidochelys olivacea*], and green turtle [*Chelonia mydas*]) found in Guyana nest at Shell Beach (Pritchard 2001). In addition to the marine turtles there are also at least four other species of turtles present within the protected area including the yellow-foot tortoise (*Geochelone denticulate*), scorpion mud turtle (*Kinosternon scorpioides*), giant river turtle (*Podocnemis expansa*), and mata (*Chelus fimbriata*).

The SBPA also supports rich bird and mammal communities. In 2004, a Rapid Biodiversity Assessment of Shell Beach documented 170 species of birds (one of the richest populations in all of Guyana, including well

known species such as Scarlet Ibis [*Eudocimus ruber*], Roseate Spoonbill [*Platalea ajaja*], and Caribbean Flamingo [*Phoenicopterus ruber*]). Parrots are also very abundant in the area. Orange-winged Amazon Parrots (*Amazona amazonica*) were historically extremely abundant and are commercially collected for the wildlife trade in the area, and several species of macaws are common in the riparian forests. Twenty species of mammals including such charismatic megafauna as howler monkeys, jaguars, and manatees are known to inhabit the Shell Beach area and surrounding coastal region (Prince et al. 2004; Kalamandeen and DaSilva 2005).

The area near Shell Beach has been inhabited for 10,000 years by Amerindian groups from the Warao, Carib, and Arawak tribes (Charles et al. 2004). 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. The principal titled indigenous communities located 5 to 10 kilometers 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 1).

Amerindian communities continue to use Shell Beach area for subsistence fishing, crabbing, trapping, farming, logging, and palm harvesting. In the Protected Area, fishing and crabbing occur at the westernmost end of Shell Beach, at the mouth of the Waini River. Many communities from Regions 1 and 2, and inland from the coast, also venture to the Shell Beach easternmost coastline near the mouth of the Pomeroon River 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 just northwest of this is a forested area where hunting, trapping, fishing, crabbing, crabwood seed harvesting, and lumbering occurs (Kandaswamy 2014).

5.3 SOCIOECONOMIC RESOURCES

5.3.1 Coastal Demographics

Guyana is divided administratively into ten regions. Six of the regions are located in the north of the country along the coast, and the remaining four comprise the interior portion of the country. With the exception of the East Berbice-Corentyne region which spans the entire eastern border of the country with Suriname from the Atlantic Coast to Brazil, the coastal regions tend to be smaller than the interior regions. Figure 5.3-1 illustrates Guyana's national borders, the regional boundaries within the country, and the most prominent towns.

5.3.1.1 *Regional Population Distribution*

Most of the country'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. The second-most populous region is East Berbice-Corentyne. The third-most populous region is Essequibo Islands-West Demerara, located west of Georgetown. Table 5.3-1 summarizes the distribution of population within the ten regions in 2012, the last year for which complete census data is 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.

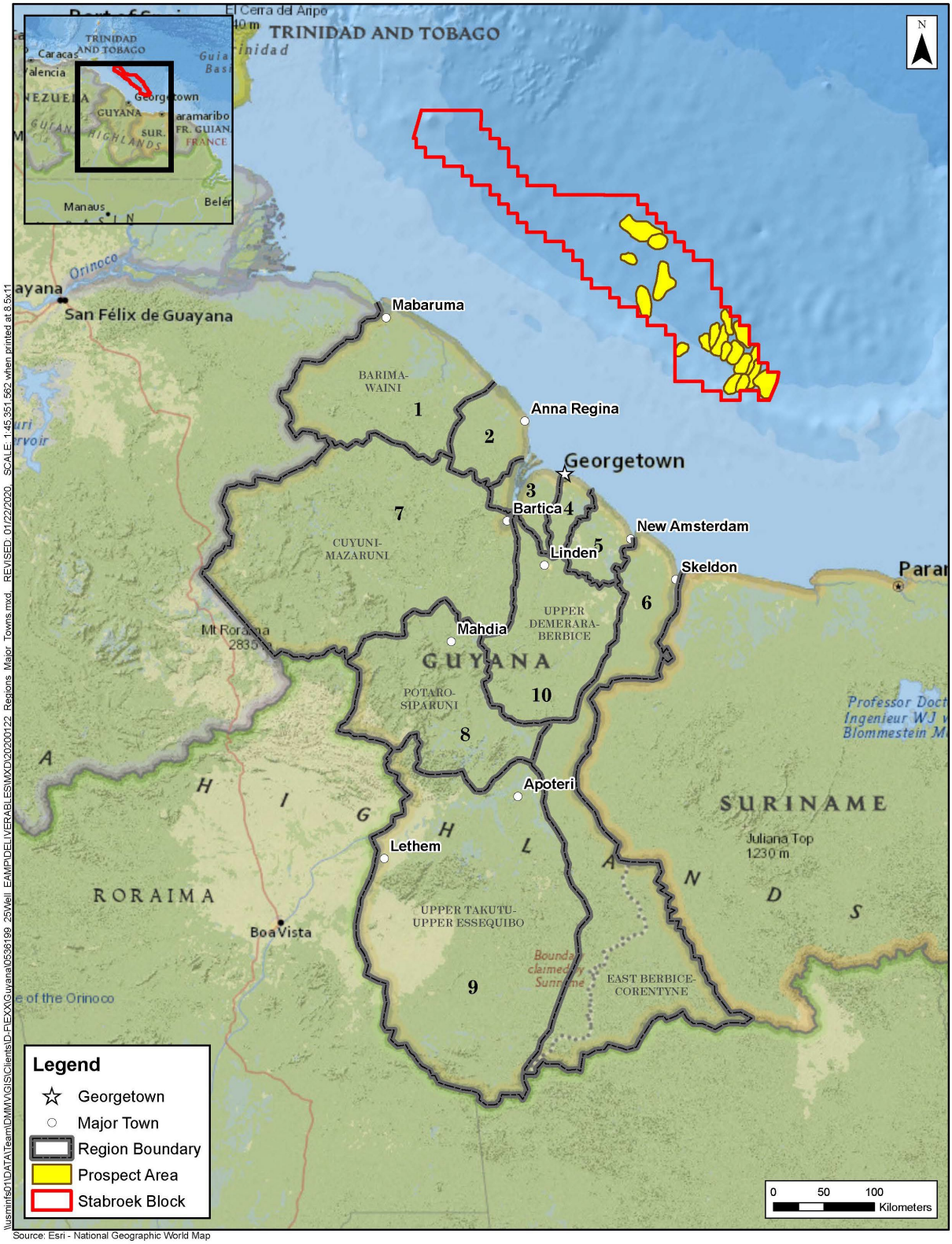
Table 5.3-1: Regional Distribution of Guyana's Population

Region		Population 2002	Population 2012	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 2002, 2012

Note: Each region's change in population should be weighted based on that region's percent of the total population; therefore, the sum of population changes in each region do not add up to the total national population change.

Figure 5.3-1: Guyana's Regions and Major Towns



5.3.1.2 *Major Cities and Towns*

In Guyana there is one city that serves as the capital (Georgetown) and nine other townships. Georgetown is the largest city, and is located in the Demerara-Mahaica region. The 2012 National Census reported a population of 118,363, which accounts for approximately 38 percent of the entire population of the Demerara-Mahaica region (see Table 5.3-2). Linden, located in the Upper Demerara - Berbice region, is the second most populous city in the country with a population of 27,277; unlike Georgetown, it is located approximately 90 kilometers inland. With the exception of Georgetown, the combined population of the five next-largest towns in the country together account for less than 10 percent of Guyana's total population, underscoring the fact that with the exception of Georgetown, Guyana is largely a rural country.

Population and other demographic information has not been historically collected or available at the community or village level (including within the 2012 census); however, informal data collected from engagement with coastal Neighborhood Democratic Councils (NDCs) in 2017/2018 (ERM/EMC 2018) and in 2019 (ERM/EMC 2019a) provide population estimates of 8,000 for Mabaruma and 10,500 for Santa Rosa, the largest towns/villages in Region 1.

Table 5.3-2: Populations of Major Towns in Guyana

City/Town	Population	Region	Percent of Regional Population	Percent of Guyana's Total Population
Georgetown	118,363	4 - Demerara-Mahaica	37.8	15.8
Linden	27,277	10 - Upper Demerara — Berbice	69.1	3.6
New Amsterdam	17,329	6 - East Berbice-Corentyne	15.8	2.3
Anna Regina	11,793	2 - Pomeroon - Supenaam	25.2	1.6
Corriverton	11,386	6- East Berbice-Corentyne	10.4	1.5
Rose Hall	5,662	6 - East Berbice/Corentyne	5.2	<1

Sources: BSG 2012

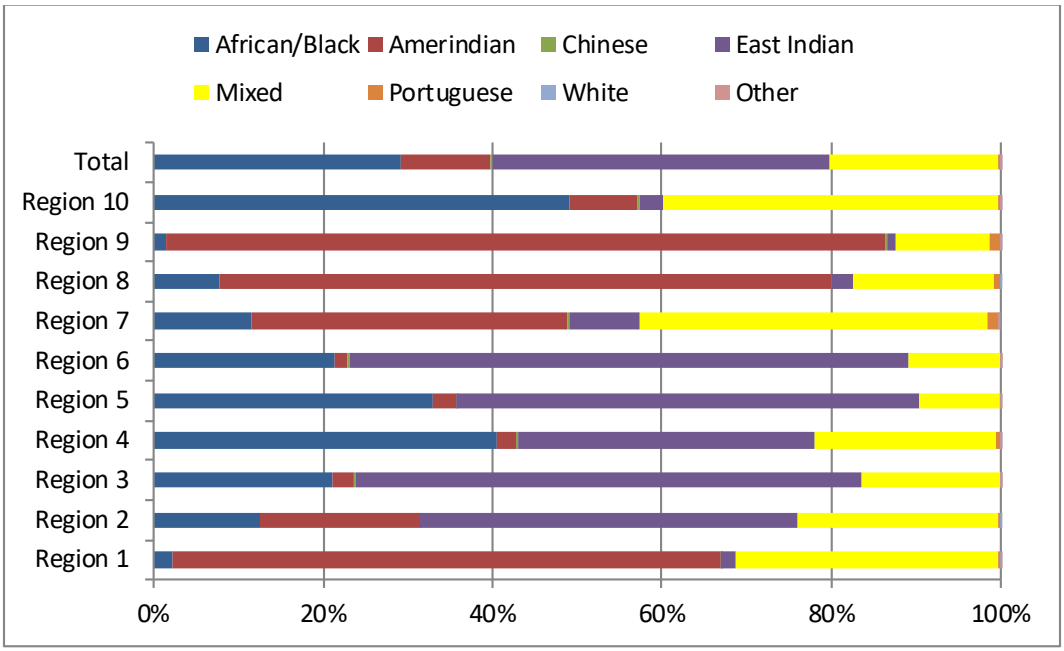
5.3.1.3 *Ethnic Composition*

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 5.3-2 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.

Figure 5.3-2: Regional Distribution of Ethnicity, 2012



Source: BSG 2012

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. Amerindians are found in significant numbers in the Hinterland Regions. They 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.

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.

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 8).

In the other regions, titled indigenous communities are located inland and not in proximity to the shore zone or coastal areas.

5.3.2 Employment and Livelihoods

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 gross domestic product (GDP) in 2018 are summarized in Table 5.3-3.

Table 5.3-3: 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	328%
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 Guyanese dollars (GYD) ($1.301 billion U.S. dollars [USD]) in 2018, down from $297.95 billion GYD ($1.42 billion USD) in 2017 (BSG 2017)[24]. 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).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 2018; 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. In addition, the labor force participation rate was only 54.5 percent of the total working-age population. This has been attributed to low labor-force participation rates

[24] Based on an exchange rate of 209 GYD = 1 USD

in rural areas, with a rate of 53.4 percent for all persons, and women with a rate of 41.5 percent.

Data from the 2002 census indicate that the unemployment rate did not change significantly between 2002 and 2012 (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. Agriculture, fishing, and forestry employ the largest proportion of workers (18.9 percent). 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.

In 2012, 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 rates for workers 15 years of age 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, this sector was second to the mining and quarrying sector. This 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[25] are dominated by male workers, with female workers making up less than 10 percent of the workers employed in these industries in these regions.

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

[25] 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.

of jobs there. Female representation in these sectors is high, with women making up 48.2 percent of workers in the sector (BSG 2016). Secondary and primary sector jobs make up 21 percent and 12 percent of employment, respectively, in Region 4.

In the SBPA in Region 1, 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 farming of coconut and other crops. 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).

5.3.2.1 *Fisheries and Aquaculture*

Marine Fisheries

There are four main types of marine fisheries in Guyana (MOA 2013), as differentiated by the species targeted, gear types used, and the depth of water where the fishery takes place. Table 5.3-4 summarizes the characteristics of these fisheries. In addition to these species, yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*), have also been identified as potential oceanic target species of commercial interest (Isaac and Ferrari 2017).

Table 5.3-4: Primary Characteristics of Marine Fisheries in Guyana

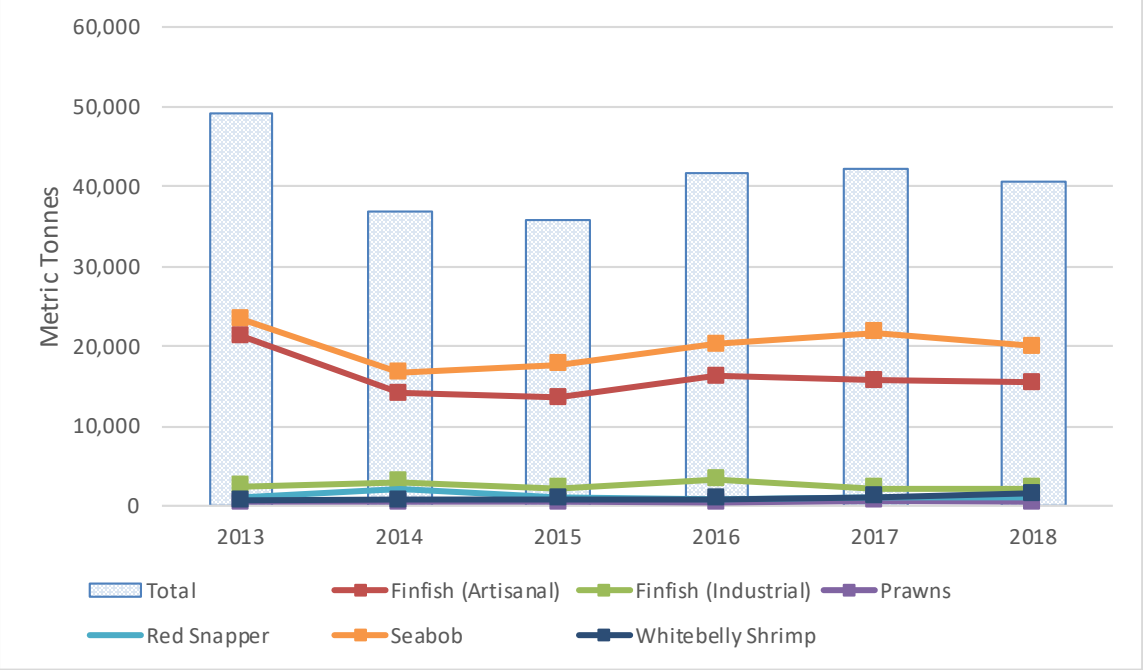
Type of Fishery	Species	Gear	Depth
Industrial	Seabob, shrimps, and prawns	Trawls	Primarily from 13–16 meters, but can occur from 0–75 meters
Semi-industrial	Red snapper and vermillion snapper	Fish traps and lines	Edge of continental shelf
Artisanal	Mixed fish and shrimp	Gillnets, seines, and others (e.g., Cadel line)	0–28 meters
Shark	Various	Trawls, gillnets, and hook and line	Throughout the continental shelf waters

According to data from the Private Sector Commission and the Ministry of Agriculture, fishery yields declined between 2014 and 2015. The Private Sector Commission 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). 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).

Fishing catches for 2013 to 2018 are shown on Figure 5.3-3. 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).

Figure 5.3-3: Commercial Fisheries Catch Volumes, 2013–2018



Source: MOA 2018

Note: Whitebelly is a species of shrimp and is included in the artisanal shrimp fishery in Table 5.3-4.

The industrial seabob shrimp sector continues to be an important commercial fishery, and industry leaders are currently in the process of applying for Marine Sustainability 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).

Fishing is important to the all of the coastal Neighbourhood Democratic Councils (NDCs) in Regions 1 through 6, providing direct employment and income for numerous fisherfolk and indirect employment for numerous others in supporting services. 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 2019a).

Table 5.3-5 provides an overview of some of the commercial fishing communities. The importance of fishing to the local community varies across NDCs. 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). While in Region 1, fishing is important for subsistence across most villages, as well as small-scale commercial sale where there is access to markets.

Table 5.3-5: 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
	Zeelugt/Rosignol	175 boats
Region 6	Macedonia/Joppa	100 persons

Source: ERM/EMC 2018

As described above, subsistence fishing also occurs throughout the coastal regions of the country, in the nearshore marine environment, estuaries, and rivers. 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. Unlike the commercial fisheries described above and in Table 5.3-5, in subsistence fishing, the catch is consumed personally by the boat crews, their families, and/or friends/associates, and sustenance is the prime motivating factor rather than profit. Subsistence fishing tends to be influenced by the season, and often occurs during "off" periods for agricultural and other activities (Maison 2007). Subsistence fishing is essentially a non-commercial activity so it is not effectively regulated.

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).

A large percentage of fish captured using artisanal methods is sold to third parties. Sale prices are subject to short-term fluctuations. According to data from the Ministry of Agriculture (MOA 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 the president of the National Aquaculture Association, aquaculture is still a small industry in Guyana. Aquaculture facilities 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 repurposed rice fields include hassa, arapaima, tilapia, and tobaki (pacu) (ERM Personal Communication 3).

Although aquaculture is considered a small industry by the National Aquaculture Association, it was assessed by stakeholders as critical to livelihoods in many coastal communities 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. 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)[26].

5.3.3 Cultural and Archaeological Resources

Prior to EEPGL's interest in the offshore blocks, no previous cultural surveys had been undertaken within the vicinity of the Prospect Areas. A website claiming to be the world's largest online shipwreck database reported that within Guyana's EEZ, most of the wrecks documented are located along the eastern coast from Georgetown to the Surinamese border, and occur within 30 kilometers of the coast (Wreck Site 2012). Submerged archaeological sites are not expected in waters deeper than approximately 125 meters, which was the approximate sea level during

[26] Based on an exchange rate of 209 GYD = 1 USD

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, 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.

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 the Stabroek Block (Fugro 2016). In 2018, EEPGL retained Fugro to conduct a similar survey of the seafloor within the Payara Field in the Stabroek Block (Fugro 2019). The remote sensing during both surveys made various contacts, which were determined to likely be modern debris, fishing nets, chain or cable coils, or geological features of no significant cultural value.

Onshore archaeological finds include discoveries as recent as 2010 of human settlements that may date back as long as 5,000 years ago; however, these occur inland and were most recently found along the Berbice River. Maps obtained from the National Trust of Guyana show the presence of several shell mounds, seashell deposits, quarries, pollen sections, tools/implements, and ceramic/pottery sites (i.e., scatters) along the Guyana coast, including archaeological sites found near Moruka, Uitvlugt, Stewartville, and Leonora. These sites are of significant cultural value to the people of Guyana and have academic value to 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.

Georgetown and the surrounding region are known for historic buildings, which date to the late eighteenth century through the mid-nineteenth century when Guyana was a first a Dutch colony and later an English colony (National Trust of Guyana 2009). Historic buildings from this period include the Stabroek Market, Fort Zeelandia, St. George's Cathedral, Parliament, the Red House, the State House, City Hall, The High Court, St. Andrew's Kirk, Church of the Sacred Heart, and the Georgetown Light House. Other historic features include several monuments and museums. Several of these buildings been nominated as UNESCO World Heritage Sites including Fort Zeelandia, St. George's Cathedral, and City Hall, but none of the nominations have been formally accepted to date (UNESCO 2014).

5.3.4 Transportation

5.3.4.1 Marine Transportation Infrastructure

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. The Demerara River channel has a dredged depth of 5.9 meters, and has historically been dredged weekly to maintain this depth (Stabroek Harbour Master 2018).The Port of Georgetown, which is equipped with over 40 separate wharves, and the country's 1,000 kilometers of navigable river waterways provide easy access to most centers of economic activity. There are also several existing portside facilities (docks) along the mouth of the Demerara River near Georgetown that can be used as staging areas or storage yards, however they are congested and space is limited.

In April 2018, a study was undertaken to record vessel traffic in Georgetown Harbour between the mouth of the harbor and the Guyana Shorebase. 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. Observations were made on a 24-hour basis, recording the time of day, type of vessels observed, and direction of travel. 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. At Kingston Outfall observation location and Quick Shipping Wharf observation location, fishing boats and trawlers accounted for most of the marine traffic (76 percent and 71 percent, respectively) while passenger boats, "other" vessels (primarily small, private boats), and larger vessels (ocean-going, coastal, and oilfield service) comprised the remaining proportion of the vessel traffic.

The Stabroek Harbour Master has advised EEPGL that Jamaican and Trinidadian vessels' shipping lanes intercept the Canje Block and Stabroek block; however, no interference with shipping traffic was experienced during previous seismic surveys in either block or the Liza drilling activities. This shipping lane does not intersect the Kaieteur Block, so interference with commercial shipping during the exploration/appraisal drilling campaign is considered unlikely. It is the responsibility of MARAD to ensure the safe efficient operation of shipping activities in Guyana territorial waters. MARAD operates in accordance with the IMO, is a party to a number of IMO Conventions including International Convention for the Safety of Life at Sea, International Convention on Standards of Training, Certification and Watchkeeping, and MARPOL.

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. 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. 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.

5.3.4.2 Land Transportation Infrastructure

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). The national road network consists of a few primary routes connecting the major towns across the coast and selected communities in the interior. Various smaller roads, many of which are unpaved connect communities across the interior. The Project would not require overland transport outside of Georgetown, so the remainder of this section focuses on the local transportation conditions in/around the capital. Georgetown has a compact, grid-based street network. Several factors negatively affect traffic conditions within the city. The port area is linked to central Georgetown via the East Bank Demerara Road. Road conditions vary widely and can be poor. Traffic signage is often ignored (OSAC 2016). Many intersections are not signal-controlled; where signals do exist, they are frequently out of service.

Driving behavior also contributes to poor and dangerous land transportation conditions. Speeding, reckless and aggressive driving, and driving under the influence of alcohol frequently contribute to traffic accidents in Georgetown. Pedestrian overpasses were recently installed at several areas along the East Bank Demerara Road to improve pedestrian safety and assist in reducing traffic congestion.

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 and traffic congestion occurs frequently, including just before and just after school hours. Driving at night poses additional concerns due to poor street lighting and road conditions, drivers not lowering high beam lights, livestock, and pedestrians congregating by the roadside (OSAC 2016).

Traffic congestion is a chronic problem in Georgetown, and the East Bank Demerara Road which is the major arterial road connecting much of the Georgetown Port area to the rest of Georgetown is particularly susceptible to congestion due to backups at the Demerara Harbour Bridge. Daily retraction of the bridge for a period of about one hour causes severe road traffic congestion at both ends of the bridge, as well as delays and inconvenience to ocean going vessels.

5.3.5 Tourism and Recreation

Data from the Guyana Tourism Authority (2018a) indicate that the number of international visitors to Guyana has doubled since the early 2000s. In 2018, 15.93 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 Guyana Tourism Authority, 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 (ERM Personal Communication 4).

Most tourism activity and infrastructure in Guyana is located along the coast, although in recent years tours into the interior have increased in popularity. Hotels and other forms of accommodation may be found in most of the major coastal cities and towns including Georgetown, Linden, Berbice, and Bartica, although most of the hotels are located in Georgetown. Five of the six major resorts in the country are located on the coast as well. Most of the major outfitters offering tours into the interior also operate from offices in Georgetown.

Local tourism and recreation is also important to the local economy in the coastal NDCs in Regions 2 through 5, including those outside Georgetown. Some regions are less dependent on tourism (e.g., Region 2), while other regions have economies that are more established and well-linked to local tourism. Warapoka village in Region 1 has a strong interest in building eco-tourism focused on Amerindian traditions and has recently built a lodge to house tourists. (ERM/EMC 2018) Region 3 and 4 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 of locals weekly (ERM/EMC 2018). In general, 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).

6 ASSESSMENT OF POTENTIAL IMPACTS AND RISKS

6.1 PHYSICAL RESOURCES

6.1.1 Marine Water Quality

6.1.1.1 Currents

The Project is expected to have no significant effect on oceanographic conditions. The regional currents, waves, tides, and other physical attributes of the ocean would not be measurably altered by the Project. The presence of the drill ship and the support vessels in the water column has the potential to create turbulence in water moving past, which would cause temporary and extremely localized disturbances in the natural current patterns. It is anticipated that these effects would dissipate within a few hundred meters of the drill ship and cease entirely after the drill ship is removed from the well site and the well is capped. The drill ship and support vessels would be present throughout the duration of the Project, so there would be no difference in the magnitude of impacts between the various phases of the Project.

The magnitude of the effects from Project-related activities on currents described above would be **Negligible** due to the small size of the impact zone. The sensitivity of the local current patterns to this level of disturbance is **Low**. Therefore, potential impacts of the Project on oceanographic conditions are considered **Negligible**.

In the event of a marine or coastal oil spill, currents, waves, and other physical attributes would not be measurably altered. Therefore, an oil spill would result in no risk to oceanographic conditions.

6.1.1.2 Marine Water Quality

The key sources of potential impacts on marine water quality from planned Project activities are the discharge of cuttings and resultant increases in TSS concentrations, and routine operational discharges from the drill ship (e.g., treated sanitary waste discharges).

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 temporarily increase TSS concentrations around the well near the seafloor. Cuttings discharged overboard from the drill ships will increase TSS concentrations temporarily in the (shallower) photic zone.

As shown in Appendix C, modeling of cuttings discharges predicts the maximum TSS concentrations at the seafloor during drilling of the initial sections of the well will be between approximately 5,358 milligrams per liter (mg/L) and 16,322 mg/L, depending on currents and well location. These concentrations refer only to the initial (top) sections of the well, where water-based drilling fluids and cuttings are discharged directly from the casing, at the seafloor. In contrast, for subsequent sections of the well, modeling indicates the maximum TSS concentrations will be between approximately 770 mg/L and 10,877 mg/L, again depending on currents and well location. These concentrations are lower because drill cuttings and fluids from the lower well sections will be processed on the drill ship to remove a substantial amount of the drilling fluid prior to discharge and then discharged from the drill ship.

Temporary increases in TSS may clog fish gills or, in the photic zone, cause light inhibition for photosynthetic organisms. A TSS threshold of 35 mg/L is recommended by MARPOL 73/78 (IMO 2006) for effluent discharges from marine vessels. This threshold was used to determine the area with the potential to contribute to health impacts on marine fauna, either through gill fouling or inhibited photosynthesis. Project activity modeling suggests that TSS concentrations above the recommended threshold will occur during drilling of the initial and subsequent well sections. During initial drilling, maximum TSS concentrations are confined to a relatively small area around the well locations, near the seafloor. In the case of subsequent well sections—where discharges occur to the photic zone, maximum predicted TSS concentrations exceeding the threshold will be short-term in duration (no more than 3 days at a time). Discharges near the surface are subjected to greater mixing from the higher current speeds near the water surface, resulting in greater dispersion of the TSS concentrations as the discharge passes through the water column.

The anticipated effects on marine water quality from operation of the drill ships would be restricted to the immediate vicinity of the drill ship and would be temporary in nature. While they would temporarily alter the physical and chemical properties of seawater within a small mixing zone around the drill ship, these effluents will be subject to rapid mixing and are expected to experience substantial reductions in constituent concentrations within a short distance from the point of discharge.

Based on the analysis above, the magnitude of Project-related effects on marine water quality is expected to be **Small**. Local water quality will be temporarily influenced, but the effects would be localized and temporary. Therefore, the sensitivity of water quality changes as a whole is considered **Medium**. Based on the magnitude of impact and resource

sensitivity, the significance of potential impacts on marine water quality from Project-related activities is considered **Minor**.

In the event of an unplanned marine oil spill (e.g., from a loss-of-well-control event), some of the spilled oil would be removed from the water column via evaporation and photo-oxidation.[27] Additionally, biodegradation processes would gradually reduce hydrocarbon concentrations in the marine environment following a spill. The proportion of the spill that mixes[28] through the water column through wave energy is subjected 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.

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 Project area would likely be a light or medium crude oil. Light or medium crude oils generally have higher biological availability and are generally associated with higher toxicity concerns, as compared to heavy crude oils. This, however, would be offset to some degree by the comparatively more rapid dissipation of a light or medium crude oil through evaporation and dispersion, which means light or medium crude oils may have less impact on the environment overall, relative to heavier crude oils (as long as sensitive resources are sufficiently distant from the origin of the spill). It is also noted that the mixing energy resulting from a loss-of-well-control event may result in 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, a marine oil spill is considered to have a **High** consequence/ severity rating with respect to potential impacts on marine water quality, taking into consideration the higher toxicity of the lighter oil fractions and the potential magnitude and extent of a loss-of-well-control 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**.

[27] Process of chemical breakdown caused by exposure to sunlight
[28] Mixing is achieved by a combination of entrainment and dissolution.

EEPGL has prepared an OSRP and Emergency Response Plan (ERP), as discussed in Section 2.6.3, Oil Spill Prevention, Control, and Emergency Response Measures, and Section 8.9, Emergency Response Plan Summary, respectively, to ensure an effective response in the very unlikely event that an unintended release of hydrocarbons occurs. As stated in the OSRP, EEPGL will use an incident-specific Net Environment Benefit Analysis (NEBA) as the foundation of its Incident Response Plan. The NEBA compares the impacts of available response options and selects the option or combination of options that minimizes overall harm to environmental and socioeconomic resources (including cultural sensitivities). The use of NEBA will ensure that EEPGL selects the most appropriate response techniques available to minimize overall environmental impact based on the conditions and sensitivities of an actual incident.

As explained in the OSRP, EEPGL would mobilize its own resources and/or (depending on the scale of the unplanned release) those of its regional oil spill response contractor, as well as notifying Guyana's government to mobilize their resources. Other available regional resources, including those from other operators, would be leveraged as necessary in the unlikely event of a spill. However, even with implementation of the OSRP, the residual risk rating would remain **Moderate**.

With respect to the coastal oil spill scenario, a spill of diesel oil would also exhibit higher toxicity from light oil fractions, but the smaller magnitude of the spill, limited geographic extent, and shorter duration of toxicity impacts, as compared to a larger marine oil spill scenario, leads to a consequence/severity rating of **Medium** with respect to impacts on marine 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**.

In the event of an emergency disconnect of the drilling riser and release of NADF near the seafloor, NADF would undergo biological degradation after being released from the drilling riser. This process can result in localized decreases in dissolved oxygen concentrations; however, due to the dissolution of NADF in the water column caused by the strong marine currents in the region, significant decreases in dissolved oxygen levels are not likely to be observed in the water column. Additionally, the NADF used by EEPGL will be a low-toxicity substance, reducing the potential for adverse changes to marine water quality. Therefore, a release of NADF is considered to have a **Medium** consequence/severity rating with respect to impacts on marine water quality. In combination with a likelihood of

Unlikely, the overall risk to marine water quality from a release of NADF would be **Minor**.

6.1.2 Air Quality and Climate

The components of the Project with the potential to result in air quality impacts include exploration well drilling, well testing, and related support activities. The well drilling and operation of related support vessels and aircraft is expected to occur in 2021 and 2022. The primary sources of potential impacts on air quality would be emissions from combustion sources (e.g., nitrogen oxides), SO_2, CO, VOCs, H_2S, and particulate matter (PM_{10} and $PM_{2.5}$). The increased concentrations of these pollutants could potentially contribute to health impacts on onshore receptors. In addition to impacts on air quality, the Project activities will also generate greenhouse gas (GHG) emissions, which may increase the concentrations of GHGs in the atmosphere. While the GHG emissions from the Project have been estimated with an acceptable level of confidence, the potential influence of those GHG emissions on global climate change is not measurable with an acceptable level of confidence; therefore, potential global climate change impacts from the Project are not addressed herein.

To assess potential impacts of the Project on air quality, air quality dispersion modeling was conducted for the emissions associated with well exploration drilling (i.e., diesel engines that power the drill ship, flaring, incineration, supply vessels, and helicopter flights). Modeling was conducted representing well exploration at three potential well locations, and the maximum concentrations at each potential onshore receptor location were predicted for all pollutants and averaging times. The highest of the individual maximum concentrations predicted for the three potential well locations was then scaled to represent a single drill ship operating continuously.

This is a conservative approach, and as shown in Appendix E, the results predicted the highest percentage of a World Health Organization ambient air quality guideline for a predicted maximum onshore concentration to be 1.1 percent (for the maximum predicted 1-hour average of NO_2). These results indicate that the exploration/appraisal wells can be located anywhere within the Project area without resulting in significant onshore concentrations. Accordingly, the magnitude of air quality impacts from the Project would be **Negligible**. 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**. Therefore, the significance of impacts of the Project on air quality would be **Negligible**.

With respect to climate, the Project's planned activities will result in emissions of GHGs (approximately 172 kilotonnes of carbon dioxide-equivalents). However, as stated above, Project-specific impacts with respect to global climate change are not measurable with an acceptable level of confidence for emissions at this small scale.

In the event of a marine or coastal oil spill, lighter hydrocarbons (including benzene, xylene, and toluene) tend to quickly evaporate into the air, and the concentrations of these constituents 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. The potential for any harmful concentrations of air contaminants to reach the Guyana coastline from a marine oil spill is considered very low, even for a large spill, considering the distance to shore from the source of such a spill (at least 160 kilometers). Therefore, the consequence/severity of impacts on air quality from a marine oil spill would be **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill event, the overall risk to air quality would be **Minor**.

In the event of a coastal oil spill, elevated concentrations of air contaminants in areas with potential human receptors would be localized to the nearshore area in which the spill is present. Balancing the closer proximity of a coastal spill to potential receptors with the reduced volume of such a spill, the consequence/severity of potential impacts on onshore Guyana air quality from an unmitigated coastal oil spill could be **Medium** to **High** (the High consequence/severity pertaining to any receptors with a high sensitivity). In combination with a likelihood rating of **Unlikely** for a marine or coastal oil spill event, the overall pre-mitigation risk to air quality would be **Minor** to **Moderate**. With implementation of the OSRP, the consequence/severity of potential impacts on onshore Guyana air quality from a mitigated coastal oil spill would be reduced to a range of **Low** to **Medium**, based on the expectation that these types of spills would typically involve non-persistent oils that can typically be relatively quickly mitigated. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall residual risk to onshore Guyana air quality from a coastal oil spill would be **Minor**.

With respect to potential climate impacts associated with a marine or coastal oil spill, there would be an indirect impact associated with fossil fuel combustion by response vessels and fuel-fired equipment, resulting in increased GHG emissions. However, as stated above, impacts with respect to global climate change are not measurable with an acceptable level of confidence for emissions at this small scale. Accordingly, in combination

with a likelihood rating of **Unlikely** for a marine or coastal oil spill, the overall risk to climate from a marine or coastal oil spill would be **Minor**.

6.1.3 Coastal and Marine Geology and Stratigraphy

The Project would disturb the shallow marine sedimentary layers and underlying geology within the well annuli, and discharge of drill cuttings would cause accumulations in the immediate area surrounding each well location. The cuttings would remain in the marine environment once discharged. However, as described in Section 5.1.3, Coastal and Marine Geology and Stratigraphy, the marine sediments offshore Guyana's coastline are highly dynamic, so the cuttings are expected to dissipate away from the well site rapidly over time. The Project would have no effect on coastal geologic resources. Use of the shorebases would have no effect on the underlying geology of the sites.

The magnitude of the Project's effects on coastal and marine geology and stratigraphy would be **Small**. The sensitivity of these resources is **Low**, so the combined significance rating of potential impacts on coastal and marine geology and stratigraphy is **Negligible**.

In the event of a marine or coastal oil spill, hydrocarbons would not sink or accumulate on the seafloor unless the oil dispersed in the water column adheres to fine-grained suspended sediments and settles on the seafloor. This is not likely to result in measurable sediment contamination for small spills (NOAA 2018). For this reason, the consequence/severity rating of an oil spill with respect to impacts on coastal or marine sediments is considered **Low**. In combination with a likelihood rating of **Unlikely** for a marine or coastal oil spill, the overall risk to coastal and marine sediments from an oil spill would be **Minor**.

In the event of an emergency disconnect of the drilling riser, NADF and cuttings would be released near the seafloor. Neither the NADF nor the cuttings would have any effect on marine geology. 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 no effects on sediments. The cuttings could potentially impact marine sediments. Cuttings would accumulate on the seafloor, and would decrease in thickness and grain size with increasing distance from the wellhead. The strength of the bottom currents in the Project area would likely erode any significant deposits near the wellhead over time, 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 natural sediment deposition would bury the deposited cuttings. Given the limited volume of cuttings

discharged and short-term nature of such an event, the consequence/severity of an NADF release with respect to impacts on marine sediments is conservatively considered **Medium**. In combination with a likelihood rating of **Unlikely** for such an event, the overall risk to marine sediments from a release of NADF would be **Minor**.

6.1.4 Bathymetry

The process of drilling the well would produce cuttings, which EEPGL currently proposes to discharge directly to the seabed during drilling of top sections of the well, and (for deeper well sections) from the drill ship into the ocean after treatment to reduce drilling fluid content to acceptable discharge thresholds.

The accumulation of discharged cuttings on the seafloor in the vicinity of the wells would have the effect of raising the seafloor slightly around the wells. This would be the only aspect of the Project that would have a direct effect on bathymetry. Cuttings discharges were modeled (see Appendix C) and the modeling results predicted that the area of cuttings deposition will be limited and will be within the immediate vicinity of each well. The maximum area above the 5-centimeter impact threshold recommended to assess potential smothering effects for benthic fauna (MarLIN 2011) was only 0.0048 to 0.0054 km² and the maximum distance across this sediment mound was 100 to 105 meters, roughly centered on the well.

The magnitude of impact on bathymetry from drill cutting deposition is thus considered **Negligible**. The sensitivity of the bathymetry to potential changes from drill cuttings deposition is considered **Low**, as the deepwater sediments on which drill cuttings will not settle in high enough concentrations to cause significant changes in the ocean's topography. Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on sediment morphology from discharge of drill cuttings is considered **Negligible**.

Neither a marine oil spill event nor the response to such an event would appreciably alter bathymetry; therefore, the consequence/severity of a marine oil spill on bathymetry is considered **Negligible**. In combination with a likelihood rating of **Unlikely**, the overall risk to bathymetry from a marine oil spill on bathymetry is **Minor**.

6.1.5 Natural Hazards

As described in Section 5.1.5, Natural Hazards, the most significant natural hazard risks for Guyana are floods and drought. None of the Project activities would substantially affect susceptibility to these hazards

or impact the protection of the coastal plain, nor would they affect the magnitude or rate at which floods or droughts occur. The magnitude of the effects on natural hazard risks is therefore considered **Negligible**. Accordingly, while the sensitivity of these natural hazard risks to the local population is **Medium,** the significance of potential Project impacts on natural hazard risks is considered **Negligible**.

A marine or coastal oil spill would not affect the rate at which floods or droughts occur. Therefore, the consequence/severity of such an event on natural hazards is **Negligible**. In combination with a likelihood rating of **Unlikely** for a marine or coastal oil spill, the overall risk to natural hazards is rated as **Minor**.

6.2 BIOLOGICAL RESOURCES

6.2.1 Coastal Habitats

The planned offshore exploration/appraisal drilling activities and associated air emissions, effluent discharges, and sound generation, which will occur at least 160 kilometers offshore, will not impact coastal habitats. Therefore, there is no potential for the Project to impact coastal habitats except as a result of an unplanned event. Operation of the existing Guyana shorebases on the east side of the Demerara River is not anticipated to impact coastal habitats. The shorebases are existing industrial facilities in Georgetown. EEPGL does not plan to make any modifications to the facilities associated with the Project.

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. Based on the results of previously completed oil spill modeling, an unmitigated marine oil spill (i.e., loss-of-well-control event) originating from the Stabroek Block indicates a relatively low probability of the oil contacting the Guyana coast. Previous modeling indicates that Region 1, which is largely characterized as mangrove forest of high or exceptional quality (see Section 6.2.1.1, Mangroves), is the only portion of the Guyana coast with the potential to be contacted by such a spill. However, based upon the modeling results for mitigated marine oil spills, no oil has been predicted to contact the Guyana shoreline.

Coastal oil spills would be expected to be small-volume (up to 500 barrels for the largest reasonably possible event), short-duration spills that would be expected to be quickly brought under control. A temporary, visible 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 coastal habitats would not be expected.

6.2.1.1 *Mangroves*

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 and they depend on a delicate balance of hydrologic conditions and sediment/water quality to thrive. As such, the sensitivity/ vulnerability/importance of these resources is considered **High**.

The planned activities of the Project are not expected to directly affect mangroves. Drilling and associated activities in the marine environment would take place at least 160 kilometers offshore from the nearest mangrove, and the shorebases to be used by the Project occupy land that has already been developed as an industrial zone.

The main risk to mangroves associated with the Project is related to the potential for a marine or coastal oil spill. The largest remaining stands of mangroves in Guyana that could be affected by an oil spill associated with the Project occur in the SBPA in Region 1. Almost all of the mangroves in this area are mature, and most have experienced significant erosion in recent years. A few mangroves have disappeared completely in recent years while in other areas accretion has promoted expansion of mature mangroves. Despite a few isolated areas of expansion, the overall trend is toward loss of mangroves along portions of Guyana's coastline that could be oiled by an oil spill event from the Project. Due to their physical location along the coastline and the ongoing loss of habitat, mangroves are vulnerable to exposure during oil spills. Additionally, mangroves are considered to be sensitive to heavy contamination by oil for a number of reasons (ITOPF undated).

For these reasons, the consequence/severity of a marine oil spill on mangroves is considered **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to coastal habitats is considered **Moderate**. In the event of a marine oil spill, EEPGL would implement its OSRP and prior modeling of mitigated spills from the Stabroek Block indicates that a marine oil spill would not reach the coast of Guyana. Further, as indicated in the OSRP, EEPGL will implement a shoreline response if released hydrocarbon shows potential to affect a shoreline, prioritizing environmentally or socioeconomically sensitive areas. This would consist of using vessel dispersant application to prevent approaching slicks from impacting socioeconomically sensitive areas and using shoreline booming to protect sensitive areas and provide collection points for hydrocarbon recovery. Initial equipment (dispersant, mechanical recovery) will come from within the country or within the

region and will be supplemented as necessary via Oil Spill Response Limited from Fort Lauderdale, Florida, as well as other Oil Spill Response Organizations with whom EEPGL has contracts in place. Effective implementation of the OSRP would thus reduce this risk to **Minor** by further reducing the extent of an oil spill and the probability of oil reaching the Guyana coastline.

An unmitigated coastal oil spill that reaches the shoreline would likely only happen near the shorebases, which are located near the mouth of the Demerara River. Coastal spills would be quickly controlled and contained because of the relatively small volumes and the ready access to spill control equipment. Although mangrove forests are not extensive near the mouth of the Demerara or the Essequibo rivers, fringe mangroves do exist and would be susceptible to exposure to an oil spill. These impacts would generally be temporary, limited in area, and readily mitigated, with rapid habitat recovery expected.

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 consequence/severity of a coastal oil spill on mangroves is considered **Low**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the (pre-mitigation) risk to coastal habitats is considered **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 consequence/severity of a mitigated coastal oil spill would likely be reduced. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall residual risk to coastal habitats from a coastal oil spill would be **Minor**.

6.2.1.2 Beaches

The assessment of potential impacts on beaches is discussed in Section 6.2.7, Protected Areas.

6.2.1.3 Mudbanks, Mudflats, and Sandflats

Mudbanks are of critical ecological importance as feeding zones for sensitive species such as migrating shorebirds, nursery areas for juvenile fish, and habitat for a variety of invertebrates. Like mangroves, many mudbanks along Guyana's coast have been degraded and are sensitive to ecological disturbance. As such, the sensitivity/vulnerability/importance of these resources is considered **High**.

Planned Project activities are not expected to directly affect mudbanks, mudflats, or sandflats along coastal Guyana. Drilling activities will take place at least 160 kilometers offshore, and the shorebases to be used by the Project occupy land that has already been developed as industrial zones.

The main risk to mudbanks associated with the Project is related to the potential for marine oil spill. If the oil from a loss-of-well-control event were to reach shore, mudbanks, mudflats, and/or sand flats could be affected by the oil and the effects could be long-term. The sensitivity of these resources to oil spills yields a consequence/severity of **High** for a marine oil spill**.** In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to these resources is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by further reducing the extent of an oil spill and the probability of oil reaching these resources.

6.2.2 Benthic Resources

Spudding of the wells will temporarily disturb a small area within the footprint of the well bore. Individual benthic organisms (sessile organisms) are likely to be killed, injured, or dislocated from these limited areas. While this would have a significant effect on individual organisms, this effect will only occur within the immediate footprint of the well bore and is expected to affect a relatively small number of organisms.

Deposition of cuttings will affect a relatively larger area, but the impacts of cuttings deposition on benthos will be less severe. With regard to potential physical impacts, discharged drill cuttings will accumulate on the seafloor close to the individual wells, and some benthic fauna will likely be impacted through burial and smothering. Cuttings discharges were modeled (see Appendix C) and the modeling results predicted that the area of cuttings deposition will be limited and will be within the immediate vicinity of each well. The maximum modeled area above the 5-centimeter per month impact threshold recommended to assess potential smothering effects for benthic fauna (MarLIN 2011) was only 0.0048 to 0.0054 km² and the maximum modeled distance across this sediment mound was 100 to 105 meters, roughly centered on the well.

With respect to potential toxicological effects, 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. Additionally, the NADF used by EEPGL will be a low-toxicity substance, reducing the potential that changes in sediment quality will lead to toxicological impacts on benthic fauna. 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. Finally, biodegradation of NADF will result in natural attenuation of toxicity to marine benthos.

Overall, the magnitude of the Project's impacts on marine benthos would be **Small**, and the sensitivity of benthic resources to these impacts is considered **Low**. Therefore the overall impact on marine benthos from planned Project activities is considered **Negligible**.

Deepwater corals are known to occur in the area, and are sensitive to physical damage due to their slow growth rates and fragility of their calcium carbonate exoskeleton. Drilling activities are a potential threat to deepwater corals (e.g., from physical disturbance, release of chemicals and discharge of drill cuttings and cement). It is currently unknown whether cold water corals occur within the specific areas that would be affected by sea-bottom disturbance or cuttings deposition (i.e., because the specific well locations have not yet been determined). If they do occur in the area, they would be more sensitive (relative to other benthic resources) to accumulations of sediment and/or cuttings.

The magnitude of the Project's impact on corals, if present, would be **Small**; taking into account the sensitivity and vulnerability of these corals, their importance to deepwater marine biodiversity, and the uncertainty surrounding their distribution in the immediate vicinity of the well locations, the sensitivity of these resources to these impacts is considered **Medium**. Therefore, the potential impacts of the Project on corals are considered **Minor** (only as they apply to potential impacts on deepwater corals).

With respect to a marine oil spill, most of the oil released from a marine oil spill would be expected to rapidly surface away from the seafloor, but some oil may bind with sediments and settle to the bottom, with the potential to expose benthic organisms to toxic constituents. Polychaete worms display varied responses to oil pollution. After an initial die off, some polychaete species may increase in abundance and rapidly colonize damaged habitat, while other species may experience reduced populations (Blackburn et al. 2014). Considering the depth of water, and likely limited geographic extent of impact, the consequence/severity of a marine oil spill on marine benthos is considered **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall risk to marine benthos from a marine oil spill is considered **Minor**. 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; rather, EEPGL's proposed embedded controls to prevent a spill from occurring represent the most effective approach to minimizing this risk.

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, the tendency of the NADF and cuttings plume to remain at or near the seafloor, and their limited capacity to move away from the impacted area compared to other marine biota. The smaller and less mobile organisms (including burrowing species, worms, and sessile lifeforms such as sponges, bryozoans, gorgonians, and most mollusks) are usually affected to greater degree by such events, while the larger and more mobile species (e.g., large crustaceans, cephalopods) are affected to a lesser degree and can move away from impacted areas. Marine currents in the Project area would mitigate the potential for burial of benthos and 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 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.

As described above, the discharge of NADF and cuttings can lead to toxicological and respiratory impacts in addition to physical habitat impacts on marine sediments; however, given the limited volume of material that could be discharged in this scenario (i.e., limited to the volume of the riser), the short-term nature of such an event, and the low-toxicity NADF to be used, the consequence/severity of an NADF release with respect to impacts on marine benthos is considered **Medium**. In combination with a likelihood rating of **Unlikely** for an NADF release, the overall risk to marine benthos from an NADF Release would be **Minor**.

6.2.3 Fishery Resources

Drilling the wells, conducting VSP, and plugging and abandonment of the wells could cause visual, auditory, and physical impacts on the marine environment, and would likely cause sensitive species to avoid the immediate area surrounding the drill ship until activities at the well sites are concluded.

Changes in water quality are expected to adversely impact fish abundance in the immediate vicinity of the well heads, but are not expected to cause significant fish mortality. Limited, localized impairments in water quality will not be significant enough to cause substantial changes in fish populations, nor will they significantly impact sensitive or important species. However, they could result in temporary changes in the

distribution and composition of the fish community within parts of the Project area.

The impact of a VSP would have a slightly larger auditory footprint than the drilling, and could affect hearing specialist species[29] and those species with well-developed swim bladders[30] more than others in the immediate vicinity. The available literature suggests that VSP would have little or no lasting effects on finfish (URS 2009; LGL 2006). Given that most sensitive receptors do not always experience impacts from impulsive sound (and they usually recover from such impacts) and that impulsive sound will only occur during short periods, population-level impacts on marine fish from auditory impacts are not anticipated.

The artificial light produced from the Project vessels will not be substantial enough to alter fish populations, nor will it be expected to significantly impact sensitive or important species; however, it may cause small changes in the distribution and/or behavior of fish in the immediate vicinity of the drill ships.

Ballasting activities have the potential to impact fish (and other small marine organisms) in two ways: physical trauma as result of pressure changes and/or impacts as they move through the ballast pumps, or competition with invasive exotic species introduced through discharges of ballast water of foreign origin. As described in Section 2, Project Description, the drill ship will be constantly ballasted to balance the ship and allow it to remain stable in the water. Constant ballasting of the drill ship means that unlike a freighter or tanker, there will be no large-volume exchanges of ballast water in Guyanese waters. Although the potential will exist for small numbers of organisms to be entrained and injured or killed in the pumps, this impact will be insignificant at the population scale due to the temporary nature of the activity and naturally high mortality rates of planktonic and small nektonic marine organisms. The small amounts of water that are discharged will originate from the nearby locations, and the only time that ballast water from outside the Stabroek Block will be discharged within the block will be when the ship first enters

[29] 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 specialists are distinguished from hearing generalists, which hear equally well across a wider range of frequencies, but do not possess the acuity of the specialists within their specific frequency range.

[30] 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.

the block en route to the first well location, so there will be little potential for introduction of invasive exotic species via discharges ballast water.

Overall, the magnitude of the Project's impacts on marine fish would be **Negligible** to **Small.** The receptor sensitivity for marine fish is 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 Project impacts. Therefore the overall impact from Project-related activities on marine fish is considered **Negligible** to **Minor**.

If an unintended release of hydrocarbons were to occur, the magnitude of impacts on fish could range from lethal, to sub-lethal, to displacement. Potential impacts on marine fish from a marine oil spill are 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 exposures are typically brief (i.e., typically measured in hours). Exposure to microscopic oil droplets may also 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. 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 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 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 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 Project area), 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.

Considering that adult fish may avoid an area affected by a spill, they are not physiologically required to breathe at the surface where oil would accumulate, and the early life stages of marine fish (which are most susceptible to the effects of a spill) naturally experience very high mortality, the consequence/severity of an unmitigated marine oil spill for marine fish populations is rated as **Medium** for pelagic species and **Low** for demersal species. A marine oil spill is considered **Unlikely**, so the overall risk of a marine oil spill to marine fish is considered **Minor.** Effective implementation of the OSRP would reduce the geographic extent of the spill, and would reduce the amount of oil at the water's surface; however, the residual risk is maintained at **Minor**.

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. If a spill were to occur in the Demerara River from Project supply vessels traveling along marine traffic routes to or from the Georgetown Harbour 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 younger 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 consequence/severity of a coastal oil spill for fish is rated as **Medium** for pelagic species and **High** for demersal species. In combination with the likelihood rating of **Unlikely** for a coastal oil spill, the overall risk of a coastal oil spill to marine fish is considered **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, would reduce the amount of oil at the water's surface; accordingly, the residual risk rating is reduced to **Minor**.

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 to low concentrations of dissolved light oils and expose deepwater-adapted fishes 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, consequence/severity is considered to be **Low** for pelagic and demersal species. A release of NADF is considered **Unlikely**, so the overall risk of an 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**.

6.2.4 Marine Turtles and Mammals

6.2.4.1 Marine Turtles

The key sources of potential impacts on marine turtles from Project-related activities include artificial light emitted from Project vessels, sound disturbance from drilling activities and vessels, and toxicological effects from exposure to Project vessel discharges. Marine turtles may also be impacted from unplanned events such as vessel strikes or a marine oil spill. Because all marine turtles with the potential to occur in the Project area are listed as CR (hawksbill turtles), EN (green turtle), or VU (leatherback and olive ridley turtle) by IUCN, the sensitivity of these receptors is considered **High** based on the conservative assumption that a CR or EN species would be affected.

There will be artificial lights in the Project area from various vessel types and Project features, and the amount of light will vary between stages of the Project. 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.

At no point will the offshore light from the Project area affect nesting marine turtles (or hatchling turtles making their way from their nest to the sea) since the Project area is located at least 160 kilometers offshore and the light will not be visible from the shore where turtle-nesting activities occur. Impacts occurring within the Project area would be short-term; coupled with the distance of the Project to shore, this yields a magnitude rating of **Negligible** for impacts on nesting turtles and immediate post-dispersal hatchlings. In combination with a conservative sensitivity rating of **High**, the significance ratings for potential impacts on marine turtles from exposure to artificial lighting are **Negligible**.

The main sources of underwater sound associated with exploratory well drilling activities are from VSP activities (generating impulsive sound) and marine vessels (generating non-impulsive sound). Sound sources from drilling 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 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 study by Nelms et al. (2016) 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. The hearing ranges overlap the sound produced by seismic airguns.

Observational records and dive profile data for tagged turtles (as described in Section 5.2.4.1, Marine Turtles) suggest that most marine turtles occupy the upper 50 meters of the ocean during the inter-nesting period, although leatherback turtles are known to dive deeper during their migration journeys. Preliminary studies indicate that individual turtles are equally likely to move toward a sound source than from it. The water depths in the potential drilling areas for the Project range from approximately 500 to approximately 2,850 meters. Leatherback turtles have been reported to dive as deep as 1,186 meters (López-Mendilaharsu et al. 2008) but they would not remain at this depth long enough to be injured by this type of noise source. In addition, EEPGL has embedded controls that include soft starts for VSP activities to minimize the chance for disturbance of marine turtles and mammals. These embedded controls include not conducting sound-producing seismic operations if marine turtles or mammals are seen within 60 minutes in water depths greater than 200 meters. 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 Project area.

Based on the above, the magnitude of potential disturbance-level sound impacts is considered to be **Small** for impulsive sounds (VSP) and **Negligible** for non-impulsive sounds (marine vessel operation). Accordingly, the significance of potential impacts from sound-related disturbances on marine turtles is considered **Negligible**.

As described in Section 2.7, Waste Generation, the Project will involve routine, permitted discharges of waste to the sea. All discharges will be treated (as needed) in accordance with industry guidelines. Furthermore, marine turtles will be transient in the Project area and 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) leave the immediate vicinity. The magnitude of potential impacts on marine turtles from exposure to permitted discharges is considered **Negligible**. Therefore the significance of potential impacts on marine turtles from exposure to permitted discharges is considered **Negligible**.

Marine turtles are transients within the Atlantic Ocean and they may encounter the drill ship or the support vessels but would not be expected to be negatively impacted by their presence unless they collided with a

support vessel transiting between the drill ship and the shorebase. 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 the higher concentrations of turtles in the shallow nearshore areas. Although isolated incidents of vessel strike on marine turtles do occur, adult marine turtles are generally able to avoid collisions by moving out of the way of approaching vessels. Hatchlings and juvenile turtles are weaker swimmers than adults and have a correspondingly smaller capacity to avoid oncoming vessels. Hatchlings of all marine turtle species disperse widely across the open ocean (Musick and Limpus 1997).

Vessel speeds will be low within the Project area 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 (i.e., SBPA); therefore, the likelihood of a Project vessel striking a mature turtle with eggs on her way to the nesting beaches, or encountering dense congregations of turtles, is low.

The consequence/severity of a vessel colliding with a marine turtle is **High**. However, the likelihood of a vessel colliding with a marine turtle is assessed based on the chance that a Project vessel's path would cross that of a turtle when either within the proposed Project area or when transiting to and from the shorebase(s). Given the relatively low number of vessel movements, limited number of marine turtles expected to be passing through the Project area or transit corridor, and the tendency of concentrations of post-nesting turtles to remain generally near the nesting beaches in the far western portion of Guyana (far removed from Project-related vessel traffic) as demonstrated by recent telemetry data, a collision with a marine turtle is considered **Unlikely**; accordingly, the overall risk of a vessel collision with a marine turtle 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**.

The most significant, albeit unlikely, potential impact of an unplanned event from the Project on marine turtles would be a marine oil spill reaching their respective nesting and feeding grounds. If spilled oil were to reach nesting beaches, it would have the potential to affect nesting adult females, eggs, and hatchlings. Nesting occurs above the high tide line, so even in the highly unlikely event of a spill reaching a shoreline, females would not be exposed to oil during the act of nesting. However, they could potentially be exposed prior to nesting and immediately

following nesting as they approach/egress the nesting beach. Eggs laid prior to a spill event would not be exposed to oil even if oil reached the nesting beach because they would be buried above the high-tide line unless a storm surge or spring tide transported the oil above the normal water line. Newly hatched turtles would be most sensitive to oil on the beach or in the nearshore zone because they are weaker than adults and would be more susceptible to negative effects from the oil.

The consequence of a marine oil spill on marine turtles is considered **High**, taking into consideration their susceptibility to oil contamination, the presence of individual turtles, and their protected status. As explained previously, a marine oil spill from a loss-of-well-control event is considered **Unlikely**, with prior oil spill modeling for loss-of-well-control releases in the Stabroek Block indicating a 5 to 20 percent chance that oil would reach the Guyana shoreline and the SBPA in an unmitigated event. Therefore, considering both consequence and likelihood, the overall (pre-mitigation) risk to marine turtles from a marine oil spill is **Moderate**. In the 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. Effective implementation of the OSRP would reduce the overall risk by reducing the probability of oil reaching the Guyana coastline. However, given the CR and EN IUCN classifications for two of the turtle species, the residual risk rating is maintained at **Moderate**.

6.2.4.2 Marine Mammals

The key sources of potential impacts on marine mammals from Project-related activities include artificial light emitted from Project vessels, sound disturbance from drilling activities and vessels, and toxicological effects from exposure to Project vessel discharges. Marine mammals may also be impacted from unplanned events such as vessel strikes, or marine/coastal oil spills.

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 could facilitate the concentration of plankton and/or small fish and squid at the surface or around the vessels, 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.

Seismic surveys are suspected of having a range of effects on marine mammals including annoyance/harassment, interference with echolocation and communication, and potential auditory injury. Although there is general consensus that seismic surveys have the potential to negatively affect marine mammals and it can be difficult to predict or quantify specific impacts, there is a growing amount of empirical evidence being gathered that shows no auditory injury from seismic surveys.

Although direct empirical evidence of physical injury or physiological effects of seismic surveys on marine mammals is scant, observed behavioral responses to seismic survey activity include changes in swimming speed, vocalization rates, dive rates, and general avoidance (Weilgart 2013). Species-specific behavioral observations of marine mammals exposed to seismic stimuli are variable and some findings are contradictory. Where feeding, orientation, hazard avoidance, migration, or social behavior is altered, it is possible that populations could be adversely affected but the biological significance of these effects has not been measured (Gordon et al. 2004).

As part of the EIA completed for the Liza Phase 1 Development Project, underwater sound modeling was conducted to assess the magnitude of potential auditory impacts on marine mammals from VSP and other underwater activities. Based on consideration of this modeling in the context of the Project, the magnitude of potential acoustic injury impacts on marine mammals was determined to be **Negligible** because the potential for marine mammals to be exposed to sufficient sound levels for a sufficient duration to cause auditory injury is extremely small. This conclusion is based on the following considerations:

- VSP will only occur during a limited time period, and therefore represents a relatively short-term source of potential impact.
- EEPGL has committed to using MMOs and soft-start procedures for VSP in accordance with JNCC guidelines.
- If an individual mammal were to approach an operating VSP, they would experience disturbance prior to being exposed to sound levels above injury thresholds, and would be expected to divert away from the source.

With respect to disturbance, anthropogenic sounds below acoustic injury thresholds have the potential to mask relevant sounds in the animals' environment. This masking can occur due to both natural and

anthropogenic sounds (Hildebrand 2005). The behavioral changes that can occur due to masking can have ecological consequences for marine mammals. These may include changes in biologically important behaviors (e.g., breeding, calving, feeding, or resting); changes in diving behavior (e.g., reduced or prolonged dive times, increased time at the surface, or changes in swimming speed); and changes in historical migration routes (NOAA undated-a).

Although the above changes could occur 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 Project area will likely be minor. The 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 found that despite more than 50 years of oil and gas exploration and development in the Gulf of Mexico, there are no data to suggest that these activities are significantly impacting marine mammal populations (BOEM 2014). Furthermore, the Project area is not known to be an important feeding, breeding, or calving area. Individual animals may divert around an operating 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, meaning some of the factors that contribute to limiting the magnitude of potential injury impacts are less relevant. Accordingly, as a conservative measure, the magnitude of potential disturbance impacts from sound on marine mammals is considered **Medium**. Given marine mammals' well documented sensitivity to acoustic stimuli, their sensitivity to Project related impacts is considered **Medium**, and the overall significance of sound-related impacts on marine mammals is considered **Moderate**.

As described in Section 2.7, Waste Generation, the Project will involve routine, permitted discharges of waste to the sea. All discharges will be

treated (as needed) in accordance with industry guidelines. Furthermore, marine mammals will be transient in the Project area and 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) leave the immediate vicinity. The magnitude of potential impacts on marine mammals from exposure to permitted discharges is considered **Negligible**, and therefore the overall impact significance is considered **Negligible**.

The likelihood of a collision of a supply or support vessel with a marine or coastal mammal would be extremely rare due to the operating speeds of the vessels and typical marine navigation best practices to be employed. Marine and coastal mammals are inherently 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. Vessel speeds will be low within the Project area and support vessels will operate at higher speeds only when transiting the continental shelf. Vessel routes in the nearshore environment are restricted to the channel of the Demerara Harbour, which is relatively deep, thereby increasing the opportunity for nearshore aquatic mammals to maneuver away from passing vessels.

The only marine mammals they are reasonably 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. Although they have not been documented conclusively within the Project area, some of the largest marine mammals in the world (e.g., blue whale [*Balaenoptera musculus*] and sei whale [*Balaenoptera borealis*]) *could* occur in the Project area, and are listed as EN by the IUCN. The loss of even a few mature breeding individuals to vessel strikes over the course of the Project life cycle would be significant from a conservation perspective. However, most marine mammals that are known to occur in the Project area, including the short-finned pilot whale, short-beaked common dolphin, and Risso's dolphin are listed as LC by the IUCN.

Balancing the conservation status of the more abundant species that are known to be present in the Project area with that of the rarer species that could be present, along with the short duration of the Project, the consequence/severity of a vessel collision with a marine mammal is considered **Medium**. A collision with a marine mammal is considered **Possible**, so the overall risk to marine mammals 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**.

Coastal marine mammal species that could potentially be encountered in the nearshore environment include the West Indian manatee (listed as VU by IUCN) and neotropical otter (listed as NT by IUCN), as they are known to occur 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 was observed in the first two riverine mammal survey events conducted in 2019). The West Indian manatee would be susceptible to vessel collision within the lower Demerara River, as it is well documented that vessel collision is one of the leading causes of death and considered the greatest impact on population growth of manatee species (Deutsch and Reynolds 2012; Runge et al. 2007). IUCN lists vessel collisions as one of the key threats to the West Indian manatee (IUCN 2019). 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 strike depth of most vessels (Edwards et al. 2016). Collision between a Project vessel and a West Indian manatee could cause injury or mortality to the affected individual or temporary behavioral changes; however, 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, and very few manatees are expected to occur in the lower Demerara River; therefore, a vessel collision with a manatee, if it were to occur, would be very infrequent. 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 collisions with neotropical otters are not expected to occur since vessel routes are restricted to the main channel of the Demerara River, where individuals are not expected to regularly occur.

The consequence/severity of a vessel collision with a coastal marine mammal is considered **Low**. A collision with a coastal marine mammal during transit to and from the Demerara Harbour is considered **Possible**, so the overall risk 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**.

In the very unlikely event of a marine oil spill, marine mammals may be exposed when they surface to breathe or breach in the area of a fresh slick. Exposure to oil may harm their respiratory tissue and eyes, and increase their susceptibility to infections. Although the magnitude of the impact of a particular spill event on marine mammals is controlled largely by the circumstances of the spill itself, marine mammals share similar biological

sensitivities to oil spills. These sensitivities cause the many species of marine mammals, and in particular whales and dolphins, to be affected in similar ways by oil spills (NOAA 2016). If a spill were to occur, the whales and dolphins that did not avoid the affected area would be exposed to the following potential categories of effects:

- Irritation of the gastrointestinal tract and/or poisoning due to ingestion of oil or oiled prey;
- Respiratory complications due to inhalation of oil or hydrocarbon vapors at the ocean surface; and
- Dermal irritation due to skin contact with oil.

Biological and behavioral traits would make certain species groups and/or life stages more susceptible to some of these effects than others. For example, species and life stages that respire frequently including the dolphins and porpoises as well as very young whales and their mothers would have a proportionately greater exposure to respiratory effects due to inhalation because they breathe more frequently and consequently spend more time at the surface than adults of the larger, deep-diving species (such as sperm whales). Species that forage near the surface (dolphins, some porpoises, and baleen whales) would also have a greater exposure to ingestion-related impacts than the larger toothed whales. Baleen whales may also be even more susceptible to such impacts because of the potential for oil to foul their baleen plates if the whales filter-feed in the vicinity of the oil spill.

Marine mammals may also be impacted by indirect impacts associated with oil spills, including increased exposure to sound and risk of injury from strikes by response vessels (see below). Although sperm whales (toothed) are the most commonly seen whales in the surveys occurring offshore Guyana, Bryde's whales, melon-headed whales, short-finned pilot whales, and several unidentified baleen whales have been observed in the Stabroek, Kaieteur, and Canje blocks.

Despite the potential impacts described above, serious health impacts or deaths in marine mammals due to oil spills are rare. This is attributed to their smooth, hairless skin, to which oil does not readily adhere, and their ability to avoid areas impacted by spills. Based on the total number of visual and acoustic detections from the 2015 through 2019 surveys (see Section 5.2.4.2, Marine Mammals), the risk to all marine mammals would be highest in November and lowest in May. For large spills in summer, dolphins and whales would both be at risk, but the risk to dolphins would be higher than the risk to whales (based on a greater relative presence). In the December through May season, the risk would shift almost entirely to

dolphins, as the swept area would shift to the comparatively shallower continental shelf, where whales have not been detected.

Considering the presence and susceptibility of baleen whales, the consequence/severity of a marine oil spill on marine mammals is considered **High**. Considering that a marine oil spill would be **Unlikely**, the overall risk of a marine oil spill on marine mammals is considered **Moderate**. Effective implementation of the OSRP would 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 consequence/severity rating to **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**.

Coastal marine mammals in Guyana would only be vulnerable to a marine oil spill that reached the Guyana coastline. An oil spill that reached the coast would negatively impact food supplies and result in similar health impacts on species as described for marine mammals; however, in the event of exposure to an unmitigated marine oil spill, coastal marine mammals would be expected to move up river (inland) to avoid or escape oil contamination. The consequence/severity of a marine oil spill on coastal marine mammals is considered **Medium**. Considering that a marine oil spill would be **Unlikely**, the overall risk of a marine oil spill on coastal marine mammals is considered **Minor**. Effective implementation of the OSRP would reduce the consequence/severity rating to **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the residual risk to coastal marine mammals from a mitigated marine oil spill would be **Minor**.

A coastal oil spill would be a small-volume, short-duration spill that would be expected to be quickly brought under control. A temporary, visible 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 ecologically important or protected species would not be expected. A few of the species described in Section 5.2.4.2, Marine Mammals, including boto, tucuxi, West Indian manatee, Guiana dolphin, and common bottlenose dolphin, are known to occur in rivers and could therefore be exposed to a coastal oil spill in or near the Demerara River.

The only marine mammal species that could be affected by a coastal oil spill are coastal species including the West Indian manatee and neotropical otter. Most other marine mammals that could be affected by a coastal oil spill are not as sensitive as the baleen whales based on conservation status, but in a confined area like the Demerara River they would not be as able to avoid the effects of a spill as they would in the

open ocean; accordingly, the consequence of a coastal oil spill on marine mammals is considered **Medium**. An oil spill in the Demerara River is predicted to be **Unlikely**. Therefore, the overall risk of a coastal oil spill on marine mammals is considered **Minor**. 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, resulting in a residual risk rating of **Minor**.

6.2.5 Seabirds

The Project has the potential to impact seabirds through disturbance leading to changes in behavior from displacement or attraction from sound and/or lighting, or toxicological effects from Project vessel discharges. Seabirds may also be impacted from unplanned events such as vessel strikes, or marine or coastal oil spills.

Some secretive seabird species may avoid the area around the drill ship while drilling operations are underway, but the presence of the drill ship and support vessels is also likely to attract more tolerant seabird species, which would use them to perch and loaf. Seabirds can be attracted to drill ships by a combination of night lighting, food, and other visual cues (Baird 1990; Wiese et al. 2001) and this attraction can render them more susceptible to certain hazards including impacts with the drill ship structure, oiling, and incineration by flares (Wiese et al. 2001).

The potential adverse impacts associated with seabird attraction to offshore facilities primarily relate to lighting and sound from the drill ships and support vessels. They will operate 24 hours a day, so at night they will be constitute a prominent source of artificial light in an otherwise dark environment. Lights on offshore vessels are known to act as an attractant to seabirds and typical offshore installation lighting extends roughly 3 to 5 kilometers 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 of time. The consequences of this may be: (1) energy wasted circling the Project structures, 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. As an embedded control to manage lighting-related impacts from the Project, lighting on the 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 Project area 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, the magnitude of potential impacts on seabirds related to attraction to Project vessels is considered **Negligible**. The sensitivity of seabirds to these impacts is rated as **Low**. Therefore, the overall significance of potential artificial lighting impacts is **Negligible**.

Rafting seabirds may suffer injury or mortality from collision with vessels transiting to and from the Project area. However, rafters are not likely to be present in large aggregations in the Project area 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 Project area from 2015 through 2019 did not document any concentrations of rafting seabirds in the area. No more than two individuals were observed at a time in offshore areas beyond 100 kilometers from shore. Should rafting seabirds be present in the Project area, 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. In the unlikely event such an interaction would occur, it would likely be limited to a few individuals; accordingly, the consequence/severity of such an event, from a population perspective, is considered **Low**. Given the low likelihood of vessels encountering rafting seabirds and EEGPL's embedded control of

providing standing instruction to Project dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from the Project area, where safe and feasible, if the birds do not move out of the vessel's path, and the low density of seabirds in the Project area, the likelihood of vessel strikes of seabirds is considered **Unlikely**. Accordingly, the risk to seabirds from potential marine vessel collisions is rated as **Minor**.

Helicopters will be used as a form of transit to/from the Guyana shorebase(s) 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 ship. It is assumed that 15 helicopter trips per month per drill ship will be required for the Project. Considering the low number of flight hours, and based on the relatively low seabird density in the Project area, the number of helicopter-bird interactions is expected to be very low.

In the event of a helicopter-bird interaction, this would likely be limited to a single individual; accordingly, the consequence/severity rating, from a population perspective, is considered **Low**. Given the low likelihood of helicopters encountering seabirds when transiting to and from Project area, the likelihood of helicopter strikes of seabirds is considered **Unlikely**. Accordingly, the risk to seabirds from potential helicopter strikes is rated as **Minor**.

An unplanned event such as a marine or coastal oil spill has the potential for measurable impacts on seabirds. If an oil spill were to occur, the magnitude of potential impacts on seabirds would be potentially higher than under normal operating conditions. During most oil spills, seabirds are harmed and killed in greater numbers than other kinds of creatures (NOAA 2016). Most seabirds would fly away from the affected area, but some would likely be oiled through contact with oil at the sea surface or ingest oil or by contaminated prey items. 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.

As described in Section 5.2.5.4, Important Bird Areas for Seabirds, no Marine IBAs have been identified in Guyana, but five IBAs in nearby countries are close enough that birds flying from these IBAs could reach the Project area. Oil spill modeling conducted as part of the Payara Development Project EIA suggests that over 40 other Marine IBAs are of global or regional importance to seabirds that lie within the area that could be swept by an unmitigated loss-of-well-control event. 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 VU or higher). Two of these Marine IBAs 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 Marine IBA sites mentioned above 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 a naturally 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 (IPIECA 2015).

Since most oils float, at least initially following a release, seabird species that spend significant time resting or foraging on the water's surface are most at risk from direct exposure. Diving birds and waterfowl are considered to have the highest risk of oiling. The consequence/severity of potential impacts on seabirds is considered **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the risk to seabirds is considered **Moderate**. However, effective implementation of the OSRP would reduce this risk to **Minor** by limiting the geographic extent of the oil spill and the number of individual birds potentially impacted.

Using drill ships as a resting place provides energetic benefits to the birds, and to the extent that the drill ships concentrate food such as small

baitfish, they may in some cases provide nutritional benefits as well. These positive effects must be weighed with the potential negative effects of being injured or killed by collisions with the flare tower or (when it is operating) its radiant heat plume. The magnitude of both the positive and negative effects of the Project on seabirds would be **Small** due to the short duration of the drilling campaign. Not considering special status seabirds (discussed separately below), the sensitivity of the overall seabird population is **Low**, considering that drill ships attract seabirds and that they experience both positive and negative effects as a result of that attraction. The overall rating of potential impacts on seabirds is **Negligible**.

6.2.6 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 (in order of least to most threatened) on the IUCN Red List Version 2019.1 (IUCN 2019) that are known or expected to occur in the Project area (Appendix D, IUCN-Listed Species in Guyana).

Of the 74 special status species known or expected to occur in the Project area, 38 are strictly coastal or inland species, so they will not be impacted by planned Project activities. They would only be affected by an unplanned event. Table 6.2-1 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 6.2-1: 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 Special Status Species Known or Expected to Occur within Project Area (IUCN Red List Status)
Marine turtles	4 (1 CR, 1 EN, 2 VU)
Marine mammals [a]	3 (1 NT, 2 VU)
Marine fish	24 (5 EN, 10 VU, 9 NT)
Seabirds [b]	4 (1 EN, 2 NT, 1 VU)

[a] Marine mammals include one true marine species and two coastal species.
[b] 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 taxa-specific impact sections above.

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 receptors, 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, or human activity; and the potential attraction to lighting from the drill ships. Potential impacts on these groups of receptors from unplanned events include oil spills and vessel and helicopter collisions with animals.

In the case of the resource-specific assessments for marine mammals and turtles, the above assessments of impact significance assume the affected receptors are all special status species, so the analyses for special status marine mammals and marine turtles are identical to those presented above. In the case of seabirds and marine fish, the resource-specific assessments presented above are not conducted on the basis of an assumed special status for the receptors. Accordingly, additional review of the magnitude ratings for seabirds and marine fish was warranted.

For almost all species, 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 receptor. However, some special status species will have different levels of exposure to some impacts because of their behavior, habitat preferences, or biology, resulting in a different magnitude rating compared with non-special status species. This more detailed evaluation of impact magnitude is warranted for the CR and EN seabird and marine fish species given their elevated conservation status.

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 for planned activities of the Project. However, in consideration of unplanned events, the magnitude of impact for Leach's Storm-Petrel (classified as VU) was elevated to **Medium** based on the results of marine bird surveys, which have documented the importance of the offshore zone as a migratory corridor for this special status marine bird.

In the case of marine fish, the more detailed evaluation identified differences in potential impact exposures, relative to marine fish as a whole, for the four CR marine fish species (Atlantic goliath grouper [*Epinephelus itajara*], daggernose shark [*Isogomphodon oxyrhynchus*], Caribbean electric ray [*Narcine bancroftii*], and largetooth sawfish [*Pristis*])—principally because of their predominant behavior and habitat

preferences. All of these species have the potential to occur in the nearshore and offshore areas of Guyana, but they spend most of their time in nearshore and estuarine environments, rather than offshore (where planned Project activities will occur). As such, their exposure to the impacts from planned Project activities is lower compared with marine fish as a whole. Hence, the magnitude ratings for potential impacts on these species are reduced relative to the magnitude ratings assigned for marine fish as a whole. Specifically, the magnitude of potential impacts on these four CR marine fish species is considered **Negligible**.

In the case of the EN marine fish species, the Nassau grouper (*Epinephelus striatus*) is listed as occurring in Guyana waters, but this species is primarily a shallow coral reef species with a depth range of 0 to 255 meters. The Project area is not known to include coral reefs and this species is thus not likely to be present—resulting in a magnitude rating of **Negligible**. Most of the other listed fish species (i.e., most of the EN, VU, and NT listed species) are pelagic species that are not prone to congregating around offshore structures; accordingly, potential impacts that are predicated on marine fish occupying areas around Project vessels (i.e., those impacts related to marine discharges, vessel sound, and attraction by light) are less of a concern than for other marine fish in general. Further, related to bottom habitat disturbance and VSP, potential impacts are not a concern for pelagic species. They would not be exposed to impacts at the seafloor and their exposure to impacts at the surface would be brief and intermittent, so the magnitude of Project impacts on these species is rated **Negligible**.

Five of the special status fish species with the potential to occur in the Project area are known to occur in offshore demersal habitats: golden tilefish (*Lopholatilus chamaelonticeps*), cownose ray (*Rhinoptera bonasus*), chola guitarfish (*Pseudobatos percellens*), sharpsnout stingray (*Fontitrygon geijskesi*), and variegated electric ray (*Diplobatis pictus*). According to the IUCN Red List habitat profiles for these species, all primarily inhabit shallower water than occurs in the Prospect Areas. The water depths within the portion of the Stabroek Block in which Project wells could be completed range from 500 to 3,000 meters. Cownose rays occur at depths from 0 to 22 meters (Barker 2006); chola guitarfish occur from 0 to 110 meters (Casper and Burgess 2016); and variegated electric rays occur at depths from 2 to 130 meters (de Carvalho and McCord 2006). Sharpsnout stingrays have been reported as deep as 810 meters, but are generally considered shallow water fish that frequent depths less than 20 meters (Chavet-Almeida and de Almeida 2016). IUCN reports golden tilefishes' depth ranges from 80 to 540 meters (Ross et al. 2015), but NOAA indicates their maximum depth is 1,200 feet (approximately 360 meters) (NOAA undated-b). For these reasons, the potential Project impacts listed above

for marine fish are all assigned a magnitude rating of **Negligible** for the remaining special status marine fish species.

The sensitivity of special status species to impacts is higher compared with non-special status species and requires special consideration 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 are based on the definitions provided in Table 6.2-2.

Table 6.2-2: 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 km^2), 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.

Contrary to other potential impacts, anthropogenic disturbance of turtles at sea (assigned a magnitude rating of **Medium;** the only potential impact 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 Project area, and between the Project area 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.

Based on the ranges of magnitudes for potential impacts from planned events of **Negligible** to **Medium** and the receptor sensitivity ratings of **Low** to **High** for the various IUCN listing levels (listed by species in Appendix D), the significance ratings for potential impacts from planned activities on special status species range from **Negligible** to **Minor**.

The consequence/severity of impacts from a marine oil spill on special status fish species would be highest for fish species ranked as CR and EN because these species are facing an extremely high or high risk of extinction in the wild due to severe population declines, very small populations, and/or very small geographic areas occupied or highly geographically fragmented subpopulations (IUCN 2001). The loss of even a few individuals in these categories could cause significant population-level impacts on CR and EN fish species. Based on this rationale, the consequence/severity of an oil spill on CR or EN fish species is considered **High**. The physical extent of the spill would need to be large to impact multiple individuals of a given species. Oil spill modeling indicates that a marine or coastal oil spill is **Unlikely**. Therefore, the overall risk of a large marine oil spill or a coastal oil spill to CR and EN fish species is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by further reducing the extent of an oil spill and the probability of oil reaching the Guyana coastline.

The vast majority of the species listed as VU or NT that could occur in the Project area are open water fish and impacts on these species from a marine or coastal oil spill would be expected to be lower than impacts on the other taxonomic groups because fish have no need to surface and can therefore avoid floating oil, and the depths present offshore of Guyana would provide sufficient opportunity to avoid slicks and sheens. Fish would have the potential to encounter emulsified oil rising through the water column from a loss-of-well-control event, but most of the fish species would rapidly vacate areas with harmful concentrations of oil in the water column, so exposure times would be brief.

The VU and NT species inhabit a mix of offshore and coastal habitats but most of the species are open water fish that would likely have limited exposure to oil, as described above. Based on this rationale, the consequence/severity of a marine oil spill on VU or NT fish species is considered **Medium**. Therefore, the overall risk of a marine oil spill to VU and NT species is considered **Minor**. Although effective implementation of the OSRP would reduce this risk by reducing the ultimate swept area

for the oil slick and the probability of oil reaching the Guyana coastline, the risk rating is maintained at **Minor**.

Given their susceptibility and sensitivity, the consequence/severity of a marine oil spill on seabirds as a whole is considered **High**, resulting in a pre-mitigation risk level of **Moderate.** Implementation of the OSRP would reduce the residual risk to **Minor** for seabirds as a whole. In the case of Leach's Storm-Petrel, however, surveys conducted to date have indicated the offshore Stabroek Block 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**. In contrast, Black-capped Petrel is not known to be present in the Project area in significant numbers. In consideration of the low likelihood that this species would be present in the unlikely event of an oil spill, combined with implementation of the OSRP, the residual risk is reduced to **Minor** for this species.

Should rafting of special-status seabirds occur in the Project area, 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. In the unlikely event such an interaction would occur, it would likely be limited to a few individuals; accordingly, the consequence/severity of such an event, from a population perspective, is considered **Low**. Given the low likelihood of vessels encountering rafting seabirds and EEGPL's embedded control of providing standing instruction to Project dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from the Project area, where safe and feasible, if the birds do not move out of the vessel's path, and the low density of seabirds in the Project area, the likelihood of vessel strikes of seabirds is considered **Unlikely.** Accordingly, the risk to special-status seabirds from potential marine vessel collisions is rated as **Minor.**

As previously discussed in Section 6.2.5, Seabirds, helicopters will be used as a form of transit to/from the Guyana shorebase(s) and offshore vessels. Considering the low number of flight hours, and based on the relatively low special-status seabird density in the Project area, 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; accordingly, the consequence/severity of such an event, from a population perspective, is considered **Low**. Given the low likelihood of helicopters encountering seabirds in the Project area, the likelihood of helicopter strikes of seabirds is considered **Unlikely.** Accordingly, the risk to special-status seabirds from potential helicopter strikes is rated as **Minor.**

Based on the range of consequence from unplanned events on special status fish or seabird species and the likelihood of these unplanned events occurring, the residual risk to special-status fish or seabird species from potential unplanned events is **Minor**, with the exception of the risk from a marine oil spill to Leach's Storm-Petrel, which is maintained at **Moderate**.

6.2.7 Protected Areas

The SBPA encompasses the entire Region 1 shoreline and adjacent inland areas (see Figure 5.2-20), and provides habitat for numerous coastal wildlife species, most notably more than 200 species of birds and several species of CR/EN/VU marine turtles. As such, the sensitivity/ vulnerability/importance of this habitat is considered **High**.

The SBPA is the only one of Guyana's protected areas that would be potentially exposed to impacts from the Project; however, planned activities of the Project will occur at least 160 kilometers offshore. Therefore, there is no potential for the Project to impact the SBPA except as a result of an unplanned event.

Shell Beach's sensitivity to Project-related impacts derives from the sensitivity of its biodiversity, which would be highly sensitive in general to releases of hydrocarbons. The key threat to Shell Beach's biodiversity is a potential marine oil spill. As discussed in Section 6.2.4, Marine Turtles and Mammals, marine turtle nesting habitat is one of Shell Beach's most important biodiversity-related attributes. Based on the biological sensitivity and importance of the SBPA, the consequence/severity of an oil spill reaching the SBPA is considered **High**.

The extremely low likelihood of such a release reaching Shell Beach is related to several factors, including the very small likelihood of a significant oil spill occurring, the tendency of ocean currents to carry hydrocarbons toward the Caribbean Sea rather than the Guyana coast, and the magnitude and duration of the wind shear or current deviations that would be necessary to re-direct hydrocarbons across at least 160 kilometers of ocean to Guyana's coast. Based on oil spill modeling results conducted to date, an unmitigated marine oil spill from a loss-of-well-control event in the Stabroek Block indicates a 5 to 20 percent probability of the oil contacting the coast in Region 1. Coupled with the fact that a marine oil spill is **Unlikely**, the overall (pre-mitigation) risk to the SBPA from a marine oil spill is considered **Moderate**. In the event of a marine oil spill, however, the OSRP would be implemented and resources and equipment would be mobilized to protect Shell Beach as necessary. Modeling of a mitigated marine oil spill indicates that oil would not contact the shoreline in Region 1. Accordingly, with the effective implementation of the OSRP, the residual (post-mitigation) risk would be

reduced to **Minor** because the oil spill prevention and response would be expected to prevent oil from reaching the Guyana shoreline.

A coastal oil spill would not be expected to impact SBPA because it would be limited to the area near the shorebase(s) and onshore support facilities utilized by the Project, which would be distant from SBPA. Accordingly, a coastal oil spill would not have the potential to impact protected areas.

6.3 SOCIOECONOMIC RESOURCES

6.3.1 Coastal Demographics

The Project would have very little effect on demographics, primarily because most of the Project-related activities and infrastructure would occur at least 160 kilometers offshore. Workers would be accommodated on the drill ship and support vessels, and would not come onshore except to re-supply the drill ship from the shorebases and transfer out of Guyana which according to EEPGL and its primary supply companies is typically one or two nights. The Project may provide a modicum of employment for a small number of local workers, but this work would last only for the length of the Project.

The Project would not require or encourage the relocation of large numbers of people within Guyana, nor would it promote influxes of foreign workers into the local labor force. Employment opportunities and use of goods and services that arise from the Project are expected to be limited to the Georgetown area and would not influence the economy or labor force elsewhere in the country. The magnitude of the Project's potential impacts on demographic patterns is **Small**, and the sensitivity/vulnerability of the demographic composition of the affected communities is **Low**. Therefore the overall impact of the Project on demographics would be **Negligible**.

An unplanned event, such as a marine or coastal oil spill, has the potential to impact coastal demographics, primarily social infrastructure, as a result of spill response efforts. Depending upon the nature of the spill, it is possible that EEPGL would establish housing or berthing for the response teams by building temporary camp structures (e.g., tents) or using a berthing vessel. Depending on the extent of the required response and associated workforce, social infrastructure along the coast (e.g., hotels, restaurants, road networks) could be impacted by an increase in demand for such services. These increased demands would only be temporary (for the duration of required clean-up; response efforts would likely be completed for the most part entirely within a year or less, 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. The consequence/severity of potential impacts on coastal demographics is considered to be no higher than **Medium**. In combination with a likelihood rating of **Unlikely** for a marine or coastal oil spill, the risk to coastal demographics is considered **Minor**.

6.3.2 Employment and Livelihoods

6.3.2.1 Regional Employment and Livelihoods

The Project would have little if any impact on regional employment and livelihoods. As described above, the employment opportunities and use of goods and services that would arise from the Project would not influence the economy or labor force outside the immediate vicinity of Georgetown, and the Project would not encourage migrants to move to these areas in search of work. In addition to the limited direct employment, the Project may result in the indirect employment of workers through procurement of select local goods and services. Local and foreign workers that are off-shift (even for one or two nights) may 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. The potential impacts on employment and livelihoods that will result from Project employment, procurement, and worker spending is considered to be **Positive**, and as such, a magnitude rating is not assigned.

Unplanned events with the potential to result in measureable impacts on socioeconomic conditions would be a marine oil spill or a coastal oil spill. Oil spills could potentially impact the fisheries sector that currently accounts for a large part of the country's GDP. These potential risks are discussed below.

6.3.2.2 Deep-sea Fisheries Resources

The Project's potential impacts on fisheries would be limited to potential interference/displacement of fisherfolk from their preferred fishing locations. This could occur if the drilling occurs in a popular fishing area, but the likelihood of drilling in an area of intense fishing effort is remote because of the considerable distance a fishing vessel would have to travel to reach the Project area.

Current fishing activities rarely occur as far offshore as the Project area, and according to various members of the industrial and artisanal fishing community as well as the Fisheries Department, the marine safety exclusion zones (500 meters) that would be in place around the drill ships are expected to have little or no impact on existing fishing activity. There is one commercial fishing company, Pritipaul Singh Investments, with 12 vessels capable of partaking in deepwater tuna fishing as far out as the Project area (ERM/EMC Personal Communication 1; ERM Personal Communication 7), 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 near the Project area, but no further information was obtained to confirm these results (ERM Personal Communication 5). If deepwater fishing continues to develop in the vicinity of the Project area, 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 industrial fishing vessels that are currently participating in deep-sea fishing, the ability to provide information in advance to these operators about EEPGL operations and marine safety exclusion zones, the relatively small area of ocean that will be affected, and the limited duration during which any such effects would be felt, the magnitude of the Project-related impacts on industrial fishing operations is considered **Negligible**.

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 have a **Medium** level of sensitivity to potential impacts on fishing activity. Based on the magnitude of impact and the receptor sensitivity ratings, the significance of potential livelihood and employment impacts on industrial fisherfolk operating in the offshore area is rated as **Negligible**.

An unplanned event, such as a marine oil spill, has the potential to impact deep-sea fishing in the vicinity of the spill. However, considering the small number of industrial fishing vessels that are currently participating in deep-sea fishing (approximately 12 vessels), and ability for those vessels to relocate to other offshore areas that are not affected, the consequence of a marine oil spill on industrial fishing operations is considered **Small**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the risk to deep-sea fisheries from a marine oil spill is considered **Minor**.

6.3.2.3 *Nearshore Fisheries Resources*

The highest potential for Project interactions with fisherfolk may be encounters with support vessels transiting between the Project area and the shorebases in Georgetown. This could result in some limited and temporary disruption to fishing activity. Unlike deepwater industrial fisherfolk, artisanal fisherfolk will not lose access to any fishing areas as a result of marine safety exclusion zones within the Project area (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 artisanal fishing vessel activities and therefore livelihoods. Considering the occasional and temporary nature of potential impacts on fishing activity from Project-related marine traffic, and the limited duration during which any such effects would be felt, the magnitude of the potential impact on these receptors is considered to be **Small**.

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. Based on the magnitude of impact and the receptor sensitivity ratings, the significance of potential livelihood and employment impacts on artisanal fisherfolk operating in the coastal area is rated as **Minor**.

An unplanned event, such as a coastal oil spill, has the potential to impact industrial and artisanal coastal fishing in the vicinity of the spill. A coastal spill near the Demerara Harbour would likely have the greatest impact considering the most important fishing port in Guyana (Meadowbank) is located in Region 4 on the Demerara River. Considering how important the fishing industry is to the national Guyanese economy, the consequence of a coastal oil spill on industrial and artisanal fishing operations in coastal and nearshore operations is considered **Medium**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the risk to nearshore or coastal fisheries from a coastal oil spill is considered **Minor**.

6.3.3 *Cultural and Archaeological Resources*

The Project would have no impacts on the historical character of the various cultural landmarks in Georgetown. Though it is reasonable to assume a shipwreck could be located in or near the vicinity of any potential offshore exploration drilling activities, performance of the geotechnical survey, shallow hazard evaluation, and site clearances would confirm whether a shipwreck or other cultural/archaeological resource is present in the vicinity of a well site. Baseline surveys performed prior to

initiating activities are generally able to identify the presence of a shipwreck and allow for the feature to be avoided. Under this scenario, impacts on cultural/archaeological resources would be minimal; however, the possibility for a resource to go unnoticed does exist.

A chance find could potentially occur prior to the start of drilling. Under this scenario, appropriate action would be taken to address the potential magnitude of the impact as well as the vulnerability of the resource. EEPGL has engaged with the National Trust of Guyana regarding their chance find procedure for projects of this type, and has ensured that the chance find protocol that would be used for this Project is approved by the National Trust of Guyana. The overall magnitude of potential impacts on cultural/archaeological resources is considered **Small**, and the sensitivity/vulnerability of cultural/archaeological resources is **Low**, yielding an overall rating of **Negligible**.

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. Considering this and the fact that baseline surveys performed prior to initiating activities are generally able to identify the presence of a shipwreck within the drilling area, the consequence/severity of an NADF release with respect to impacts on underwater cultural heritage is therefore considered **Low**. In combination with a likelihood rating of **Unlikely** for an NADF release, the risk to cultural and archeological resources is considered **Minor**.

6.3.4 Transportation

6.3.4.1 Navigation and Marine Transportation

Project-related potential impacts on navigation and marine transportation are expected to be similar to potential impacts on fishing. Other marine vessels would likely encounter the support vessels and may pass by the drill ships. The Stabroek Harbour Master has advised EEPGL that Jamaican and Trinidadian vessels shipping lanes intersect the exploration blocks; however, 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. No interference with shipping traffic was reported during previous seismic surveys or exploration drilling activities. EEPGL also expects to be able to locate the drill ship at each well location such that it does not impede shipping traffic. Therefore, there is no reason to believe that the Project activities will meaningfully impede non-Project

shipping traffic either within the harbor or offshore. The magnitude of impacts on navigation and marine transport for commercial shipping are therefore expected to be **Small**. The sensitivity/vulnerability of shipping to such impediments would be **Low**, as commercial cargo vessels would be able to easily avoid the exclusion zone. Therefore the overall significance of potential impacts on navigation and marine transportation for marine traffic in general is considered **Negligible**.

Most subsistence fishing occurs in nearshore areas and most commercial fishing occurs between the coast and the edge of the continental shelf. 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 vicinity of Georgetown, and can alter their fishing grounds to avoid defined marine safety exclusion zones. 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. The magnitude of impacts on navigation and marine transport is therefore expected to be **Small.** Neither commercial nor subsistence fishing vessels are specifically accustomed to the type of activity proposed by the Project; therefore, their sensitivity/vulnerability would be **Medium**. Therefore, the significance of potential impacts on navigation and marine transportation for commercial or subsistence fishing is considered **Minor.**

Unplanned events with the potential to result in measureable impacts on navigation and marine transportation would be an oil spill or a marine vessel collision. 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 (see Section 6.3.2, 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, 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.

Therefore, with respect to impacts on marine use and transportation, the consequence/severity of a marine oil spill is considered **Medium**. 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 **Low**. In combination with a likelihood rating of **Unlikely** for an oil spill, the risk to navigation and marine transportation is considered **Minor**.

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 consequence/severity of a vessel collision with respect to potential impacts on marine use and transportation is considered **Low**. The likelihood of a collision between a Project vessel and a third-party vessel in or around Georgetown Harbour is considered **Unlikely**. The risk to navigation and marine transportation as a result of a marine vessel collision is considered **Minor**.

6.3.4.2 Land Transportation

The only component of the Project that could potentially affect land transportation is Project-related vehicle movements between the shorebases and other onshore facilities (e.g., for the transport of materials and supplies between potential offsite pipe yards or storage/warehousing facilities areas and the shorebases).

Project-related vehicles using the shorebases will travel along the East Bank Demerara Road. As part of the Liza Phase 2 and Payara Development Project EIAs, traffic impact modeling was conducted to assess potential changes in traffic congestion that could occur as a result of EEPGL's activities around the shorebases.

The level of service modeling for a number of modeled scenarios confirmed that the addition of projected Project-related traffic will not meaningfully change level of service ratings along the East Bank Demerara Road; therefore, it is expected that Project traffic will not measurably change existing traffic congestion in Georgetown. On this basis, the magnitude of impact on ground transportation as a result of the Project is considered to be **Negligible**. The receptors that could potentially experience impacts on ground transportation include current users of the Georgetown road network. Existing drivers are considered to 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. Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential ground transportation impacts on community stakeholders is **Negligible**.

Unplanned events with the potential to result in measureable impacts on land transportation would include a vehicular accident involving a Project-related vehicle. With respect to impacts on road congestion resulting from such an accident, an accident would be expected to be cleared from the roadway relatively quickly. The consequence/severity of this potential impact is therefore considered **Low**. In combination with a likelihood rating of **Unlikely** for vehicular accident given the low rate of increase of Project-related traffic compared to existing traffic, the risk to land transportation is considered **Minor**.

6.3.5 Tourism and Recreation

The bulk of the Project-related activities will occur offshore, and thus will not affect existing tourism operations. Activities at the shorebase would occur within an industrial zone that would not be expected to attract tourists. Therefore the magnitude of impacts on tourism and recreation would be **Small**. The sensitivity of tourism and recreation to the Project-related potential impacts would be **Low**, and thus the significance of potential impacts on tourism and recreation is considered **Negligible**.

With respect to potential impacts on tourism and recreation, an unplanned event, such as a marine or coastal oil spill, could have the potential to impact tourism and recreation. A large-scale marine oil spill could deter foreigners from choosing Guyana as their destination. A coastal oil spill could impact domestic tourists and locals from choosing coastal destinations, such as Georgetown, for leisure and recreation.

However, considering that tourism is not a major contributor to Guyana's GDP and coastal use is not prevalent for most domestic tourists (aside from major holidays and events when residents frequent beaches to celebrate, such as Easter and the annual Kite Flying festival), the consequence/severity of this potential impact is considered **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the risk to tourism and recreation is considered **Minor**.

6.4 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 to result from unplanned events that may occur, specifically oil spills. As previous oil spill modeling conducted for EEPGL's development projects indicates (and as summarized in EEPGL's affiliate-level OSRP, which applies to exploration- and production-related oil spill scenarios), transboundary impacts could potentially occur as a result of a Tier III loss-of-well-control event. 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). Previous deterministic modeling conducted for a Tier III loss-of-well-control event in excess of 30 days indicates 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.

Based on previous modeling that has been incorporated into the affiliate-level OSRP, an oil spill in the Stabroek Block would be expected to travel generally toward the northwest, regardless of season. Seasonal differences in wind speed and direction result in a range of shoreline lengths and locations predicted to be oiled. Previously completed modeling indicates that 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.

Although a marine oil spill remains **Unlikely**, such an event would have the potential to impact the same resources and receptors discussed in this chapter for Guyana, but in these other countries. The mechanisms of impacts on these transboundary resources and receptors would be similar to those discussed elsewhere in Chapter 6 for resources in 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 Guyana's middle and outer continental shelf and continental slope (ERM 2018a and ERM 2018b) but are more common or more widespread in other countries in the region. Impacts on these resources could potentially be much more extensive in other countries than in Guyana. Leveraging the results of prior modeling completed for marine oil spills in the Stabroek Block, a general overview of potential effects in each of the countries that could be affected by a Worst Case Discharge (WCD) loss-of-well-control event in the Stabroek Block is provided below.

6.4.1 Potential Transboundary Effects from a Loss-of-Well-Control Event

A loss-of-well-control event in the Stabroek Block 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 December to May season, a slick from an unmitigated 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 June to November season would track slightly more to the north, across the central Caribbean Sea and the central and southern portions of the Lesser Antilles.

The following sections describe the specific coastal sensitivities in each of the countries that could be affected by a loss-of-well-control event in the Stabroek Block and are organized according to the three main regions described above. The extent, duration, and time until first oiling would depend on location, season, and volume of the spill among other factors. The descriptions below are not based on potential Project well location-specific modeling, but on general trends observed in previous modeling conducted for affiliate-level oil spill planning purposes.

6.4.1.1 *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 would likely be at the greatest risk of oiling from a loss-of-well control event in the Stabroek Block. The islands' southern and eastern coasts would be at the greatest risk. Sensitive coastal resources in these areas include mangroves, manatee habitat, marine turtle nesting beaches, and forest reserves from Redhead in the north to Guayaguayare in the south. In Tobago, the area at greatest risk includes numerous marine turtle nesting beaches and coral reefs, as well as several large seagrass meadows in the south near the Mount Pleasant area.

Depending on the location, volume, duration, and season, resources along Tobago's western coast could also be affected by oil from a loss-of-well-control event in the Stabroek Block, but these areas (including Tobago's remaining marine turtle nesting beaches and its largest coral reef, Buccoo Reef, located adjacent to the southwest tip of the island) would be at a lower risk than southern and eastern coastlines. 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, and/or feeding areas for pelagic species) of global or regional importance to seabirds have been designated in Trinidad and Tobago. The IBAs along the south and east coasts of both islands would be at greatest risk of oiling from a loss-of-well-control event in the Stabroek Block.

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 farther 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 in the Stabroek Block.

Potential Effects on Venezuela

Previous modeling of an unmitigated spill identifies five main areas of the Venezuelan coast at risk of oiling:

- The Orinoco Delta
- The Paria Peninsula
- Margarita Island
- The central coast from approximately Puerto Píritu to Caracas
- 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 risk would generally increase with spill volume and in a westerly direction. The western portion of the Orinoco River 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 largest 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 main factor in determining risk in this area is location, with the western portion of the peninsula at substantially higher risk of oiling from a loss-of-well-control event in the Stabroek Block in all seasons.

Margarita Island has several important coastal bird habitats, two coral reefs, mangrove areas along its southern coast, and several shallow marine lagoons. 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[31] 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.

Several of Venezuela's offshore islands would be at risk of oiling under a loss-of-well-control scenario. 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 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 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.

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 River Delta, including much of the Paria Peninsula and several of the offshore islands. 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 in the Stabroek Block.

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

[31] 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.

of the country. The most prominent feature on the peninsula is Macuira National Park, which is an 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.

Potential Effects on Bonaire

Much of the east coast of Bonaire could be at risk of oiling from a loss-of-well-control event in the Stabroek Block. 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 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 potential oiling from a loss-of-well-control event in the Stabroek Block. 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 largely protected from oiling under all loss-of-well-control scenarios.

Potential Effects on Aruba

Like Bonaire, much of Aruba's east coast could potentially be at risk of oiling from an unmitigated loss-of-well-control scenario in the Stabroek Block. 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.

Potential Effects on Curaçao

Similar to Aruba, much of Curaçao's east coast would be at risk of oiling under an unmitigated Tier III loss-of-well-control scenario in the Stabroek Block. The most prominent environmental feature that would be at risk is the Christoffel/Shete Boka Park, which protects approximately 6 kilometers 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 kilometers along the southeastern coast from Willemstad to the southern end of the island and is Curaçao's only Marine Protected Area. It reportedly supports 65 species of coral, more than 350 species of fish, mangroves, and seagrass. The park would be naturally protected from oiling, owing to its location on the leeward side of the island.

6.4.1.2 Southern Lesser Antilles (excluding Trinidad and Tobago)

The Lesser Antillean countries north of Tobago at greatest risk of oil coming ashore from a loss-of-well-control event in the Stabroek Block are Grenada and St. Vincent and the Grenadines. Previously completed oil spill modeling suggests that nearshore waters of both countries could be at risk of being affected by a slick, but the severity of the risk would vary according to location, season, and volume.

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, 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 not only adjacent to the main island but also adjacent to several of the smaller offshore cays, including Ronde Island and the South Carricou Islands. Most of the country's seagrass and coral habitats are located along the east coast where they would have the highest risk of exposure, 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 several small mangroves are on the south coast and several more small mangroves are 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.

6.4.1.3 Greater Antilles

Previous modeling that has been incorporated into the affiliate-level OSRP suggests that in general, risks to the Greater Antilles would peak in the latter half of the calendar year, when easterly winds are at their weakest, which would allow a slick originating in the Stabroek Block to track further north than it likely would under the windier conditions that typically prevail early in the year.

Potential Effects on the Dominican Republic

Risks of coastal oiling in the Dominican Republic would be greatest along the southwestern coast. 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 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).

Potential Effects on Haiti

Similar to the Dominican Republic, 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 a series of sandy beaches interspersed with rocky shoreline. Mangroves occur there, but are sparse. No other environmental sensitivities have been mapped in this area.

Potential Effects on Jamaica

Similar to Haiti, the greatest risk of shoreline oiling in Jamaica would be along the southern coast. 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 km^2 (201 square miles [mi^2]) 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 approximately 15 kilometers west of the PBPA and Jamaica's largest wetland. It supports the IUCN-listed American crocodile (VU). It is listed as an IBA by Birdlife International.

Outside the PBPA, several significant reefs are along Jamaica's southern coast. Three reef areas exist between the PBPA 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.

6.4.2 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 2019b). No Marine IBAs have been identified in Guyana, but 49 Marine IBAs are of global or regional importance to seabirds that lie within the zone that has been shown to be at risk of oiling in modeling analyses of potential unmitigated spills arising from the Stabroek Block. 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 VU or higher). Two of these 49 Marine IBAs 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 EN).

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 potential swept zone of an unmitigated loss-of-well-control spill from the Stabroek Block 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).

6.4.3 Mitigation of Transboundary Impacts

It should be noted that previously conducted unmitigated oil spill modeling and used to characterize potential transboundary impacts in the EA&MP did not take into consideration any emergency response actions. Implementation of the affiliate-level 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 a well location within 9 days in certain circumstances (e.g., where there is no debris that would prevent or delay installation of the capping stack). When the modeling on which this evaluation is based was conducted, the response time associated with a capping stack deployment was based off preliminary and conservative logistics assumptions. After establishing a subscription to the Boots & Coots Global Rapid Intervention Package system, and in conjunction with an ongoing capping stack study, the response time model has been refined to reflect current logistics strategies and it is now estimated that the capping stack deployment is possible within 5 days. Once deployed, final capping operations would occur and the well could be shut-in within 6 days. However, oil spill modeling has been conservatively based on a 9-day installation of the capping stack at the well for the WCD scenario and that timing is therefore reflected in the mitigated scenarios modeling discussed herein. Mitigated scenario modeling has demonstrated that this, in combination with other response measures (e.g., dispersant application), would significantly reduce the extent of transboundary

impacts below the geographical extent described in the above country-specific summaries. 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.

7 CUMULATIVE IMPACT ASSESSMENT

A cumulative impact arises as a result the synergies between Project-related potential impacts and impacts from other activities. Cumulative impacts can result from minor, but collectively substantial, actions undertaken over time. The approach for assessing cumulative impacts is based on a consideration of the approval/existence status of the "other" activity and the nature of information available to aid in predicting the magnitude of impact from the other activity.

The CIA for this EA&MP includes three major tasks:

- Determining the scope of the cumulative analysis, including relevant resources, geographic extent, and time frame;
- Identifying the other activities that have the potential to impact the relevant resources together with the Project; and
- Assessing potential cumulative impacts on the relevant resources.

This section discusses a CIA conducted to evaluate the potential contribution of the Project toward cumulative impacts on resources (identified herein as Valued Environmental Components [VECs]).

7.1 INTRODUCTION

The Project area is located at least 160 kilometers offshore, so there are limited opportunities for the Project to cumulatively impact resources that would be impacted by other activities. The other non-Project activities with the potential to contribute to cumulative impacts include the following:

- Other EEPGL activities
  - Liza Phase 1 Development Project
  - Liza Phase 2 Development Project
  - Payara Development Project
  - Hammerhead Development Project
  - Stabroek Block Exploration Drilling (ongoing 12-well campaign)
  - Canje Block Exploration Drilling (proposed 3-well campaign)
  - Kaieteur Block Exploration Drilling (proposed 1-well campaign)
- Potential future offshore Guyana oil and gas exploration by other developers

- Other non-oil and gas projects:
  - Guyana Mariculture Project
  - Replacement of the Demerara Harbour Bridge

These Project and non-Project activities together could cumulatively impact some resources such as special status species and marine animals (e.g., via risks from potential vessel strikes or exposure to underwater sound) and marine transportation (e.g., via marine traffic congestion, especially near Georgetown Harbour), among others analyzed and discussed in this chapter.

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. 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) [32] 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).

7.2 *OBJECTIVES AND SCOPE OF THE CUMULATIVE IMPACT ASSESSMENT*

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 EA&MP, information generated for the Project area, 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;

[32] PACs are defined in the Handbook as local communities potentially directly affected by the Project (consistent with IFC Performance Standard 1, paragraph 1 [IFC 2012a]).

- 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.

7.3 METHODOLOGY

7.3.1 Definitions of Key Terminology for the CIA

The following are definitions for 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 based on 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 social 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);

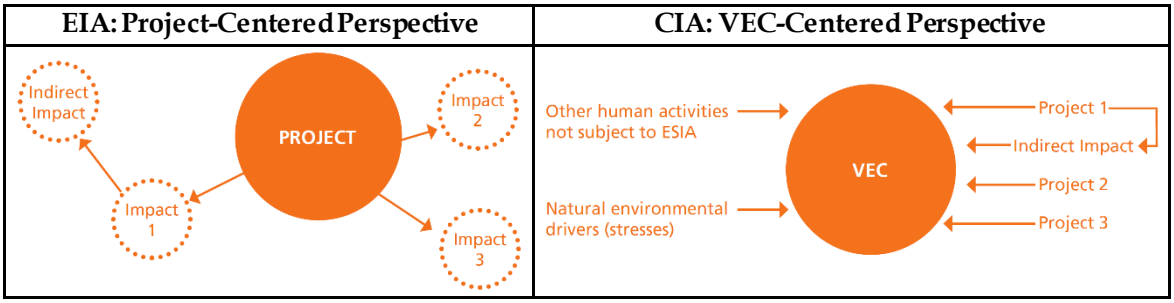
- Social conditions (e.g., community health, economic conditions); and
- Cultural heritage or cultural resources aspects (e.g., archaeological, historic, traditional sites).

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 ecological pathways.

7.3.2 *Overall CIA Approach*

Unlike an assessment of project (only) impacts, 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 7.3-1). In a CIA, the overall resulting condition of the VEC and its related viability are assessed.

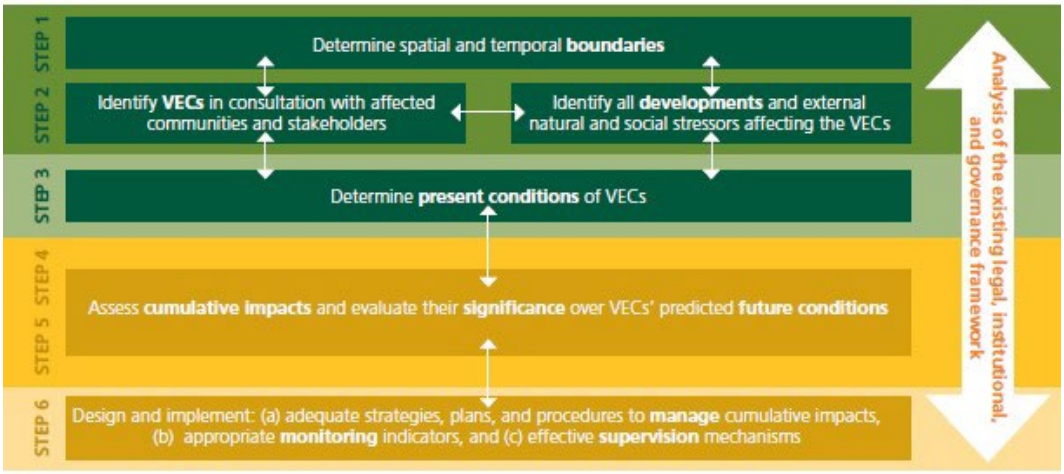
Figure 7.3-1: Comparing EIA and CIA



Source: IFC 2013

As previously described, the CIA is derived from desktop reviews of publicly available information, and information obtained from the various assessments performed for EEPGL projects between 2015 and 2019. The assessment follows the six steps for a CIA (see Figure 7.3-2). 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.

Figure 7.3-2: Summary of IFC's CIA Methodology



Source: IFC 2013

7.3.3 *Limitations*

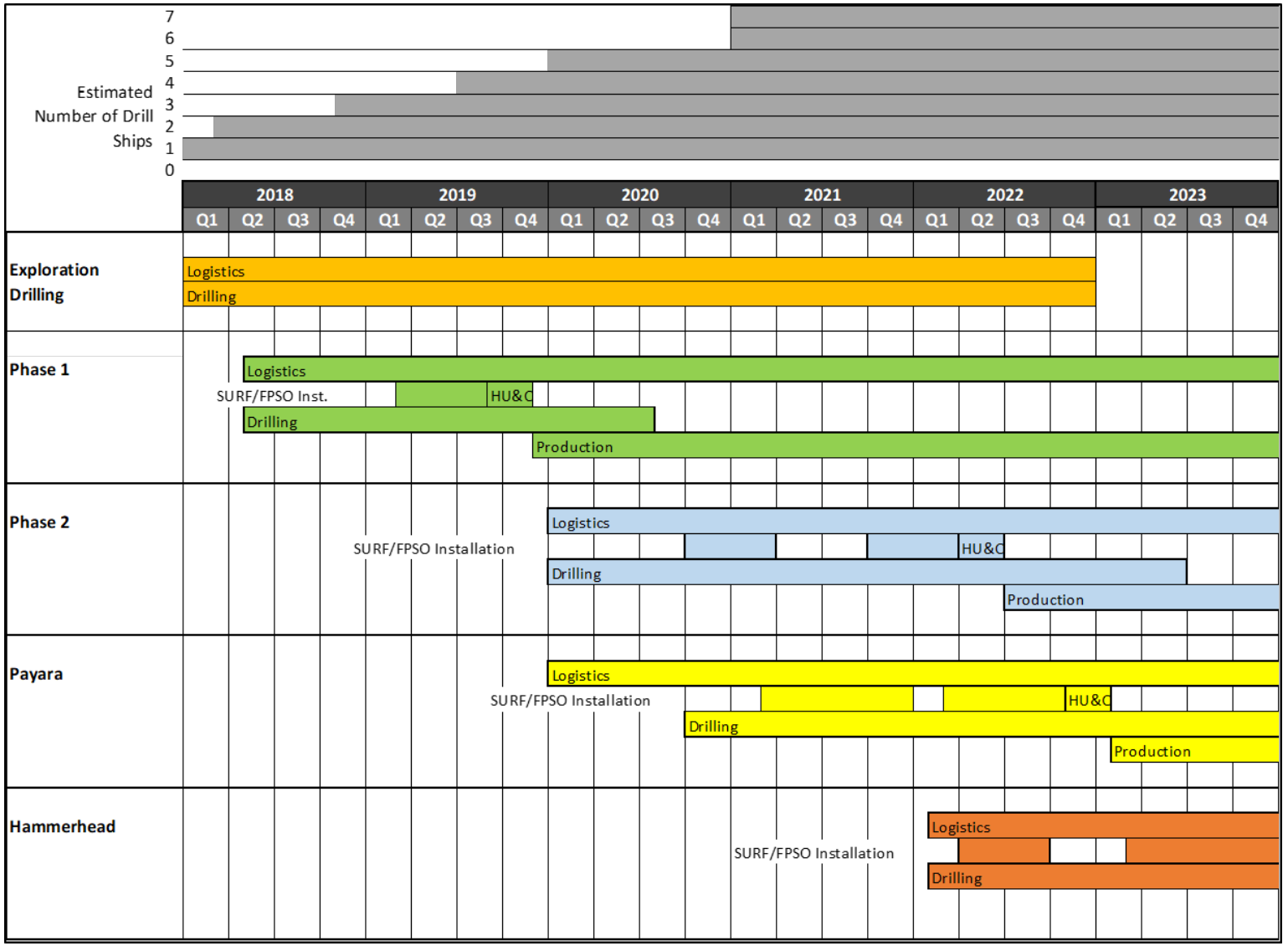
The Handbook takes into consideration the limitations that a private developer may face carrying out a CIA. The limitations applicable to this CIA, include: (1) incomplete information about other projects and activities (e.g., the information is not available in the public domain); (2) uncertainty with respect to the implementation of future projects; and (3) difficulty in establishing thresholds or limits of acceptable change for VECs, and therefore the priority of cumulative impacts.

7.3.4 *Determination of Spatial and Temporal Boundaries*

The geographic scope for a CIA is typically defined by the extent of the influence of the Project. The spatial extent of the Project's influence on the relevant resources for this CIA includes the Stabroek Block, the shorebases the Project may use, and the route that would be traversed by the support vessels between the shorebases and the Project area.

Temporal delimitation for a CIA is frequently a challenge due to the uncertainty inherent to potential future projects. For this reason, good international industry practice suggests consideration of no more than a 3-year temporal boundary when conducting a CIA. In this case, the estimated Project timeline includes portions of 2 calendar years (expected to initiate in 2021 and conclude in 2022). However, for informational purposes, other non-Project EEPGL activities occurring prior to the Project and anticipated to occur after the Project are shown on Figure 7.3-3.

Figure 7.3-3: Temporal Boundary of the CIA for EEPGL's Projected Offshore Activities (Conceptual for CIA Purposes)



As discussed further in Section 7.4.1, Other EEPGL Projects, the other planned EEPGL projects considered in the CIA include: (1) Liza Phase 1 Development Project; (2) Liza Phase 2 Development Project; (3) Payara Development Project (currently undergoing an application for an Environmental Permit); and (4) Hammerhead Development Project (for which an Application for Environmental Authorisation has recently been submitted to the EPA); and (5) other exploration activities in the Stabroek, Kaieteur, and Canje blocks. Note that the environmental authorizations for the Payara Development Project, Hammerhead Development Project, and exploration in the Kaieteur and Canje blocks have not been received as of the writing of this document. Accordingly, their timelines should be considered preliminary in nature, and would be refined as needed in the future based on regulatory approvals and evolving EEPGL plans in Guyana.

7.3.5 Identification of VECs, Other Projects, and External Drivers

7.3.5.1 VECs

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 and some combination of other projects and external drivers.

In support of EEPGL's exploration and development activities since 2011, ERM and its in-country partners (collectively, "the Consultants") conducted or participated in various disclosure meetings, one-on-one key informant interviews, focus groups, and other general meetings. These engagements with key stakeholders have included local and national government agencies, non-governmental organizations, academia, local communities, civil society, and local industries. These engagements allowed the Consultants to develop a list of preliminary VECs and to establish the value or importance of receptors to the stakeholders. Table 7.3-1 presents the stakeholder groups engaged by the Consultants; information from these engagements was considered in the selection of VECs.

Table 7.3-1: Key Stakeholder Groups Interviewed

Project Activity	Objective/Desired Outcome	Stakeholders/Audience
Liza-1 Well Drilling Program [August 2011 to November 2013]	Liza-1 well Strategic Environmental Assessment and Environmental Permit	Ministry of Natural Resources
		GGMC
		EPA
		Natural Resource Management Division of EPA
		Environmental Assessment Board
		Ministry of Labor, Human Services and Social Security, and Special Department of Occupational, Safety and Health Department
		Ministry of Labour, Human Services and Social Security Special Department of Occupational, Safety and Health Department
		Ministry of Local Government and Regional Development
		Guyana Defense Forces and Guyana Police Forces
		Ministry of Local Government – Solid Waste Management Department
		MARAD
		Transportation and Harbours Division, and Harbour Master
		National Trust Department
		Mangrove Restoration Project – National Agriculture Research and Extension Institute (NAREI)
		Guyana Marine Conservation Society (GMCS) and Volunteer Youth Corp (Math and Science Initiative)
Six-Well Drilling Program (Liza-2 and Liza-3 wells) [mid-December 2015 to February 2016]	Six-well Drilling Program Environmental Management Plan (EMP) and Environmental Permit(s) and present outcomes of Multi-well EMP Process	EPA, GGMC, Conservation International (CI), World Wildlife Fund (WWF) and other external stakeholders
	Ongoing dialogues with agencies	EPA/GGMC
	Presidential briefing	President of Guyana

Project Activity	Objective/Desired Outcome	Stakeholders/Audience
Liza Phase 1 Development Environmental Impact Assessment (EIA) [July 2016 to present]	Continue to build public support for the Project and confidence in EEPGL capability. Identify potential roadblocks/issues before they cause project risk.	
	General briefing Ensure timelines and process are well understood. Identify potential roadblocks/ issues before they cause project risk.	EPA/GGMC
	EIA information sharing and baseline data collection interviews	Ministry of Agriculture, Department of Fisheries
		Ministry of Communities
		Ministry of Public Health
		Department of Tourism
		Ministry of Social Protection
		Ministry of Indigenous Peoples Affairs
		Ministry of Public Infrastructure
		Maritime Administration Department
		Guyana Land and Surveys Commission
		Bureau of Statistics
		National Trust of Guyana
		Private Sector Commission
		Protected Areas Commission
		University of Guyana Centre for the Study of Biological Diversity
		GMCS
		Conservation International
		WWF

Project Activity	Objective/Desired Outcome	Stakeholders/Audience
		Association of Trawler Owners and Seafood Processors
		National Aquaculture Association of Guyana
		Guyana Rice Producers' Association
		Supenaam-Parika Speedboat Owners' Association
		Mainstay Amerindian Village
		Vilvordeen-Fairfield Women's Association
		Pomeroon Women's Agro-Processors Association
		West End Agricultural Development Society
		Big Bird and Sons Fishing Complex
		Lima Fishermen's Development Co-op
		Georgetown Fishermen's Co-op Society Ltd.
		Parika Fishermen's Development Co-op
		Ogle International Airport
		African Culture Development Association
		Guyana Hindu Dharmic Sabha
		Region 2 Development Council
	Two Agency EIA scoping meetings led by EPA	Multiple public and private agencies and non-governmental organizations including EPA, GGMC, Ministry of Public Health, Ministry of the Presidency, Protected Areas Commission, GMCS, WWF, CI, others.
	Six Public EIA scoping meetings (Regions 1-6) led by EPA	Various national, regional, and local agency representatives as well as private citizens
	Agency-specific EIA disclosure meetings	Guyana Marine Conservation Society
		EPA
		Ministry of Natural Resources
		Community Development Council (CDC) and MARAD
		Ministry of Indigenous Peoples' Affairs
		National Trust of Guyana
		Ministry of Communities

Project Activity	Objective/Desired Outcome	Stakeholders/ Audience
		Guyana Hindu Dharmic Sabha
		Ministry of Public Health
	One multi-agency EIA disclosure meeting	MARAD, GGMC, Ministry of Natural Resources, CDC, Ministry of Agriculture (Department of Fisheries)
	Two Public EIA disclosure meetings led by Environmental Resources Management	
Liza Phase 1 EIA Post-Permit Studies [June 2017 to May 2018]	Coordination and Planning Workshop	EPA, Protected Areas Commission, GMCS, CI, National Toshoas Council, University of Guyana
	Consultations for planning and execution of post-permit studies	EPA
		Ministry of Agriculture (Department of Fisheries)
		Various fishing associations, boat owners, and equipment suppliers
		39 coastal regional, democratic and Village Council (VC) meetings in Regions 1-4 More than 369 neighborhood and VC leaders and community members engaged
		Protected Areas Commission
		Fisherfolk throughout Regions 2-6
Liza Phase 1 Development Drilling [April 2018]		Fisheries Department, fishing associations, boat owners, fisherfolk throughout Regions 2-6
Liza Phase 2 Development EIA [January 2018 to August 2018]	One Agency Terms of Reference scoping meeting led by EPA	Multiple public and private agencies and non-governmental organizations including EPA, GGMC, Ministry of Public Health, Ministry of the Presidency, GMCS, WWF, CI, others
	Continued engagement; scoping discussions (January 2018)	24 coastal regional, democratic and VC meetings in Regions 5 and 6 More than 167 neighborhood and VC leaders and community members engaged
	Seven Public EIA scoping meetings (Regions 1-6) led by EPA (January and February 2018)	Various national, regional, and local agency representatives as well as private citizens
		14 coastal regional and VC meetings in Region 1

Project Activity	Objective/Desired Outcome	Stakeholders/ Audience
	Scoping and baseline data collection interviews (April and May 2018)	More than 167 neighborhood and VC leaders and community members engaged
		Protected Areas Commission
		GMCS
		GGMC
		Conservation International
		Ministry of Agriculture, Fisheries Department
		Fishing associations, boat owners, fisherfolk throughout Regions 2-6
		National Trust of Guyana
		WWF
	Continued engagement with Region 1 coastal communities (June 2018)	Shell Beach Protected Area residents; Protected Areas Commission Rangers.
	Eight public EIA informational meetings (Regions 1-6) led by EPA (July 2018)	Various national, regional, and local agency representatives as well as private citizens
	EIA workshop with EPA and Environmental Assessment Board (August 2018)	EPA, Environmental Assessment Board, Ramboll Consulting
All Projects [November 2018]	Ongoing engagement related to improving capacity of social infrastructure	Ministry of Tourism
Liza Phase 1 Development Drilling [January 2019]	Ongoing monitoring – stakeholder engagement	Fisheries Department, fishing associations, cooperatives, boat owners, artisanal and commercial fisherfolk throughout Regions 1-6
Liza Phase 1 EIA Post-Permit Studies Follow-up [January to July 2019]	Turtle Telemetry Capacity Building Workshop (January 2019)	Chelonian Research Institute, Protected Areas Commission, EPA, GMCS, Department of Wildlife, Fisheries Department
	GIS and coastal mapping capacity building (March 2019)	NAREI, EPA

Project Activity	Objective/Desired Outcome	Stakeholders/Audience
	Coordination on Ecosystem Services Validation Efforts in Region 1 (April 2019)	Ministry of Indigenous Affairs; National Toshaos Council; Region 1 leadership
	Region 2 validation of 2017/2018 ecosystem services data (May 2019)	60 stakeholders in 6 NDCs: Charity/Urasara; Evergreen/Paradise; Aberdeen/Zorg-en-Vlygt; Anna Regina Town Council; Annandale/Riverstown; Good Hope/Pomona
	Region 4 validation of 2017/2018 ecosystem services data (May 2019)	58 stakeholders in 9 NDCs/Town Council (TC): Georgetown; Industry/Plaisance; Better Hope/La Bonne Intention; Beterverwagting/Triumph; Mon Repos/La Reconnaissance; Buxton/Foulis; Unity/Vereeniging; Haslington/Grove; Enmore/Hope
	Region 5 validation of 2017/2018 ecosystem services data (May 2019)	74 stakeholders in 9 NDCs: Woodlands/Farm; Hamlet/Chance; Profit/Rising Sun; Mahaicony/Abary; Union/Naarstigheid; Seafield/Tempie; Bath/Woodley Park; Woodlands/Bel Air; Zeelust/Rosignol
	Region 1 validation of 2017/2018 ecosystem services data (June 2019)	175 stakeholders, National Toshaos Council Representative, GMCS representative in 13 VCs, TC: Father's Beach, Manawarin, Haimokabra/Waramuri, Santa Rosa, Assakata, Warapoka, Three Brothers, Mabaruma, Aruka Mouth, Morawhanna, Smith's Creek, Imbotero, Almond Beach
	Region 6 validation of 2017/2018 ecosystem services data (June 2019)	97 stakeholders in 15 NDCs, TCs: Ordinance/Fort Lands No. 38; Kintyre/No. 37; Gibraltar/Fyrish; Kilcoy/Hampshire; Rose Hall Town Council; Port Mourant/John; Bloomfield/Whim; Lancaster/Hogstye; Good Hope/No. 51; Macedonia/Joppa; Bushlot/Adventure; Maida/Tarlogie; No. 52/No. 74; Corriverton Town Council
	Region 3 validation of 2017/2018 ecosystem services data (July 2019)	110 stakeholders in 10 NDCs: 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
Payara Development [March 2019 – February 2020]	Five Public EIA scoping meetings (Regions 1-6) led by EPA (March 2019)	Various national, regional, and local agency representatives as well as private citizens
	Scoping and baseline data collection on fisheries through	100+ fisherfolk at 16 fisheries landing sites in Regions 1 to 6: Smith's Creek; Waramuri

Project Activity	Objective/Desired Outcome	Stakeholders/ Audience
	Participatory Fishing Study focus groups (April–July 2019)	Charity; Hampton Court; Lima; Zeeburg; Windsor Forest; LaGrange; Ogle; Riverview (Unity/Mahaica); Mahaicony; Bush Lot; Rosignol; Albion; Rose Hall; Complex 66
	Scoping and baseline data collection on fisheries through Participatory Fishing Study focus groups at cooperatives (April–July 2019)	Lima Fishing Co-op; Parika Co-op; Rosignol Co-op; #66 Co-op
	Continued engagement with Region 1 — Year 2 Turtle Telemetry Research (May 2019)	Shell Beach Protected Area residents; Protected Areas Commission Rangers; EPA; University of Guyana
	Scoping and baseline data collection key informant interviews (May and June 2019)	Bureau of Statistics
		Ministry of Agriculture
		GGMC
		Conservation International
		Ministry of Agriculture, Fisheries Department
		NAREI
		National Trust of Guyana
		WWF
		Centre for Local Business Development
		University of Guyana, Department of Engineering
		Ministry of Social Protection
		Guyana Lands and Surveys Commission
		Ministry of Business Department of Tourism
		Ministry of Communities
		Ogle Airport
		Protected Areas Commission

Project Activity	Objective/Desired Outcome	Stakeholders/Audience
	Collect baseline data on lodging and housing capacity in/around Georgetown (May to July 2019)	14 hotels and 8 real estate entities in Region 4
	EEGPL-led public informational meeting/targeted engagement with Region 3 stakeholders (July 2019)	Region 3 community leaders and members in Wakenaam and Leguan
	Participatory Fishing Study focus groups and one-on-one engagement (August 2019–ongoing)	19 volunteer fisherfolk participants plus other fishing community members at 16 fisheries landing sites in Regions 1 to 6: Smith's Creek, Waramuri, Charity, Hampton Court, Lima, Zeeburg, Windsor Forest, La Grange, Ogle, Riverview (Mahaica), Mahaicony, Bushlot, Rosignol, Albion, Rose Hall, Complex 66
	EEPGL-led Payara EIA Open House in Georgetown for the general public (September 2019)	More than 180 people from the general public, civil society, government, and academia attended the Open House.
	Six public EIA informational sessions (Regions 1-6) led by EPA (October–November 2019)	Various national, regional, and local agency representatives as well as private citizens
	Ecosystem Services Study Information provision meetings (December 2019)	61 NDCs, CDC, VCs, TCs along the coast in Regions 1 to 6 who participated in the Ecosystem Services Study baseline and validation efforts
	EIA and other government agency meetings to review EIA (January and February 2020)	Various government entities, including third party reviewers

In many cases, relevant stakeholders were also asked about other current or planned projects and activities, such as land use, agriculture, cultural heritage, private sector development, tourism developments, energy projects, or new infrastructure, which could be important for the Consultants to consider. 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.

During community-level engagements for the Ecosystem Services Study (ERM/EMC 2018) and validation field effort (ERM/EMC 2019a), the Consultants directly interviewed, engaged with, or received comments from over 700 local community leaders and residents in the six coastal regions. 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 7.5.1, Selection of VECs.

During May 2019 to July 2019, the Consultants completed the validation stage of the Liza Phase 1 Post-Permit Ecosystem Services Study data by conducting unique engagements with the same 62 coastal NDCs, Regional Democratic Councils, Town Councils, and Village Councils in Regions 1 to 6 that participated in the original Ecosystem Services Study. The purpose was to validate the data collected during the original scoping phase of the study.

7.3.5.2 Other Projects

Through a thorough review of publicly available information and interviews with EEPGL, government authorities, and proponents of other potential planned projects, the ongoing and future planned projects within the spatial and temporal boundaries of the CIA that have the potential to result in cumulative impacts on identified VECs were identified. Section 7.4.1, Other EEPGL Projects, and Section 7.4.2, Other Non-EEPGL Projects, describe these other projects.

7.3.5.3 External Drivers

Regionally present external drivers and stressors were identified through publicly available information. Section 7.4.3, External Drivers, describes these identified external drivers.

7.3.6 Description of VEC Conditions

Based on publicly available information and the data presented in the existing conditions sections of this EA&MP, the baseline conditions of the selected VECs were briefly described (see Section 7.5, VEC Selection and Description). The VEC baselines provide information on the VECs' anticipated resilience against external stressors and their potential impacts (cumulative impacts and sources of stress) and thus provide an indication of their viability and sustainability.

7.3.7 Assessment of Cumulative Impacts on VECs

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 or projects under evaluation. This step of the CIA assesses the future conditions of the VECs, considering the Project, other projects, and external drivers. If the residual impact on a VEC was rated as **Minor** or higher for at least one potential impact associated with planned Project activities or at least one risk rating of **Moderate** or higher for an unplanned event (refer to Chapter 6, Assessment of Potential Impacts and Risks, for impact significance and risk ratings) the VEC was identified as potentially eligible for the CIA.

The results of the CIA are presented in tabular format in Section 7.6, 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. 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. 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 actions are required to mitigate potential adverse cumulative impacts on the VEC.

7.3.8 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 this EA&MP 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 8). Supplementing these controls and management measures, the CIA provides recommendations for EEGPL to apply in the context of the Project (as well as in its other projects) to manage potential cumulative impacts on these VECs.

7.4 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-1 discovery, EEPGL has made several additional discoveries since 2016, an environmental authorization process for the Payara Development Project is currently underway (EPA and other government agency meetings to review the EIA were undertaken in January and February 2020), and an application to initiate the environmental authorization process for the Hammerhead Development Project has just been submitted. Based on publicly available information, Repsol, Tullow, and CGX may potentially be planning to conduct future exploration in the Kanuku, Orinduik, and Corentyne blocks, respectively. No additional details are available at the time of writing this EA&MP, and ERM has not made assumptions about the nature or timing of future exploration or development by these other companies. In any case, other than for periodic vessel transit across the Stabroek Block, such operations would take place outside of the Stabroek Block.[33]

Other (non-Project) activities that have been identified as potentially relevant with respect to the potential for their impacts to interact with Project impacts on a given VEC are described below, organized as Other

[33] 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.

EEPGL projects (Section 7.4.1) and Other non-EEPGL projects (Section 7.4.2).

7.4.1 Other EEPGL Projects

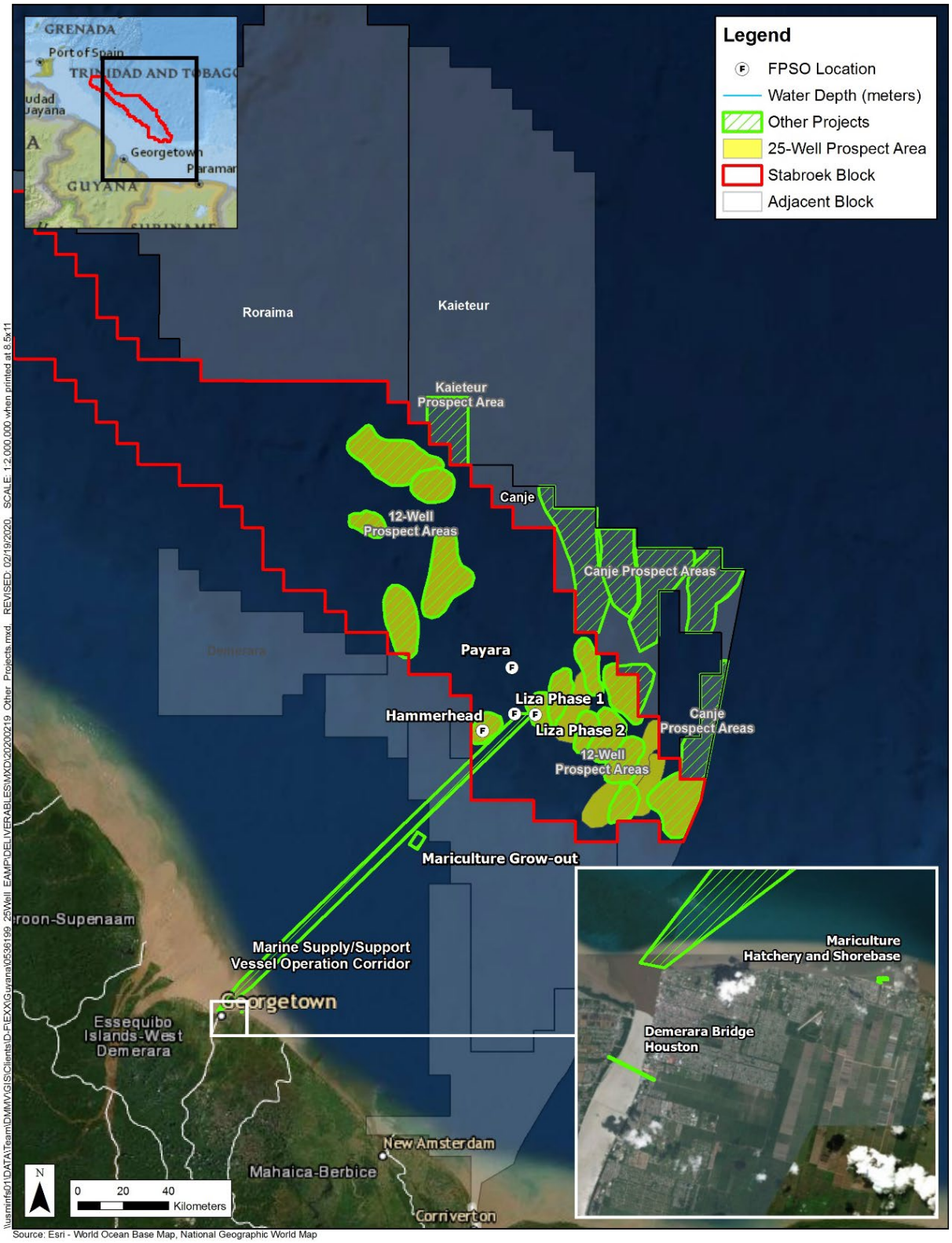
After consulting with EEPGL, ERM identified the following Other EEPGL Projects to be considered for the CIA: (1) Liza Phase 1 Development Project; (2) Liza Phase 2 Development Project; (3) Payara Development Project; (4) Hammerhead Development Project; (5) (Other) Exploration Activities in the Stabroek Block; (6) Exploration Activities in the Canje Block; and (7) Exploration Activities in the Kaieteur Block. Summaries of these projects are presented below. Figure 7.4-1 shows the location of the Liza Phase 1 Floating Production, Storage, and Offloading vessel (FPSO), the planned locations of the Liza Phase 2 FPSO, the Payara FPSO, and the Hammerhead FPSO, and the potential target areas (referred to as "prospect areas") for other exploration activities in the Stabroek, Canje, and Kaieteur blocks.

7.4.1.1 Liza Phase 1 and Liza Phase 2 Development Project

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 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 Project Development Area (PDA), where the drilling and production operations activities will collectively occur, is a 50 km^2 (19.3 mi^2) area 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.

Figure 7.4-1: Conceptual Locations of Other Projects



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 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 was completed and production operations began in the fourth quarter of 2019.

The distance from the Liza Phase 1 FPSO location to the nearest Project well location is approximately 20.8 kilometers. The distance from the Liza Phase 2 FPSO location to the nearest Project well location is approximately 12.4 kilometers.

Potential Impacts

The Liza Phase 1 and Liza Phase 2 Project EIAs assessed potential environmental and socioeconomic impacts of the Project resulting from planned activities and potential unplanned events (specifically an oil spill), as well as (based on best available information at the time) the Liza Phase 1 Project's and Liza Phase 2 Project's contributions to cumulative impacts on resources and receptors.

The Liza Phase 1 and Liza Phase 2 Projects are not expected to disturb natural onshore habitats. 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. The only resources with the potential to incur any meaningful adverse impacts from planned Liza Phase 1 and Liza Phase 2 Project activities would be offshore air quality and marine-oriented resources (i.e., marine sediments, marine water quality, and biological resources such as fish, mammals, and turtles). The Liza Phase 1 and Liza Phase 2 projects 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.

There would be a minor (approximately 0.3 km^2 for Liza Phase 1 and 0.8 km^2 for Liza Phase 2) permanent loss of benthic habitat 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 re-colonization of the impacted areas.

7.4.1.2 Payara Development Project

Project Summary

The Payara Development Project (Payara) has been proposed to develop the offshore resource by drilling approximately 45 subsea development wells and using an FPSO to process, store, and offload the recovered oil. The FPSO will be connected to the wells via associated 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 Payara PDA, where the drilling and production operations activities will collectively occur, is an approximately 80 km^2 area located approximately 207 kilometers offshore. The Payara Project will 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 the Payara Project across project stages. 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, flights may increase at peak to a total of approximately 45 to 55 round-trip helicopter 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 production operations and continued development-drilling activities.

Based on current drilling activities and past experience with similar developments, it is estimated that during development drilling and FPSO/SURF installation for Payara, total vessel round trips per week will average 12 to 15 round-trips to the Stabroek Block. During FPSO/SURF production operations, it is estimated that this number will be reduced to approximately 5 to 10 round-trips per week.

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 Project

During the Project, it is anticipated that a minimum of one drill ship (and likely two) will be working in the Stabroek Block to drill the Payara development wells; pending receipt of environmental authorization, drilling is expected to occur from late 2020 through 2025. Installation is expected to start in early 2021 and extend into early 2023, with initiation of the production operations phase in 2023. The distance from the proposed Payara FPSO location to the nearest well is approximately 23.8 kilometers.

Potential Impacts

Based on the EIA (ERM et al 2019) completed for the Payara Development Project (under EPA review as of the time of writing), the same types of potential environmental and socioeconomic impacts associated with the Liza Phase 1 and the Liza Phase 2 projects are generally relevant for Payara.

7.4.1.3 Hammerhead Development Project

Project Summary

The Hammerhead Development Project (Hammerhead) has been proposed to develop the offshore resource by drilling approximately 26 to 30 subsea development wells and using an FPSO to process, store, and offload the recovered oil. The FPSO will be connected to the wells via associated 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 Hammerhead PDA, where the drilling and production operations activities will collectively occur, is located approximately 160 kilometers offshore. The Hammerhead Project will 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 the Hammerhead Project across project stages. Logistical support will be optimized and shared among Liza Phase 1, Liza Phase 2, Payara, and Hammerhead.

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 Project

The estimated timeline for the Hammerhead Development Project shows development well drilling initiating in the first quarter of 2022, SURF installation starting during the first or second quarter of 2023 (assuming

an environmental authorization is issued) and continuing through late-2023, and production starting in the third quarter of 2024. The distance from the proposed Hammerhead FPSO location to the nearest Project well is approximately 35.9 kilometers.

Potential Impacts

While an EIA has not yet been conducted for Hammerhead, the same types of potential environmental and socioeconomic impacts associated with the Liza Phase 1, Liza Phase 2, and Payara projects will be generally relevant for Hammerhead.

7.4.1.4 Stabroek Multiwell Exploration Campaign

Project Summary

The Stabroek Multiwell Exploration Campaign (Stabroek Multiwell Campaign) has been permitted as an extension of EEPGL's previously approved exploration drilling campaign in the Stabroek Block, and includes up to an additional 12 wells. This campaign is underway as of the writing of this document, with the final locations for some wells still in the planning stages.

The Stabroek Block, with an area of approximately 2.7 million hectares, is the largest of eight petroleum exploration blocks currently awarded offshore Guyana. While the exact locations of the 12 additional wells comprising the Stabroek Multiwell Campaign have not yet been finalized, EEPGL has defined an Exploration Drilling Area within the eastern portion of the Stabroek Block. The Exploration Drilling Area encompasses approximately 3,925 km^2 and accounts for slightly less than 15 percent of the total area of the Stabroek Block. Within the Exploration Drilling Area, EEPGL has identified a number of prospect areas. These prospect areas are the areas within which the 12 additional wells may be drilled for exploration purposes. It is also possible that some of the 12 additional wells may be drilled as appraisal wells within the proximity of previously drilled exploration areas.

The process of drilling these wells will be very similar to the process followed during prior exploration drilling campaigns and may include one or more sidetracks, well tests, or VSP. The wells will be drilled consecutively in a yet-to-be-determined order, with time in between each well for any ancillary activities and mobilization between well sites. The specific features and activities for each well are still being finalized and will be provided to the EPA in advance of spudding.

EEPGL will use the existing Guyana shorebases located on the east side of the Demerara River as the primary shorebases supporting the Stabroek Multiwell Campaign. 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 Stabroek Multiwell Campaign. 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.

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 shorebases; 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 utilized.

Emergency preparedness and oil spill response supplies will be staged at the shorebases as needed along with those to be maintained on the drill ships, response vessels, and support vessels. Additional pipe yards or further offsite storage/warehousing facilities may be necessary depending on holding times for long lead items, and space restrictions or security considerations for select goods and materials needed in advance of drilling.

The same or similar support vessels that are being used to support current exploration and development drilling activities in the Stabroek Block will be used to support the drilling of the Project exploration wells.

In terms of aviation assets, additional aircraft are not anticipated to be required to support the Stabroek Multiwell Campaign; however, an additional crew of pilots will likely be added to afford the ability to fly simultaneous crew change flights. Therefore, although the total number of helicopters will not increase, the total number of flight hours will increase.

Project Schedule and Distance from the Project

Drilling in the prospect areas for the 12 additional wells in the Stabroek Multiwell Campaign has begun and will continue into late 2020 or early 2021. The drilling will be conducted simultaneously with the current exploration drilling of the final wells covered under the prior 25 July 2018 authorization for Stabroek Block exploration drilling, as well as the Liza Phase 1 Project development well drilling program and the Liza Phase 2 Project development well drilling program. Factors that can influence this notional schedule include new discoveries, determination of the need for sidetracks, and/or well tests that would extend the drilling period for such exploration wells as well as influence the location and sequence of subsequent wells.

The smallest distance between a completed or potential Stabroek Multiwell Exploration Campaign well location is approximately 6.4 kilometers.

Potential Impacts

ERM conducted a detailed identification, evaluation, and analysis of the expected impacts associated with the Stabroek Multiwell Project. This effort concluded that the significance for most of the potential impacts assessed for the project is **Negligible**, with some instances of **Minor** or **Moderate** significance ratings.

7.4.1.5 Kaieteur 1-Well Exploration Drilling Campaign

Project Summary

EEPGL has applied to the EPA for authorization to drill one exploration/appraisal well in the Kaieteur Block using a dynamically positioned drill ship. The design and final location of the well is still in the planning stages; however, it is currently anticipated that the Kaieteur exploration well will be drilled in the southwestern part of the Kaieteur Block in an area referred to as Prospect Area 1.

The Kaieteur Block comprises an area of approximately 1.3 million hectares. Prospect Area 1 encompasses approximately 432.8 km^2, and accounts for 3.2 percent of the total area of the Kaieteur Block.

The process of drilling the well will be very similar to the process followed during prior EEPGL exploration drilling campaigns and will include mobilization, drilling, potential ancillary processes (possibly including sidetracks, well tests, and/or VSP), and demobilization. The specific features and activities for the well are still being finalized and will be provided to the EPA in advance of spudding.

Existing shorebase activities are sufficient to support the drilling campaign and will be consistent with the activities associated with prior exploration and development drilling operations to date. Specifically, 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 supporting the Project. All onshore support 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 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 has not been included herein.

Emergency preparedness and oil spill response supplies will be staged at the shorebases as needed along with those to be maintained on the drill ships, response vessels, and support vessels. Additional pipe yards or further offsite storage/warehousing facilities may be necessary depending on holding times for long-lead items, and space restrictions or security considerations for select goods and materials needed in advance of drilling.

The same or similar support vessels that are being used to support current exploration and development drilling activities in the Stabroek Block will be used to support the drilling of the Kaieteur 1-Well Exploration Drilling Campaign, taking into consideration that support vessels will be shared across other operations in the Stabroek and Canje blocks.

In terms of aviation assets, currently six helicopters support the concurrent operation of four drill ships and of installation of the Liza Phase 2 Development Project SURF components. A seventh helicopter is anticipated to be added to the fleet in 2020, ahead of a fifth drill ship. Additional crews also have been added in order to have the ability to fly simultaneous crew change flights.

Project Schedule and Distance from the Project

It is anticipated that drilling the exploration/appraisal well in the Kaieteur Block will, pending receipt of authorization, occur in 2020. The drilling will be conducted simultaneously with the Stabroek Multiwell Exploration Campaign, as well as the Liza Phase 1 Project development well drilling program, and the Liza Phase 2 Project development well drilling program. Pending EPA's approval, drilling in the Kaieteur Block could possibly overlap with development-well drilling for the Payara Development Project, exploration/appraisal drilling in the Canje Block, and drilling of Project wells. Factors that can influence this notional schedule include new discoveries, determination of the need for sidetracks, and/or well tests that would extend the drilling period for the exploration well.

The shortest distance between a potential Project well location and the edge of Kaieteur Prospect Area 1 is approximately 10.7 kilometers.

Potential Impacts

As part of the pending authorization process, an assessment of the potential impacts of the Kaieteur 1-Well Exploration Drilling Campaign is underway. However, the impacts from the Kaieteur 1-Well Exploration Drilling Campaign are expected to be similar to those of other exploration well activities previously assessed.

7.4.1.6 *Canje 3-Well Exploration Campaign*

Project Summary

EEPGL is currently planning exploration activities in the Canje Block. Pending receipt of authorization, the exploration campaign will consist of up to three wells, the locations of which have not been identified. In terms of drilling procedures and nature of proposed activities, this exploration campaign will be very similar to the proposed Project described in this EA&MP.

Project Schedule and Distance from the Project

Pending receipt of authorization, the Canje exploration campaign is assumed for the purpose of this CIA to begin in 2020 and to be completed in 2021. The Canje Block is adjacent to the Stabroek Block to the southeast. Well locations have not been defined for the campaign, but because Canje Prospect Area 1 extends to the edge of the Canje Block, it is assumed that a Canje exploration well may be completed near the border of the block. The smallest distance between a potential Project well location and the edge of the Canje Block is approximately 3.3 kilometers.

Potential Impacts

Considering the similarity between the proposed Canje campaign and those of prior exploration campaigns, the impacts associated with the Canje campaign are expected to be similar.

7.4.2 *Other Non-EEPGL Projects*

7.4.2.1 *Non-EEPGL Oil and Gas Exploration*

Based on publicly available information, three other companies may potentially be planning to conduct future exploration activities in the area: (1) Repsol in the Kanuku Block; (2) Tullow in the Orinduik Block; and (3) CGX in the Corentyne Block. No additional details regarding the specific scope or timing of their proposed future exploration (or development) activities are available at the time of writing this EA&MP. ERM has therefore not made assumptions about the nature or timing of future exploration or development by these companies; accordingly, potential cumulative impact contributions from these activities are addressed at a high level.

7.4.2.2 *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 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.

At the time of this CIA, it is unclear when or if the replacement bridge project will proceed. However, it is being included in the CIA as a reasonably foreseeable project.

Project Schedule and Distance from Project

The new bridge is proposed to be located in close proximity to the shorebases that EEPGL is planning to use to support the Project. However, based on the current state of planning for the bridge replacement project it is assumed that this other project will not coincide with the Project.

Potential Impacts

The proposed Houston–Versailles bridge location was found by the feasibility study author to be the alternative with the least urban and environmental impacts. However, the author concluded there are some potential impacts that would need to be mitigated by others, such as resettlement of houses, potential impacts on the Muneshwers terminal, and potential impacts on the PSI Fishing terminal adjacent to the bridge.

In addition, the author identified potential impacts on the west bank of the Demerara River, including damage or modification to mangroves, the current drainage channel, and a timber company. Other potential impacts identified in the feasibility report for the relocation project are impacts on the harbor and on river navigation. Procedures for river navigation would

have to be reconsidered and new lead lines developed. The study concludes that all these potential impacts and challenges are manageable.

To evaluate traffic-related impacts, the feasibility study predicted traffic growth and the results were used to assess impacts 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.

Potential biodiversity impacts from construction of the new bridge are anticipated by the feasibility study author to include impacts on mangroves on both banks of the Demerara River. According to the study, mangroves on the east bank are already impacted by anthropogenic activities, and the mangrove fringe on the east bank is also characterized as being considerably smaller than the mangrove fringe on the west bank. The study suggests technical solutions could be proposed to ensure low impact on biodiversity.

The feasibility study concludes that the overall social impact of the bridge replacement project would be positive, especially if links and bypasses are constructed simultaneously with bridge construction. Shorter traffic time and economic development would benefit the communities. Nevertheless, the study also points out that some residents may suffer impacts from noise emissions and air quality emissions during construction, and by being exposed to heightened road safety risk (these impacts would be expected to be worse during construction). In addition, the proposed Houston–Versailles location would require resettlement of a number of households adjacent to the selected alignment.

7.4.2.3 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 in size, approximately 109 kilometers from an area north of Devonshire Castle, and approximately 160 kilometers from an area north of the boundary between Administrative Regions 1 and 2. Figure 7.4-1 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 following species would be grown: southern red snapper (*Lutjanus purpureus*); Atlantic grouper (*Epinephelus itajara*); cobia (*Rachycentron canadum*); grey snapper (*Cynoscion acoupa*); and gillbacker (*Sciades parkeri*). The summary document briefly describes the mariculture operation. 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 m^3. The broodstock would then be induced using environmental manipulation, so as to facilitate spawning. This would involve manipulation of photoperiod, water quality, and nutrition. 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.

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 m^3 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 GYD ($15 million USD). Production capacity is projected to be 100,000 pounds of fish per month.

Project Schedule and Distance from the 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, the onshore components of the mariculture project would be located approximately 10 kilometers southeast of the mouth of the Demerara River. The offshore component (growout area) would be located somewhere within a 24 km^2 area, with its closest boundary approximately 185 kilometers from the nearest potential Project well location.

Potential Impacts

The project summary report includes a list of potential environmental effects for the proposed project, and their corresponding mitigation measures, as follows:

- 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, which could 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 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.
- 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 8 to 12 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 sewerage, which represents a potential source of pollution.

7.4.3 External Drivers

7.4.3.1 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.

7.4.3.2 *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 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, of the Liza Phase 2 Development EIA), 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 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., Cadel line) to target shrimp and a mix of fish species, at depths of 0 to 28 meters.
- 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 (ERM/EMC 2019b) 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 1; ERM Personal Communication 6). The fishing industry is one of the most important direct and indirect economic drivers in Guyana. However, relatively 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 2018a).

7.5 VEC SELECTION AND DESCRIPTION

7.5.1 Selection of VECs

All the resources evaluated in the EA&MP were considered for CIA eligibility 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 impact significance rating of **Minor** or above for a planned Project activity or at least one 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 7.5-1 summarizes whether the resources were considered potentially eligible VECs for the CIA based on the degree to which they are potentially significantly impacted by the Project (i.e., at least one potential impact significance rating of **Minor** or

above for a planned Project activity or at least one risk rating of **Moderate** or above for an unplanned event).

Unplanned events assessed for the purpose of selection of VECs for the cumulative impact assessment do not include oil spills because there is no credible scenario in which two loss-of-well-control events would happen simultaneously. In the event of a loss-of-well-control event occurred at a 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.

For each of the resources identified in Table 7.5-1 as being potential eligible VECs for the CIA, Table 7.5-2 assesses the degree to which the resource could be affected by one or more other projects or external drivers.

Table 7.5-1: Consideration of Resources for Cumulative Impact Assessment

Resource	Planned Activity Impact Significance Rating	Unplanned Event Risk Rating [a]	Potentially Eligible for Cumulative Impact Assessment
Marine Water Quality	Minor	Moderate (marine oil spill) Minor (coastal oil spill, NADF release)	Yes
Coastal and Marine Geology and Stratigraphy	Negligible	Minor (coastal oil spill, NADF release)	No
Air Quality and Climate	Negligible	Minor (marine and coastal oil spill)	No [b]
Bathymetry	Negligible	Negligible (marine oil spill)	No
Natural Hazards	Negligible	Negligible (marine and coastal oil spill)	No
Coastal Habitats	None	Minor (marine and coastal oil spill)	No
Fishery Resources	Negligible to Minor	Minor (marine and coastal oil spill, NADF release)	Yes
Seabirds	Negligible	Minor (vessel or helicopter strike, marine oil spill)	No
Benthic Resources	Negligible to Minor [c]	Minor (marine oil spill, NADF release)	No [c]
Marine Turtles	Negligible	Moderate (vessel strike) Moderate (marine oil spill)	Yes
Marine Mammals	Negligible to Moderate	Moderate (vessel strike) Minor (marine oil spill) Minor (coastal oil spill)	Yes

Resource	Planned Activity Impact Significance Rating	Unplanned Event Risk Rating [a]	Potentially Eligible for Cumulative Impact Assessment
Special Status Species	Negligible to Minor	Minor to Moderate [d] (marine oil spill Minor (coastal oil spill) Minor (vessel or helicopter strike)	Yes
Protected Areas	None	Minor (marine oil spill)	No
Coastal Demographics	Negligible	Minor (marine and coastal oil spill)	No
Employment and Livelihoods	Negligible to Minor [e]	Minor (marine and coastal oil spill)	No
Cultural and Archaeological Resources	Negligible	Minor (NADF release)	No
Marine Transportation	Negligible to Minor	Minor (marine and coastal oil spill) Minor (vessel collision)	Yes
Land Transportation	Negligible	Minor (vehicular accident)	No
Tourism and Recreation	Negligible	Minor (marine and coastal oil spill)	No

[a] Oil spills are not included in the eligibility for the Project CIA, and all ratings are based on embedded controls.
[b] Although not considered eligible for the Project CIA, cumulative air quality dispersion modeling was conducted, as discussed below.
[c] Minor significance rating is precautionary, and relates only to the potential presence of deepwater corals (this has not yet been confirmed for the potential exploration well locations, so this resource is not screened into the CIA).
[d] Moderate significance rating relates only to Leach's Storm Petrel
[e] Potential impacts associated with the Minor significance rating are discussed as part of the marine transportation resource.

Table 7.5-2: Selected VECs for Inclusion in CIA

VEC	Valued by Stakeholders	Potentially Affected by the Project [a]	Potentially Affected by One or More Other Projects	Potentially Affected by One or More External Drivers
Special Status Species	Yes	Yes	Yes	Yes
Marine Mammals	Yes	Yes	Yes	Yes
Marine Turtles	Yes	Yes	Yes	Yes
Fishery Resources	Yes	Yes	Yes	Yes
Marine Transportation	Yes	Yes	Yes	Yes
Marine Water Quality	Yes	Yes	Yes	Yes

[a] At least one potential impact significance rating of **Minor** or above for a planned Project activity or at least one risk rating of **Moderate** for a (non-oil spill) unplanned event.

7.5.1.1 Air Quality

Air quality and climate were not determined to be an eligible VEC for the CIA because the Project´s potential impact on these resources was determined to be of **Negligible** significance. However, cumulative air dispersion modeling was carried out to assess potential cumulative air quality impacts for onshore human receptors.

Total emissions from Other EEPGL Projects described above, combined with those of the Project, were assessed for their cumulative impact on onshore air quality, and thus were included in the modeling. Cumulative impacts on air quality from Other non-EEPGL projects (such as the Demerara Harbour Bridge Replacement Project) are not expected because these projects are believed unlikely to proceed while the Project is being executed.

Additional potential exploration well drilling activities by Tullow, Repsol, and CGX were not modeled explicitly (as the nature and timing of these activities are not known), but were evaluated in comparison to emissions included in the explicit modeling analysis.

This comparison concluded that the added impacts from these non-EEPGL activities would, like the impacts from other EEPGL activities, be negligible with respect to resulting ground-level concentrations at potential onshore receptors. Further details regarding this additional evaluation can be found in Appendix E.

The methodology for cumulative assessment involved conducting air quality modeling of the emissions associated with exploration well drilling (i.e., diesel engines that power the drilling, flaring, incineration, supply vessels and helicopter flights). Modeling was conducted representing drilling at each of the 25 potential Project well locations, and the maximum concentrations at each potential onshore receptor location were predicted for all pollutants and averaging times. The predicted maximum concentrations were then added to the modeled concentrations resulting from emissions from the Liza Phase 1, Liza Phase 2, and Payara Development Projects, and from exploration drilling in the Stabroek, Kaieteur, and Canje blocks at each receptor for each year, by selecting the 25 potential Project-well-specific values and scaling results upward to reflect three drill ships supporting the Project (2021) or four drill ships supporting the Project (2022) operating continuously.

This conservative approach predicted that the highest percentage of a World Health Organization ambient air quality guideline for an onshore concentration was 3.6 percent (for NO_2). These results confirm that the cumulative impacts from the Project and the Other EEPGL Projects considered will not significantly affect onshore air quality.

7.5.1.2 Waste Management

Although waste management was not included as a specific resource/ receptor or VEC on which impacts were assessed in the EA&MP, this section provides a discussion of the existing waste management infrastructure and its sufficiency to handle the Project's waste management needs together with other EEPGL waste management needs.

The Haags Bosch landfill is currently operating a single landfill "cell," and in mid-2019, the landfill operator had estimated that the capacity of this cell was to be exhausted by the end of 2019. However, this has not been found to be the case, as solid and municipal waste continues to be managed into 2020. Construction of a second cell within the existing landfill footprint was planned and is being executed by the Ministry of Communities. The expansion of the Haags Bosch landfill has continued to progress with the construction of an 800,000 m^3 Cell 2 in three phases. As of the writing of this EA&MP, the first phase is 75 percent complete with an expected life of 7 to 9 years. It is understood that there is a further plan for two additional cells.

With respect to hazardous waste management infrastructure capacity, in May 2019, EEPGL conducted a capacity review of the hazardous waste treatment facility that is supporting its offshore operations, 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.

Subsequent expansion of independent third-party commercial waste handling, storage, and treatment facilities for hazardous waste in Georgetown have included the acquisition of a total of 6,400 m^2 of property to enable the addition of a pug mill (for waste stabilization), an additional vertical infrared thermal unit, and a wash bay with pre-/post-treated water storage (for waste treatment). Construction is continuing in 2020 to add a further 2,000-barrel treated water storage tank, additional vertical infrared thermal unit capacity, a pug mill, and storage for post-treatment solids.

In addition, EEPGL issued a Request for Information followed by the issuance of an Invitation to Tender to provide additional third-party commercial waste management facilities and services in Guyana, with the award planned for the first quarter of 2020. These may include a thermal desorption unit, incinerators, wastewater treatment plant, waste skips, containers, and trucks, among others.

Based on the progress of landfill cell construction and the hazardous waste treatment capacity expansion efforts described above, EEPGL has concluded that the Project's local non-hazardous solid waste management needs and hazardous waste management needs (as well as those of EEPGL's other waste management needs) can be met.

7.6 ASSESSMENT OF CUMULATIVE IMPACTS ON VECS

For the CIA, the potential impacts from the Other EEPGL Projects (Liza Phase 1, Liza Phase 2, Payara, Hammerhead, and other exploration drilling) being planned or contemplated by EEPGL are discussed together, and are assumed to be similar to those associated with those of the Project (for the planned activities and unplanned events common between these projects and the Project). The potential impacts from Other Non-EEPGL Projects are discussed separately.

7.6.1 Quantitative Analyses Informing CIA

In addition to the air quality modeling (see Section 7.5.1.1, Air Quality), quantitative analyses of cumulative impacts were also conducted for potential water quality impacts resulting from simultaneous drilling at multiple locations (i.e., across the potential Project well locations, as well as across Liza Phase 1, Liza Phase 2, Payara, Hammerhead, and other EEPGL exploration drilling locations).

7.6.1.1 Modeling of Total Suspended Solids Concentrations

Project drilling activities were modeled to evaluate the potential for TSS plumes from drill cutting discharges from the Project and other non-Project EEPGL drilling to overlap. Detailed results of this modeling exercise are provided in Appendix C.

As described in Appendix C, the evaluation indicates that there is theoretically a potential for TSS plumes from drilling of a Project well and drilling of another well, based solely on comparison of the maximum extent of a TSS plume and the minimum distance between a potential Project well location and another well location. However, this would only occur if the wells are actually drilled this close to one another, and only in situations where the two wells were being drilled at the same time. It is also noted that beyond the first few kilometers from a well, the TSS plumes are extremely spotty and fragmented. For any overlap to occur spatially, the individual patches of higher TSS would need to occur at the same exact location, and at the same time, which is also unlikely. Note also that at any given time, the currents will move the TSS plumes in the same direction for all wells (if drilled at the same time). For instance, an easterly current will move the patches of high TSS concentrations to the

east, in the same manner for both wells, not in opposite directions (which would be necessary to facilitate overlapping of the plumes). This means that the separation distance between the plumes will to a large extent be maintained at the separation distances of the wells themselves, further reducing the potential for overlap. Furthermore, as discussed above, the short-term existence of the elevated TSS plumes further reduces the possibility of overlap occurring, as the individual spots of high TSS would need to occur within the same timeframe (i.e., within the same few days as seen from temporal plots). Beyond these limited timeframes, suspended solids would continue to disperse and settle, thus reducing the potential for any cumulative impact.

7.6.1.2 Modeling of Drill Cuttings Deposition

Project drilling activities were modeled to evaluate the potential for cuttings deposition mounds from drill cutting discharges from the Project and other non-Project EEPGL drilling to overlap. Detailed results of this modeling exercise are provided in Appendix C.

As described in Appendix C, the evaluation concluded that the maximum widths of these mounds is far smaller than the closest distances between a potential Project well location and another well location, indicating that it is highly unlikely for any overlap to occur.

7.6.2 VEC-Specific Cumulative Impact Discussions

This section discusses the following potential impacts for each VEC identified as eligible for the CIA:

- Potential impacts from the Project
- Potential impacts from Other EEPGL Projects:
  - Liza Phase 1 Development Project
  - Liza Phase 2 Development Project
  - Payara Development Project
  - Hammerhead Development Project
  - Stabroek Block Exploration Drilling (ongoing 12-well campaign)
  - Canje Block Exploration Drilling (proposed 3-well campaign)
  - Kaieteur Block Exploration Drilling (proposed 1-well campaign)
- Potential impacts from Other Non-EEPGL Projects
- Potential impacts from external drivers
- Description of potential cumulative impacts
- Cumulative impact priority rating
- Other EEPGL activities

As discussed above, the CIA considers potential impacts and risks from the planned activities and unplanned events (aside from oil spills) assessed for the Project in prior sections.

7.6.2.1 Special Status Species

Potential Impacts from the Project

Based on the ranges of magnitudes for potential Project impacts and the receptor sensitivity ratings applicable for the various IUCN listing levels, the significance ratings for potential residual impacts on special status species range from **Negligible** to **Minor**. Untreated wastewater discharges, vessel strikes, and helicopter strikes (all potential unplanned events) are assessed as **Minor** risks to special status species.

Potential Impacts from Other EEPGL Projects

Due to the similarity between activities of the Project that could impact special status species and activities of Other EEPGL Projects that could impact special status species, similar levels of impacts and risks to those of the Project are expected (i.e. **Negligible** to **Minor** impacts; **Minor** risks**)**.

Potential Impacts from Other Non-EEPGL Projects

New Demerara Harbour Bridge - Based on the information available, ERM does not foresee impacts from the New Demerara Harbour Bridge Project on this VEC, or they would be considered **Negligible**.

Caribbean Mariculture Project - Based on the information available, ERM foresees the potential for impacts from the Mariculture Project on special status marine fish. This is in consideration of a potential impact related to the predation of fingerlings of various species of wild fish, as they can enter the cages, which will be used as growing structures. 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 Oil and Gas Exploration Projects (Repsol, Tullow, and CGX) - Although exploration activities by other operators will have the potential to affect special status species in much the same way as the Project, there should be no significant spatial overlap between these effects (and possibly no temporal overlap). Given that all reasonably foreseeable exploration activities by other operators will occur in different blocks and given the distance between likely exploration areas, it is unlikely that the same individuals would be impacted by more than one exploration campaign. These impacts are therefore considered **Negligible**.

Potential Impacts from External Drivers

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. Rising temperatures associated with longer-term global climate change could potentially affect some special status species' ranges.

Description of Potential Cumulative Impacts

Of the 74 special status species known or expected to occur in the Project area, 38 are strictly coastal or inland species. Therefore, they would not be impacted by planned Project activities; they would only potentially be affected by an unplanned event.

Planned Project activities could result in a number of potential impacts on these receptors, 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, or human activity; and the potential attraction to lighting from the drill ships. The number of non-coastal special status species potentially affected by planned Project activities includes 4 marine turtles, 1 marine mammal, 24 marine fish, and 4 seabirds.

The Project, in combination with other projects, could have potential negative impacts on special status marine fish and seabird species. However, the Project's embedded controls would mitigate Project impacts to an acceptable level (i.e., **Negligible** to **Minor**). External drivers such as commercial trawl fishing and global climate change could also potentially negatively affect this VEC. However, it is not expected that the Project in combination with other projects or external drivers would have an incremental contribution to the negative effects.

Priority Ranking

Based on the assessment discussed above, a cumulative impact priority rating of **Low** is assigned for special status species.

7.6.2.2 Marine Mammals

Potential Impacts from the Project

The Project is likely near or southward of the southern boundary of the primary habitat for whales offshore Guyana. These findings also suggest that dolphins may be present throughout the Project area and at all times

of the year; however, they are likely to be more abundant in the Project area in the autumn and winter months.

Shorebase facilities where Project-related vessel traffic and onshore infrastructure operations will occur are located in potential habitat for five other aquatic mammals that live in inland and coastal riverine and wetland environments, as well as nearshore marine environments in Guyana. These species include the West Indian manatee, giant otter, neotropical otter, Amazon river dolphin (also locally referred to as boto; *Inia geoffrensis*), and gray river dolphin.

During drilling, the key potential impacts from the Project are:

- Acoustic injury from underwater sound exposure - **Negligible**;
- Disturbance from underwater sound exposure, potentially leading to deviation from the area - **Moderate**;
- Attraction of fish (marine mammal food sources) to artificial light from the drill ships – **Positive**; and
- Exposure to permitted discharges from the drill ships – **Negligible**.

Vessel strikes (an unplanned event) are also assessed as a **Moderate** risk to marine mammals.

Potential Impacts from Other EEPGL Projects

Due to the similarity between activities of the Project that could impact marine mammals and activities of Other EEPGL Projects that could impact marine mammals, similar levels of impacts and risks to those of the Project are expected.

Potential Impacts from Other Non-EEPGL Projects

New Demerara Harbour Bridge - Based on the information available, ERM estimates that the West Indian manatee (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.

Caribbean Mariculture Project - Based on the information available, ERM does not foresee impacts from the Mariculture Project on this VEC, or they would be considered **Negligible**.

Other Oil and Gas Exploration Projects (Repsol, Tullow, and CGX) - Although exploration activities by other operators will have the potential to affect marine mammals in much the same way as the Project, there will be no spatial overlap (and possibly no temporal overlap) between these effects.

Potential Impacts from External Drivers

Rising temperatures (including sea temperatures) associated with global climate change could potentially affect some fish species distribution and, in consequence, alter the distribution of marine mammals that prey on them.

Description of Cumulative Impacts

Marine mammals visually observed during EEPGL activities from 2015 to 2019 include Bryde's whale, sperm whale, melon-headed whale, short-finned pilot whale, pygmy killer whale, Atlantic spotted dolphin, common bottlenose dolphin, short-beaked common dolphin, long-beaked common dolphin, Fraser's dolphin, pantropical spotted dolphin, Risso's dolphin, rough-toothed dolphin, spinner dolphin, and clymene dolphin.

The only marine mammals reasonably likely to be encountered on the continental shelf are dolphins, which are agile by comparison and much more likely to avoid a vessel strike than the larger whales. Although they have not been documented conclusively within the Project area, some of the largest marine mammals in the world (e.g., blue whale and sei whale) could occur in the Project area, and are listed as EN by the IUCN. The loss of even a few mature breeding individuals to vessel strikes over the course of the Project life cycle would be significant from a conservation perspective. However, most marine mammals known to occur in the Project area, including the short-finned pilot whale, short-beaked common dolphin, and Risso's dolphin are listed as LC by the IUCN.

During drilling, the key potential impacts are acoustic injury from underwater sound exposure (**Negligible**) and disturbance from underwater sound exposure, potentially leading to deviation from the area (**Moderate**). The activities associated with the highest potential for sound disturbance impacts are short-term drilling phase activities (i.e., VSP, if conducted), which are unlikely to overlap temporally among EEPGL wells.

A potential impact comes from offshore lighting; it is considered a **Positive** impact as it is an attractant for fishes, and therefore has the potential to concentrate food sources for some marine mammals, as well as the lack of documented adverse effects on marine mammals from artificial lighting.

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.

Given that all reasonably foreseeable exploration activities by other operators will occur in different blocks and given the distance between likely exploration areas, it is unlikely that the same individuals would be impacted by more than one exploration campaign. However, the other projects will involve support vessel movements to and from the drilling areas, which will contribute to additional risk of vessel strikes.

Balancing the conservation status of the more abundant marine mammal species known to be present in the Project 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 risk is relevant to the Project as well as Other EEPGL Projects, which will entail marine vessel movements within the Stabroek and/or adjacent Canje and Kaieteur blocks (as well as possibly non-EEPGL oil-and-gas-related vessel movements); therefore, the Project in combination with other projects could incrementally contribute to adverse cumulative impacts from potential vessel strikes.

Priority Ranking

Based on the assessment discussed above, a cumulative impact priority rating of **Medium** is assigned for marine mammals.

7.6.2.3 Marine Turtles

Potential Impacts from the Project

The key potential Project impacts on marine turtles are:

- Disturbance from artificial lighting from the drill ships - **Negligible**;
- Displacement from habitat or foraging/migration pathways as a result of disturbance from support vessel activity - **Negligible**;
- Acoustic injury from underwater sound exposure - **Negligible**; and
- Exposure to permitted discharges - **Negligible**.

Potential Impacts from Other EEPGL Projects

Due to the similarity between activities of the Project that could impact marine turtles and activities of Other EEPGL Projects that could impact marine turtles, similar levels of impacts and risks to those of the Project are expected.

During drilling, the key potential impacts on marine turtles are:

- Disturbance from artificial lighting (**Negligible**);
- Displacement from habitat or foraging/migratory pathways as a result of disturbance from support vessel activity (**Negligible**);
- Acoustic injury from underwater sound exposure (**Negligible**); and
- Exposures to permitted discharges, potentially leading to toxicological or metabolic impacts - **Negligible**.

Vessel strikes (an unplanned event) are assessed as a **Moderate** risk to marine turtles.

Potential Impacts from Other Non-EEPGL Projects

New Demerara Harbour Bridge - Based on the information available, ERM does not foresee impacts from the New Demerara Harbour Bridge Project on this VEC, or they would be considered **Negligible**.

Caribbean Mariculture Project - Based on the information available, ERM does not foresee impacts from the Caribbean Mariculture Project on this VEC, or they would be considered **Negligible**.

Other Oil and Gas Exploration Projects (Repsol, Tullow, and CGX) - Although exploration activities by other operators will have the potential to affect marine turtles in much the same way as the Project, there will be no spatial overlap (and possibly no temporal overlap) between these effects. Given that all reasonably foreseeable exploration activities by other operators will occur in different blocks, and given the distance between likely exploration areas, it is unlikely that the same individuals would be impacted by more than one exploration campaign. However, the other projects will involve vessel movements, which contribute to additional risk of vessel strikes.

Potential Impacts from External Drivers

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.

Description of Cumulative Impacts

The key sources of potential impacts on marine turtles from Project-related activities and other projects include artificial light emitted from vessels, sound disturbance from drilling activities and vessels, and

toxicological effects from exposure to vessel discharges. Vessel strikes (an unplanned event) are also 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. However, marine turtles are transients within the Atlantic Ocean, and while they may encounter the drill ships or support vessels, they would not be expected to be negatively impacted by their presence unless they collided with a support vessel transiting between the drill ship and the shorebase.

Because all marine turtles with the potential to occur in the Project area are listed as CR (hawksbill turtles), EN (green turtle), or VU (leatherback and olive ridley turtle) by IUCN, the sensitivity of these receptors is considered **High** based on the conservative assumption that a CR or EN species would be affected. However, vessel speeds within the Project area and other projects will be low where the water is shallower in proximity to the shoreline, but no planned vessel movements will occur on the western portion of Guyana's continental shelf near the marine turtles' nesting beaches (i.e., SBPA); therefore, the likelihood of a vessel striking a mature turtle with eggs on her way to the nesting beaches, or encountering dense congregations of turtles is **Low**. Therefore, planned activities of the Project and 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 this negative effect due to the **Negligible** significance of its impacts. Therefore, no additional actions from EEPGL are required to mitigate potential adverse cumulative impacts on the VEC beyond the Project's proposed embedded controls and mitigation measures.

Priority Ranking

Based on the assessment discussed above, a cumulative impact priority rating of **Low** is assigned for marine turtles.

7.6.2.4 Fishery Resources

Potential Impacts from the Project

The key potential Project impacts are:

- Auditory impacts on demersal species from VSP (if conducted) - **Negligible**;
- Auditory impacts on pelagic species from vessel activity - **Negligible**;
- Disturbance from or attraction to offshore lighting (pelagic species) - **Negligible**;

- Exposure to permitted discharges, potentially leading to toxicological impacts - **Negligible**; and
- Changes in distribution of offshore pelagic and demersal fish from altered water quality - **Minor**.

Potential Impacts from Other Projects

New Demerara Harbour Bridge—Based on the information available, ERM does not foresee impacts from the New Demerara Harbour Bridge Project on this VEC, or they would be considered **Negligible**.

Caribbean Mariculture Project—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 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.

Other Oil and Gas Exploration Projects (Repsol, Tullow, and CGX) - Although exploration activities by other operators will have the potential to affect fishery resources in much the same way as the Project, there will be no spatial overlap (and possibly no temporal overlap) between these effects.

Potential Impacts from External Drivers

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. Rising temperatures associated with longer-term global climate change could potentially affect some marine fish species distribution ranges.

Description of Cumulative Impacts

The Project and other projects could have potential negative impacts on marine fish species. Given that all reasonably foreseeable exploration activities by EEPGL and other operators will occur in different blocks and given the distance between likely exploration areas, there is virtually no potential for synergistic effects from overlapping mixing zones, cuttings deposition areas, or other effects on fishery resources between the Project and other non-EEPGL oil and gas projects.

Further, considering the small number of industrial fishing vessels that are currently participating in deep-sea fishing, the ability to provide information in advance to these operators about EEPGL operations and marine safety exclusion zones, the relatively small area of ocean that will be affected, and the limited duration during which any such effects would be felt, the magnitude of the Project-related impacts on industrial fishing operations is considered **Negligible**.

The Project's embedded controls would mitigate its 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 actions from EEPGL are required to mitigate potential adverse cumulative impacts on the VEC beyond the Project's proposed embedded controls and mitigation measures.

Priority Ranking

Based on the assessment discussed above, a cumulative impact priority rating of **Low** is assigned for fishery resources.

7.6.2.5 Marine Transportation

Potential Impacts from the Project

The key potential Project impacts are:

- Increased vessel traffic in Georgetown Harbour, in the coastal waters between Georgetown and the Project area, and 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 drill ships.

These potential impacts could have an effect on:

- Commercial cargo and commercial fishing vessels - **Negligible**; and
- Subsistence fishing vessels - **Minor**.

A marine vessel collision involving Project vessels and non-Project vessels (unplanned events), potentially resulting in a temporary obstruction to a marine navigation route, is assessed as a **Minor** risk to marine transportation.

Potential Impacts from Other EEPGL Projects

Due to the similarity between activities of the Project that could impact marine transportation and activities of Other EEPGL Projects that could impact marine transportation, similar levels of impacts and risks to those of the Project are expected:

- Increased vessel traffic in Georgetown Harbour, in coastal waters between Georgetown and the Stabroek, Canje, and Kaieteur blocks, and 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 drill ships and workover vessels.

The potential impacts could have an effect on:

- Commercial cargo and commercial fishing vessels - **Minor**; and
- Subsistence fishing vessels - **Minor**.

A marine vessel collision involving Project vessels and non-Project vessels (unplanned events), potentially resulting in a temporary obstruction to a marine navigation way, is assessed as a **Minor** risk to marine transportation.

Potential Impacts from Other Non-EEPGL Projects:

New Demerara Harbour Bridge - Some of the potential adverse 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.

Caribbean Mariculture Project - Based on the information available, ERM does not foresee impacts from the Caribbean Mariculture Project on this VEC, or they would be considered **Negligible**.

Other Oil and Gas Exploration Projects (Repsol, Tullow, and CGX) - Although exploration activities by other operators will have the potential to affect marine transportation in much the same way as the Project, the magnitude of the combined impact is not expected to be significant.

Potential Impacts from External Drivers

To the extent the frequency or intensity of severe storms and flooding could be influenced by climate change, these could potentially impact harbor conditions, although this is unlikely to result in significant impacts during the Project life cycle (at least 20 years). Commercial fishing vessels contribute significantly to local marine traffic in the region.

Description of Cumulative Impacts

The Project, Other EEPGL Projects, the Harbor Bridge Replacement Project, and external drivers could contribute to:

- Increased vessel traffic in Georgetown Harbour, in coastal waters between Georgetown and the Stabroek, Canje, and Kaieteur blocks, and 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 drill ships and workover vessels.

The most vulnerable receptors to these types of effects would likely be subsistence fishing vessels operating near the mouth of the Demerara River (which could experience some degree of interference with nearshore navigation as a result of supply vessel transits).

Given that all reasonably foreseeable exploration activities by other operators will occur in different blocks, vessel traffic will disperse after leaving port and congestion at sea is therefore unlikely. The presence of additional oilfield vessels will be most noticeable in port; however, exploration activities by other operators are in relatively early stages compared to EEPGL's activities, so they are not expected to increase vessel traffic significantly.

Priority Ranking

Based on the assessment discussed above, a cumulative impact priority rating of **Low** is assigned for marine transportation.

7.6.2.6 Marine Water Quality

Potential Impacts from the Project

The key potential Project impacts on water quality relate to discharge of drill cuttings and the resultant increases in TSS concentrations in the water column, potentially contributing to health impacts on marine life (rated as **Minor** significance).

Potential Impacts from Other EEPGL Projects

Due to the similarity between activities of the Project that could impact water quality and activities of Other EEPGL Projects that could impact water quality, similar levels of impacts and risks to those of the Project are expected (i.e., increased TSS concentrations from drill cuttings discharges, potentially contributing to health impacts on marine life.

Potential Impacts from Other non-EEPGL Projects

New Demerara Harbour Bridge - Based on the information available, ERM does not foresee impacts from this project on this VEC, or they would be considered **Negligible**.

Caribbean Mariculture Project - The main adverse potential impact on water quality from this activity would be associated with the discharge of effluents containing fish waste products from farms into the environment, 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.

Other Oil and Gas Exploration Projects (Repsol, Tullow, and CGX) - Although exploration activities by other operators will have the potential to affect water quality in much the same way as the Project, there will be no spatial overlap between these effects.

Potential Impacts from External Drivers

Increases in severe flooding events could intensify the degree to which rivers might discharge sediment loads into the ocean environment, including from agricultural fields. However, while this could temporarily affect marine water quality in coastal areas, it is unlikely to affect water quality significantly in the Stabroek Block.

Description of Cumulative Impacts

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. It is likely that in the immediate vicinity of the grow-out or culture area, there could be an increase of certain compounds, such as ammonia and nitrates, resulting from protein metabolism by the cultured species. Given that all reasonably foreseeable exploration activities by other operators will occur in different blocks and given the distance between likely exploration areas, there is virtually no potential for synergistic effects from overlapping TSS plumes or other effects on water quality among projects. Further, the suite of embedded controls related to water quality management included in the Project's design, would appropriately mitigate the negative impacts and contribution.

Priority Ranking

Based on the assessment discussed above, a cumulative impact priority rating of **Low** is assigned for water quality.

7.7 CUMULATIVE IMPACTS MANAGEMENT FRAMEWORK

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.

7.7.1 *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, 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 have been proposed to address potential impacts from the Project.

At the Project level, the above measures are considered sufficient to address the contributions of the Project to cumulative impacts.

7.7.2 *EEPGL Level*

One medium-priority cumulative impact on a VEC (i.e., for marine mammals) was identified, suggesting that additional consideration should be given in the medium term to address potential cumulative impacts on this VEC. The medium priority ranking derives primarily from the potential cumulative impacts that could arise from additional vessel movements from simultaneous oil exploration and/or production operations already occurring in the Stabroek Block and from exploration activities in the adjacent Kaieteur and/or Canje blocks that could potentially overlap temporally with the Project (leading to the potential for an increased risk from vessel strikes).

Accordingly, it is recommended that EEPGL, when designing and undertaking additional projects/activities, implement the same level of potential impact management developed for prior projects with activities similar to that of the Project (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 and exploration 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 potential cumulative impacts on marine mammals.

7.7.3 Regional Level

The CIA did not identify any high priority cumulative impacts on VECs. Therefore, ERM does 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.

8 ENVIRONMENTAL AND SOCIOECONOMIC MANAGEMENT PLAN

8.1 INTRODUCTION

This section of the EA&MP summarizes the mitigation measures that are recommended to manage the potential impacts of the Project. Each of the avoidance, minimization, and mitigation measures described in this section is recommended to address a specific Project-related impact described above.

8.2 SCOPE

The regulatory requirements potentially applicable to the Project are covered in Chapter 3, Administrative Framework; this section of the EA&MP covers EEPGL's environmental and socioeconomic policies as well as the environmental and socioeconomic management requirements for the Project.

8.3 POLICY FRAMEWORK

8.3.1 EEPGL's Profile, Management Policies, and Commitments

ExxonMobil 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). Effective and consistent application of these policies will constitute the primary safeguards against occupational hazards for Project workers, and all Project workers and contractors will receive training on implementation of these principles and will be required to adhere to them in the daily execution of their duties.

ExxonMobil's OIMS Framework[34] 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 has been adopted by all ExxonMobil affiliates, with particular emphasis on design, construction, and operations. Management is responsible for ensuring that management systems satisfying the OIMS Framework are in place. Implementation is consistent with the risks associated with the business activities being planned and performed. Figure 8.3-1 provides a high level description of the OIMS Framework and its 11 essential elements.

Figure 8.3-1: The OIMS Framework



8.3.2 *Occupational Safety & Health Management*

OIMS establishes expectations and requirements for identifying and managing occupational safety and health risks associated with EEPGL's operations. Examples of the key elements of EEPGL's occupational safety and health programs that will be utilized during the Project life cycle are discussed in Table 8.3-1. The occupational safety and health program elements in Table 8.3-1 are focused on personnel safety and health risks associated with the offshore drilling, installation, production operations,

[34] https://corporate.exxonmobil.com/Energy-and-environment/Tools-and-processes/Risk-management-and-safety/Operations-Integrity-Management-System

and decommissioning stages of the Project; design considerations are not included.

Table 8.3-1: Key Occupational Safety & Health Management Elements

Program Element	Description
Safety	
Personal Protective Equipment (PPE)	Used to reduce personal exposure to hazards when engineering and administrative controls are not feasible or are not effective in reducing exposure to an acceptable level. A PPE program addresses the hazards to be encountered; the selection, maintenance, and use of PPE; the training of personnel; and monitoring of the program for ongoing effectiveness. Includes basic and specialty PPE.
Confined Space Entry	Controls hazards associated with personnel entering spaces not designed for human occupancy, where egress is limited, and where hazards pose a risk to injury or illness from hazardous substances or conditions (e.g., hazardous atmosphere, fire, exposure to hazardous substance, temperature, physical hazards, etc.). Includes controls such as atmospheric testing, forced air ventilation, attendants, signage, entry permits, etc.
Energy Isolation	Utilizes controls to prevent the unexpected energizing, start-up, or release of stored energy (e.g., hydraulic, pneumatic, thermal, chemical, gravity, mechanical) while working with plant and equipment which have one or more energy sources. Also known as Lockout/Tagout.
Electrical	Controls hazards encountered by personnel who install, use, maintain, repair, or test various types of permanent and temporary plant and equipment, as well as other personnel who work in the proximity of such plant and equipment. Includes controls such as electrical codes, classified areas, qualified persons, signage, specialty PPE, grounding, guarding, etc.
Hot Work	Utilizes controls necessary to safely perform hot work (work methods which produce ignition sources; sparks, flame, heat) in the proximity of flammable gases, liquids, or materials. Includes controls such as safe welding areas, gas testing, fire watch, firefighting equipment, permits, etc.
Fall Protection	Manages the risk of personnel working above 1.8 meters (6 feet) and includes use of personal fall arrest systems and safe anchoring points.
Scaffolding, Work Platforms, Ladders, and Personnel Lifting Equipment	Scaffolding, work platforms, and ladders are utilized to elevate workers performing work at heights. Scaffolding and work platforms require controls for use of competent scaffold builders, standards for erection, safe work loads, and inspection/tagging systems. Includes safe work practices for ladders. Includes controls and safe work practices for mechanized personnel lifting (e.g., aerial lifting equipment, work baskets).

Program Element	Description
Dropped Objects Management	Uses control to prevent dropped objects such as tools, materials, and debris from falling onto work areas below, which could cause injury to personnel or damage to equipment. Includes controls such as overhead protection, hard barricades, soft barricades, tool tethering, etc.
Mechanized Lifting and Rigging	Includes the utilization of various types of mechanized lifting equipment (e.g., stationary cranes, mobile cranes, overhead cranes) by equipment operators and rigging personnel, as well as rigging apparatus (e.g., spreader bars, slings, straps, hooks). Utilizes controls related to operator and equipment certification, inspection and maintenance, load ratings, general safe work practices for routine lifts, and procedures for non-routine lifts.
Tools and Equipment	Identifies controls and safe work practices for managing the risks associated with various types of hand tools and portable equipment (e.g., hammering, chipping, welding, burning, cutting, cleaning, smoothing, breaking, shaping, torqueing). Includes inspection, maintenance, safety devices, etc.
Marine Transportation and Personnel Transfers	Includes controls and safe work practices associated with marine transportation of personnel by crew boat. Also includes controls and safe work practices for infield personnel movements between vessels or facilities (e.g., collapsible rope man-baskets, gangways).
Aviation Transportation	Includes controls and safe work practices associated with rotary wing aviation aspects (e.g., refueling operations, aircraft inspection and maintenance, design of helidecks, pilot training and credentials, weather criteria) and personnel transportation considerations (e.g., water survival training, helicopter egress training, in-flight aviation procedures).
Housekeeping	Utilizes controls and monitoring processes to eliminate various types of incidents, including fires, exposure to hazardous chemicals, dropped objects, and slips, trips, and falls.
Driving	Utilizes controls to manage ground transportation hazards in an urban environmental, including general driving rules, licensing, defensive driving training, fatigue management, alcohol and drug avoidance, inspection and maintenance, journey management, etc.
Health	
Hazard Communication	Includes controls to verify that materials are reviewed for hazards prior to use, are communicated to potentially affected persons, and the necessary controls are implemented to provide safety and health protections. Includes making Safety Data Sheets available to personnel.
Respiratory Protection Program	Provides controls to ensure personnel select the appropriate respiratory protective equipment for certain activities. Certain respirators require training, fit testing, and use by medically qualified personnel.

Program Element	Description
Noise and Hearing Conservation Program	Identifies high noise areas (exposures above 85 decibels), evaluates personnel exposure, provides protective equipment, and implements appropriate engineering and administrative control measures to prevent occupational hearing loss.
Exposure Monitoring	Includes exposure monitoring to identify, analyze, and manage occupational health risks. Results of monitoring against defined criteria (e.g., threshold limit values) are communicated to personnel and effective control measures are established to mitigate worker risks.
Radiation Management	Establishes controls to safely manage use of radioactive sources, source materials, radiation producing devices, and naturally occurring radioactive materials.
Heat Stress Management	Utilizes controls and safe work practices to assess the work environment in order to reduce potential injury or illness where temperature extremes may result in significant health impacts on personnel.
Medical Screening and Fitness for Work	Includes controls to ensure personnel are fit for work, including general medical fitness for duty, job-specific fitness-for-duty, vaccinations, pre-screening for contagious diseases, alcohol and drug testing, etc.
Tuberculosis Control Program and Other Communicable Disease Concerns	Provides Tuberculosis (TB) controls to promote early detection, isolations, and prompt treatment of TB cases at sites where TB transmission may exist and where personnel live together in congregate settings (e.g., offshore vessels). Includes other controls for other relevant communicable diseases of concern (e.g., Dengue, Zika, Lymphatic Filariasis) based on risk of exposure in the work location.
Water Safety	Includes controls to ensure potable water sources are safe for consumption on offshore vessels. Includes standards and periodic verification testing by qualified personnel.
Administrative Processes	
Contractor and Subcontractor Management	Includes a structured evaluation and selection process that addresses safety and health considerations, identifies the minimum safety and health requirements through contract language, provides performance monitoring during execution/operations, and provides a feedback mechanism to contractor/subcontractor management.
Orientation and Training	Training program includes a systematic means of providing, enhancing, and/or sustaining the safety and health knowledge and skills of personnel. Includes a training matrix, competency assessment, documentation of training, etc. Orientation program includes a structured induction process to ensure that personnel arriving at a work location for the first time understand the applicable safety and health expectations and requirements. Orientation program also includes an abridged version for visitors.
SIMOPs	Includes a structured process to verify that incompatible activities between different offshore teams (Drilling, Installation, Production, Logistics) are safely managed.

Program Element	Description
Work Management System	A work management system (also known as a permit to work system) is a systematic process for planning, executing, and controlling critical and/or non-routine tasks at a work location. Includes processes for work authorization and permit validity (duration, suspension, cancellation). Includes coordination meetings, pre-task planning, and assessment. Defines when certain types of work permits are required (e.g., hot work, confined space entry, energy isolation, critical mechanized lifts).
Worker Hazard Management Processes	Includes a suite of programs aimed at engaging workforce personnel in hazard management; including: pre-shift safety meetings, job safety analysis, personal risk assessment, near miss and hazard condition reporting, behavioral observations, stop work authority, etc.
Inspections	Provides a systematic process for designated work site personnel to identify and resolve safety and health issues at a work location. Typically focuses on both physical conditions and personnel behaviors.
Audits	Includes structured verification processes to periodically evaluate the effectiveness of various types of safety and health policies, processes, procedures, and work practices, in order to identify opportunities for improvement and develop and steward action plans to drive improvement.

8.3.3 Organizational Structure

As part of design and implementation for the Project, EEPGL has established an organizational structure within the affiliate that is responsible for managing the Project activities. A dedicated in-country organization will be in place throughout each Project stage. The organizational size and makeup will evolve over time to accommodate the business needs associated with the Project.

The in-country organization will be led by a Lead Country Manager, and supported by various discipline managers such as Operations, Engineering, Human Resources, Public & Government Affairs, Business Services (e.g., Procurement, Controllers, Information Technology), Law, and Safety, Security, Health, and Environment (SSHE). The in-country organization will also be supported by a number of technical, business, and administrative specialists located inside and outside of Guyana. The in-country organization is responsible for all in-country Project activities, and will be the organization that interfaces with government and stakeholders.

The EEPGL management team will be supported by an SSHE team that provides technical expertise, training, and administrative support for OIMS implementation, which addresses disciplines such as safety, security, health, environmental, regulatory, and socioeconomics.

The in-country organization will also be supported by several teams that are responsible for managing certain types of Project activities. Examples of such teams include a Drilling Team that manages the drilling and completion of the development wells and a Logistics Team that manages logistical support (e.g., shorebases, aviation, marine vessels). Each of these teams has a suite of discipline managers to support the planning and execution of the Project activities for which they are responsible, including SSHE. These teams interface with the EEPGL in-country organization in a seamless manner to deliver their scopes of work for the Project.

Figure 8.3-2 illustrates the preliminary organizational structure that will support implementation of the ESMP. Key roles and responsibilities as they relate to the ESMP are outlined in Table 8.3-2.

Figure 8.3-2. Preliminary Organizational Structure—ESMP Responsibilities

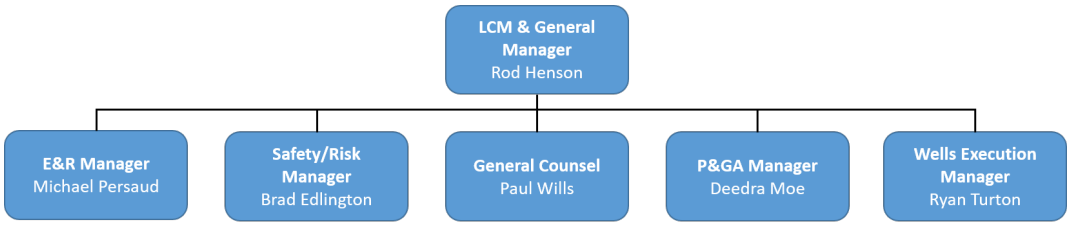


Table 8.3-2. ESMP Roles and Responsibilities

Role	Responsibilities
Lead Country Manager (LCM) & General Manager	• Approves the ESMP • Sets the expectation to comply with ESMP requirements
Environment & Regulatory (E&R) Manager	• Endorses the ESMP • Administrative owner of the ESMP documentation • Accountable for ESMP implementation • Provides technical support to operational staff for safety, health, environmental, and regulatory compliance-related ESMP requirements • Coordinates interfaces with Government agencies and external stakeholders on safety, health, environmental, regulatory compliance matters • Manages OIMS implementation and execution such that EEPGL meets the Corporate OIMS expectations • Responsible for EEPGL SSHE stewardship and performance reporting
Safety & Risk Manager	• Endorses the ESMP • Responsible for EEPGL Safety stewardship and performance reporting • Participates in risk assessments associated with the Project • Participates in development of the emergency response and oil spill response plan development

Role	Responsibilities
General Counsel	• Endorses the ESMP • Evaluates application and interpretation of relevant laws, regulations, and other legal frameworks • Advises on appropriate mechanisms to ensure compliance with legal requirements by the company
Wells Execution Manager	• Endorses the ESMP • Implements the operational requirements of the ESMP within the Wells organization • Responsible for implementation of operations integrity requirements related to Wells • Coordinates with Wells contractor community to enhance local content
Public and Government Affairs (P&GA) Manager	• Endorses the ESMP • Jointly accountable with Operations Management for implementation of the Socioeconomic Management Plan within the ESMP • Provides technical support to operational staff for socioeconomic-related ESMP requirements • Coordinates interfaces with Government agencies and external stakeholders regarding public and government affairs

The EEPGL management team is accountable for managing the Project activities in alignment with OIMS and EEPGL's established SSHE policies, in compliance with the laws and regulations of Guyana, and in line with the commitments and obligations associated with the Project EA&MP and ESMP.

EEPGL defines SSHE roles and responsibilities for its organizations and individuals to ensure that they understand expectations.

8.4 COMPETENCY, TRAINING, AND AWARENESS

EEPGL will assign suitably competent personnel to manage and support the Project activities in alignment with OIMS, which provides guidelines for personnel selection, placement, and competency verification. EEPGL will provide/validate that its personnel have been provided the appropriate SSHE training, in alignment with OIMS.

EEPGL will verify that its contractors have competency, training, and awareness programs in place that are consistent with EEPGL's programs, in alignment with OIMS.

EEPGL and its contractors will provide SSHE training and awareness programs which include:

- Country/site-specific inductions for new personnel and visitors;
- General training covering broad SSHE roles and responsibilities for all personnel;

- Management training directed at management and supervisory level personnel;
- Operational training for operational and engineering personnel; and
- Project- and job-specific training specific to those with direct duties and roles in SSHE, commensurate with their level of responsibility.

EEPGL will include EA&MP-related training and awareness in the above programs, as appropriate to ensure that personnel with EA&MP roles and responsibilities understand expectations related to commitments and obligations, mitigation measures, monitoring programs, and reporting. Table 8.4-1 provides a conceptual overview of roles and responsibilities for EEPGL's competency, training, and awareness program.

Table 8.4-1: Training Roles and Responsibilities

Position	Responsibilities
Management	• Endorse overall training processes and procedures • Verify competent and trained personnel are available to support Project activities
Site Supervision	• Require their personnel to have the required knowledge and skills to perform job tasks • Review and approve training plans for their personnel • Provide time/resources required for their personnel to complete/maintain training • Review training progress for their personnel on an annual basis • Consult with management on actions to take when a person does not meet the requisite knowledge/skills after training has occurred
Personnel	• Complete training requirements • Provide feedback on training received
SSHE Personnel	• Provide SSHE training programs with support from training resources
Training Resources	• Provide SSHE training programs with support from SSHE personnel • Assist with delivery of training (where appropriate) and evaluate training results

8.4.1 Training Programs and Delivery

EEPGL will develop competency, training, and awareness program appropriate to the Project's needs. Training may be provided through a variety of means, which may include but is not limited to: briefings, toolbox talks, coaching/mentoring, on-the-job training in specific elements or tasks, self-study, instructor-led training, seminars, workshops, computer-based training, or the provision of specific skills, as necessary. These and other means (such as posters, signs, site newsletters, etc.) may

be used to promote environmental, socioeconomic, and regulatory compliance awareness. Training programs may be delivered by both EEPGL, contractor, and third party training resources.

8.5 EEPGL'S ENVIRONMENTAL POLICY

It is EEPGL's policy to conduct its business in a manner that is compatible with the balanced environmental, social, and economic needs of the communities in which it operates. EEPGL is committed to continuous efforts to improve environmental, socioeconomic, and health performance throughout its operations. Accordingly, the EEPGL Environmental Policy is to:

- Comply with all applicable environmental laws and regulations and apply responsible standards where laws and regulations do not exist;
- Encourage concern and respect for the environment, emphasize every employee's responsibility in environmental performance, and foster appropriate operating practices and training;
- Work with government and industry groups to foster timely development of effective environmental laws and regulations based on sound science and considering risks, costs and benefits, including effects on energy and product supply;
- Manage its business with the goal of preventing incidents and of controlling emissions and wastes to below harmful levels, and design, operate, and maintain facilities to this end;
- Respond quickly and effectively to incidents resulting from its operations, cooperating with industry organizations and authorized government agencies;
- Conduct and support research to improve understanding of the impact of its business on the environment, improve methods of environmental protection, and enhance its capability to make operations and products compatible with the environment;
- Communicate with the public on environmental and socioeconomic matters and share its experience with others to facilitate improvements in industry performance; and
- Undertake appropriate reviews and evaluations of its operations to measure progress and to ensure compliance with this environmental policy.

8.6 DESCRIPTION OF MITIGATION AND PREVENTATIVE MEASURES

This section of the EA&MP identifies the measures EEPGL will implement to reduce environmental and socioeconomic impacts. While mitigating risks is EEPGL's overall goal, in the unlikely event that an incident should occur, EEPGL, the drill ship operators, waste transporters, and the waste contractors all have ERPs to address emergency contingencies such as spills, fires, and explosions. In cases other than very minor spills, the EEPGL ERP will be activated. The ERP includes specific and actionable steps for each possible scenario (see Section 8.9, Emergency Response Plan). The action steps and the resources applied increase as the severity of the emergency increases. In the case of scenarios that exceed local capability, EEPGL will activate the ExxonMobil Americas Regional Response Team (ARRT). The ARRT is a large group of highly trained responders that is prepared for response actions around the world.

The ERP also includes all required internal and external incident communications processes and contact numbers.

In addition, an affiliate-level OSRP and WMP were submitted to the EPA as part of the Payara Development Project EIA in February 2020. These plans currently cover oil spill response-related and waste management-related aspects for EEPGL's activities in Guyana.

Tables 8.6-1 through 8.6-6 summarize the mitigation measures that will be implemented by EEPGL (beyond standard operating procedures) and the potential impacts that they are intended to address.

Table 8.6-1: Air Quality Management Measures

Source of Impact	Receptor	Management Measure	Involved Facility
Emissions to Atmosphere	Air Quality and Climate	If well testing[35] 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[36] 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.	Drill Ships
Emissions to Atmosphere	Air Quality and Climate	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.	Drill Ships, Other Marine Vessels, Shorebases
Emissions to Atmosphere	Air Quality and Climate	Regularly inspect and service shorebase cranes and construction equipment to reduce air emissions to the extent reasonably practicable.	Shorebases
Emissions to Atmosphere	Air Quality and Climate	Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.	Drill Ships, Other Marine Vessels, Shorebases

[35] While well testing is not planned for the Project, there is the potential it could be needed, in which case EEPGL will implement the measures in Table 8.6-1.

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

Source of Impact	Receptor	Management Measure	Involved Facility
Emissions to Atmosphere	Air Quality and Climate	Utilize low-sulfur fuels for major Project vessels.	Drill Ships, Other Marine Vessels
Emissions to Atmosphere	Air Quality and Climate	Utilize dust suppression measures at the shorebases to reduce impacts on air quality.	Shorebases
Emissions to Atmosphere	Air Quality and Climate	Operate incinerators in accordance with the manufacturers' operating manuals and WMP. Ensure that incinerators are operated only by trained personnel.	Drill Ships

Table 8.6-2: Water Quality Management Measures

Source of Impact	Receptor	Management Measure	Involved Facility
Operational Discharges	Marine Water Quality	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.	Drill Ships, Other Marine Vessels
Operational Discharges	Marine Water Quality	Adhere to operational controls regarding material storage, wash-downs, and drainage systems.	Drill Ships, Other Marine Vessels
Wastewater Discharge to Sea	Marine Water Quality	Ensure wastewater released from the onboard sewage treatment plant complies with aquatic discharge standards in accordance with MARPOL 73/78 regulations.	Drill Ships, Other Marine Vessels
Wastewater Discharge to Sea	Marine Water Quality	Treat bilge water in accordance with MARPOL to comply with an oil in water content of less than 15 parts per million as applicable.	Drill Ships, Other Marine Vessels
Wastewater Discharge to Sea	Marine Water Quality	Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.	Drill Ships, Other Marine Vessels

Source of Impact	Receptor	Management Measure	Involved Facility
Discharge of Cuttings to Sea	Marine Water Quality	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 Association of Oil and Gas Producers Group III NADF.	Drill Ships
Discharge of Cuttings to Sea	Marine Water Quality	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.	Drill Ships
Discharge of Cuttings to Sea	Marine Water Quality	Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.	Drill Ships
Drilling and Operational Discharges	Marine Water Quality	Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with IMO/MARPOL 73/78 requirements.	Drill Ships, Other Marine Vessels
Drilling and Operational Discharges	Marine Water Quality	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.	Drill Ships, Other Marine Vessels
Hydrocarbon Spills	Marine Water Quality	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	Drill Ships
Hydrocarbon Spills	Marine Water Quality	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.	Drill Ships

Source of Impact	Receptor	Management Measure	Involved Facility
Hydrocarbon Spills	Marine Water Quality	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).	Drill Ships
Hydrocarbon Spills	Marine Water Quality	Utilize leak detection systems for equipment, treatment, and storage facilities (fuel, chemical, etc.) on drill ships in accordance with international offshore petroleum industry standards.	Drill ships
Hydrocarbon Spills	Marine Water Quality	Utilize secondary containment for storage of bulk fuel, drilling fluids, and hazardous materials, where reasonably practicable.	Drill Ships, Shorebases
Hydrocarbon Spills	Marine Water Quality	With respect to prevention of spills of hydrocarbons and chemicals: • Regularly (e.g., monthly) check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks. • Regularly inspect and service shorebase cranes and construction equipment to mitigate the potential for spills to the extent reasonably practicable.	Shorebases
Hydrocarbon Spills	Marine Water Quality	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.	Drill Ships, Other Marine Vessels, Shorebases
Hydrocarbon Spills	Marine Water Quality	Implement the Oil Spill Response Plan (OSRP) in the unlikely event of an oil spill, including: • Conducting air quality monitoring during emergency response; • Requiring use of appropriate Personal Protective Equipment by response workers; and • Implementing a Wildlife Oil Response Program, as needed.	Drill Ships, Other Marine Vessels, Shorebases

Table 8.6-3: Marine Ecosystem Management Measures

Source of Impact	Receptor	Management Measure	Involved Facility
Collision Between Vessels and Marine Species	Marine Mammals, Marine Turtles, 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. • Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from Project area.	Drill Ships, Other Marine Vessels
Collision Between Vessels and Marine Species	Marine Turtles	• 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).	Drill Ships, Other Marine Vessels
Auditory Impacts on Marine Species	Marine Mammals, Marine Turtles, Marine Fish	• During VSP, gradually increase intensity of seismic impulses to allow sensitive species to vacate area before injury occurs (i.e., soft starts) in accordance with Joint Nature Conservation Committee guidelines (JNCC 2017). • Employ trained Marine Mammal Observers (MMOs) during the conduct of seismic-related activities. Although use of MMOs is more effective for identification of marine mammals, these individuals can also detect marine turtles depending on weather conditions, and they will be tasked with observing for marine turtles as well. • Conduct a continuous observation of a mitigation zone (500 meters 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 (265 feet), or 60 minutes prior to commencing sound-producing operations in water depths greater than 200 meters (265 feet). • Adhere to the JNCC Guidelines (2017) during the conduct of seismic-related activities.	Drill Ships, Other Marine Vessels

Source of Impact	Receptor	Management Measure	Involved Facility
		• 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 VSP, etc.) to reduce noise to levels that do not cause material harm or injury to marine species.	
Entrainment or Impingement of Marine Fish	Marine Fish	Provide screening for seawater intakes to avoid entrainment and impingement of marine flora and fauna.	Drill Ships
Visual Disturbance of Marine Species	Marine Turtles, Seabirds	Where reasonably practicable, direct lighting on 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.	Drill Ships

Table 8.6-4: Socioeconomic Management Measures

Source of Impact	Receptor	Management Measure	Involved Facility
Project Employment	Guyanese Population	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.	Project[37]
Project Procurement	Guyanese Population	Procure Project goods and services locally when available on a timely basis and when they meet minimum standards and are commercially competitive.	Project
Project Workforce	Guyanese Population	Proactively communicate the Project's limited staffing requirements as a measure to reduce the magnitude of potential population influx to Georgetown from job seekers.	Project
Project Workforce	Guyanese Population	Require Project workers to adhere to a Worker Code of Conduct, which will address shore-leave considerations.	Project
Project Workforce	Guyanese Population	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 supplement the local medical infrastructure.	Drill Ships
Waste Generation	Waste Management	Avoid, reduce, reuse, or recycle wastes preferentially prior to disposal in accordance with waste management hierarchy.	Shorebases, Drill Ships

[37] "Project" indicates these measures are not specific to an individual facility or group of facilities; they are companywide policies that would be applied across all Project-associated activities.

Source of Impact	Receptor	Management Measure	Involved Facility
Waste Generation	Waste Management	Perform onshore waste treatment for certain categories of waste, thereby reducing demand on landfill capacity.	Waste Management Contractors
Waste Generation	Waste Management	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 Contractors
Waste Generation	Waste Management	For wastes that cannot be reused, treated, or discharged/disposed on the drill ships, ensure they are manifested and safely transferred to appropriate onshore facilities for management.	Drill Ships
Waste Generation	Waste Management	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.	Shorebases, Drill Ships
Waste Generation	Waste Management	Periodically audit waste contractors to verify appropriate waste management practices are being used.	Waste Management Contractors
Waste Generation	Waste Management	To address future waste capacity constraints in Georgetown relative to the Project's predicted waste management needs: • Continue to 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. • Issue a Request for Information followed by the issuance of an Invitation to Tender (completed in October 2019) to provide additional third-party commercial waste management facilities and services in Guyana, with the award planned for the first quarter of 2020. These may include a thermal desorption unit, incinerators, wastewater treatment plant, waste skips, containers, and trucks, among others—needed to manage and treat hazardous and non-hazardous waste liquids, solids, and semi-solids. • Continue to monitor the Ministry of Communities' planned construction of Cell 2 at the Haags Bosch landfill, which is expected to be completed and operational in the first half of 2020, and/or (if approved by the EPA) construction of additional landfill sites in Georgetown, or identify suitable alternative (interim) local solutions for non-hazardous waste management.	Waste Management Contractors
Various	Guyanese Population	Implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) early on, prior to onset of Project activities. Ensure CGM mechanism is well publicized and understood by the public.	NA
Various	Guyanese Population	Develop and implement a Stakeholder Engagement Plan.	NA

Source of Impact	Receptor	Management Measure	Involved Facility
Various	Guyanese Population	Monitor grievances received and resolved by the CGM; adjust CGM and other management measures, as appropriate.	NA

Table 8.6-5: Marine Transportation Management Measures

Source of Impact	Receptor	Management Measure	Involved Facility
Marine Casualty Event (Collision)	Non-Project Marine Vessels	• Use a Class 3 Dynamic Positioning (DP) system, which includes numerous redundancies; • Ensure rigorous personnel qualifications and training; • Use sea trials and acceptance criteria; • Continuous DP proving trials; • Conduct a System Failure Mode and Effects Analysis; • Conduct a continuous DP failure consequence analysis; and; • Establish well-specific operations guidelines.	Drill Ships
Increased Vessel Traffic; Marine Casualty Event (Collision, Grounding); Reduced Ocean Surface Area Available for Non-Project Activities	Commercial Cargo and Fishing Vessels; Subsistence Fishing Vessels	• 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. • Issue Notices to Mariners via MARAD, the Trawler's Association, and fishing co-ops for movements of major marine vessels (including the 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. • Equip Project vessels with radar systems and communication mechanisms to communicate with third-party mariners. • Maintain marine safety exclusion zones to be issued through MARAD with a 500-meter (approximately 1,640-foot) radius around drill ships to prevent unauthorized vessels from entering areas with an elevated risk of collision. • Implement a Stakeholder Engagement Plan that includes a CGM process for stakeholders, including local fishing interests.	Shorebases, Drill Ships, Other Support Vessels

Table 8.6-6: Air and Road Transportation Management Measures

Source of Impact	Receptor	Management Measure	Involved Facility
Increased Aviation Traffic	Other Aircraft and Users of Ogle Airport	Coordinate with relevant aviation authorities and stakeholders to understand peak Project-related utilization rates.	Drill Ships
Vehicular Accidents	Local Communities	Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to vehicle incidents.	Shorebases and Onshore Support Infrastructure
Vehicular Accidents	Local Communities	Implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The Road Safety Management Procedure has been implemented as of the writing of this EA&MP, and the procedure includes 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.	Shorebases and Onshore Support Infrastructure

8.7 DESCRIPTION OF MONITORING PROGRAM

This section describes the monitoring program that EEPGL will put in place to ensure the effective implementation of mitigation measures. The monitoring program described in this section comprises baseline measuring, impact monitoring, and socioeconomic monitoring.

8.7.1 Baseline Environmental Condition Characterization

EBS campaigns have been conducted in 2014, 2016, 2017, 2018, and 2019 in the Stabroek Block. EBS campaigns have also been conducted in the adjacent Canje and Kaieteur blocks in 2018 and 2019 respectively. The reports from these EBSs describe the physical, chemical, and biological (benthic community) properties of sediment and the water column to document baseline conditions in these blocks.

The EBSs emphasized water and sediment because they are a major repository for introduced environmental substances to the marine environment. Sediments can provide an integrated view of historical and contemporary contaminant inputs and depositional events. Benthic infauna (macrofauna) communities are a useful indicator of environmental health due to their relative sensitivity to changes in sediment physical and chemical conditions. The studies document current concentrations of hydrocarbons and metals in offshore sediments, as these are the main contaminants potentially introduced from petroleum exploration and development.

The primary objective of the Stabroek EBS campaigns was to define the range of sediment habitat conditions and to examine chemical and biological patterns of variability in relation to sediment physical characteristics and water depth within the area that could be affected by the proposed drilling activities.

8.7.2 Impact (or Performance) Monitoring

Assurance activities implemented within ExxonMobil's OIMS are a combination of monitoring, inspection activities, and periodic assessments. The requirement for monitoring and inspection stems from the need to verify operations are proceeding in accordance with commitments made and to provide information to regulators and other relevant stakeholders. As such, there is a requirement for the results of monitoring and inspection to be integrated with EEPGL's internal and external communication program.

Based on discussions with the EPA, EEPGL understands that requirements for monitoring specific environmental media (air, water,

etc.) are guided by Guyana law, but also that monitoring/reporting plans can be developed on a case by case basis and tailored to the specific impacts anticipated from each project.

Table 8.7-1 summarizes the monitoring measures to be implemented during the Project.

8.7.3 Socioeconomic Monitoring and Management

To ensure efficient socioeconomic management, EEPGL will be responsible for monitoring mitigation measures relevant to protecting socioeconomic aspects and adhering to established socioeconomic processes, such as socioeconomic impact assessment, chance finds, OSRP socioeconomic sensitivity, communication and training, human rights, national content, and grievance management.

A plan for socioeconomic impact assessment and monitoring will be established to identify socioeconomic impacts/risks and evaluate the effectiveness of appropriate risk management measures in accordance with the avoid/mitigate/compensate hierarchy. Where reasonable, the Affiliate Office will pursue socioeconomic opportunities/benefits to enhance positive impacts. A Chance Find Procedure will be established to guide appropriate action to address the potential magnitude of the impact as well as the vulnerability of the cultural/archaeological resource. The procedure will include chance find communication and training, as well as a fair and transparent compensation approach to address inadvertent damages to discovered cultural heritage resources or if cultural heritage sites or resources can be or need to be preserved in-place or relocated. EEPGL will work with the National Trust to develop and implement a project-specific Chance Find Procedure. The Chance Find Procedure will be based on the following management hierarchy:

- Avoidance (if practicable)
- Preservation
- Recovery and relocation of artifacts

Human rights will be managed in accordance with applicable laws and regulations, and as set forth in ExxonMobil's statement on Labor and the Workplace and its Standards of Business Conduct (Appendix B). Standard contract language will adhere to all applicable laws and regulations, including those related to safety, security, health and the environment. Procurement will include clauses in requests for quotations that require business partners to abide by the prohibition of child and forced labor and the payment of wages in accordance with local regulations. Project supplier and contractor screenings will be conducted regarding human rights, policies, positions, and performance.

Table 8.7-1: Monitoring Measures for Project Impacts

Source of Impact	Aspect	Receptor	Activity	Involved Facility	Timing	Report
Emissions to Atmosphere	Air Emissions	Air Quality	Record volume of fuel used by drillship	Drill Ship	Monthly	Health, Safety, and Environment (HSE) drill ship daily report
Emissions to Atmosphere	Air Emissions	Air Quality	Monitor volume of fuel used by support vessels	Support Vessel	Monthly	Support vessels daily report
Emissions to Atmosphere	Air Emissions	Air Quality	Monitor volume of fuel used in helicopter transfer	Helicopter	Monthly	Helicopter daily report
Emissions to Atmosphere	Air Emissions	Air Quality	Report air emissions from required activities	Project Activities	Annually	Reporting form required by EPA
Emissions to Atmosphere	Air Emissions	Air Quality	Quantify and report direct GHG 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 Activities	GHG emissions will be calculated annually for the previous year	Annual Compliance Report
Emissions to Atmosphere	Air Emissions	Air Quality	Monitor on an ongoing basis the volume of fuel used by all combustion sources and other marine vessels	Marine Vessels	Monthly from each vessel	Fuel usage and specifications will be the basis for air emission calculations, which will be provided in the Annual Compliance Report

Source of Impact	Aspect	Receptor	Activity	Involved Facility	Timing	Report
Drilling Discharges	Hazardous Waste	Water Quality	Before and after drilling, an ROV will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.	Drill Ship	Before and after drilling at each well	End of Well Reports will be submitted within 90 days following the completion of drilling operations for each well.
Drilling Discharges	Hazardous Waste	Water Quality	Monitor daily during drilling to ensure that end of well maximum weighted mass ratio averaged over all well sections drilled using NADF shall not exceed 6.9 percent wet weight base fluid retained on cuttings.	Drill Ship	Daily	The averaged retained NABF on cuttings (%) will be supplied to EPA in the End of Well Report for each well. End of Well Reports will be submitted within 90 days following the completion of drilling operations for each well.
Waste Management	Waste	Air Quality, Surface Water Quality, Groundwater Quality	Record type and quantity of each individual waste stream on board any time a new waste is generated.	Drill Ship, Support Vessels	Ongoing	Annual types and quantities of wastes including hazardous waste generated, treatment, and disposal (both onshore and offshore) will be provided to the EPA in the Annual Compliance Report.
Waste Management	Waste	Air Quality, Surface Water Quality, Groundwater Quality	Inspect waste storage area and containers daily; log inspections.	Drill Ship, Support Vessels	Daily	None

Source of Impact	Aspect	Receptor	Activity	Involved Facility	Timing	Report
Waste Management	Waste	Air Quality, Surface Water Quality, Groundwater Quality	Document marine waste transfer.	Drill Ship, Support Vessels, Shorebases	As required	None
Waste Management	Waste	Air Quality, Surface Water Quality, Groundwater Quality	Sample and perform analytical testing as needed to properly classify waste.	Waste Management Facility	As needed	Records will be kept by the onshore waste contractor.
Waste Management	Waste	Air Quality, Surface Water Quality, Groundwater Quality	Complete Recoverable Material and Waste Summaries.	Drill Ship, Support Vessels	Ongoing	Annual types and quantities of wastes including hazardous waste generated, treatment, and disposal (both onshore and offshore) will be provided to the EPA in the Annual Compliance Report.
Waste Management	Waste	Air Quality, Surface Water Quality, Groundwater Quality	Complete and submit reports required per the Environmental Permit.	Drill Ship, Support Vessels	Annually	Annual types and quantities of wastes including hazardous waste generated, treatment, and disposal (both onshore and offshore) will be provided to the EPA in the Annual Compliance Report.

Source of Impact	Aspect	Receptor	Activity	Involved Facility	Timing	Report
Waste Management	Waste	Air Quality, Surface Water Quality, Groundwater Quality	Conduct waste facility audits and inspections periodically.	Waste Management Facility	Annually	Inspections and audits will be documented and kept on file and provided upon request.
Physical Presence	Physical Presence	Artisanal and Commercial Fishing/Marine Traffic and Navigation	Monitor engagement with fishing communities to record locations of fisheries activities and to check for adherence to communications protocol and grievances follow up	Project Activities	During the project	Environmental weekly report
Operational Discharges	Mud, Cuttings, and Cement	Benthic Organisms	Estimate and record volume (m^3), rate (bbl hr/hr) and type of drilling fluids, cuttings, brine, proppant, cement, and other permitted discharges into the sea	Drill Ship	Daily	HSE drill ship daily report
Unplanned Situations	Protection and Spill Response	Biological Resources	Perform audits to ensure safeguards built into the design and implementation of the drilling activities are undertaken as planned	Drill Ship	During the project	Environmental weekly report
Unplanned Situations	Protection and Spill Response	Biological Resources	Carry out regular checks for leaking pipes, storage tanks and equipment associated with drilling	Drill Ship	During the project	Environmental weekly report
Unplanned Situations	Protection and Spill Response	Biological Resources	Maintain a record on maintenance of equipment	Drill Ship	During the project	Project start report
Unplanned Situations	Protection and Spill Response	Biological Resources	Undertake a record of training courses/ training exercises	Drill Ship	During the project	Environmental weekly report
Unplanned Situations	Protection and Spill Response	Biological Resources	Keep attendance records of training courses	Drill Ship	During the project	Project start report
Unplanned Situations	Protection and Spill Response	Biological Resources	Record volumes of chemicals transferred and stored	Drill Ship	During the project	HSE drill ship daily report/ HSE Environmental monthly report

Source of Impact	Aspect	Receptor	Activity	Involved Facility	Timing	Report
Unplanned Situations	Protection and Spill Response	Biological Resources	In case of an accidental fuel spill, EEPGL will monitor the release and associated response measures, including effectiveness of containment and cleanup, in accordance with the Oil Spill Contingency Plan	Drill Ship	During the project	Environmental weekly report
Operational Discharges	Mud, Cuttings, and Cements	Seawater Quality	Estimate and record volume (m^3) and type of drilling fluids and cuttings, brine, proppant, cement, and other permitted discharges into the sea	Drill Ship	When activity takes place	HSE drill ship daily report
Operational Discharges	Black Water, Grey Water, and Food Waste	Seawater Quality	Monitor chlorine concentration of treated sewage discharges	Drill Ship	Monthly	HSE drill ship daily report
Operational Discharges	Black Water, Grey Water, and Food Waste	Seawater Quality	Perform daily visual inspection of discharge point to ensure absence of floating solids and discoloration of the water	Drill Ship	Daily	Environmental weekly report
Operational Discharges	Black Water, Grey Water, and Food Waste	Seawater Quality	Record estimate of grey water and quantity of macerated food waste discharged (estimate kilograms based on personnel on board and water consumption) in Garbage Record Book	Drill Ship	Daily	HSE drill ship daily report
Operational Discharges	Deck Drainage and Bilge Water	Seawater Quality	Perform continuous oil in water content (automatic) monitoring	Drill Ship	Daily	HSE drill ship daily report
Operational Discharges	Mud, Cuttings, and Cements	Seawater Quality	Observe surface of the sea in the discharge area to ensure no formation of oil sheen	Drill Ship	Daily	HSE drill ship daily report
Operational Discharges	Deck Drainage and Bilge Water	Seawater Quality	Record Oil in water concentration (Oil Record Book)	Drill Ship	Daily	Environmental weekly report
Operational Discharges	Ballast Water	Seawater Quality	Continuous: oil in water content monitoring	Drill Ship	Daily	HSE drill ship daily report

Source of Impact	Aspect	Receptor	Activity	Involved Facility	Timing	Report
Operational Discharges	Ballast Water	Seawater Quality	Record estimated volume of ballast water discharged and location (per ballasting operation) recorded in a Ballast Water Record Book	Drill Ship	Daily	HSE drill ship daily report
Operational Discharges	Ballast Water	Seawater Quality	Record Oil in water content of ballast water discharged in Oil Record Book	Drill Ship	Daily	HSE drill ship daily report
Operational Discharges	Deck Drainage and Bilge Water	Seawater Quality	Measure discharge into the sea to ensure oil content in the discharge stream complies with MARPOL 73/78 oil in water threshold of <15 parts per million; observe surface of the sea in the discharge area to ensure no formation of oil sheen	Drill Ship	Daily	Environmental weekly report
Operational Discharges	Mud, Cuttings, and Cements	Seawater Quality	Measure maximum flow rate (every hour during discharge), and average daily flow of discharge	Drill Ship	Daily and hourly	HSE drill ship daily report
Operational Discharges	Mud, Cuttings, and Cements	Seawater Quality	Monitor Base Fluid Residual on Cuttings percentage of base fluid retained on cuttings	Drill Ship	Every 300 meters or at least once per day	HSE drill ship daily report
Operational Discharges	Mud, Cuttings, and Cements	Seawater Quality	When discharge to sea is selected as an alternative, the following are to be considered: there shall be no discharge of free oil as a result of the discharge of NADF cuttings, WBFs muds and WBFs cuttings.	Drill Ship	During the project	Environmental weekly report

Source of Impact	Aspect	Receptor	Activity	Involved Facility	Timing	Report
Operational Discharges	Offshore Wastewater Discharge	Seawater Quality	Effluents from offshore facilities: Sewage, food waste, storage displacement water, bilge water and deck drainage (hazardous and non-hazardous) must comply with MARPOL 73/78. Desalination brine is to be mixed with other discharge waste streams if feasible.	Drill Ship	During the project	Project start report
Operational Discharges	Offshore Effluent Discharge	Seawater Quality	Track additional effluent discharges according to field reporting spreadsheet: e.g., seawater, fresh water, cement slurry/dye, dry cement/bentonite/barite, BOP fluid, waste water from drill ship pits	Drill Ship	During the project	HSE drill ship daily report
Operational Discharges	Mud, Cuttings, and Cements	Seawater Quality/ Benthic Organisms	Record volume (m^3) of muds and cuttings sent to shore for disposal	Drill Ship	When activity takes place	HSE drill ship daily report

Employment opportunities and use of goods and services that arise from the Project are not expected to influence the economy or labor force in Guyana outside the immediate vicinity of Georgetown. Local content efforts will continue to identify opportunities to create local jobs and purchase local goods and services from qualified suppliers and develop and implement any plans in coordination with P&GA, Procurement, Human Resources, and SSHE. To ensure effectiveness, EEPGL tracks and reports use of Guyanese resources employed and leveraged as part of its quarterly reporting.

EEPGL will be responsible for the management of all engagements of stakeholders relative to the work activities. The general objectives of the engagements are the sharing of information about the work and to address questions and concerns by the stakeholders. EEPGL will have a Stakeholder Engagement Plan to define how these engagements will be managed and the P&GA Manager will be responsible for these engagements. Contractors may be asked to participate in engagements related to their work scope to provide accurate information about their activities. There may be times when contractors will need to engage with stakeholders without EEPGL representation, i.e., interactions with fishermen out in the ocean. Contractors will be required to have their own Stakeholder Engagement Plans that spell out how these engagements will be handled as well as any subsequent reporting requirements.

A Grievance Management mechanism was established for Affiliate Office and contractors to track as well as adequately and efficiently address any Project-related community complaint. The P&GA Manager will be responsible for grievance management, communication, monitoring, and assigning actions to resolve grievances. The grievance mechanism will apply to all aspects of the project and will be open to any affected stakeholder.

8.8 IMPLEMENTATION, RECORD KEEPING, AND REPORTING

In accordance with local requirements and project timing, an implementation schedule and reporting procedures will be established for EEPGL and contractors to monitor environmental and socioeconomic impacts and the effectiveness of mitigation and management measures. The implementation schedule will indicate mitigation, monitoring and reporting actions and owners responsible (i.e., internal or third-party monitoring, reporting frequency, and key performance indicators).

The requirement for monitoring and inspection stems from the need to verify operations are proceeding in accordance with commitments made and to provide information to regulators and other relevant stakeholders. As such, there is a requirement for the results of monitoring and

inspection to be integrated with EEPGL's internal and external communication program.

Incident reporting related to field operations and EEPGL management will be handled in accordance with OIMS and other applicable corporate stewardship and management guides.

Environmental monitoring and reporting requirements include those stipulated in the following:

- Applicable regulations required by Guyana and related to the granted licensing agreement;
- Project commitments, regulatory filings, and project agreements; and
- Corporate requirements as outlined in the Upstream Environmental and Socioeconomic Management Standard and OIMS.

Environmental reporting requirements include, but are not limited to:

- Emergency/incident reporting
- Close-out reporting at the conclusion of each exploration activity

Socioeconomic monitoring and reporting shall be established in line with corporate requirements and identified project socioeconomic impacts and mitigations. Per the Planning Section Chief, the Affiliate Office shall be responsible for stewardship of overall environmental and socioeconomic performance.

8.9 EMERGENCY RESPONSE PLAN SUMMARY

This section provides a summary overview of the EEPGL ERP covering EEPGL operations in Guyana. The EEPGL ERP is a country-level document that provides structured processes, tools, and guidelines to assist production, project, drilling, exploration, and office facilities management teams in effectively responding to an emergency that originates from or escalates into EEPGL operations. The EEPGL ERP describes the overall emergency response model utilized by EEPGL, with a focus on how emergencies are managed at the country level in Guyana.

The EEPGL ERP describes emergency interfaces with the EEPGL field organizations, mutual aid responders, regional response teams, Georgetown-based emergency response teams, and headquarters-based emergency response teams in the United States. The EEPGL ERP does not attempt to duplicate or describe in detail the tactical emergency response

procedures managed by its field emergency response teams or by external organizations.

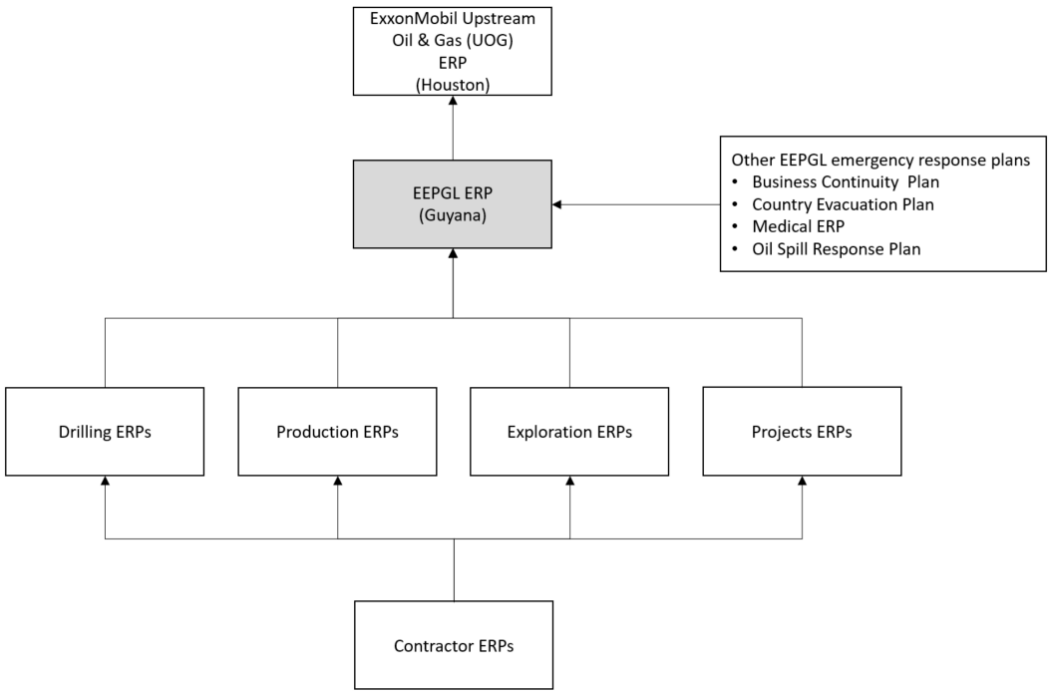
The EEPGL ERP is complemented by a number of standalone emergency response documents that provide additional processes, tools, and guidelines in support of overall emergency response planning and response. Examples of these complementary documents include:

- Business Continuity Plans
- Personnel Evacuation Plans
- OSRPs
- Medical ERPs
- Security Management Plans (covering security related response)
- Site-specific ERPs (facilities, vessels, worksites)

Where contractors or subcontractors serve as the dominant on-site organization at a worksite or for an activity, they are required to develop site specific ERPs, which are bridged into the EEPGL ERP.

Figure 8.9-1 illustrates how the EEPGL ERP fits into the hierarchy of ERPs supporting EEPGL operations.

Figure 8.9-1: Hierarchy of Emergency Response Plans



The EEPGL OSRP is a comprehensive, standalone emergency response plan that describes how EEPGL manages oil spills. The EEPGL ERP is a parent document to the OSRP.

The EEPGL ERP and its associated plans (as needed) may be activated in response to emergency events that pose, or could pose, a threat to people, the environment, assets, and reputation.

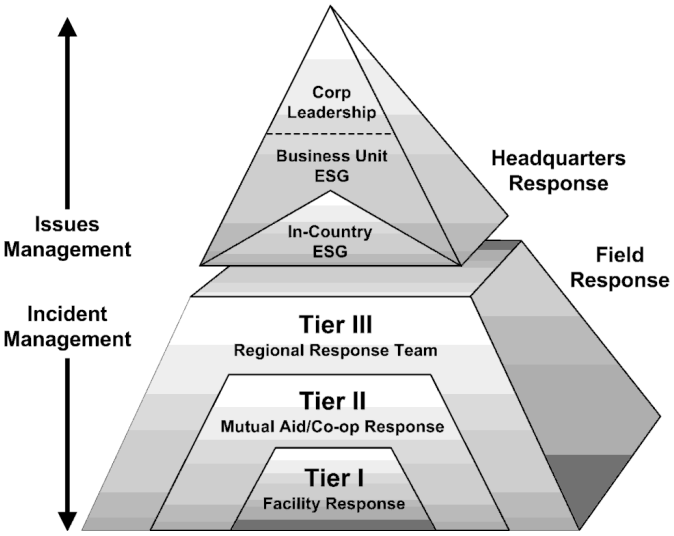
8.9.1 Document Ownership and Administration

The EEPGL Country Manager is the Owner of the EEPGL ERP, while the EEPGL SSHE Manager serves as the EEPGL ERP Plan Administrator. The Owner and Administrator review this plan on an annual basis, at minimum, to ensure it is current based upon EEPGL's operations. Similarly, subordinate EEPGL ERPs have Owners and Administrators.

8.9.2 Emergency Response Model

ExxonMobil affiliates utilize a worldwide emergency response model in their operations. The model is a proven tiered response system which provides operational and management teams with guidelines for an appropriate field and issues management response to an emergency event, at both tactical and strategic levels. The model illustrates the multiple levels of organizational support that is available to EEPGL operational field teams and management. The model is represented in Figure 8.9-2.

Figure 8.9-2: Emergency Response Model



As illustrated in the emergency response model, emergency response (at the field operational level) follows a tiered approach. Tier levels are generally matched to the physical size of an emergency event (e.g., oil spill, fire, medical response, natural disaster). Labeling an emergency event by tier level provides a quick and convenient way of classifying the relative size of the response team(s) and resources needed to respond to an emergency. A tiered approach provides for the seamless escalation of

tactical field operational response efforts (as needed); tier levels are defined in Table 8.9-1.

Table 8.9-1: Tier Level Definitions

Tier	Definition
I	Incident is small, under control, and may involve a response from a local company-managed resource.
II	Incident is large, under control, and involves mutual aid cooperative response.
III	Incident is large, not under control, and requires response by the appropriate Regional Response Team and specialized resources.

Emergency response follows the organizational structure of the model.

- Tactical response to an initiating incident for field operations (Field Response) is managed at the lowest appropriate level through implementation of a Site Specific ERP by a Site Emergency Response Team (ERT) at a worksite.
- Site emergency response follows the tiered response model concept as needed to address escalating emergency events.
  - Where an emergency escalates beyond the Tier 1 capability of the Site ERT, additional organizations/resources are activated to provide a complementary response.
  - Where an emergency event escalates to Tier II or III, an EEPGL Incident Management Team (IMT) is activated to provide broad-level operational coordination of the emergency event.
  - Complementary response may be provided by mutual aid organizations, ExxonMobil's ARRT, and/or industry response organizations (e.g., oil spill response organization) as necessary.
  - Where complementary response organizations/resources are activated, they supplement the EEPGL IMT and are managed through the Incident Command System (ICS).
- Government response organizations/resources may also be activated by the relevant government authorities after notification.
- Strategic in-country response and issues management (Headquarters Response) are implemented at EEPGL in Georgetown through the activation of the EEPGL Emergency Support Group (ESG), as required based on the complexity and severity of the emergency event.
- Strategic response and issues management is implemented in Houston (United States) through activation of the ExxonMobil

Upstream Oil & Gas (UOG) ESG, as required based on the complexity and severity of the emergency event.

- Corporate strategic support is implemented in Dallas (United States) through activation of the Emergency Management Review Group, as required based on the complexity and severity of the emergency event.

EEPGL has defined protocols in place to activate the various in-country and ex-country emergency response organizations.

8.9.3 Emergency Severity Assessment and Internal/External Notification

EEPGL has a structured system to assign an internal severity level to an emergency event. The system has four classification levels that help the management team understand the appropriate level of internal notification relative to the severity level.

As a general rule, the pace and extent of upward notification increase as the severity of an emergency event increases. For more significant emergency events, upward notification occurs up to ExxonMobil corporate headquarters.

Even where activation of emergency response support outside of Guyana is not required, structured management monitoring protocols are in place to keep the appropriate level of management team support abreast of an emergency event.

Notifications are also provided to the appropriate Guyanese authorities in alignment with regulatory requirements. EEPGL has a structured process for government notification and maintains an evergreen contact list to facilitate timely notification.

8.9.4 Overview of Emergency Response Organizations

8.9.4.1 Site Emergency Response Teams

Site ERTs are responsible for implementing site-specific ERPs at their respective worksites. A Site ERT provides tactical response to an emergency event. A Site ERT is the operational team which carries out the physical response at a work location, and the team is staffed with personnel who are resident at the worksite.

A Site ERP includes the following emergency response elements:

- Site ERT structure and associated roles and responsibilities;
- Defined interfaces with other offsite response organizations

- Internal communications protocols, and associated contact information;
- External communications protocols and associated contact information;
- Defined risk scenarios;
- Emergency action plans for defined risk scenarios;
- Method for activating emergency response;
- Method for personnel accounting;
- Defined evacuation procedures;
- Defined protocols for resuming work;
- Training requirements for responders and non-responders; and
- Requirements for drills, simulations, and exercises.

Where contractors or subcontractors serve as the dominant on-site organization at a worksite (e.g., installation vessel, shorebase operator), they will develop Site ERPs that bridge into the EEPGL ERP as appropriate. EEPGL has structured mechanisms to review, approve, and monitor contractor and subcontractor Site ERPs.

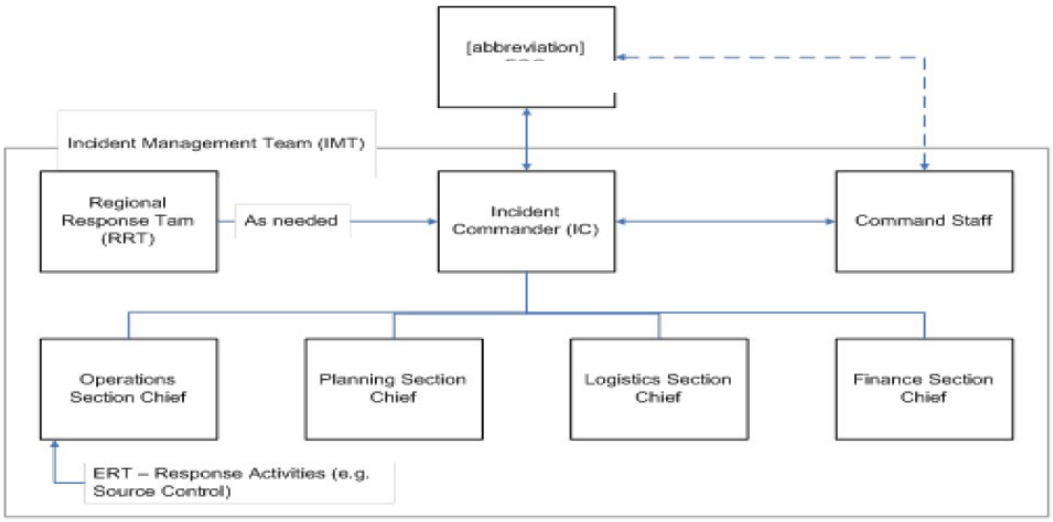
8.9.4.2 Incident Management Team

The EEPGL IMTs are responsible for providing tactical support to EEPGL/contractor/subcontractor managed Site ERTs. The EEPGL IMT is activated when the emergency response capabilities of a worksite have been exceeded, and the Site ERT needs additional emergency response operational support. As such, the EEPGL IMT is generally activated when an emergency escalates to a Tier II or III level. The EEPGL IMT provides broad level operational coordination of an emergency event once activated, typically from an onshore in-country coordination center.

When the EEPGL IMT is activated, it is organized in accordance with the ICS. ICS is a proven, standardized emergency response organization structure and process that is used in many jurisdictions around the world.

Figure 8.9-3 illustrates a typical ICS organizational structure. The ICS includes an Incident Commander and General Staff and Command Staff that provide technical support across several disciplines. Interfaces between the EEPGL IMT, EEPGL ESG, and Site ERTs are shown.

Figure 8.9-3: Typical ICS Organizational Structure



In some cases, the EEPGL IMT provides an adequate level of resources to support an emergency response event with in-country core resources. In other cases, the EEPGL IMT has to be expanded to accommodate larger and/or more complex emergency events. Where the EEPGL IMT has to be expanded with additional emergency response resources, and the ExxonMobil ARRT will be activated and integrated into the EEPGL IMT's ICS organization.

Where complementary response organizations/resources are activated, they supplement the EEPGL IMT and are managed through the EEPGL IMT's ICS organization.

The key initial roles of the EEPGL IMT are described below:

- Incident Commander (IC) is responsible for managing the onsite operational incident response. The IC provides guidance to the General Staff (Section Chiefs) and Command staff. The IC is also the main interface with the EEPGL ESG.
- General Staff consists of four Section Chiefs.
    1. Operations Section Chief is responsible for the management of response to the incident. The Operations Section Chief provides guidance to the Site ERT.
    2. Planning Section Chief is responsible for the collection, evaluation, and dissemination of response information and maintaining status of assigned resources.
    3. Finance Section Chief is responsible for all financial and cost analysis aspects.
    4. Logistics Section Chief is responsible for providing facilities, services, and material in support of the incident.

- Command Staff includes P&GA, SSHE, and Liaison activities. Depending on the size and complexity of the emergency event, the Command Staff may be duplicated or shared within the EEPGL ESG.

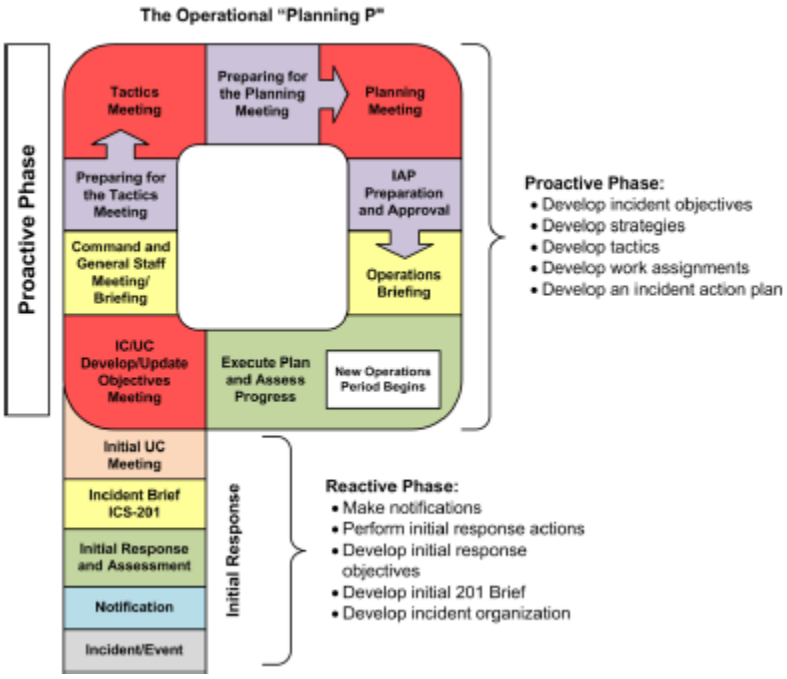
EEPGL maintains an evergreen list of the EEPGL IMT members with backups, all of which are trained in ICS. The ICS utilizes a proven, standardized process and suite of tools to manage an emergency event. Standardization allows for efficient and effective interfaces between multiple organizations/personnel that may be brought together to support an emergency response event.

The ICS is comprised of two main phases.

1. Reactive Phase: notifications, initial response, and assessment
2. Proactive Phase: planning meetings, action plan development, formal briefings, and updates

The standardized ICS Planning Cycle, commonly referred to as the Operational "Planning P" or "Planning P," is depicted on Figure 8.9-4.

Figure 8.9-4: ICS Planning Cycle



The Proactive Phase is typically for emergency events that are more complex and longer term in nature, such as a major facility fire or offshore spill. The majority of the emergency events are successfully managed during the Reactive Phase. Few incidents require the complete "Planning P" cycle.

In general, the EEPGL IMT will typically focus on the Reactive Phase; the Planning Phase would generally be implemented for large and/or complex incidents that require assistance from the ARRT. In such circumstances, the ARRT-sourced members of the IMT would provide expert guidance on the full ICS process as part of their established role.

During the Reactive Phase, EEPGL will:

- Assign pre-designated personnel to the initial roles of the IMT
- Perform notifications:
  - Follow the notification process previously described.
  - If required, implement protocols for activating additional emergency response resources.
- Perform initial response and assessment:
  - Monitor and support initial response to the emergency event, following the response procedures detailed in the Site ERP.
- Conduct incident briefing.

The full suite of ICS tools/forms/etc. is immediately available in the designated emergency response command center for the EEPGL IMT to utilize upon activation. Roles and responsibilities for each IMT position are defined.

8.9.4.3 Regional Response Team

Where the EEPGL IMT has to be expanded to accommodate larger and/or more complex emergency events, the ExxonMobil ARRT will be activated and integrated into the EEPGL IMT's ICS organization, providing depth and breadth to the core EEPGL IMT.

The Houston-based ARRT Emergency Response Advisor can initiate ARRT activation following instruction from the EEPGL Country Manager.

Prior to activation, the ARRT is comprised of a mix of emergency response personnel sourced from various ExxonMobil organizations outside of Guyana. The ARRT team members are generally part-time members who remain on call in a "ready to mobilize" mode, and they maintain competency through periodical training, drills, simulations, and exercises.

The ARRT maintains an evergreen list of ARRT members with backups, all of which are trained in ICS. Roles and responsibilities for each ARRT position are defined.

The ARRT can be partially or fully activated, depending on the size and/or complexity of the emergency event. Partial activation may be implemented when technical support is required by Site ERTs at the

worksites where the emergency is occurring. In such cases, ARRT members will typically be embedded within the Site ERT structure.

For larger and/or more complex emergency events that require an extensive amount of tactical operational support work, ARRT members can be integrated into the EEPGL IMT to provide support.

In the event that the ARRT is activated, one or more command centers will be established in-country to accommodate the full EEPGL IMT.

8.9.4.4 Emergency Support Groups

ESGs are utilized as needed to support strategic emergency response and issue management considerations. This level of support is typically described as "headquarters response" and is generally not operational in nature.

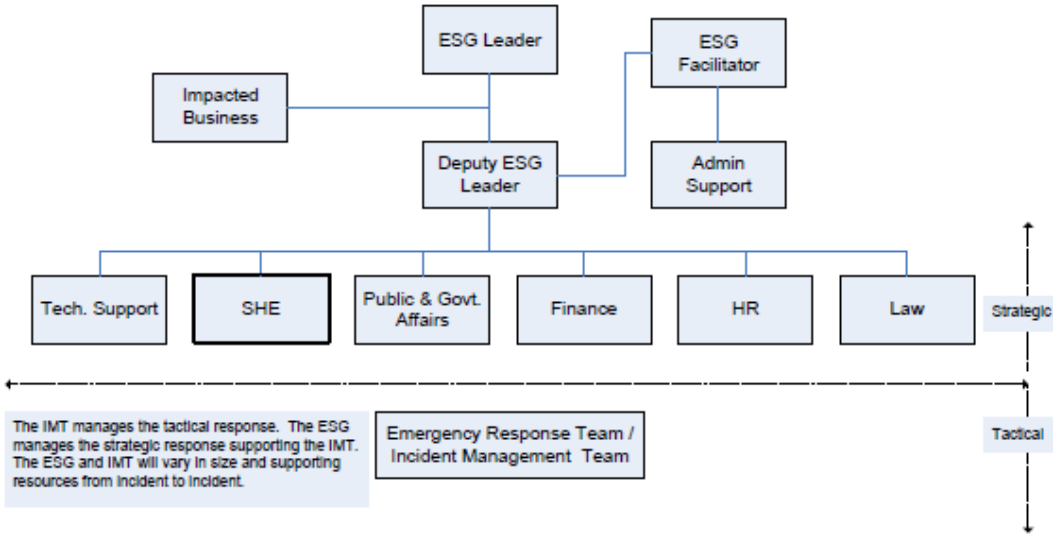
ESG organizations are located in Georgetown (Guyana) and Houston (United States). The Georgetown-based ESG is managed by the EEPGL in-country management team, while the Houston-based ESG is managed by the ExxonMobil UOG management team.

These teams are activated as needed based on the complexity and severity of an emergency event. In general, ESGs do not need activation when an emergency can be adequately managed by a Site ERT.

Protocols are in place for communications between the EEPGL ESG and the EEPGL IMT, as well as between the EEPGL ESG and the UOG ESG.

Figure 8.9-5 illustrates EEPGL ESG organizational structure, which is consistent with the UOG ESG. Positions are assigned as needed to match strategic support requirements.

Figure 8.9-5: EEPGL ESG Structure



Key strategic support objectives of the EEPGL ESG include:

- Support the EEPGL IMT and Site ERT as needed;
- Manage the strategic aspects of the emergency event;
- Respond to government groups, regulators, media, and other stakeholders;
- Determine the principal and potential impacts of an emergency event; and
- Facilitate the worst-case scenario process.

Upon activation of the EEPGL ESG, a full suite of ESG tools/forms is immediately available to EEPGL ESG members in the designated in-country ESG command center, which is a separate location than the EEPGL IMT.

EEPGL/UOG maintains evergreen lists of ESG members with backups, all of which are trained in ESG. Roles and responsibilities for each ESG position are defined.

8.9.5 *Emergency Response Scenarios*

EEPGL has developed a list of emergency situations that could potentially be encountered within its operations. Examples include, but are not limited to:

- Bomb threat
- Civil disturbance/protests
- Extortion/kidnapping
- Intruder response/security threat
- Medical emergency response (injury/illness)

- Natural disasters (onshore/offshore)
- Search and rescue/aviation incident
- Fire/explosion/gas release
- Hydrocarbon spill
- Vessel collision
- Automobile accident

8.9.6 Emergency Response Action Plans

EEPGL has developed emergency response action plans to address the identified emergency response scenarios. Each action plan describes the key steps to mitigate the consequences of the associated emergency event. Checklists are available to emergency response team organizations. The action plans are periodically drilled, simulated, and exercised to ensure readiness.

8.9.7 Emergency Response Training

EEPGL provides introductory and advanced emergency response training to its personnel who have an active role as emergency response responders (ESG, IMT, Site ERT). EEPGL personnel who are considered non-responders participate in awareness level emergency response training. EEPGL maintains training records for emergency response training.

8.9.8 Drills, Simulations, and Exercises

EEPGL develops an annual plan for drills, simulations, and exercises in order to maintain readiness for the identified emergency response scenarios in the EEPGL ERP. Personnel with emergency response roles (EEPGL ESG, EEPGL IMT, Site ERT) are involved in the planning and execution of drills, simulations, and exercises. Lessons learned from drills, simulations, and exercises are integrated into emergency response procedures and protocols.

9 SUMMARY

This section summarizes the potential environmental and socioeconomic impacts of the Project resulting from planned Project activities and potential unplanned events, as well the Project's potential contributions to cumulative impacts on resources and receptors.

9.1 PROJECT-SPECIFIC IMPACTS

As stated in Chapter 1, Introduction, the impact assessment conducted for this EA&MP was built on the knowledge and baseline data gathered from earlier surveys, studies, and assessments, which included the 2014 SEA, the 2015 SEA Addendum, the 2015 EMP, the 2016 EMP Addendum, the 2018 EMP Addendum Update, the 2019 Stabroek Revised EMP, the Canje 3-well EA&MP, and the Kaieteur 1-well EA&MP, as well as the 2017 Liza Phase 1, 2018 Liza Phase 2, and 2019/2020 Payara Development Project EIAs. With the preparation and completion of these surveys, studies, and assessments, the overall knowledge and understanding of the Guyana coastal habitats and marine environment has increased substantially over the past 6 years.

Taken together, the desktop studies, multi-year field surveys, coastal ecosystem services, biodiversity field verification and validation studies, and impact assessments conducted to date have rendered a detailed characterization of the existing physical, environmental, and biological conditions across Guyana's six coastal regions and the offshore, nearshore, shelf, and slope areas of the Guyana EEZ.

On the basis of this breadth of knowledge, and considering the specific components of the Project, ERM conducted a detailed identification, evaluation, and analysis of the potential impacts and risks of the Project according to the methodology described in Chapter 4, Methodology for Preparing the Environmental Assessment and Management Plan. This effort concluded that the significance of most of the potential impacts from planned activities of the Project is **Negligible**, with some instances of **Minor** or **Moderate** significance ratings.

Table 9.1-1 provides a summary of the predicted residual impact significance ratings (taking into consideration proposed mitigation measures) for potential impacts from planned Project activities, residual risk ratings for potential unplanned events, and cumulative impact priority ratings—for each of the resources considered.

Table 9.1-1: Summary of Planned Activity Impact Significance Ratings, Unplanned Event Risk Ratings, and Cumulative Impact Priority Rankings

Resource	Planned Activity Residual Impact Significance Rating	Unplanned Event Residual Risk Rating	Cumulative Impact Priority Ranking
Marine Water Quality	Minor	Minor to Moderate	Low
Air Quality and Climate	Negligible	Minor	NA
Coastal and Marine Geology and Stratigraphy	Negligible	Minor	NA
Bathymetry	Negligible	Minor	NA
Natural Hazards	Negligible	Minor	NA
Coastal Habitats [a]	None	Minor	NA
Benthic Resources	Negligible to Minor	Minor	NA
Fishery Resources	Negligible to Minor	Minor	Low
Marine Turtles	Negligible	Moderate	Low
Marine Mammals	Negligible to Moderate	Minor to Moderate	Medium
Seabirds	Negligible	Negligible to Minor	NA
Special Status Species	Negligible to Minor	Minor to Moderate	Low
Protected Areas	None	Minor	NA
Coastal Demographics	Negligible	Minor	NA
Employment and Livelihoods	Negligible to Minor	Minor	NA
Cultural Heritage and Archaeology	Negligible	Minor	NA
Marine Transportation	Negligible to Minor	Minor	Low
Land Transportation	Negligible	Minor	NA
Tourism and Recreation	Negligible	Minor	NA

NA = not applicable; VEC determined to be not eligible for consideration under CIA
[a] Coastal Habitats include Mangroves; Beaches; and Mudbanks, Mudflats, and Sandflats

As discussed in the preceding sections, a major oil spill event is 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 loss-of-well-control event during the drilling stage. EEPGL has previously conducted oil spill modeling for several WCD loss-of-well-control scenarios in the Stabroek Block to evaluate the range of possible spill trajectories and rates of travel. The distance of the Project area from shore,

prevailing northwest currents, and the region's warm waters would all help reduce the severity of a spill with respect to potential shoreline impacts.

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 within the Project area would likely impact 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. 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 Project area). Effective implementation of the OSRP would reduce this risk by reducing the duration of the release and 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 extensive preventative measures employed by EEPGL, could include collisions between Project vessels and non-Project vessels; and Project vessel strikes of marine mammals, marine turtles, or rafting seabirds. 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 and marine turtles; adherence to international and local marine navigation procedures) will also serve to reduce the likely extent of impact, were such an event to occur.

9.2 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 and Liza Phase 2 Development Projects, the proposed Payara Development Project, and approved and proposed exploration drilling in the adjacent Kaieteur and Canje blocks. 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.

The Project activities, other planned EEPGL activities, and non-EEPGL activities together could cumulatively impact some resources such as marine mammals or marine turtles (e.g., via vessel strikes) and marine transportation (via additional marine congestion, especially near Georgetown Harbour). However, most of the above potential impacts that require offshore interaction between the Project and others have a limited chance of occurring. Table 9.1-1 summarizes the cumulative impact priority rankings assigned based on the CIA.

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/activities, implement the same level of potential impact management developed based on prior impact assessments with activities similar to those proposed in the Project. In addition, with the intention of minimizing the potential interactions between effects of multiple projects, EEPGL can actively manage, where feasible and practicable, the spatial and temporal overlap of their additional projects activities. This approach would be expected to be sufficient to address contributions of the Project and other EEPGL projects to cumulative impacts.

9.3 DEGREE OF IRREVERSIBLE DAMAGE

The planned Project activities would not cause irreversible damage to any onshore areas of Guyana. There would be very minor loss of benthic habitat offshore as a result of the exploratory/appraisal drilling, and even this minor habitat loss would be expected to recover over time. 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.

9.4 IMPACT MANAGEMENT

The approach taken by EEPGL to manage potential impacts from the Project will be consistent with the mitigation and management measures developed over the multiple EPA-approved EMPs/EA&MPs and EIAs prepared for various EEPGL activities over the past 6 years. Specific management and monitoring measures for the Project are described herein, and reference is made to the recently updated (as part of the Payara Development Project EIA) versions of EEPGL's OSRP and WMP, which cover EEPGL's activities in Guyana.

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10.1 PERSONAL COMMUNICATIONS

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ERM Personal Communication 6. Interview with Romeo De Freitas, 2018.

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ERM Personal Communication 8. Interview with RDC 2 Chairman. 16 April 2018.

Environmental Resources Management/Environmental Management Consultants

ERM/EMC Personal Communication 1. Interview with Department of Fisheries, May 2, 2019.

Appendix A
Waste Management Plan

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Esso Exploration and Production Guyana Limited
Waste Management Plan for Guyana Development Projects

March 2020

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Acronyms and Abbreviations

Name	Description
EEPGL	Esso Exploration and Production Guyana Limited
EPA	Guyana Environmental Protection Agency
ESMP	Environmental and Socioeconomic Management Plan
FPSO	floating production, storage, and offloading (vessel)
HW	hazardous waste
MARPOL	International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978
PPE	personal protective equipment
SDS	safety data sheet
SURF	subsea, umbilicals, risers, and flowlines
WMP	Waste Management Plan

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1 INTRODUCTION

The objective of this Waste Management Plan (WMP) is to govern waste management associated with Esso Exploration and Production Guyana Limited's (EEPGL's) development drilling, installation, commissioning, production, and decommissioning activities in Guyana (collectively "Projects")—inclusive of the Liza Phase 1, Liza Phase 2, and Payara projects—in a manner that meets regulatory requirements and manages impacts on the surrounding environment. This WMP has been prepared in conjunction with the Environmental and Socioeconomic Management Plans (ESMPs) developed for use in executing EEPGL's approved and proposed development projects and outlines EEPGL's approach for the proper handling, storage, and disposal of hazardous and non-hazardous wastes. It is an evergreen document and will be updated as needed (i.e., as additional projects are proposed).

This document:

- Defines and categorizes the different types of waste that may be generated by offshore development and production activities;
- Specifies and documents the management and disposal practices that apply to each category of waste; and
- Specifies and documents the monitoring and reporting guidelines that apply to each category of waste.

This WMP is applicable to the management of wastes generated during all development project phases, including development well drilling; subsea, umbilicals, risers, and flowlines (SURF) and floating production, storage, and offloading (FPSO) vessel installation; FPSO commissioning, production operations, and decommissioning. Descriptions of the individual development projects covered under this WMP and estimated annual waste quantities are included in Attachment A. The scope of this document covers waste management procedures and practices from the points of generation—both offshore and onshore - through storage, treatment, transportation, recycling, re-use, and disposal. Planned discharges (e.g., produced water, cooling water) are managed under the ESMP and under individual vessel-specific Garbage Management Plans, and are therefore outside the scope of this document. Other non-effluent wastes that cannot be managed offshore at the point of generation will be transported to onshore waste management facilities operated by qualified permitted third-party waste management service providers for further segregation, consolidation, treatment, transportation and/or disposal to the final approved recycling, reuse, or disposal facilities.

2 SCOPE AND OBJECTIVES

The scope of the WMP includes the following:

- Identifying the sources and processes that generate recoverable materials and wastes;
- Identifying opportunities to avoid waste generation and minimize both the quantities and associated hazards of waste generated;
- Identifying those recoverable materials eligible for recycling, reclaiming, and reuse;
- Identifying the hazards associated with each waste type;
- Estimating the annual quantities for each recoverable material and expected waste type over the various Project stages;
- Selecting approved containers and ensuring proper segregation of materials and wastes;
- Identifying preferred management, storage, treatment, and disposal methods for wastes;
- Identifying and assessing acceptable waste management facilities;
- Identifying and assessing acceptable waste management service providers for transporting recoverable materials received at the shorebases from points of origin such as the FPSOs; drill ships; and installation, supply, and support vessels that cannot be managed offshore to the final recycling, reclaiming, handling, storage, treatment, and disposal facilities approved by EEPGL;
- Providing the process knowledge and Safety Data Sheets (SDSs) to ensure safe handling of materials and wastes - to reduce the risk of worker exposure or a release to the environment, including personal protective equipment (PPE).
- Ensuring proper reporting and recordkeeping is performed through the utilization of multiple logbooks and records to document the generation, storage, transportation, and final disposition of recoverable materials and wastes, including an annual waste summary report and incorporation of waste summary information in end-of-activity reports (i.e. End of Well, End of Survey, or End of Stage Reports).

The objectives of this WMP are as follows:

- Verify EEPGL manages the recoverable materials and wastes generated in accordance with internationally accepted standards and applicable local (i.e., Guyana) regulations;
- Verify contractors, including drill ship; FPSO; and installation, supply, and support vessel contractors, manage their recoverable materials and waste in accordance with their individual vessel-specific Garbage Management Plans, internationally accepted standards, and applicable Guyanese laws and waste regulations.
- Provide practical methods for handling, storing, transporting, recycling, and disposing of wastes, with prioritization on waste avoidance and reduction.

3 EEPGL ROLES AND RESPONSIBILITIES

EEPGL is the Owner of this WMP and is responsible for its implementation, maintenance, and periodic update as necessary.

EEPGL's obligations include:

- Verify drilling, installation, hook-up & commissioning, production operations, and decommissioning conform to the requirements of this WMP;
- Ensure recoverable materials and wastes are properly characterized and profiled based on process knowledge and the sampling and analysis of hazardous wastes as required per the WMP;
- Perform routine inspections and periodic self-assessments to verify compliance with applicable regulations;
- Identify qualified third-party waste service providers capability of the storage, transportation, treatment, recycling, reuse, and disposal of wastes;
- Perform periodic audits/assessments of third-party waste service providers utilized by EEPGL to verify they are properly permitted and have similar processes and procedures in place in their own individual WMPs;
- Verify that vessel owners and operators supporting EEPGL properly track and manage waste from the point of generation offshore through storage, treatment, reuse, and, if needed, transportation to shore for further handling.
- Confirm chain of custody and manifest records are kept, documenting the subsequent transfer of recoverable materials and wastes at the shorebase to the third-party waste service providers who will perform the final transport, storage, segregation, consolidation, recycle, reuse, treatment, and disposal of materials and wastes in accordance with their WMPs; and
- Verify that Contractors managing waste on behalf of EEPGL have in place programs for keeping recoverable materials and waste records; and required annual reports are prepared, reviewed, and submitted to the Guyana Environmental Protection Agency (EPA) as required, and copies are retained by EEPGL for its records, as related to waste generated from EEPGL activities.

3.1 EEPGL SPECIFIC RESPONSIBILITIES

In accordance with its specific responsibilities as relates to this WMP, EEPGL:

- Will promote sufficient resourcing (e.g., people, time, expertise and finances) to manage and monitor waste issues, including oversight of FPSOs', drill ships', EEPGL-supporting vessels' and waste service providers' contractual obligations relevant to waste management;
- Will confirm that the WMP is implemented, maintained, and periodically reviewed and updated as needed;
- Will identify the permits required and support timely applications to the appropriate authorities;
- Will require that permits/licenses are in place prior to carrying out applicable work;
- Will keep relevant third parties informed as the projects progress;
- Will inform EEPGL Management Team of waste management issues;
- Will write procedures for area-specific issues;
- Will aid in the alignment, implementation and oversight of WMP-specified duties associated with activities where waste is generated (e.g., drill ships; FPSOs; installation, supply, and support vessels); onshore logistics; and waste service providers;
- Will monitor third parties used for the offshore and onshore transport of recoverable materials and disposal of wastes;
- Will review the WMP procedures developed by contractors and subcontractors;
- Will undertake and carry out internal audits on waste management in line with the program of audits agreed upon by EEGPL and ensure remedial actions are closed out;
- Will monitor that contractors maintain necessary permits associated with their waste management activities;
- Will monitor that waste management contractors maintain proper documentation in accordance with requirements for generation, transportation, and disposal of wastes;
- Will promote with waste management contractors the maintenance of proper documentation in accordance with contractual obligations for generation, transportation, and disposal of wastes;
- Will provide waste-related input to WMP procedures;
- Will control hierarchical waste management approach integral to the EEPGL waste management strategy; and
- Will confirm that waste records are maintained for review.

3.2 MARINE VESSEL OWNER/OPERATOR-SPECIFIC RESPONSIBILITIES (SUPPLY, SUPPORT, AND INSTALLATION VESSELS; DRILL SHIPS; AND FPSOs)

In accordance with their specific responsibilities as relates to this WMP, marine vessel owner/operators:

- Will ensure that the correct equipment and containers are on site/vessel, as required;
- Will ensure that equipment and recoverable material/waste storage areas are well maintained and inspected;
- Will be responsible for the completion and maintenance of waste manifests as they are progressed through the chain of custody process;
- Will carry out inspections as necessary to ensure any waste issues are identified and managed accordingly. This includes ensuring wastes are correctly segregated;
- Will carry out or supervise waste monitoring ensuring that waste records are fully completed and correctly stored and filed. This includes ensuring waste is manifested separate from cargo with details recorded as to type of waste, volume of waste, characteristics of waste, and final destination.
- Will ensure required labels and placards are in use and are correct. This will need to be coordinated with the waste contractors;
- Will have designated personnel to coordinate with shorebase operators;
- Will maintain an up-to-date recoverable material/waste inventory;
- Will maintain and inspect recoverable material/waste storage areas;
- Will ensure remedial actions identified by monitoring and inspections offshore and/or at the shorebases are closed out;
- Will keep copies of necessary permits associated with waste management activities; and
- Will notify EEPGL Logistics Representative of recoverable materials/wastes to be transported to shore.

3.3 WASTE SERVICE PROVIDER-SPECIFIC RESPONSIBILITIES

In accordance with their specific responsibilities as relates to this WMP, waste service providers:

- Will spot-check and inspect loads (e.g., bags, containers, skips, totes, and tanks) to verify they conform to the paperwork, bill of ladings, and trip tickets prepared by the generator of the recoverable materials and wastes for transport to the shorebase;
- Will ensure loads are properly labeled by the generator and identify the hazards of such materials and wastes;
- Will oversee the safe offloading and transfer of recoverable materials and waste to vehicles for final transport, storage, recycling, recovery, treatment, or disposal;
- Will ensure that any transfers are recorded;
- Will manage the completion of manifests and other documents to record the final disposition of materials and wastes, with copies to EEPGL and regulatory authorities, and will maintain the original records as required;
- Will perform periodic self-assessments of waste management activities;
- Will provide guidance, training, and local capacity building on waste management issues, as requested by EEPGL;
- Will ensure waste transport vehicles are thoroughly inspected and placarded before they leave the shorebases or other EEPGL project locations for disposal facilities;
- Will supervise waste transfer operations to ensure they are correctly implemented;
- Will provide a point of contact to the EEPGL Logistics Supervisor; and
- Will ensure proper inspection, maintenance, and use of its equipment.

Supplementing the detailed responsibilities above, Table 1 summarizes the overall roles in the waste management process.

Table 1: Summary Roles—Waste Management

Task	Waste Service Providers	Operators*	EEPGL
Implement WMP	R	R	A
Designate waste storage areas	R/A	R/A	C
Minimize waste	R/A	R/A	C
Correctly use equipment and containers on site; ensure wastes are correctly segregated; required labels and placards are used	R/A	R/A	C
Designate personnel to coordinate with shorebase operators and waste contractor	I	R/A	C
Properly use required waste transfer and disposal forms	R	R	A
Keep up to date with waste laws and requirements	R/A	I	R/A
Maintain waste inventory	R	I	A
Document date waste is removed from site	R	A	I
Coordinate contractor procedures	I	R	R/A
Provide periodic waste training	R	R	A
Assess waste facilities and service providers	I	I	R/A

Responsible (R), Accountable (A), Consulted (C), Informed (I)
* Includes operators of FPSOs, Drill Ships, Marine Vessels, and prime Contractors supporting the offshore development drilling activities, construction, installation, and commissioning of offshore facilities

4 REGULATORY REQUIREMENTS AND GUIDELINES

This document supports the ESMPs prepared for EEPGL's development projects. The WMP has been developed to comply with the requirements of the laws of Guyana, applicable international conventions, and local guidelines, including:

- Environmental Protection Act of 1996;
- Regulations made under the Environmental Protection Act 1996 (No. 11 of 1996) of 2000;
- Environmental Guidelines for the Transportation, Storage and Occupational Handling of Chemical/Industrial Hazardous Waste of 2011 (as appropriate);
- Environmental Guidelines for Removal, Treatment & Disposal of Oily Sludge of 2011 (as applicable) (as appropriate);
- Environmental Guidelines for the Storage, Transportation & Occupational Handling of Biomedical Waste of 2011 (as appropriate and as applicable to medical waste that may be generated);
- MARPOL 73/78—International Convention for the Prevention of Pollution from Ships, Revised Annex V, Ship Garbage Management Plans and Record Books;
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (if applicable, no such shipments are currently planned); and

Further details on these laws and conventions are contained in the following sections.

4.1 LOCAL REGULATORY REQUIREMENTS AND WASTE DEFINITIONS

This WMP deals with recoverable materials and wastes that will be generated from the drilling, installation, hook-up and commissioning, production, and decommissioning activities for EEPGL's development projects. Limited recoverable materials and wastes will also be generated by support operations conducted at the shorebases, offices, and warehouses utilized to support offshore operations, and this WMP applies to those support operations as well.

The definition of a hazardous waste per the Guyana Hazardous Waste Regulation, 2000 Part I, 2(e) is:

> "A hazardous waste means a waste or combination of wastes which, because of its quantity, concentration or physical, chemical or infectious characteristics, may pose a substantial hazard to human health and belong to any category contained in Schedule I unless they do not contain any of characteristics contained in Schedule II and includes waste that is:

(i) Hazardous industrial waste;

(ii) Acute hazardous waste chemical;

(iii) Hazardous waste chemical;

(iv) Severely toxic waste;

(v) Flammable waste;

(vi) Corrosive waste;

(vii) Reactive waste;

(viii) Radioactive waste;

(ix) Clinical waste; or

(x) Leachate toxic waste or polychlorinated biphenyl waste,

and includes a mixture of acute hazardous waste chemical, hazardous waste chemical, pathological waste, radioactive waste, or severely toxic waste and any other waste or hazardous material."

Further descriptions of such wastes can be found in Schedule I of this regulation.

- A "liquid industrial waste" means a waste that is both liquid and industrial waste but does not include:

  (i) Hauled sewage;

  (ii) Waste from the operation of sewage works;

  (iii) Waste from the operation of water works;

  (iv) Waste that is produced in any month in an amount less than twenty-five litres or otherwise accumulated in an amount less than twenty-five litres;

  (v) Waste directly discharged by a generator from a waste generation facility into a sewage works or sewage system;

  (vi) Waste that results directly from food processing and preparation operations, including food packaging, food preserving and restaurants;

  (vii) Drilling fluids and produced waters associated with the exploration or production of crude oil or natural gas;

  (viii) Processed organic waste; or

  (ix) Asbestos waste.

- A “clinical waste” means:
  - (i) Any part of the human body including tissues and bodily fluids, but excluding fluids, extracted teeth, hair, nail clippings, and the like that are not infectious;
  - (ii) Any part of the carcass of an animal infected with a communicable disease;
  - (iii) Non-anatomical waste infected with communicable disease; or
  - (iv) Any waste that is generated in the diagnostic, treatment, or immunization of human beings or animals and related activities that include research or autopsies;
- A “flammable waste” means a waste that is either solid, liquid, an oxidizing substance, or an ignitable compressed gas, which, under certain conditions may be readily combustible or may cause or contribute to fire through friction, absorption of moisture or spontaneous chemical changes and when ignited, burns so vigorously and persistently that it creates a danger; and
- An “incinerator waste” means the residue from incineration, other than incinerator ash and fly-ash.

Additional regulations and guidelines govern specific wastes, including chemical, industrial, and biomedical wastes. EEPGL and its contractors may generate, as a result of offshore clinic operations and associated medical treatment, small quantities of sharps or other biological material or biomedical waste (also referred to as “Red Bag Waste” due to the color of the containers used and special labeling to denote such a potential biohazard). Such wastes could be incinerated offshore or brought to shore for proper treatment and disposal per the Guyana biomedical waste guidelines.

As noted above, sewage and other planned discharges are excluded from these chemical/industrial hazardous waste guidelines. Planned discharges from EEPGL offshore operations have been described in and will be managed under the ESMPs for EEGPL’s development projects and under individual vessel-specific Garbage Management Plans.

4.2 NATIONAL ENVIRONMENTAL LEGISLATION

In 1996, the Environmental Protection Act (hereinafter referred to as the Act) was enacted to implement the environmental provisions of the Guyana Constitution. The Act authorized the formation of the EPA as the lead agency on environmental matters in Guyana (FAO, 2013).

Environmental compliance of EEPGL’s development projects will be regulated under several statutes. These statutes contain measures that must be implemented to ensure compliance with applicable policies, guidelines, and legislation in Guyana. They include the Maritime Zone Act of 2010 No 18: 2010 and the Act of 1996 (as amended in 2005).

4.3 GUYANA PERMITS AND LICENSES

EEPGL's development projects will be governed under the provisions of the Petroleum Sharing Contract, Joint Operating Agreement, Liza Production License for the Stabroek Block, and Environmental Authorisations that have been issued by the EPA upon review and approval of the project-specific environmental impact assessments and supporting plans, including this WMP. These documents may contain general and specific waste management commitments, obligations, and conditions. The WMP will be updated as needed upon issuance of the project-specific Environmental Authorisations to reflect any additional requirements contained in those documents.

4.4 INTERNATIONAL CONVENTIONS

4.4.1 MARPOL 73/78

EEPGL will operate its offshore activities consistent with the provisions of the MARPOL 73/78 Convention.

The MARPOL 73/78 Convention ("the Convention") places restraints on the contamination of the sea, land, and air by ships. The Convention includes two protocols dealing with reports on incidents involving harmful substances and arbitration, and six annexes that contain regulations for the prevention of various forms of pollution. Table 2 provides short descriptions of each Convention annex.

Table 2: MARPOL 73/78 Annexes[1]

MARPOL Annex	Description
Annex I: Regulations for the Prevention of Pollution by Oil	Prevention of pollution by oil from operational measures as well as from accidental releases.
Annex II: Control of Pollution by Noxious Substances	Details the criteria and measures for the control of pollution by noxious liquid substances carried in bulk.
Annex III: Prevention of Pollution by harmful Substances Carried by Sea in Packaged Form	Contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitation, exception, and notifications.
Annex IV: Prevention of Pollution by Sewage from Ships	Requirements to control pollution of the sea by sewage and grey water.
Annex V: Prevention of Pollution by Garbage from Ships	Deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of.
Annex VI: Prevention of Air Pollution from Ships	Sets limits on certain air pollutants and prohibits deliberate emissions of ozone depleting substances.

[1] International Maritime Organization (IMO). (2015). International Convention for the Prevention of Pollution of Ships (MARPOL). Accessed 9 December 2015 at http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx.

Where offshore vessels are equipped with incinerators, solid combustible waste (except for food waste) suitable for incineration will be managed on the drill ships and FPSOs as the first preference - where offshore incineration is an option; the remainder will be stored on board and sent back to shore for treatment or disposal in accordance with local regulations. Food waste will be comminuted or ground prior to discharge. Black water / sewage will be treated, including chlorination, per MARPOL standards and discharged overboard. Management and monitoring measures implemented to ensure treatment standards for these discharges are described in the project-specific ESMPs.

The primary provisions of MARPOL 73/78 relevant to waste management for EEPGL's development projects are those applicable to offshore vessels, as follows:

- Waste Management Plan: A formal WMP shall be developed and enforced by the Unit owner;
- Waste Record Book: wastes generated should be recorded in the Waste Record Book;
- Plastic Waste and General Waste (except Food Waste): The disposal to the sea of all plastics, including but not limited to synthetic ropes, synthetic fishing nets, and plastic garbage bags, and all other general waste, including paper products, rags, glass, metal, bottles, crockery, dunnage, lining and packing materials, is prohibited;
- Food Waste: The disposal to the sea of food wastes that have been passed through a comminuter or grinder shall be made not less than 12 nautical miles from the nearest land. Such comminuted or ground food waste shall be capable of passing through a screen with openings no greater than 25 mm; and
- When waste to be disposed of is a mix of waste types having different disposal requirements, the more stringent requirements shall apply.

4.4.2 BASEL CONVENTION

The objective of the Basel Convention is to control the transboundary movements of hazardous waste and their disposal and by such protect human health and the environment against the adverse effects of hazardous waste if not managed correctly. Its scope covers a wide range of wastes defined as “hazardous wastes” based on their origin and/or composition and their characteristics, as well as two types of wastes defined as “other wastes” – household waste and incinerator ash.

The primary provisions of the Basel Convention center around the following principles:

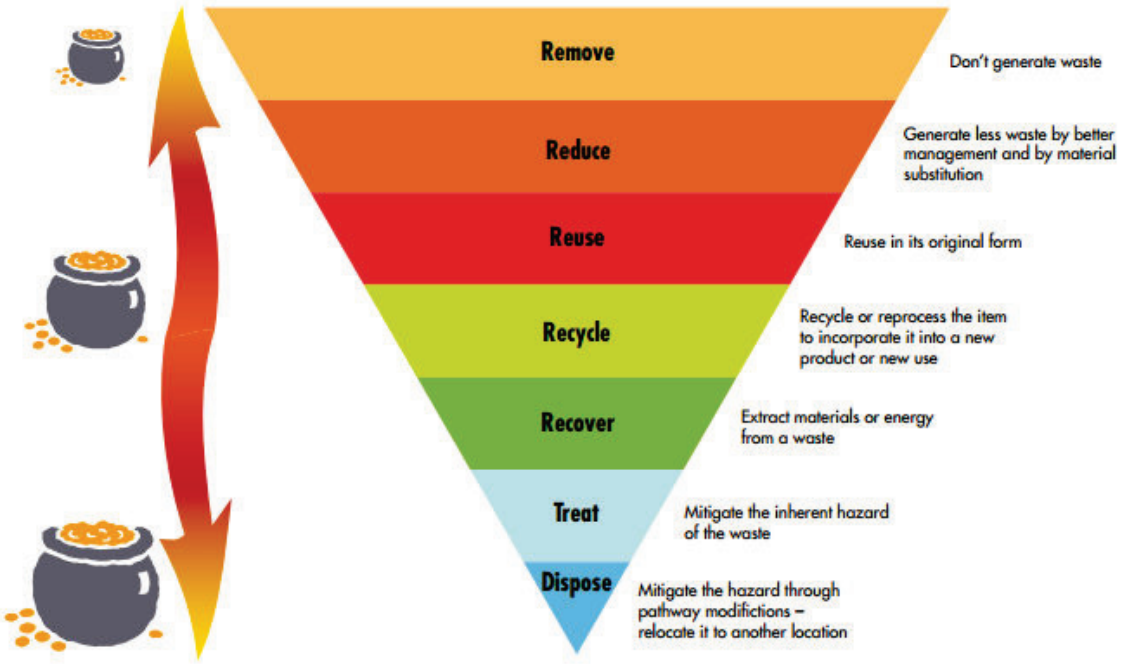
- The reduction of hazardous waste generation and the promotion of environmentally sound management of hazardous wastes, wherever the place of disposal;
- The restriction of transboundary movements of hazardous wastes except where it is perceived to be in accordance with the principles of environmentally sound management; and
- A regulatory system applying to cases where transboundary movements are permissible.

Guyana became a signatory to the Basel Convention on March 7, 2001.

5 WASTE MANAGEMENT STRATEGY

The WMP is underpinned by EEPGL's commitment to the waste management hierarchy, which is described below.

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.



Source: OGP. (2009). Guidelines for waste management with special focus on areas with limited infrastructure. Accessed 21 November 2015 at http://www.ogp.org.uk/pubs/413.pdf.

Figure 1: Waste Management Hierarchy

EEPGL will encourage its contractors and suppliers (e.g., of equipment, materials, goods and services) to minimize packaging on products wherever possible, or to package products in recyclable materials, to limit waste generation at each stage of its development projects. Whenever practicable, surplus and unused materials will be returned to a vendor or recycled as

the means of management (i.e., reused for the same or a new purpose, converted into a new product), enabling reduction in the consumption of a new product or raw material.

Where possible, measures will be implemented to minimize contractor waste generation. These include:

- Avoiding single use items where reusable items could be used (e.g., using washable plates rather than paper plates);
- Purchasing supplies with minimal or recyclable packaging;
- Using reusable and/or biodegradable materials;
- Ordering only what is needed;
- Storing products properly to prevent spillage or contamination;
- Keeping product containers in good condition, clearly labeled; and
- Maintaining good housekeeping and maintenance of facilities.

5.1 WASTE CATEGORIES

Descriptions of the recoverable materials, common waste types, and categories expected to be generated by EEPGL's development projects have been summarized in Table 3.

Table 3: Recoverable Materials, Waste Types, and Categories

#	Waste Category	Waste Types
1	Non-hazardous wastes	General & domestic trash, incinerator ash & residue (must be tested), production solids (e.g. scale, sand), dry filters, abrasive blast media, filter media, desiccant/drying agents
2	Recyclable materials	Wood, paper, cardboard, glass, aluminum cans, plastic, scrap metal including metal packaging, clean empty steel drums, empty/punctured aerosol cans
3	Hazardous waste liquids	Used lube/motor oil, contaminated hydrocarbons (crude, diesel, etc.), oily water, contaminated water-based drilling fluid, non-aqueous drilling fluid, drilling slops, well treatment & completion fluids, waste brines, treatment chemicals, liquid paint waste, drum/container rinse, acid & caustic solutions, hydraulic fluid
4	Hazardous waste solids	Production solids & sludges, oily trash/debris, oily/wet filters, drums/containers with chemical residues, dried paint waste, consumables (e.g. non-empty aerosol cans, oil filters, grease tubes, dope brushes)
5	Special hazardous wastes	Medical/biological waste, batteries (including alkaline, lead-acid, nickel-cadmium), fluorescent light bulbs & ballasts, mercury and mercury-containing equipment, radioactive waste including Naturally Occurring Radioactive Material, electronic waste

5.2 WASTE MANAGEMENT PRACTICES

The key waste management practices covered by this WMP include:

- Proper waste classification and identification;
- Proper handling, segregation, and storage;
- Proper recycling, reclaiming, or recovery; and
- Proper treatment and disposal.

Each of the categories and individual types of wastes listed above has been summarized, with the preferred waste management practices to be used, in Table 4.

Table 4: Preferred Waste Management Practices

Preferred Waste Management Practices	Recoverable Materials and Waste Streams
Recycle	Plastic, glass, scrap metal including empty steel drums and empty/punctured aerosol cans
Landfill	General trash, used PPE, dessicant and other drying agents, filter media, abrasive blast media, uncontaminated cement, incinerator ash and other hazardous waste treatment residues that have been tested to ensure they are safe for land disposal
Recycle into FPSO Process	When possible, the following will be recycled into the FPSO production/separation process: used lube/motor oil, used glycol, oily water, *de minimis* quantities of off-spec product/materials, by-products, oil slops
Offshore Incineration, Non-hazardous Wastes (where applicable)	Wood, paper, cardboard, general trash
Offshore Incineration, Hazardous Wastes (where applicable)	Used lube/motor oil (when not possible to recycle into FPSO process), contaminated hydrocarbons (crude, diesel, etc.), oil filters and oily debris (rags, gloves, wood, vegetation, sorbent pads, paper, etc.), paint waste, medical waste
Onshore Treatment*	Drilling slops (mixture of used drilling muds, water, cement spacer, additives), oil-contaminated cement and completion brines, used drilling muds not discharged w/ cuttings, production sludges and solids, tank bottom sludge, pigging waste, used and unused chemicals/solvents, hazardous drum rinse, oily water, contaminated drums, containers, packaging, non-empty aerosol cans, batteries (lead acid, nickel-cadmium, lithium, mercury cell), electrical/electronic waste, mercury-containing equipment (e.g. thermometers and other instruments; should be very little), radioactive/NORM waste (only in case that it is produced)

*After treatment of hazardous wastes, the residual non-hazardous solid wastes that are not recycled, reclaimed, or reused will be transported for disposal in an approved landfill.

5.3 WASTE CLASSIFICATION

Proper waste management begins with an accurate classification of each waste, which is critical for safe storage, transportation, and treatment/disposal planning. This will be based on generator processes and process knowledge, review of manufacturers' SDSs, product specifications, and select laboratory testing and analysis, as required to ensure the hazards are known for each waste including whether they are flammable, corrosive (acid or base), reactive (oxidizer, pyrophoric, reducer), and/or toxic.

Whenever supporting analytical results are necessary to initially profile and characterize a waste stream, the following analytical tests will commonly be performed:

- Ignitability (flashpoint);
- Corrosivity (pH);
- Toxicity (Toxicity Characteristic Leaching Procedure metals, and in some cases volatiles); and
- Reactivity (reactive sulfides, reactive cyanides).

The disposal contractor will be consulted to ensure appropriate analytical methods and tests are performed. EEPGL will audit and approve labs used to analyze EEPGL's waste and other materials.

Waste sampling will be performed by properly trained personnel using the appropriate PPE. Samples will be packaged in appropriate containers and properly labeled. A chain of custody form (sample provided in Attachment E) must accompany samples during transport.

5.4 HANDLING OF WASTES

Personnel involved in the handling of hazardous/scheduled wastes must recognize and understand the associated potential hazards and will be trained to a level commensurate with their job duties.

Standard PPE for hazardous/scheduled waste-handling activities includes the following:

- Gloves: leather or chemically resistant (depending on the type of waste);
- Safety glasses, goggles or face shield;
- Hard hat;
- Steel-toed shoes or boots; and
- Coveralls or other suitable work clothes.

Additional PPE may be required for specific hazardous/scheduled wastes (e.g., latex boot covers, respirator). Further information is also contained in the SDSs.

5.5 HANDLING OF HAZARDOUS MATERIALS

Hazardous materials will be stored in designated areas where the potential for damage to containers is minimized (e.g., paint stored in paint locker, acids stored in enclosed areas, etc.). Additionally, hazardous materials will be stored in areas with adequate containment.

Any hazardous materials transported for use will not be accepted by the drill ships; FPSOs; installation, supply and support vessels, or other users unless the following requirements are met:

- Appropriate SDSs must accompany the materials;
- Materials have been accounted for under the Guyana Revenue Authority Investment Development Agreement;
- Applicable requirements have been met for materials import, customs clearance, and use; and
- Materials have been approved under the Guyana Pesticides and Toxic Chemicals Control Act of 2000 (if applicable).

Hazardous materials will be transported in proper containers affixed with a hazardous waste label and placard(s) indicating the applicable hazard class(es). Placards containing internationally recognized symbols exist for the following hazard classes (see Attachment I):

1. Explosives
2. Flammable liquids
3. Flammable solids or waste solids other than explosives which may be readily combustible
4. Oxidizing substances
5. Organic peroxides
6. Poisonous substances
7. Infectious substances
8. Corrosives
9. Toxic gases
10. Toxic substances which if inhaled or ingested may cause delayed or chronic effects
11. Ecotoxic substances which, if released, may present immediate or delayed adverse impacts to the environment by means of bioaccumulation and/or toxic effects upon systems; and
12. Materials capable, after disposal, of yielding another material that possesses any of the characteristics specified in items 1–11.

Containers with hazardous materials transferred to and from the drill ships; FPSOs; installation, supply, and support vessels, and onshore work locations must be clearly identified on cargo manifests, properly placarded per the hazard classes listed above, and accompanied by SDSs, as applicable.

5.6 WASTE SEGREGATION AND STORAGE

Waste generated will be collected in appropriately labeled bin collectors, tanks, bottles, drums, or other designated receptacle. Proper containers will be used for hazardous and non-hazardous materials, chemicals, and wastes. For liquid hazardous materials and wastes, spill prevention controls will be in place to prevent a release to the environment during marine transport, handling, and storage—including use of primary containers in good condition as well as a second barrier of protection for liquid hazardous materials and wastes in the form of certified offshore CCUs (cargo carrying units). All vessels are equipped with spill response materials in the event of a spill from a container on the deck of the vessel.

Non-hazardous waste, including recyclables, will be physically separated from Hazardous Waste (HW) and segregated by type in order to:

- Maximize the possibilities for waste recycling or reuse;
- Minimize the possibility of contamination of non-hazardous wastes by HW;
- Ensure that waste storage is contained; and
- Ensure the proper management of each specific waste;

Additionally, the following segregation and storages practices will be utilized:

- Wastes will be stored in containers that are in good condition and compatible with characteristics of the materials in question;
- Sealable containers will be provided for hazardous/scheduled wastes;
- Incompatible wastes will be segregated to minimize potential chemical reactions;
- Containers bearing wastes will be labeled in accordance with regulatory requirements; and
- Different types of HW will be stored separately from each other and from non-hazardous waste.

Containers bearing wastes will be labeled with the following information:

- Classification (i.e., hazardous or non-hazardous);
- Name/description of the waste
- Applicable hazardous waste characteristics (see list in Section 6.5);
- Physical state of the waste (i.e., solid or liquid).

In addition to the requirements stated above, HW containers will be labeled with the following information:

- Name and address of EEPGL;
- Placard(s) corresponding to the applicable hazard class(s) (during transport only); and
- Packaging or start of accumulation date.

HWs will be labelled in the specified format as follows:

- The size of the label should not be less than 20 centimeters (cm) x 30 cm [7.9 inches (in) x 11.8 in];
- Labels should have a yellow background with black lettering conspicuously marked in paint or another permanent form of marking;
- The material of the label should be scratch proof, resistant to tampering and able to withstand open weather exposure;
- Generally, the label should be attached to the side of the vessel, container, tank, or containment building. In case of a vessel, container, tank, or containment building that is used repeatedly, the label should ideally be a plate that is hung on the side of it. For containment buildings, hazardous wastes types contained in the building should be included on the plate;
- The label should identify the hazardous characteristic(s) of the waste (e.g., flammable, corrosive, toxic)

The basic label form is provided below in Table 5. Labelling procedures should be completed at the location where the waste was generated and should be retained at the destination treatment, storage, and disposal facilities.

Table 5: Basic Label Form

Hazardous Waste		
Waste Information	Waste type / description	Name and/or description of the waste/material
	Waste Classification	Hazardous or non-hazardous
	Hazard Class	Name of the hazard class (see placards in Attachment I; e.g. Toxic, Corrosive, Flammable, Explosive, Reactive, Infectious)
	Physical Form	Liquid, Solid, or Sludge
	Quantity	Quantity of the hazardous waste contained in the vessel, container or tank
	Packaging date	Date the hazardous waste is packed in the vessel, container or tank
	Shipping date	Date the hazardous waste must be removed from the storage area and transported off site if applicable
	Waste transport record number	Manifest number if transported off site
Container Information	Capacity	Maximum capacity or volume of the container
	Material	Material that a vessel, container or tank is made of
Generator Information	Name	Name of the waste generator (company name)
	Address	Address of the waste generator
	Telephone #	Telephone number of the waste generator

5.7 WASTE TRACKING PROCESS

A Marine Transport Manifest (sample included in Attachment F) will be used for vessel shipments of hazardous and non-hazardous wastes and must contain the types and quantities of hazardous and non-hazardous wastes being transported.

Additionally, a waste manifest (sample included in Attachment G) and waste information data sheet (sample included in Attachment H) will be completed and must accompany shipments of hazardous and non-hazardous wastes. This includes over-water shipments as well as land shipments. The purpose of this manifest is to track each shipment of waste from the point of generation to the point of final treatment, recycling or disposal. EEPGL is responsible for completing waste manifests prior to shipment.

In compliance with MARPOL 73/78, marine vessels, including the supply, support, and installation vessels, as well as the drill ships, and FPSOs, will maintain a Garbage Record Book and record of used oil generated (See Attachments C and D). The Garbage Record Books can be modified to allow tracking of project-related wastes outside the scope of the categories

specified in MARPOL 73/78; therefore, this will be referred to as a Waste/Garbage Record Book in the remainder of this document.

Vessels must retain copies of Marine Transport Manifests and waste manifests with the Waste/Garbage Record Book for a minimum of two years.

5.8 WASTE TRANSFER TO SHORE

Marine vessels used to transport waste will be required to have necessary licenses and approval from the Guyana authorities. Crews on vessels that transport hazardous waste will have training in basic emergency response, and knowledge of labeling and placarding requirements.

Vessels transporting waste will carry both a completed Marine Transport Manifest (see Attachment F), a completed waste manifest (see example in Attachment G), and a waste information data sheet (see Attachment H). These documents will contain the name, description, and quantity of wastes being transported.

Waste containers will be labeled per the requirements described in Section 6.6. Hazardous waste containers will be affixed with the appropriate placard(s) corresponding to the hazard class(es) of the waste being transported.

EEPGL will confirm vessel waste transporters and shipments meet the requirements above and that vessel crews have completed and documented compliance with the minimum training requirements.

5.9 WASTE TRANSFER FROM SHORE TO OFFSITE WASTE MANAGEMENT FACILITY

Vehicles used to transport waste from the shore to offsite waste management facilities will be required to have necessary licenses and approval from the Guyana authorities. Crews that transport hazardous waste will have training in basic emergency response and knowledge of labeling and placarding requirements. Vehicles transporting waste will carry a completed waste manifest (see example in Attachment G). This document will contain the names, descriptions, and quantities of wastes being transported.

Waste containers will be labeled per the requirements described in Section 6.6. Hazardous waste containers will be affixed with the appropriate placard(s) corresponding to the hazard class(es) of the waste being transported.

EEPGL will confirm vehicle waste transporters and shipments meet the requirements above and that crews have completed and documented compliance with the minimum training requirements.

6 WASTE MANAGEMENT METHODS

The following treatment and disposal methods may be employed to manage EEPGL development project waste:

- **Offshore:**
  - Incineration (where applicable);
  - Discharge (macerated food);
  - Other methods allowed by Environmental Permit.
- **Onshore:**
  - Incineration;
  - Other thermal treatment (e.g., thermal desorption);
  - Neutralization;
  - Stabilization (e.g., solidification);
  - Bioremediation;
  - Liquid waste treatment;
  - Burial disposal (landfill);
  - Beneficial reuse.

EEPGL's contracted waste service providers will be expected to furnish required equipment and facilities for the storage, handling, transportation, treatment, and disposal of hazardous and non-hazardous waste brought onshore. In some cases (e.g., special hazardous wastes), waste may need to be shipped to other approved facilities owned and/or operated by a different service provider.

6.1 INCINERATION/THERMAL TREATMENT

Thermal treatment, including incineration, is a preferred technology for the management of combustible solid wastes and liquid wastes. It can be performed utilizing a variety of incinerators (single and dual chamber), thermal desorption units, or other thermal treatment technologies. The design basis for the drill ships and FPSOs may include incinerators designed to handle the types and quantities of combustible wastes specified in this WMP and capable of destroying hazardous constituents in those waste streams. EEPGL's contracted waste service providers may also utilize incineration or other forms of thermal treatment for hazardous and non-hazardous wastes that cannot be managed offshore. Incinerator ash and residue will be analyzed as described in Section 6.3 to assess suitability for land disposal prior to shipment to the landfill. There can be an expected 75 - 85 percent reduction by volume for incinerated solid wastes, and a significantly higher percent reduction for incinerated liquid wastes.

6.2 NEUTRALIZATION

Neutralization is an effective treatment method for certain waste acids and caustics; it involves mixing of the waste with other materials to raise or lower the pH to a more neutral level. Appropriate health and safety considerations must be taken and specific controls put in place when performing neutralization. It is important to verify that waste liquids can be safely neutralized prior to mixing with materials, which can often result in an exothermic reaction. Commonly used chemicals for neutralization are 98 percent sulfuric acid (to neutralize a base) and 50 percent sodium hydroxide or calcium hydroxide (lime) (to neutralize an acid).

6.3 STABILIZATION

Stabilization can be any process used to alter the physical or chemical properties of a waste to render it more amenable for land disposal or further treatment. One form of stabilization is solidification, in which waste is physically or chemically bound or encapsulated in a stabilizing material to form a hardened block that will reduce the tendency of constituents of concern (e.g., metals) to be released or leached into the environment. Common binding agents or stabilizing materials are cement, clay, fly ash, or asphalt. Stabilization/solidification is sometimes used as a secondary treatment following incineration for wastes that may have residual leachable constituents after volatiles and hydrocarbons have been removed through thermal treatment.

6.4 BIOREMEDIATION

Bioremediation can be an effective form of treatment for organic wastes, such as hydrocarbon or hydrocarbon-contaminated wastes (e.g., hydrocarbon-impacted soil). Bioremediation is often performed in open pits or other open spaces where naturally occurring or added organisms are used to break down the organic material in the waste until biodegradable constituents are reduced to a level suitable for land disposal. A synthetic liner is one example of a potential barrier to protect groundwater sources beneath the bioremediation area, and other engineering controls are often considered during facility design as measures to reduce potential runoff or other migration of potential contaminants outside of the designated bioremediation area. EEPGL has strict criteria for which wastes are eligible for bioremediation (generally only exploration and production wastes in which hydrocarbons are demonstrated through analytical testing to be the only hazardous constituent present). Once the hydrocarbon content of bioremediated waste is reduced to 5 percent or less, it can become eligible for beneficial reuse.

6.5 LIQUID WASTE TREATMENT

There are a variety of forms of industrial liquid waste treatment that can be used to remove hazardous constituents from liquid wastes, making them more amenable to land disposal. A properly designed treatment plant is the preferred management method for large volume liquid wastes, such as slops, oily water, or washwater from vessel tank cleanouts.

6.6 BURIAL DISPOSAL (LANDFILL)

Non-hazardous solid wastes that are not recycled, reclaimed, or reused will be transported for disposal in an approved and permitted landfill. Wastes must be demonstrated to meet standards for land disposal through generator knowledge or analytical testing prior to landfilling. In Guyana, the Haags Bosch Landfill has been permitted by the Guyana EPA and is managed by the Ministry of Communities. Should additional engineered landfills become available in Guyana, those will be assessed and reviewed for use.

6.7 BENEFICIAL REUSE

It may be possible to use production wastes for beneficial purposes. EEPGL has strict standards for when a waste is eligible for beneficial reuse. Untreated wastes that are demonstrated through analytical testing to meet certain criteria (e.g., hydrocarbon content less than 5 percent and other constituents of concern below levels that could cause harm to the environment) can be eligible for beneficial reuse. Wastes that do not initially meet these criteria may be treated to meet the standard. Such reuse can offer important environmental benefits such as waste minimization (avoids unnecessarily using up landfill space), dust suppression, and improved road maintenance.

7 SPILL AND EMERGENCY RESPONSE

EEPGL, other waste generators (e.g., marine vessel operators), waste transporters, and waste service providers will have Emergency Response Plans to address possible emergency contingencies such as spills, fires, and explosions. These plans include specific and actionable steps for multiple risk scenarios. The action steps and the resources applied increase as the seriousness of the emergency or release increases. Tier I (lowest level) emergencies will be handled by local resources. In the case of scenarios outside the local capability (i.e., Tiers II and III), EEPGL will activate its Regional Response Team. The Regional Response Team is a large group of responders that have been trained for response actions around the world. The Emergency Response Plans also include required internal and external incident communications processes and contact numbers.

7.1 OIL SPILL CLEANUP – WASTE MANAGEMENT

Waste generated as a result of oil spill cleanup activities will be managed in accordance with this WMP, EEPGL's Oil Spill Response Plan, and Guyana laws and local regulations. The typical waste streams associated with a cleanup could include recovered product not able to be reintroduced into the system, oily water, absorbent materials, decontamination materials, contaminated trash and debris, general trash and debris, and affected vegetation/foliage, among others. Should a significant oil spill occur, an incident-specific WMP may be developed as part of the response. Additional waste management provisions including procedures for the disposition of deceased wildlife can be found in the EEPGL Oil Spill Response Plan.

8 WASTE MONITORING AND REPORTING GUIDELINES

Monitoring and reporting of those recoverable materials and wastes and their final management are critical components to the successful implementation of this WMP.

8.1 WASTE MONITORING

The waste monitoring program will be facilitated by regular inspections conducted by EEPGL. A summary of monitoring guidelines is provided in Table 6.

Table 6: Waste-Monitoring Guidelines

Monitoring Activity	Frequency	Originator	Documentation
Record type and quantity of each new individual waste stream onboard	Any time new waste is generated	Dedicated personnel on vessels	Waste/Garbage Record Book; Oil Record Book; Incinerator Log
Inspect waste storage area and containers; log inspections	Daily	Dedicated personnel on vessels, at shorebases, and at Waste Management Service Provider's facilities	Daily inspection log
Document marine waste transfer	Each instance waste is transported	Dedicated personnel on vessels and at shorebases	Marine Transport Manifest and Waste Manifest
Sample and perform analytical testing	As needed to properly classify waste	Waste Management Service Provider / EEPGL	Chain of Custody; Laboratory analysis results
Complete Recoverable Material and Waste Summaries	Monthly; Annual	Waste Management Service Provider / EEPGL	Monthly Waste Inventory and Annual Waste Summary Report
Complete and submit reports required per the Environmental Permit	Dependent on final permit conditions	EEPGL	End of Survey, End of Well, End of Stage Reports, EPA Recording and Reporting Form, any other reports required by Environmental Permit
Waste facility audits & inspections	Periodic	EEPGL	Inspection logs & reports

8.2 WASTE RECORDKEEPING AND REPORTING

Waste management performance will be measured against agreed-upon reporting and recordkeeping requirements including:

- Types and volumes of wastes (hazardous and non-hazardous) generated;
- Maintenance of required vessel Waste/Garbage Record Book and Oil Record Books;
- Maintenance of required incinerator logs;
- Maintenance of Marine Transport Manifests and waste manifests to document custody transfer and the final means of disposition for each recyclable material and waste;
- Preparation of waste reports required per the Environmental Permit, such as the Guyana EPA Recording and Reporting Form shown in Attachment B;
- Maintenance of monthly waste inventories;
- Preparation of annual waste management summary reports;
- Routine inspections and periodic assessments of Waste Management Service Provider's facilities; and
- Maintenance of hazardous substances / chemical inventory register and transboundary shipment forms, if required. These forms should be kept by EEPGL personnel at either the shorebases or venture office.

Any issue of non-compliance will be tracked and documented in a monthly report.

9 WASTE TRAINING

General training will be conducted for EEPGL personnel, contractors, and any others - as appropriate - that will be involved with recoverable material and waste generation and management during the life of EEPGL's development projects. This training will cover:

- EEPGL Waste Management Practices;
- Environmental Permit requirements;
- Typical waste streams;
- Identification, classification, and labelling of hazardous and non-hazardous waste;
- Handling, segregation, storage, and treatment/disposal options;
- PPE requirements; and
- Waste management during normal operating conditions, as well as emergencies.

In addition to the general waste management training, additional offshore- and onshore-specific waste training will be provided to the appropriate personnel.

9.1 OFFSHORE WASTE MANAGEMENT TRAINING

EEPGL personnel and contractors working offshore will attend a training focused on waste management in the offshore environment. This training will support compliance with both Guyana regulations as well as EEPGL's responsible waste management practices. Topics to be covered in these trainings will include, but not be limited to:

- Opportunities to minimize waste generation;
- Waste generation offshore and potential impacts on marine life;
- Specific types of hazardous and non-hazardous waste that can be generated offshore and associated risks;
- Handling, storing, and transporting wastes, with particular focus on hazardous waste to ensure safety of personnel and environment; and
- Waste tracking, monitoring, and auditing standards and practices.

9.2 ONSHORE WASTE MANAGEMENT TRAINING

Onshore waste management training will be conducted for EEPGL personnel and contractors as appropriate. The waste management service providers will also provide training for their waste management personnel and verify training has been performed for waste transporters. This training will cover more specific topics, including:

- Application of Guyana laws and guidelines;
- Opportunities to minimize onshore waste generation;
- Waste generation onshore and potential risks to health, safety, and the environment;
- Specific types of hazardous and non-hazardous wastes that can be generated offshore and sent to shore for treatment/disposal, as well as potential waste generated from onshore activities;
- Handling, storing, and transporting wastes onshore, with particular focus on hazardous waste to ensure safety of personnel and the environment; and
- Waste tracking, monitoring, and auditing standards and practices.

ATTACHMENT A PROJECT DESCRIPTIONS, WASTES, MANAGEMENT METHODS, AND ESTIMATED ANNUAL QUANTITIES

A.1 Liza Phase 1 Project

A.1.1 Project Description

The Liza Phase 1 Project proposes to develop the offshore resource by drilling approximately 17 subsea development wells and using a FPSO vessel to process, store, and offload 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, produced water) from production wells to the FPSO, as well as treated gas and water from the FPSO to the injection wells.

The Liza Phase 1 Project consists of five primary stages: drilling, installation, hook-up and commissioning, production operations, and decommissioning. The Liza Phase 1 Project will generate a variety of recoverable materials as well as solid, semi-solid, and liquid wastes that are both hazardous and non-hazardous, which will vary over time by Liza Phase 1 Project stage. Updated estimated recoverable materials, waste types, and volumes to be generated during each stage of the Liza Phase 1 Project are provided herein.

Waste volumes generated will increase early in the Liza Phase 1 Project as concurrent drilling and SURF installation activities occur from 2018 - 2019, which are then followed by the hookup and commissioning of the FPSO. Waste volumes will then begin to decrease as drilling activities conclude in 2020, and will significantly decrease thereafter during the stage of production operations alone from 2021 to approximately 2040. When production operations cease, some waste will be generated during the decommissioning stage.[2]

[2] Any dates specified in this document are based on the current Liza Phase 1 Project schedule, which is subject to change. They are provided to help conceptualize anticipated duration of each Liza Phase 1 Project stage.

Summary Liza Phase 1 Project Waste Estimate

	Volume By Year / Metric Tonnes				
Waste Generated by Category	**2019**	**2020**	**2021**	**2022-2039**	**2040**
Non-Hazardous (total) [a]	580	630	330	330	330
Hazardous (total) [a]	3180	2090	300	300	300
Totals by Management Method / Final Destination					
Landfill	330	400	220	220	220
Recycle (if feasible) or Landfill	310	290	130	130	130
Solids Thermal Treatment at Approved Third Party Facility / Landfill *	420	270	70	70	70
Liquids Wastewater Treatment / Thermal Treatment and/or Discharge Onshore at Approved Third Party Facility	2680	1740	180	180	180
Special Waste / Send to Approved Facility	10	20	20	20	20

*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.

[a] Totals may not sum exactly due to rounding.

Liza Phase 1 Project Waste Future Estimates, Hazardous Wastes*

Waste Information: Hazardous Wastes				Volume By Year / Metric Tonnes				
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2019	2020	2021	2022-2039	2040
Contaminated drums, containers, packaging (metal)	Operations and general maintenance	Rinse - Recycle		10	10	10	10	10
Contaminated drums, containers, packaging (plastic)	Operations and general maintenance	Rinse - Landfill		60	50	10	10	10
Batteries (Lead Acid, Nickel-Cadmium, Lithium, Mercury Cell)	Instruments and small equipment	Send to approved/ permitted facility	Store pending availability of such facilities or transboundary shipment	10	20	20	20	20
Electrical/electronic waste	Instruments and computer related equipment	Send to approved/ permitted facility	Store pending availability of such facilities or transboundary shipment	3	1	1	1	1
Mercury-containing equipment	Asset maintenance	Send to approved/ permitted facility	Store pending availability of such facilities or return to supplier/vendor	<1	<1	<1	<1	<1
Radioactive waste	Naturally Occurring Radioactive Material	Send to approved/ permitted facility	Store pending availability of such facilities or transboundary shipment	0	1	1	1	1
Fluorescent bulbs	Replacement of light tubes	Thermal treatment (onshore)		<1	<1	<1	<1	<1

Waste Information: Hazardous Wastes				Volume By Year / Metric Tonnes				
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2019	2020	2021	2022-2039	2040
Aerosol Cans	General maintenance activities	Thermal treatment (onshore)		2	1	1	1	1
Contaminated hydrocarbons (contaminated crude, diesel, etc.)	General maintenance activities and spill response	Thermal treatment (onshore)	When practicable, recycle into FPSO process	20	10	5	5	5
Medical waste	First aid and routine clinical procedures	Thermal treatment (onshore)	Offshore incineration (where practicable)	1	1	1	1	1
Oil sludge/Tank bottom sludge	Operations and vessel equipment maintenance	Thermal treatment (onshore)		50	20	20	20	20
Oily Debris (rags, filter, gloves, wood, vegetation, sorbent pads, paper, etc.)	Routine operations & maintenance, rags and oil spill clean-up activities	Thermal treatment (onshore)	Offshore incineration (where practicable)	50	50	40	40	40
Paint waste	Equipment and facilities activities and maintenance during all phases	Thermal treatment (onshore)		10	4	1	1	1
Sack Waste (contaminated)	Mixing chemicals / muds	Thermal treatment (onshore)		2	1	0	0	0
Slops containing used drilling muds (NAF), cement spacer, chemical additives, washwater	Drilling operations	Thermal treatment (onshore)		280	160	0	0	0
Used lube oil/motor oil	Equipment and vehicle maintenance and repair (of internal-combustion engines, pumps, and compressors)	Thermal treatment (onshore)	When practicable, recycle into FPSO process	10	10	10	10	10

Waste Information: Hazardous Wastes				Volume By Year / Metric Tonnes				
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2019	2020	2021	2022-2039	2040
Unused or contaminated solvents/ chemicals	Operations, wastewater or water treatment systems, laboratories	WWT / Thermal Treatment (onshore)		10	60	60	60	60
Oil contaminated completion fluids	Well completion activities	WWT / Thermal Treatment (onshore)	When practicable, recycle into FPSO process	20	10	0	0	0
Glycol	Operations and vessel equipment maintenance	WWT / Thermal Treatment (onshore)	When practicable, recycle into FPSO process	3	10	10	10	10
Oily water	Tank and operating equipment cleaning	WWT / Thermal Treatment (onshore)	When practicable, recycle into FPSO process	10	10	10	10	10
Vessel Tank Cleanout (Liquids)	Drilling operations, general maintenance activities	WWT / Thermal Treatment (onshore)		2620	1630	100	100	100
Wash water	Pipe cleaning	WWT / Thermal Treatment (onshore)		20	20	5	5	5

*After treatment of hazardous wastes, the residual non-hazardous solid wastes that are not recycled, reclaimed, or reused will be transported for disposal in an approved landfill.

Liza Phase 1 Project Waste Future Estimates: Non-Hazardous Wastes

Waste Information: Non-Hazardous Wastes				Volume By Year / Metric Tonnes				
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2019	2020	2021	2022-2039	2040
Bulk Solids (Uncontaminated)	Barite, cement, blast media, dessicant, silica. Vessel dry bulk Tank cleaning	Landfill		120	80	10	10	10
General/Domestic Trash (non-recyclable)	Discarded items from kitchen, living quarters, bathroom, laundry, warehouse, offices	Landfill		130	260	200	200	200
Sack Waste (uncontaminated)	Cement mixing processes	Landfill		10	10	0	0	0
Incinerator Ash (offshore)	Incinerator (FPSO)	Landfill		0	0	0	0	0
Scrap metal	Equipment maintenance, metal packaging	Recycle (if feasible)	Landfill	120	110	50	50	50
Dry Filters	General Maintenance	Recycle (if feasible)	Landfill	2	10	10	10	10
Paper & Cardboard	Paper & Cardboard packaging, documents	Recycle (if feasible)	Landfill	30	20	20	20	20
Wood	Wooden pallets, construction, general maintenance	Recycle (if feasible)	Landfill	140	110	30	30	30
Recyclable domestic trash (plastic & glass)	Discarded items from, kitchen, living quarters, bathroom, laundry, warehouse, offices	Recycle (if feasible)	Landfill	20	20	20	20	20

A.2 Liza Phase 2 Project

A.2.1 Project Description

The Liza Phase 2 Project proposes to develop the offshore resource by drilling approximately 30 subsea development wells and using a FPSO vessel to process, store, and offload recovered oil. The FPSO will be connected to the wells via associated equipment, collectively referred to as SURF, to 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 the injection wells.

The Liza Phase 2 Project consists of five primary stages: drilling, installation, hook-up and commissioning, production operations, and decommissioning. The Liza Phase 2 Project will generate a variety of recoverable materials as well as solid, semi-solid, and liquid wastes that are both hazardous and non-hazardous, which will vary over time by Liza Phase 2 Project stage. Updated estimated recoverable materials, waste types, and volumes to be generated during each stage of the Liza Phase 2 Project are provided herein.

As per the current Liza Phase 2 Project schedule, waste could be generated as early as 2020. Waste volumes generated will increase early in the project as concurrent drilling and SURF installation activities occur from 2020 - 2022, which are then followed by the hookup and commissioning of the FPSO. Waste volumes will then begin to decrease as drilling activities conclude in 2023 and significantly decrease thereafter during the stage of production operations alone from 2024 to approximately 2042. When production operations cease, some waste will be generated during the decommissioning stage.[3]

[3] Any dates specified in this document are based on the current Liza Phase 2 Project schedule, which is subject to change. They are provided to help conceptualize anticipated duration of each Liza Phase 2 Project stage.

Liza Phase 2 Project Waste Estimates

Waste Generated by Category	Volume By Year / Metric Tonnes					
	2020	2021	2022	2023	2024-2041	2042
Non-Hazardous (total) [a]	1050	1050	1220	830	530	530
Hazardous (total) [a]	6210	6200	6350	3370	480	480
Totals by Management Method / Final Destination						
Landfill	630	630	740	520	350	350
Recycle (if feasible) or Landfill	550	550	620	390	210	210
Solids Thermal Treatment at Approved Third Party Facility / Landfill*	720	720	760	410	120	120
Liquids Wastewater Treatment / Thermal Treatment and/or Discharge Onshore at Approved Third Party Facility	5340	5340	5430	2850	300	290
Special Waste / Send to Approved Facility	20	20	30	30	40	40

*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.
[a] Totals may not sum exactly due to rounding.

Liza Phase 2 Project Waste Estimates, Hazardous Wastes *

Waste Information: Hazardous Wastes				Volume By Year / Metric Tonnes					
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2020	2021	2022	2023	2024-2041	2042
Contaminated drums, containers, packaging (metal)	Operations and general maintenance	Rinse - Recycle		10	10	10	10	20	20
Contaminated drums, containers, packaging (plastic)	Operations and general maintenance	Rinse - Landfill		120	120	130	70	20	20
Batteries (Lead Acid, Nickel-Cadmium, Lithium, Mercury Cell)	Instruments and small equipment	Send to approved/permitted facility	Store pending availability of such facilities or transboundary shipment	10	10	20	20	30	30
Electrical/electronic waste	Instruments and computer related equipment	Send to approved/permitted facility	Store pending availability of such facilities or transboundary shipment	2	2	3	1	2	2
Mercury-containing equipment	Asset maintenance	Send to approved/permitted facility	Store pending availability of such facilities or return to supplier/vendor	0	0	0	0	0	0
Radioactive waste	Naturally Occurring Radioactive Material	Send to approved/permitted facility	Store pending availability of such facilities or transboundary shipment	0	0	0	1	1	1
Fluorescent bulbs	Replacement of light tubes	Thermal treatment (onshore)		1	1	1	0	0	0

Waste Information: Hazardous Wastes				Volume By Year / Metric Tonnes					
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2020	2021	2022	2023	2024-2041	2042
Aerosol Cans	General maintenance activities	Thermal treatment (onshore)		1	1	2	1	2	2
Contaminated hydrocarbons (contaminated crude, diesel, etc.)	General maintenance activities and spill response	Thermal treatment (onshore)	When practicable, recycle into FPSO process	30	30	40	20	10	10
Medical waste	First aid and routine clinical procedures	Thermal treatment (onshore)	Offshore incineration (where practicable) [a]	1	1	1	1	1	1
Oil sludge/Tank bottom sludge	Operations and vessel equipment maintenance	Thermal treatment (onshore)		50	50	60	30	20	20
Oily Debris (rags, filter, gloves, wood, vegetation, sorbent pads, paper, etc.)	Routine operations & maintenance, rags and oil spill clean-up activities	Thermal treatment (onshore)	Offshore incineration (where practicable) [a]	50	50	80	60	70	70
Paint waste	Equipment and facilities activities and maintenance during all phases	Thermal treatment (onshore)		10	10	10	10	2	2
Sack Waste (contaminated)	Mixing chemicals / muds	Thermal treatment (onshore)		5	5	5	2	0	0
Slops containing used drilling muds (NAF), cement spacer, chemical additives, washwater	Drilling operations	Thermal treatment (onshore)		560	560	560	280	0	0

Waste Information: Hazardous Wastes				Volume By Year / Metric Tonnes					
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2020	2021	2022	2023	2024-2041	2042
Used lube oil/motor oil	Equipment and vehicle maintenance and repair (of internal-combustion engines, pumps, and compressors)	Thermal treatment (onshore)	When practicable, recycle into FPSO process	10	10	10	10	10	10
Unused or contaminated solvents/chemicals	Operations, wastewater or water treatment systems, laboratories	WWT / Thermal Treatment (onshore)		4	4	30	60	90	90
Oil contaminated completion fluids	Well completion activities	WWT / Thermal Treatment (onshore)	When practicable, recycle into FPSO process	30	30	30	20	0	0
Glycol	Operations and vessel equipment maintenance	WWT / Thermal Treatment (onshore)	When practicable, recycle into FPSO process	2	2	10	10	20	20
Oily water	Tank and operating equipment cleaning	WWT / Thermal Treatment (onshore)	When practicable, recycle into FPSO process	20	20	20	20	20	20
Vessel Tank Cleanout (Liquids)	Drilling operations, general maintenance activities	WWT / Thermal Treatment (onshore)		5250	5250	5300	2720	160	160
Wash water	Pipe cleaning	WWT / Thermal Treatment (onshore)		40	40	40	20	10	10

* 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.

[a] The Liza Phase 2 FPSO and development drill ships are not anticipated to have incinerators onboard.

Liza Phase 2 Project Waste Estimates, Non-Hazardous Wastes

Waste Information: Non-Hazardous Wastes				Volume By Year / Metric Tonnes					
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2020	2021	2022	2023	2024-2041	2042
Bulk Solids (Uncontaminated)	Barite, cement, blast media, dessicant, silica. Vessel dry bulk Tank cleaning	Landfill		250	250	250	130	10	10
General/Domestic Trash (non-recyclable)	Discarded items from kitchen, living quarters, bathroom, laundry, warehouse, offices	Landfill		240	240	340	310	320	320
Sack Waste (uncontaminated)	Cement mixing processes	Landfill		20	20	20	10	0	0
Incinerator Ash (offshore)	Incinerator (FPSO)	Landfill [a]		0	0	0	0	0	0
Scrap metal	Equipment maintenance, metal packaging	Recycle (if feasible)	Landfill	230	230	250	160	80	80
Dry Filters	General Maintenance	Recycle (if feasible)	Landfill	2	2	10	10	20	20
Paper & Cardboard	Paper & Cardboard packaging, documents	Recycle (if feasible)	Landfill	30	30	40	30	30	30
Wood	Wooden pallets, construction, general maintenance	Recycle (if feasible)	Landfill	270	270	280	160	50	50
Recyclable domestic trash (plastic & glass)	Discarded items from, kitchen, living quarters, bathroom, laundry, cwarehouse, offices	Recycle (if feasible)	Landfill	30	30	30	30	30	30

[a] The Liza Phase 2 FPSO and development drill ships are not anticipated to have incinerators onboard.

A.3 Payara Project

A.3.1 Project Description

The Payara Project proposes to develop the offshore resource by drilling up to approximately 45 subsea development wells and using a FPSO vessel to process, store, and offload recovered oil. The FPSO will be connected to the wells via associated equipment, collectively referred to as SURF, to 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 the injection wells.

The Payara Project consists of five primary stages: drilling, installation, hook-up and commissioning, production operations, and decommissioning. The Payara Project will generate a variety of recoverable materials as well as solid, semi-solid, and liquid wastes that are both hazardous and non-hazardous, which will vary over time by Payara Project stage. Estimated recoverable materials, waste types, and volumes to be generated during each stage of the Payara Project are provided herein.

As per the current project schedule, waste could be generated as early as 2020. Waste volumes generated will increase early in the Payara Project as concurrent drilling and SURF installation activities occur from 2021 - 2023, which are then followed by the hookup and commissioning of the FPSO. Waste volumes will then begin to decrease as drilling activities conclude in 2025 and significantly decrease thereafter during the stage of production operations alone in 2026 to approximately 2044. When production operations cease, some waste will be generated during the decommissioning stage.[4]

[4] Any dates specified in this document are based on the current Payara Project schedule, which is subject to change. They are provided to help conceptualize anticipated duration of each Payara Project stage.

Summary Payara Project Waste Estimate

Waste Generated by Category	Volume By Year / Metric Tonnes							
	2020	2021	2022	2023	2024	2025	2026-2043	2044
Non-Hazardous (total) [a]	250	1070	1100	1320	1340	1340	530	530
Hazardous (total) [a]	1530	6240	6270	6420	6430	6430	480	480
Totals by Management Method / Final Destination								
Landfill	150	640	640	810	830	830	350	350
Recycle (if feasible) or Landfill	130	570	590	650	660	660	210	210
Solids Thermal Treatment at Approved Third Party Facility / Landfill*	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

*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.

[a] Totals may not sum exactly due to rounding.

Payara Project Waste Estimates, Hazardous Wastes *

Waste Information: Hazardous Wastes				Volume By Year / Metric Tonnes							
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2020	2021	2022	2023	2024	2025	2026 - 2043	2044
Contaminated drums, containers, packaging (metal)	Operations and general maintenance	Rinse - Recycle		1	10	10	20	20	20	20	20
Contaminated drums, containers, packaging (plastic)	Operations and general maintenance	Rinse - Landfill		30	120	130	130	130	130	20	20
Batteries (Lead Acid, Nickel-Cadmium, Lithium, Mercury Cell)	Instruments and small equipment	Send to approved/permitted facility	Store pending availability of such facilities or transboundary shipment	2	10	20	30	30	30	30	30
Electrical/electronic waste	Instruments and computer related equipment	Send to approved/permitted facility	Store pending availability of such facilities or transboundary shipment	0	3	3	2	2	2	2	2
Mercury-containing equipment	Asset maintenance	Send to approved/permitted facility	Store pending availability of such facilities or return to supplier/ vendor	<1	<1	<1	<1	<1	<1	0	0

Waste Information: Hazardous Wastes				Volume By Year / Metric Tonnes							
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2020	2021	2022	2023	2024	2025	2026 - 2043	2044
Radioactive waste	Naturally Occuring Radioactive Material	Send to approved/permitted facility	Store pending availability of such facilities or transboundary shipment	0	0	0	1	1	1	1	1
Fluorescent bulbs	Replacement of light tubes	Thermal treatment (onshore)		0	1	1	1	1	1	0	0
Aerosol Cans	General maintenance activities	Thermal treatment (onshore)		0	2	3	1	1	1	2	2
Contaminated hydrocarbons (contaminated crude, diesel, etc.)	General maintenance activities and spill response	Thermal treatment (onshore)	When practicable, recycle into FPSO process	10	30	40	40	40	40	10	10
Medical waste	First aid and routine clinical procedures	Thermal treatment (onshore)	Offshore incineration (where practicable) [a]	0	1	2	1	1	1	1	1
Oil sludge/Tank bottom sludge	Operations and vessel equipment maintenance	Thermal treatment (onshore)		10	60	70	50	50	50	20	20
Oily Debris (rags, filter, gloves, wood, vegetation, sorbent pads, paper, etc.)	Routine operations & maintenance, rags and oil spill clean-up activities	Thermal treatment (onshore)	Offshore incineration (where practicable) [a]	10	70	80	80	80	80	70	70

Waste Information: Hazardous Wastes				Volume By Year / Metric Tonnes							
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2020	2021	2022	2023	2024	2025	2026 - 2043	2044
Paint waste	Equipment and facilities activities and maintenance during all phases	Thermal treatment (onshore)		3	10	10	10	10	10	2	2
Sack Waste (contaminated)	Mixing chemicals / muds	Thermal treatment (onshore)		1	5	5	5	5	5	0	0
Slops containing used drilling muds (NAF), cement spacer, chemical additives, washwater	Drilling operations	Thermal treatment (onshore)		140	560	560	560	560	560	0	0
Used lube oil/motor oil	Equipment and vehicle maintenance and repair (of internal-combustion engines, pumps, and compressors)	Thermal treatment (onshore)	When practicable, recycle into FPSO process	2	10	10	10	20	20	10	10
Unused or contaminated solvents/chemicals	Operations, wastewater or water treatment systems, laboratories	WWT / Thermal Treatment (onshore)		0	5	10	50	60	60	90	90
Oil contaminated completion fluids	Well completion activities	WWT / Thermal Treatment (onshore)	When practicable, recycle into FPSO process	10	30	30	30	30	30	0	0
Glycol	Operations and vessel equipment maintenance	WWT / Thermal Treatment (onshore)	When practicable, recycle into FPSO process	0	2	3	10	10	10	20	20

Waste Information: Hazardous Wastes				Volume By Year / Metric Tonnes							
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2020	2021	2022	2023	2024	2025	2026 - 2043	2044
Oily water	Tank and operating equipment cleaning	WWT / Thermal Treatment (onshore)	When practicable, recycle into FPSO process	3	20	20	20	20	20	20	20
Vessel Tank Cleanout (Liquids)	Drilling operations, general maintenance activities	WWT / Thermal Treatment (onshore)		1310	5250	5250	5340	5350	5350	160	160
Wash water	Pipe cleaning	WWT / Thermal Treatment (onshore)		10	40	40	40	40	40	810	10

* 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.
[a] The Payara FPSO and development drill ships are not anticipated to have incinerators onboard.

Payara Project Waste Estimates, Non-Hazardous Wastes

Waste Information: Non-Hazardous Wastes				Volume By Year / Metric Tonnes							
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2020	2021	2022	2023	2024	2025	2026 - 2043	2044
Bulk Solids (Uncontaminated)	Barite, cement, blast media, dessicant, silica. Vessel dry bulk Tank cleaning	Landfill		62	248	248	255	256	256	13	13
General/Domestic Trash (non-recyclable)	Discarded items from kitchen, living quarters, bathroom, laundry, warehouse, offices	Landfill		55	242	249	406	421	421	320	320

Waste Information: Non-Hazardous Wastes				Volume By Year / Metric Tonnes							
Waste Stream	Waste Source	Primary Management Method Anticipated	Alternate Management Methods Anticipated	2020	2021	2022	2023	2024	2025	2026 - 2043	2044
Sack Waste (uncontaminated)	Cement mixing processes	Landfill		5	22	22	22	22	22	0	0
Incinerator Ash (offshore)	Incinerator (FPSO)	Landfill [a]		0	0	0	0	0	0	0	0
Scrap metal	Equipment maintenance, metal packaging	Recycle (if feasible)	Landfill	54	229	231	262	265	265	78	78
Dry Filters	General Maintenance	Recycle (if feasible)	Landfill	0	2	2	10	11	11	16	16
Paper & Cardboard	Paper & Cardboard packaging, documents	Recycle (if feasible)	Landfill	5	34	39	37	37	37	26	26
Wood	Wooden pallets, construction, general maintenance	Recycle (if feasible)	Landfill	66	266	267	290	293	293	46	46
Recyclable domestic trash (plastic & glass)	Discarded items from, kitchen, living quarters, bathroom, laundry, warehouse, offices	Recycle (if feasible)	Landfill	4	30	35	34	34	34	30	30

[a] The Payara FPSO and development drill ships are not anticipated to have incinerators onboard.

ATTACHMENT B GUYANA HAZARDOUS WASTE RECORDING AND REPORTING FORM

EPA-EMD2012HWRRF1R1

RECORDING AND REPORTING FORM OF HAZARDOUS WASTES (*for* New and Existing Operations)

General Instructions/Requirements/Information

The Recording and Reporting Form must be completed by the holder of an Environmental Authorization no later than forty-five days after the end of the operating year.

Note: The report should be prepared on activities relating to the previous calendar year.

1. This Form must be completed in BLOCK LETTERS (preferably completed electronically) and a hard copy along with any additional information requested submitted to:

   The Executive Director
   Environmental Protection Agency
   Ganges Street
   Sophia, Georgetown, Guyana
   Telephone: (592) 225-2062 / 1218 / 0506 / 6917
   Fax: (592) 225-5481
   Email: epa@epaguyana.org Website: www.epaguyana.org

2. The information provided in this form must be kept by the holder of the authorization for a period of not less than three years or for such other extended time as the Agency may determine.

Specific Instructions for Completing Form

3. **Block A:** Provide the Permit Reference number, the name of the Company, Project address, mailing address (if different). In this section also provide the name, designation, telephone number, email/fax of a contact person.

4. **Block B:** Provide a description of the operation process. Identify all hazardous materials/chemicals used within the operation process. Also provide the number of years the project has been operational.

5. **Block C:** Provide information on **hazardous materials/chemicals used** in the life cycle of the project. Provide the type of hazardous material/chemicals used (see attached list), its hazardous, physical and chemical characteristics (see attached list), the quantity and the type of storage e.g. containers, bags etc.

6. **Block D**: Provides information on the **hazardous wastes generated.** Provide the type of hazardous material/chemicals used (see attached list), its hazardous, physical and chemical characteristics (see attached list), the quantity and the type of storage e.g. containers, bags etc.

7. **Block E**: Once authorized all spills must be reported. Provide information on the date of incident, type and amount of waste spilled, measures taken to mitigate incident.

EPA-EMD2012HWRRF1R1

A. IDENTIFICATION INFORMATION			
Generator's Permit Reference Number:			
Company Name:			
Project Address:		Region	
Mailing Address (if Different):		Region	
Contact Personnel			
Name :			
Designation:			
Telephone number:			
FAX:			
Email:			

B. OPERATION DETAIL

Brief description of operating process and raw materials (specifically hazardous materials and quantity) used:

No. of Years of Operation: 1-4 years ☐ 5-19 years ☐ over 20 years ☐

C. HAZARDOUS MATERIALS/ CHEMICALS (All Parts of This Section Must Be Completed)

Types of Hazardous Materials/ Chemical	Hazardous Characteristics	Quantity of Hazardous Materials/Chemical		Physical Characteristics	Chemical Characteristics	Type of Storage

EPA-EMD2012HWRRF1R1

D. HAZARDOUS WASTES (All Parts of this Section Must Be Completed)						
Type of Hazardous Wastes generated	Hazardous Characteristics	Quantity of Hazardous Waste Generated		Physical Characteristics	Chemical Characteristics	Type of Storage
		Mass (kg/gallons)	Volume (m^3)			

E. SPILLS/CHEMICALS RELEASE		
Date/s of Incident	Type and Approximate Amount of Waste Lost (kg/gallons)	Measures Taken to Resolve the Incident

OTHER	
Data for off-site Shipment of Waste (transporter and receiver details, location of the off-site facility, etc.)	
Treatment Standard for Waste (if applicable)	
Waste Minimization Efforts (different ways used by the company to reduce the waste generated)	
Details on any Pollution Prevention Plan by the company	
Other Information (e.g. Emergency Response Plan, Occupational Handling Measures)	

ATTACHMENT C SAMPLE WASTE/GARBAGE RECORD BOOK

Ship's Name:

Official No:

IMO No:

Garbage Categories:

- Category 1: Plastics
- Category 2: Floating dunnage, lining, or packing material
- Category 3: Ground-down paper products, rags, glass, metal, bottles, crockery, etc.
- Category 4: Cargo residues, paper products, rags, glass, metal, bottles, crockery, etc.
- Category 5: Food waste
- Category 6: Incinerator ash except from plastic products which may contain toxic or heavy metal residues
- Other Releases - Treated sanitary wastewater, grey water, ballast

NOTE: The discharge of any garbage other than food waste is prohibited in special areas. Garbage other than Category 1 transferred to reception facilities need only be listed as a total estimated amount.

Waste Type	Date/ Time	Position of the Ship	Estimated Amount of Waste Generated Solid (m3); Liquid (L)	Category 1-6	Estimated Amount of Food Waste Comminuted and Discharged (m3)	Estimated Amount Transferred to Reception Facilities or to Other Ship Solid (m3); Liquid (L)	Estimated Amount Incinerated Solid (m3); Liquid (L)	Certification / Signature
Food Waste	1/1/17; 13:00		2 m3	5	2 m3	NA	NA	
Paper Products	1/15/17; 07:30		15 m3	3	NA	NA	15 m3	
Used Oil	2/20/17; 15:20		50 L	4	NA	50 L		

Master's Signature:

Date:

ATTACHMENT D SAMPLE OIL RECORD BOOK FORM

Ship's Name: _____

Distinctive Number or Letters: _____

Gross Tonnage: _____

Period From: _____ To: _____

Machinery Space Operations (All Ships) or Cargo / Ballast Operations (Oil Tankers)

(*Delete that operation above which does not apply*)

Date	Code Letter	Item Number	Record of Operations / Signature of Officer in Charge

Master's Signature:

Date:

ATTACHMENT E SAMPLE CHAIN OF CUSTODY FORM FOR SAMPLES

CHAIN-OF-CUSTODY RECORD

1. Facility Information:

   Facility Name_____

2. Sample Information:

   Time Sample Collected _____:_____ [ ] AM or [ ] PM (Check One)

   Date Sample Collected _____/_____/_____ (Month/Day/Year)

   Name of Sampler (Print) _____

   Signature of Sampler _____

   Sampler's Company Name _____

   Analysis Information: _____

3. Chain-of-Custody: (To be completed by each person relinquishing sample)

Name (Please Print)	Signature	Facility	Relinquished To (Name / Facility)	Date mm/dd/yr	Time

4. Laboratory Shipping Information:

   Laboratory Name: _____

   Laboratory Address: _____

   _____

   Date Shipped: _____/_____/_____ (Month/Day/Year)

   Estimated Arrival Date: _____/_____/_____ (Month/Day/Year)

   Estimated Arrival Time: Collected _____:_____ [ ] AM or [ ] PM (Check One)

ATTACHMENT F SAMPLE MARINE TRANSPORT MANIFEST

Generator:		From	MANIFEST Nr: GUY-18-XXX
Prepared Date:	Day- Month - Year	Well Nr/Ref:	OPERATOR REF: Vessel Owner-Operator
Shipped Date:	Day- Month - Year	VESSEL:	OTHER REF:
Lease Holder:	EEPGL		DESTINATION: Georgetown Supply Base

ITEM	QTY	WASTE CAT	DG REF	UN CODE	PACKING	S/N ID/REF	OTHER REF	DESCRIPTION	OWNER
1	1	n/a	n/a	n/a	n/a	13220		Containers o/w:	
	8	8	n/a	n/a	Bags			Old Grout Bag, Non Hazardous, Non Recyclable	
	6	8	n/a	n/a	Big Bags			Sack Room Waste, Non Hazardous, Non Rec	
2	1	n/a	n/a	n/a	n/a	13190		Containers o/w:	
	6	1	n/a	n/a	Big Bags			General - Non Hazardous - Non Recyclable	
3	1	n/a	n/a	n/a	n/a	13258		Containers o/w:	
	1	3	n/a	n/a	Skip			Wood - Non Hazardous - Non Recyclable	
4	1	n/a	n/a	n/a	n/a	13262		Containers o/w:	
	1	3	n/a	n/a	Skip			Wood - Non Hazardous - Non Recyclable	
5	1	n/a	n/a	n/a	n/a	13195		Containers o/w:	
	6	8	n/a	n/a	Big Bags			Sack Room Waste, Non Hazardous, Non Rec	
									Sub Totals

1st Transporter	2nd Transporter	Final Destination	
DATE:	VEHICLE REG/ID:	DATE	VEHICLE REG/ID:
NAME:		NAME	
SIGN:		SIGN	

Totals

Grand Totals

Final destination receiver to return a completed signed copy to originator.

Waste Categories

Glass	8 Chemical Waste	Oily Effluents	Tetra Pack
d - Aluminium	9 Hospital Waste	Hydraulic / Lube Oil / Fuel	Vegetable Oil
		14 Mud	Others
		15 Waste Water Mud	

Declaration: I hereby declare that the information contained herein, is true and correct, to the best of my knowledge:

Vessel Name: _____ ***Signature:*** _____

Name: (Print) _____

ATTACHMENT G SAMPLE WASTE MANIFEST FORM

WASTE GENERATOR INFORMATION

Generator: _____
Address: _____
Contact Information: Office _____ Mobile _____email_____
Contact Person: _____ Position_____
Manifest Number:_____

WASTE INFORMATION (To be completed by waste generator)

Waste Description: ☐ Hazardous ☐ Non Hazardous

(Provide a brief description)_____
Process Generating Waste: _____
_____
Physical State ☐ Solid ☐ Liquid ☐ Sludge ☐ Other _____
Physical Properties Colour _____
Odour _____
MSDS ☐ Yes ☐ No
Special Handling Requirements ☐ Yes ☐ No
Waste Volume ☐ _____Barrels (42 Gal.) ☐_____ Drum (55 Gal.) ☐_____ Gallons
☐ _____ Cubic Meters ☐_____Pounds

DISPOSAL INFORMATION (To be completed by TTTU)

Disposal Option ☐ Recycling ☐ Thermal Desorption
☐ Incineration ☐ Landfill
Disposal Facility ☐ Tiger Tanks ☐ Haag Bosch
☐ Other (Recycling) _____
Haulage /Storage ☐ Truck ☐ HWS Skip ☐ Cuttings Box ☐ Other

WASTE RECEIPT AT GENERATORS FACILITY

Physical State ☐ Solid ☐ Liquid ☐ Sludge ☐ Other _____
Physical Properties Colour _____
Odour _____
MSDS ☐ Yes ☐ No
Waste Volume ☐ _____Barrels (42 Gal.) ☐_____ Drum (55 Gal.) ☐_____ Gallons
☐ _____ Cubic Meters ☐_____Pounds

Dispatched By: _____ Signature_____ Date _____
Received By:_____ Signature_____ __ Date_____

ATTACHMENT H SAMPLE WASTE INFORMATION DATA SHEET

GENERATOR INFORMATION

Generator: _____ Date _____

Address: _____

Contact Information: Office _____ Mobile _____ email _____

Contact Person: _____ Position _____

Waste Manifest Number : _____

WASTE INFORMATION

MSDS to be provided for all chemical drums, buckets and tote tanks for disposal.

Waste Description		***WMF***	***DN***	***Volume***			***Comments***
				lbs	*units*	*m^3*	
Hazardous Waste Liquids							
Oil contaminated water based drilling fluid							
Liquid oil residue / slops							
Oil contaminated completion brines							
Oil contaminated produce water or water							
Non-aqueous drilling fluid							
Contaminated deck drainage or other oily water							
Liquid treatment/ chemicals							
Solvents /paints/ Glycols							
Acid/ caustic solutions							
Used lube oil/motor oil/ grease							
Surplus fuels Heli, contaminated diesel							
Oil sludge							
Hydrocarbon contaminated sand							
SOBM / cement slops							
Hazardous waste solid/ other							
Contaminated solid products with oil or grease	*Rags*						
	Clothing						
	Absorbent pads						
	Wood						
	Used oil						
	Grease tubes						
	Dope brushes						
	Filter						
	Other						
Storage mediums contaminated	*Metal drums/ container*						
	Plastic drums/ container						

with hazardous waste such as chemicals, oils, paints	*Cardboard drums/ container*						
	Totes						
	Buckets						
	Threaded protectors						
	Biohazard/ Medical waste						
	Aerosol cans						
	Chemical drums						
Batteries	*Alkaline/ Lead acid batteries*						
	Ni-Cd/ Lithium Batteries						
Bulbs/ White Fluorescent tubes							
Light Ballast electronic equipment							
Recyclables	*Paper/ cardboard*						
	Scrap metal						
	Plastic bottles						
	Glass bottles						
	Aluminum can						
	Plastic packaging and wood						
Non- hazardous General waste/ other							
Water base drilling fluid							
Non- contaminated cement							
Other non-hazardous liquids							
Non-hazardous waste	*Food / Sanitary waste*						
	Sewage						
	Non- hazardous sludge/slops						
	Non hazardous solid industrial waste/ general trash						

ATTACHMENT I HAZARD CLASS SYMBOLS FOR HAZARDOUS WASTES AND MATERIALS



Appendix B
ExxonMobil's
Corporate Standards:
Standards of Business Conduct

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INTRODUCTION

The high quality of the directors, officers, and employees of Exxon Mobil Corporation is the Corporation's greatest strength. The resourcefulness, professionalism, and dedication of those directors, officers, and employees make the Corporation competitive in the short term and well positioned for ongoing success in the long term.

The Corporation's directors, officers, and employees are responsible for developing, approving, and implementing plans and actions designed to achieve corporate objectives. The methods we employ to attain results are as important as the results themselves. The Corporation's directors, officers, and employees are expected to observe the highest standards of integrity in the conduct of the Corporation's business.

The Board of Directors of the Corporation has adopted and oversees the administration of the Corporation's *Standards of Business Conduct*. The policies in the *Standards of Business Conduct* are the foundation policies of the Corporation. Wholly-owned and majority-owned subsidiaries of Exxon Mobil Corporation generally adopt policies similar to the Corporation's foundation policies. Thus, the Corporation's foundation policies collectively express the Corporation's expectations and define the basis for the worldwide conduct of the businesses of the Corporation and its majority-owned subsidiaries.

The directors, officers, and employees of Exxon Mobil Corporation are expected to review these foundation policies periodically and apply them to all of their work. The Corporation publishes from time to time guidelines with respect to selected policies. Those guidelines are interpretive and administrative and are not part of the *Standards of Business Conduct*. Any employee who has questions concerning any aspect of these policies should not hesitate to seek answers from management or the other sources indicated in the section below called "Procedures and Open Door Communication."

No one in the ExxonMobil organization has the authority to make exceptions or grant waivers with respect to the foundation policies. Regardless of how much difficulty we encounter or pressure we face in performing our jobs, no situation can justify the willful violation of these policies. Our reputation as a corporate citizen depends on our understanding of and compliance with these policies.

Rex W. Tillerson
Chairman
November 2011

GUIDING PRINCIPLES

Exxon Mobil Corporation is committed to being the world's premier petroleum and petrochemical company. To that end, we must continuously achieve superior financial and operating results while simultaneously adhering to high ethical standards.

The following principles guide our relationships with our shareholders, customers, employees, and communities:

Shareholders - We are committed to enhancing the long-term value of the investment dollars entrusted to us by our shareholders. By running the business profitably and responsibly, we expect our shareholders to be rewarded with superior returns. This commitment drives the management of our corporation.

Customers - Success depends on our ability to consistently satisfy ever changing customer preferences. We commit to be innovative and responsive, while offering high quality products and services at competitive prices.

Employees - The exceptional quality of our workforce provides a valuable competitive edge. To build on this advantage, we will strive to hire and retain the most qualified people available and to maximize their opportunities for success through training and development. We are committed to maintaining a safe work environment enriched by diversity and characterized by open communication, trust, and fair treatment.

Communities - We commit to be a good corporate citizen in all the places we operate worldwide. We will maintain high ethical standards, obey all applicable laws, rules, and regulations, and respect local and national cultures. Above all other objectives, we are dedicated to running safe and environmentally responsible operations.

Exxon Mobil Corporation aspires to be at the leading edge of competition in every aspect of our business. That requires the Corporation's resources – financial, operational, technological, and human – to be employed wisely and evaluated regularly.

While we maintain flexibility to adapt to changing conditions, the nature of our business requires a focused, long-term approach. We will consistently strive to improve efficiency and productivity through learning, sharing, and implementing best practices. We will be disciplined and selective in evaluating the range of capital investment opportunities available to us. We will seek to develop proprietary technologies that provide a competitive edge.

We aspire to achieve our goals by flawlessly executing our business plans and by adhering to these guiding principles and the foundation policies that follow.

ETHICS POLICY

The policy of Exxon Mobil Corporation is to comply with all governmental laws, rules, and regulations applicable to its business.

The Corporation's Ethics policy does not stop there. Even where the law is permissive, the Corporation chooses the course of highest integrity. Local customs, traditions, and mores differ from place to place, and this must be recognized. But honesty is not subject to criticism in any culture. Shades of dishonesty simply invite demoralizing and reprehensible judgments. A well-founded reputation for scrupulous dealing is itself a priceless corporate asset.

The Corporation cares how results are obtained, not just that they are obtained. Directors, officers, and employees should deal fairly with each other and with the Corporation's suppliers, customers, competitors, and other third parties.

The Corporation expects compliance with its standard of integrity throughout the organization and will not tolerate employees who achieve results at the cost of violation of law or who deal unscrupulously. The Corporation's directors and officers support, and expect the Corporation's employees to support, any employee who passes up an opportunity or advantage that would sacrifice ethical standards.

It is the Corporation's policy that all transactions will be accurately reflected in its books and records. This, of course, means that falsification of books and records and the creation or maintenance of any off-the-record bank accounts are strictly prohibited. Employees are expected to record all transactions accurately in the Corporation's books and records, and to be honest and forthcoming with the Corporation's internal and independent auditors.

The Corporation expects candor from employees at all levels and adherence to its policies and internal controls. One harm which results when employees conceal information from higher management or the auditors is that other employees think they are being given a signal that the Corporation's policies and internal controls can be ignored when they are inconvenient. That can result in corruption and demoralization of an organization. The Corporation's system of management will not work without honesty, including honest bookkeeping, honest budget proposals, and honest economic evaluation of projects.

It is the Corporation's policy to make full, fair, accurate, timely, and understandable disclosure in reports and documents that the Corporation files with the United States Securities and Exchange Commission, and in other public communications. All employees are responsible for reporting material information known to them to higher management so that the information will be available to senior executives responsible for making disclosure decisions.

CONFLICTS OF INTEREST POLICY

It is the policy of Exxon Mobil Corporation that directors, officers, and employees are expected to avoid any actual or apparent conflict between their own personal interests and the interests of the Corporation. A conflict of interest can arise when a director, officer, or employee takes actions or has personal interests that may interfere with his or her objective and effective performance of work for the Corporation. For example, directors, officers, and employees are expected to avoid actual or apparent conflict in dealings with suppliers, customers, competitors, and other third parties. Directors, officers, and employees are expected to refrain from taking for themselves opportunities discovered through their use of corporate assets or through their positions with the Corporation. Directors, officers, and employees are expected to avoid securities transactions based on material, nonpublic information learned through their positions with the Corporation. Directors, officers, and employees are expected to refrain from competing with the Corporation.

CORPORATE ASSETS POLICY

It is the policy of Exxon Mobil Corporation that directors, officers, and employees are expected to protect the assets of the Corporation and use them efficiently to advance the interests of the Corporation. Those assets include tangible assets and intangible assets, such as confidential information of the Corporation. No director, officer, or employee should use or disclose at any time during or subsequent to employment or other service to the Corporation, without proper authority or mandate, confidential information obtained from any source in the course of the Corporation's business. Examples of confidential information include nonpublic information about the Corporation's plans, earnings, financial forecasts, business forecasts, discoveries, competitive bids, technologies, and personnel.

DIRECTORSHIPS POLICY

It is the policy of Exxon Mobil Corporation to restrict the holding by officers and employees of directorships in nonaffiliated, for-profit organizations and to prohibit the acceptance by any officer or employee of such directorships that would involve a conflict of interest with, or interfere with, the discharge of the officer's or employee's duties to the Corporation. Any officer or employee may hold directorships in nonaffiliated, nonprofit organizations, unless such directorships would involve a conflict of interest with, or interfere with, the discharge of the officer's or employee's duties to the Corporation, or obligate the Corporation to provide support to the nonaffiliated, nonprofit organizations. Officers and employees may serve as directors of affiliated companies and such service may be part of their normal work assignments.

All directorships in public companies held by directors of the Corporation are subject to review and approval by the Board of Directors of the Corporation. In all other cases, directorships in nonaffiliated, for-profit organizations are subject to review and approval by the management of the Corporation, as directed by the Chairman.

GIFTS AND ENTERTAINMENT POLICY

It is the policy of Exxon Mobil Corporation to base commercial decisions on commercial criteria. That policy serves the Corporation's business interests and fosters constructive relationships with organizations and individuals doing business, or seeking to do business, with the Corporation. In many cultures, those constructive relationships may include incidental business gifts and entertainment. Directors, officers, employees, and third parties acting on behalf of the Corporation providing or receiving third party gifts and entertainment in their corporate capacities are expected to exercise good judgment in each case, taking into account pertinent circumstances, including the character of the gift or entertainment, its purpose, its appearance, the positions of the persons providing and receiving the gift or entertainment, the business context, reciprocity, and applicable laws and social norms. Gifts and entertainment must not be intended to create an improper advantage for the Corporation. All expenditures for gifts and entertainment provided by the Corporation must be accurately recorded in the books and records of the Corporation.

ANTI-CORRUPTION POLICY

It is the policy of Exxon Mobil Corporation that directors, officers, employees, and third parties acting on its behalf are prohibited from offering or paying, directly or indirectly, any bribe to any employee, official, or agent of any government, commercial entity, or individual in connection with the business or activities of the Corporation. A bribe for purposes of this policy is any money, goods, services, or other thing of value offered or given with the intent to gain any improper advantage for the Corporation.

No director, officer, employee, or third party should assume that the Corporation's interest ever requires otherwise.

POLITICAL ACTIVITIES POLICY

It is the policy of Exxon Mobil Corporation to refrain from making contributions to political candidates and political parties, except as permitted by applicable laws and authorized by the Board of Directors.

It is the Corporation's policy to communicate information and views on issues of public concern that have an important impact on the Corporation.

The Corporation considers that registering and voting, contributing financially to the party or candidate of one's choice, keeping informed on political matters, serving in civic bodies, and campaigning and officeholding at local, state, and national levels are important rights and responsibilities of the citizens of a democracy.

Directors, officers, and employees engaging in political activities are expected to do so as private citizens and not as representatives of the Corporation. Personal, lawful, political contributions and decisions not to make contributions will not influence compensation, job security, or opportunities for advancement.

INTERNATIONAL OPERATIONS POLICY

It is the policy of Exxon Mobil Corporation to comply with all governmental laws, rules, and regulations applicable to its operations outside the United States and to conduct those operations to the highest ethical standards.

Laws that apply to operations outside the United States include those of the countries where the operations occur, and may also include certain United States laws which govern international operations of United States companies and United States persons, broadly defined. Accordingly, directors, officers, and employees of the Corporation who are involved with the Corporation's operations outside the United States should consult with the Law Department for advice on applicable United States laws, especially laws regarding boycotts, trade sanctions, export controls, and foreign corrupt practices, and are expected to comply with those laws.

ANTITRUST POLICY

It is the policy of Exxon Mobil Corporation that directors, officers, and employees are expected to comply with the antitrust and competition laws of the United States and with those of any other country or group of countries which are applicable to the Corporation's business.

No director, officer, or employee should assume that the Corporation's interest ever requires otherwise.

It is recognized that, on occasion, there may be legitimate doubt as to the proper interpretation of the law. In such a circumstance, it is required that the directors, officers, and employees refer the case through appropriate channels to the Law Department for advice.

HEALTH POLICY

It is Exxon Mobil Corporation's policy to:

- identify and evaluate health risks related to its operations that potentially affect its employees, contractors or the public;

- implement programs and appropriate protective measures to control such risks, including appropriate monitoring of its potentially affected employees;

- communicate in a reasonable manner to potentially affected individuals or organizations and the scientific community knowledge about health risks gained from its health programs and related studies;

- determine at the time of employment and thereafter, as appropriate, the medical fitness of employees to do their work without undue risk to themselves or others;

- provide or arrange for medical services necessary for the treatment of employee occupational illnesses or injuries and for the handling of medical emergencies;

- comply with all applicable laws and regulations, and apply responsible standards where laws and regulations do not exist;

- work with government agencies and others to develop responsible laws, regulations, and standards based on sound science and consideration of risk;

- conduct and support research to extend knowledge about the health effects of its operations;

- undertake appropriate reviews and evaluations of its operations to measure progress and to foster compliance with this policy;

- provide voluntary health promotion programs designed to enhance employees' well being, productivity, and personal safety. These programs should supplement, but not interfere with, the responsibility of employees for their own health care and their relationships with personal physicians. Information about employees obtained through the implementation of these programs should be considered confidential and should not be revealed to non-medical personnel except: at the request of the employee concerned, when required by law, when dictated by overriding public health considerations, or when necessary to implement the Alcohol and Drug Use policy.

ENVIRONMENT POLICY

It is Exxon Mobil Corporation's 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. The Corporation is committed to continuous efforts to improve environmental performance throughout its operations.

Accordingly, the Corporation's policy is to:

- comply with all applicable environmental laws and regulations and apply responsible standards where laws and regulations do not exist;

- encourage concern and respect for the environment, emphasize every employee's responsibility in environmental performance, and foster appropriate operating practices and training;

- work with government and industry groups to foster timely development of effective environmental laws and regulations based on sound science and considering risks, costs, and benefits, including effects on energy and product supply;

- manage its business with the goal of preventing incidents and of controlling emissions and wastes to below harmful levels; design, operate, and maintain facilities to this end;

- respond quickly and effectively to incidents resulting from its operations, in cooperation with industry organizations and authorized government agencies;

- conduct and support research to improve understanding of the impact of its business on the environment, to improve methods of environmental protection, and to enhance its capability to make operations and products compatible with the environment;

- communicate with the public on environmental matters and share its experience with others to facilitate improvements in industry performance;

- undertake appropriate reviews and evaluations of its operations to measure progress and to foster compliance with this policy.

SAFETY POLICY

It is Exxon Mobil Corporation's policy to conduct its business in a manner that protects the safety of employees, others involved in its operations, customers, and the public. The Corporation will strive to prevent all accidents, injuries, and occupational illnesses through the active participation of every employee. The Corporation is committed to continuous efforts to identify and eliminate or manage safety risks associated with its activities.

Accordingly, the Corporation's policy is to:

- design and maintain facilities, establish management systems, provide training and conduct operations in a manner that safeguards people and property;

- respond quickly, effectively, and with care to emergencies or accidents resulting from its operations, in cooperation with industry organizations and authorized government agencies;

- comply with all applicable laws and regulations, and apply responsible standards where laws and regulations do not exist;

- work with government agencies and others to develop responsible laws, regulations, and standards based on sound science and consideration of risk;

- conduct and support research to extend knowledge about the safety effects of its operations, and promptly apply significant findings and, as appropriate, share them with employees, contractors, government agencies, and others who might be affected;

- stress to all employees, contractors, and others working on its behalf their responsibility and accountability for safe performance on the job and encourage safe behavior off the job;

- undertake appropriate reviews and evaluations of its operations to measure progress and to foster compliance with this policy.

PRODUCT SAFETY POLICY

It is Exxon Mobil Corporation's policy to:

- identify and manage risks associated with its products and not manufacture or sell products when it is not possible through proper design, procedures, and practices to provide an appropriate level of safety for people and the environment;

- specify precautions required in handling, transporting, using, and disposing of its products and take reasonable steps to communicate them to employees, customers, and others who might be affected;

- comply with all applicable laws and regulations and apply responsible standards where laws and regulations do not exist;

- work with government agencies and others, as appropriate, to develop responsible laws, regulations, and standards based on sound science and consideration of risk;

- include identification and control of potentially adverse health, safety, and environmental effects as priority considerations in the planning and development of products;

- conduct and support research to extend knowledge about the health, safety and environmental effects of its products, and promptly apply significant findings and, as appropriate, share them with its employees, contractors, customers, the scientific community, government agencies, and the public;

- undertake appropriate reviews and evaluations of its operations to measure progress and to foster compliance with this policy.

CUSTOMER RELATIONS AND PRODUCT QUALITY POLICY

Exxon Mobil Corporation recognizes customer satisfaction is of primary importance to its success. Mindful of its responsibility to the consumers it serves directly and the customers who resell its products, the Corporation strives to understand their requirements and concerns and to merit their business by responding effectively to their needs.

Specifically, the Corporation's policy is to:

- provide high-quality products that meet or exceed equipment specifications and consumer needs under all reasonable circumstances;
- furnish services that reliably meet responsible standards of performance, efficiency, and courtesy;
- furnish accurate and sufficient information about its products and services, including details of guarantees and warranties, so that customers can make informed purchasing decisions;
- require truth in advertising and other communications.

In addition, where the Corporation's products reach the ultimate consumer through independent parties, such as service station dealers and distributors, the Corporation's policy is to actively encourage such parties to achieve standards comparable to those which have been established for the Corporation's own performance.

ALCOHOL AND DRUG USE POLICY

Exxon Mobil Corporation is committed to a safe, healthy, and productive workplace for all employees. The Corporation recognizes that alcohol, drug, or other substance abuse by employees will impair their ability to perform properly and will have serious adverse effects on the safety, efficiency and productivity of other employees and the Corporation as a whole. The misuse of legitimate drugs, or the use, possession, distribution or sale of illicit or unprescribed controlled drugs on company business or premises, is strictly prohibited and is grounds for termination. Possession, use, distribution, or sale of alcoholic beverages on company premises is not allowed without prior approval of appropriate senior management. Being unfit for work because of use of drugs or alcohol is strictly prohibited and is grounds for termination of employment. While this policy refers specifically to alcohol and drugs, it is intended to apply to inhalants and all other forms of substance abuse.

The Corporation recognizes alcohol or drug dependency as a treatable condition. Employees who suspect they have an alcohol or drug dependency are encouraged to seek advice and to follow appropriate treatment promptly before it results in job performance problems. Employee Health Advisory Program or medical professional staff will advise and assist in securing treatment. Those employees who follow approved treatment will receive disability benefits in accordance with the provisions of established benefit plans and medical insurance coverage consistent with existing plans.

No employee with alcohol or drug dependency will be terminated due to the request for help in overcoming that dependency or because of involvement in a rehabilitation effort. However, an employee who has had or is found to have a substance abuse problem will not be permitted to work in designated positions identified by management as being critical to the safety and wellbeing of employees, the public, or the Corporation. Any employee returning from rehabilitation will be required to participate in a company-approved aftercare program. If an employee violates provisions of the employee Alcohol and Drug Use policy, appropriate disciplinary action will be taken. Such action cannot be avoided by a request at that time for treatment or rehabilitation. If an employee suffering from alcohol or drug dependency refuses rehabilitation or fails to respond to treatment or fails to meet satisfactory standards of effective work performance, appropriate disciplinary action, up to and including termination, will be taken. This policy does not require and should not result in any special regulations, privileges, or exemptions from normal job performance requirements.

ALCOHOL AND DRUG USE POLICY *(continued)*

The Corporation may conduct unannounced searches for drugs and alcohol on company owned or controlled property. The Corporation may also require employees to submit to medical evaluation or alcohol and drug testing where cause exists to suspect alcohol or drug use, including workplace incidents.

Unannounced periodic or random testing will be conducted when an employee meets any one of the following conditions: has had a substance abuse problem, or is working in a designated position identified by management, a position where testing is required by law, or a specified executive position. A positive test result or refusal to submit to a drug or alcohol test is grounds for disciplinary action, including termination.

Contractor, common carrier, and vendor personnel are also covered by paragraph one and the search provisions of paragraph four of this policy. Those who violate the policy will be removed from company premises and may be denied future entry.

In addition to the above policy, it is a requirement of the Corporation that all applicants accepting offers of regular employment must pass a drug test.

EQUAL EMPLOYMENT OPPORTUNITY POLICY

It is the policy of Exxon Mobil Corporation to provide equal employment opportunity in conformance with all applicable laws and regulations to individuals who are qualified to perform job requirements. The Corporation administers its personnel policies, programs, and practices in a nondiscriminatory manner in all aspects of the employment relationship, including recruitment, hiring, work assignment, promotion, transfer, termination, wage and salary administration, and selection for training.

Managers and supervisors are responsible for implementing and administering this policy, for maintaining a work environment free from unlawful discrimination, and for promptly identifying and resolving any problem area regarding equal employment opportunity.

In addition to providing equal employment opportunity, it is also the Corporation's policy to undertake special efforts to:

- develop and support educational programs and recruiting sources and practices that facilitate employment of minorities and women;
- develop and offer work arrangements that help to meet the needs of the diverse work force in balancing work and family obligations;
- establish company training and developmental efforts, practices, and programs that support diversity in the work force and enhance the representation of minorities and women throughout the Corporation;
- foster a work environment free from sexual, racial, or other harassment;
- make reasonable accommodations that enable qualified disabled individuals to perform the essential functions of their jobs;
- emphasize management responsibility in these matters at every level of the organization.

Individuals who believe they have observed or been subjected to prohibited discrimination should immediately report the incident to their supervisors, higher management, or their designated Human Resources Department contacts.

Individuals will not be subjected to harassment, intimidation, discrimination, or retaliation for exercising any of the rights protected by this policy and the various EEO statutes.

EQUAL EMPLOYMENT OPPORTUNITY POLICY
(modified for application in the United States)

It is the policy of Exxon Mobil Corporation to provide equal employment opportunity in conformance with all applicable laws and regulations to individuals who are qualified to perform job requirements regardless of their race, color, sex, religion, national origin, citizenship status, age, genetic information, physical or mental disability, veteran, sexual orientation, gender identity or other legally protected status. The Corporation administers its personnel policies, programs, and practices in a nondiscriminatory manner in all aspects of the employment relationship, including recruitment, hiring, work assignment, promotion, transfer, termination, wage and salary administration, and selection for training.

Managers and supervisors are responsible for implementing and administering this policy, for maintaining a work environment free from unlawful discrimination, and for promptly identifying and resolving any problem area regarding equal employment opportunity.

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- foster a work environment free from sexual, racial, or other harassment;
- make reasonable accommodations that enable qualified disabled individuals to perform the essential functions of their jobs;
- emphasize management responsibility in these matters at every level of the organization.

Individuals who believe they have observed or been subjected to prohibited discrimination should immediately report the incident to their supervisors, higher management, or their designated Human Resources Department contacts.

Individuals will not be subjected to harassment, intimidation, threats, coercion, discrimination, or retaliation for opposing any unlawful act or practice, or making a complaint, assisting or participating in an investigation or any other proceeding, or otherwise exercising any of the rights protected by this policy or any federal, state, or local EEO laws.

HARASSMENT IN THE WORKPLACE POLICY

It is the policy of Exxon Mobil Corporation to prohibit any form of harassment in any company workplace. The objective of this policy is to provide a work environment that fosters mutual employee respect and working relationships free of harassment. The Corporation specifically prohibits any form of harassment by or toward employees, contractors, suppliers, or customers.

Under the Corporation's policy, harassment is any inappropriate conduct which has the purpose or effect of:

- creating an intimidating, hostile, or offensive work environment;
- unreasonably interfering with an individual's work performance; or
- affecting an individual's employment opportunity.

Harassment will not be tolerated. Forms of harassment include, but are not limited to, unwelcome verbal or physical advances and sexually, racially, or otherwise derogatory or discriminatory materials, statements, or remarks. All employees, including supervisors and managers, will be subject to disciplinary action up to and including termination for any act of harassment.

Individuals who believe they have been subjected to harassment should immediately report the incident to their supervisors, higher management, or their designated Human Resources Department contacts. All complaints will be promptly and thoroughly investigated.

Employees or supervisors who observe or become aware of harassment should immediately advise their supervisors, higher management, or their designated Human Resources Department contacts. No employee should assume that the Corporation is aware of a problem. All complaints and concerns should be brought to management's or the Human Resources Department's attention so that appropriate corrective steps can be taken.

No retaliation will be taken against any employee because he or she reports a problem concerning possible acts of harassment. Employees can raise concerns and make reports without fear of reprisal. Questions about what constitutes harassing behavior should be directed to the employee's supervisor or Human Resources Department contact.

HARASSMENT IN THE WORKPLACE POLICY
(modified for application in the United States)

It is the policy of Exxon Mobil Corporation to prohibit any form of harassment in any company workplace. The policy prohibits unlawful harassment based on race, color, sex, religion, national origin, citizenship status, age, genetic information, physical or mental disability, veteran, sexual orientation, gender identity or other protected status, as well as any other form of harassment, even if the harassing conduct is lawful. The objective of this policy is to provide a work environment that fosters mutual employee respect and working relationships free of harassment. The Corporation specifically prohibits any form of harassment by or toward employees, contractors, suppliers, or customers.

Under the Corporation's policy, harassment is any inappropriate conduct, which has the purpose or effect of:

- creating an intimidating, hostile, or offensive work environment;
- unreasonably interfering with an individual's work performance; or
- affecting an individual's employment opportunity.

Harassment will not be tolerated. Forms of harassment include, but are not limited to, unwelcome verbal or physical advances and sexually, racially, or otherwise derogatory or discriminatory materials, statements, or remarks. All employees, including supervisors and managers, will be subject to disciplinary action up to and including termination for any act of harassment.

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Employees or supervisors who observe or become aware of harassment should immediately advise their supervisors, higher management, or their designated Human Resources Department contacts. No employee should assume that the Corporation is aware of a problem. All complaints and concerns should be brought to management's or the Human Resources Department's attention so that appropriate corrective steps can be taken.

No retaliation will be taken against any employee because he or she reports a problem concerning possible acts of harassment. Employees can raise concerns and make reports without fear of reprisal. Questions about what constitutes harassing behavior should be directed to the employee's supervisor or Human Resources Department contact.

PROCEDURES & OPEN DOOR COMMUNICATION

Exxon Mobil Corporation encourages employees to ask questions, voice concerns, and make appropriate suggestions regarding the business practices of the Corporation. Employees are expected to report promptly to management suspected violations of law, the Corporation's policies, and the Corporation's internal controls, so that management can take appropriate corrective action. The Corporation promptly investigates reports of suspected violations of law, policies, and internal control procedures.

Management is ultimately responsible for the investigation of and appropriate response to reports of suspected violations of law, policies, and internal control procedures. Internal Audit has primary responsibility for investigating violations of the Corporation's internal controls, with assistance from others, depending on the subject matter of the inquiry. The persons who investigate suspected violations are expected to exercise independent and objective judgment.

Normally, an employee should discuss such matters with the employee's immediate supervisor. Each supervisor is expected to be available to subordinates for that purpose. If an employee is dissatisfied following review with the employee's immediate supervisor, that employee is encouraged to request further reviews, in the presence of the supervisor or otherwise. Reviews should continue to the level of management appropriate to resolve the issue.

Depending on the subject matter of the question, concern, or suggestion, each employee has access to alternative channels of communication, for example, the Controller's Department; Internal Audit; the Human Resources Department; the Law Department; the Safety, Health and Environment Department; the Security Department; and the Treasurer's Department.

Suspected violations of law or the Corporation's policies involving a director or executive officer, as well as any concern regarding questionable accounting or auditing matters, should be referred directly to the General Auditor of the Corporation. The Board Affairs Committee of the Board of Directors of the Corporation will initially review all issues involving directors or executive officers, and will then refer all such issues to the Board of Directors of the Corporation.

Employees may also address communications to individual non-employee directors or to the non-employee directors as a group by writing them at Exxon Mobil Corporation, 5959 Las Colinas Boulevard, Irving, Texas 75039, U.S.A., or such other addresses as the Corporation may designate and publish from time to time.

PROCEDURES & OPEN DOOR COMMUNICATION *(continued)*

Employees wishing to make complaints without identifying themselves may do so by telephoning 1-800-963-9966 or 1-972-444-1990, or by writing the Global Security Manager, Exxon Mobil Corporation, P. O. Box 142106, Irving, Texas 75014, U.S.A., or such other telephone numbers and addresses as the Corporation may designate and publish from time to time. All complaints to those telephone numbers and addresses concerning accounting, internal accounting controls, or auditing matters will be referred to the Audit Committee of the Board of Directors of the Corporation.

All persons responding to employees' questions, concerns, complaints, and suggestions are expected to use appropriate discretion regarding anonymity and confidentiality, although the preservation of anonymity and confidentiality may or may not be practical, depending on the circumstances. For example, investigations of significant complaints typically necessitate revealing to others information about the complaint and complainant. Similarly, disclosure can result from government investigations and litigation.

No action may be taken or threatened against any employee for asking questions, voicing concerns, or making complaints or suggestions in conformity with the procedures described above, unless the employee acts with willful disregard of the truth.

Failure to behave honestly, and failure to comply with law, the Corporation's policies, and the Corporation's internal controls may result in disciplinary action, up to and including separation.

No one in the Corporation has the authority to make exceptions or grant waivers to the Corporation's foundation policies. It is recognized that there will be questions about the application of the policies to specific activities and situations. In cases of doubt, directors, officers, and employees are expected to seek clarification and guidance. In those instances where the Corporation, after review, approves an activity or situation, the Corporation is not granting an exception or waiver but is determining that there is no policy violation. If the Corporation determines that there is or would be a policy violation, appropriate action is taken.

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Appendix C
Drill Cuttings Deposition and Total Suspended Solids Modeling Report

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Esso Exploration and Production Guyana Limited

Drill Cuttings Deposition and Total Suspended Solids Modeling Report

Stabroek Block 25-Well Exploration Drilling Campaign

March 2020

Project No.: 0536199

The business of sustainability

ERM

Signature Page

March 2020

Drill Cuttings Deposition and Total Suspended Solids Modeling Report

Stabroek Block 25-Well Exploration Drilling Campaign



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Acronyms and Abbreviations

Name	Description
EA&MP	Environmental Assessment and Management Plan
EEPGL	Esso Exploration and Production Guyana Limited
km^2	square kilometers
MARPOL 73/78	International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978
mg/L	milligrams per liter
TSS	total suspended solids

1. INTRODUCTION

1.1 Approach

In this report, potential impacts on water quality and the benthic environment from the planned discharge of drill cuttings were evaluated. The evaluation is for potential impacts from individual wells and potential cumulative impacts during the planned drilling of exploration wells as part of Esso Exploration and Production Guyana Limited's (EEPGL's) proposed 25-well exploration drilling campaign in the Stabroek Block (hereafter, "the Project"). The exact locations for the 25 wells have not been determined; based on information collected to date, a number of targeted areas (referred to herein as "Prospect Areas") have been identified by EEPGL and proxy locations for the 25 wells (referred to hereinafter as "potential Project well locations") have been selected within these areas for the purpose of modeling (see Figure 1-1).

This assessment assumed that there will be a direct discharge (i.e., near the seabed) of cuttings with water-based drilling fluids during drilling of the initial riserless open-hole section and the second section at each well. For the remaining two (deeper) well sections, it was assumed that cuttings, after treatment on the drill ship, will be discharged from the ship with a small fraction of adhered non-aqueous drilling fluid from material removed in the lower well sections.

Modeling was performed to predict the following as a result of these cuttings and fluids discharges:

- Total suspended solids (TSS) concentrations in the water column; and
- Accumulation (thickness) of the adhered muds and drill cuttings on the seafloor.

To evaluate cumulative impacts, locations of previously completed exploration wells, potential Project well locations, potential well locations for other approved or proposed exploration programs, and locations of previously completed or proposed development wells were considered. The proximities of these other completed or proposed wells to the potential Project well locations were reviewed to understand the potential cumulative effects. A mapping exercise was then performed to evaluate the potential for overlap of impacted areas from these individual discharges.

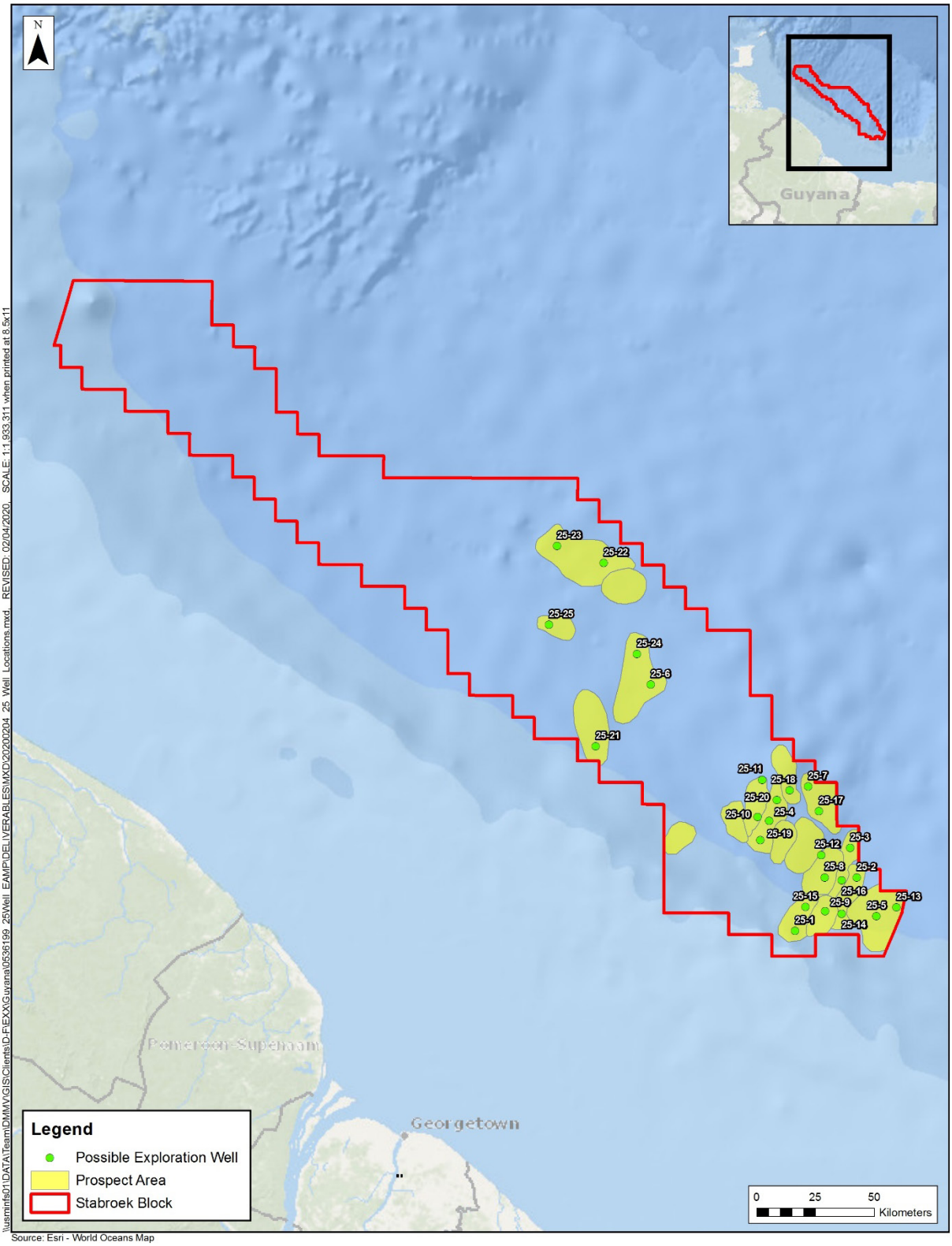


Figure 1-1: Potential 25-well Stabroek Exploration Campaign Well Locations

1.2 Simulation Design

Released material will pass vertically through the water column because cuttings and muds are denser than the receiving water. Released material will also migrate horizontally due to advection by local and regional currents. The dispersion of cuttings and muds is fundamentally a three-dimensional phenomenon requiring three-dimensional hydrodynamic fate and transport modeling.

Drill cuttings, mud deposition, and TSS impacts were modeled at 2 of the 25 potential Project well locations. The locations of the proposed Project wells selected for modeling were chosen based primarily on the water depths within the Stabroek Block. Because the released material migrates downward, the depths that these cuttings and muds have to travel determines the time they are in suspension, and eventually how far they spread laterally. A shallow location generally will result in quicker settling and, consequently, a smaller lateral spread. At a deeper location, cuttings and muds generally will take longer to settle, facilitating a larger lateral spread. However, the relative differences in the magnitude of the current at different locations may also significantly influence this expected outcome for lateral spread.

The water depths within the portion of the Stabroek Block in which Project wells could be completed range from 500 to 3,000 meters. For the two potential Project well locations modeled, a shallow well location (labeled “S25-1”) and a deep well location (labeled “S25-25”) were selected (see Table 1-1). For each of these locations, the minimum and maximum monthly averaged, depth-averaged currents scenarios were modeled to represent a range of impacts in seabed cuttings accumulation and TSS concentrations.

Table 1-1: New Modeling Locations and Water Column Depths

Name	X	Y	Latitude	Longitude	Approximate Water Depth (m)
S25-1	537480	839928	7.598513	-56.6602	717
S25-25	433018	969673	8.771756	-57.609	2,319

2. ASSESSMENT CRITERIA

2.1 Total Suspended Solids

Increases in the concentration of TSS will occur due to discharges of drill cuttings and adhered mud. The highest concentration increases will exist at the point of discharge from the drillship during drilling of bottom well sections or at the seafloor during drilling of the riserless sections; these will decrease over time and distance as the suspended solids plume dissipates and settles. Larger particles will settle out more quickly than fine particles, such that a TSS plume of tiny particles may linger and travel farther than plumes of larger grain sizes. As such, elevated TSS concentrations may form in regions where tiny suspended particles linger in a cloud and mix with subsequent discharges. Impacts on biological resources related to elevated TSS may occur if light penetration is impeded significantly for long periods such that it reduces the ability of plants and phytoplankton to photosynthesize. Increases in TSS concentrations may also decrease water clarity and clog fish gills. The guidance value for TSS provided by MARPOL 73/78 is 35 milligrams per liter (mg/L) for effluent discharges (IMO 2006).

2.2 Depositional Thickness

Drill cuttings and adhered mud discharges will create a footprint on the seabed. The deposition of cuttings and adhered muds may result in physical damage and habitat loss or disruption over a defined area of the seabed through physical smothering.

Burial by drill cuttings and adhered mud may cause physical impacts on benthic communities. The specific burial thickness that may cause an impact varies depending on the benthic species and the amount of oxygen depletion that may occur; the deposition could cause anoxic conditions beneath the depositional layer.

The severity of burial impacts also depends on the sensitivity of the benthic organism, the thickness of deposition, the amount of oxygen-depleting material, and the duration of the burial. Thickness thresholds vary by species and sediment permeability. A suggested threshold deposition rate of 5 centimeters (50 millimeters) per month is recommended for considering impacts on benthic communities based on publications by Ellis and Heim (1985) and MarLIN (2011), and this threshold is used for this evaluation. While the threshold value represents a rate of deposition rather than a total deposition, it was assumed for the purpose of individual well analyses that all deposition from the well drilling occurs within a 30-day period, and the deposition rate was therefore used for comparison to total deposition predictions generated by the modeling.

3. INDIVIDUAL WELL RESULTS

3.1 Total Suspended Solids

3.1.1 Shallow Well (S25-1)

3.1.1.1 Minimum Currents

The minimum currents scenario for the shallow well had a maximum TSS concentration of 5,743 mg/L, which occurred near the surface. Figure 3-1 shows maximum TSS concentrations near the sea bottom and Figure 3-2 shows maximum TSS concentrations near the surface. The area exceeding 35 mg/L is larger near the surface and covers an area of 0.33 square kilometer (km²). The maximum TSS concentration is sustained for a very short period, as ambient currents tend to spread suspended solids, and settling tends to remove particles from the water column. The TSS peaks (within the water column) across time are shown in Figure 3-3. The peak TSS levels (within the water column) stay above the impact threshold (35 mg/L) for no more than about 3 days at any one time.

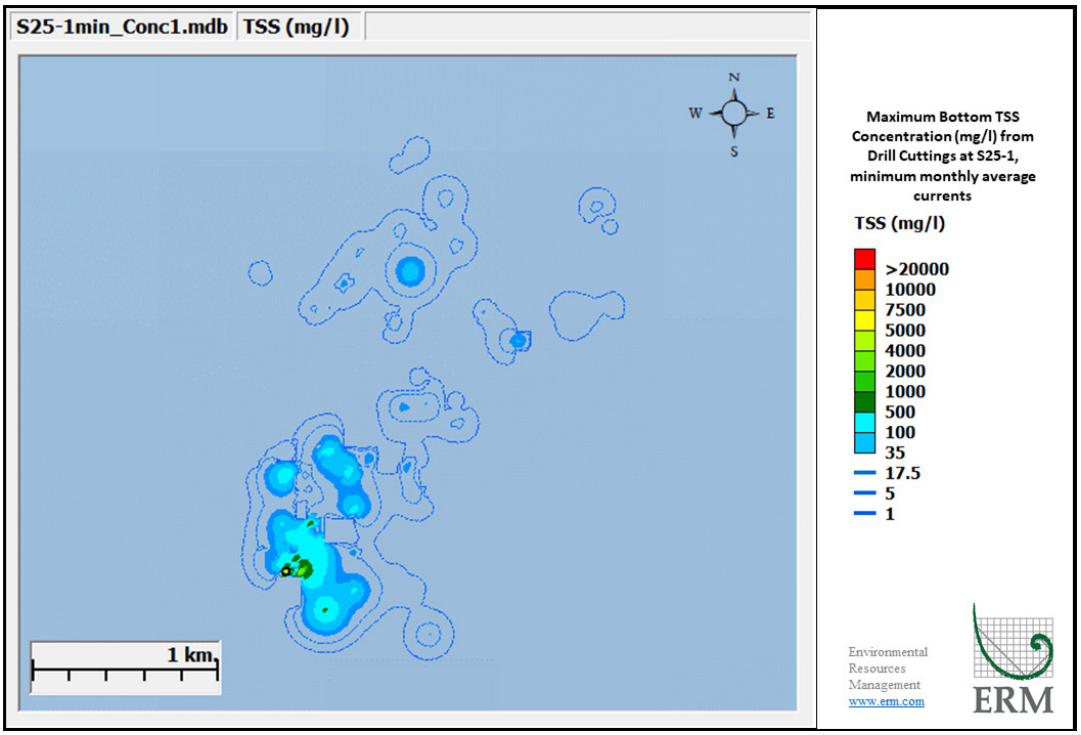


Figure 3-1: Maximum TSS Concentrations at Sea Bottom at the Shallow Well under Minimum Currents

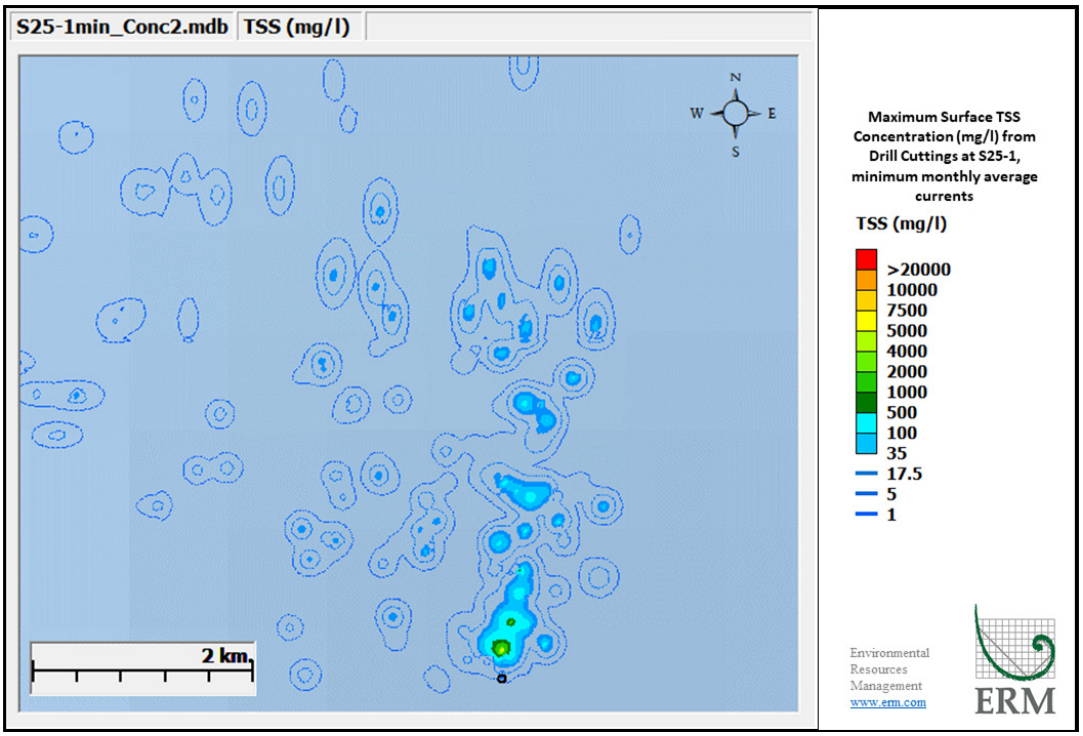


Figure 3-2: Maximum TSS Concentrations at Surface at the Shallow Well under Minimum Currents

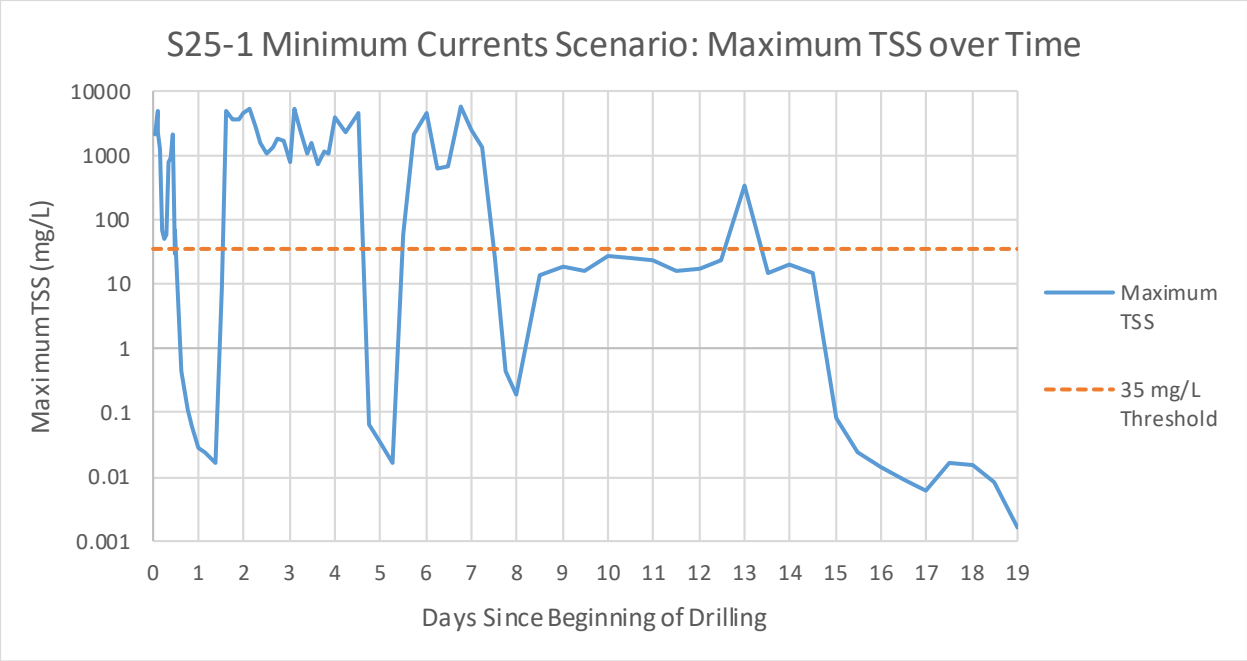


Figure 3-3: Maximum TSS Concentration Peak at Shallow Well Within the Water Column with Time under Minimum Currents

3.1.1.2 Maximum Currents

The maximum currents scenario for the shallow well had a maximum TSS concentration of 16,322 mg/L, which occurred near the sea bottom. Figure 3-4 shows maximum TSS concentrations near the sea bottom and Figure 3-5 shows maximum TSS concentration near the surface. The area exceeding 35 mg/L is larger at the sea surface and covers 0.48 km^2. Temporally, the TSS peaks exist only for a short duration as shown in Figure 3-6. The peak TSS levels (within the water column) stay above the impact threshold (35 mg/L) for no more than about 3 days at any one time.

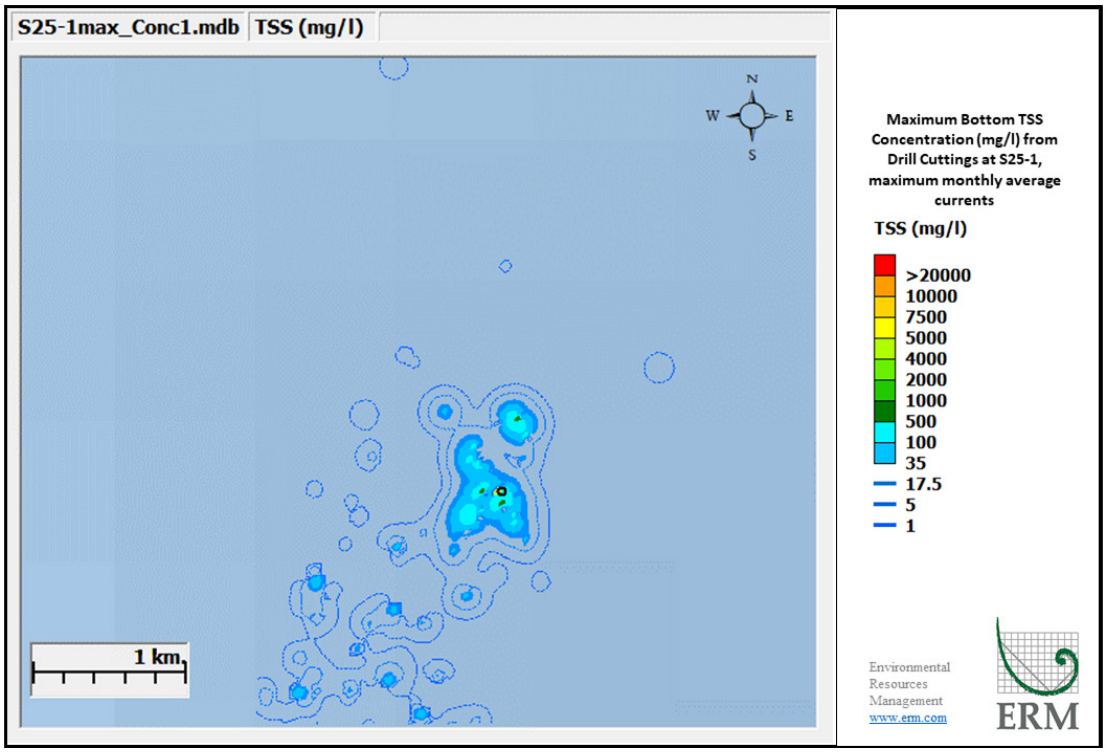


Figure 3-4: Maximum TSS Concentrations at Sea Bottom at the Shallow Well under Maximum Currents

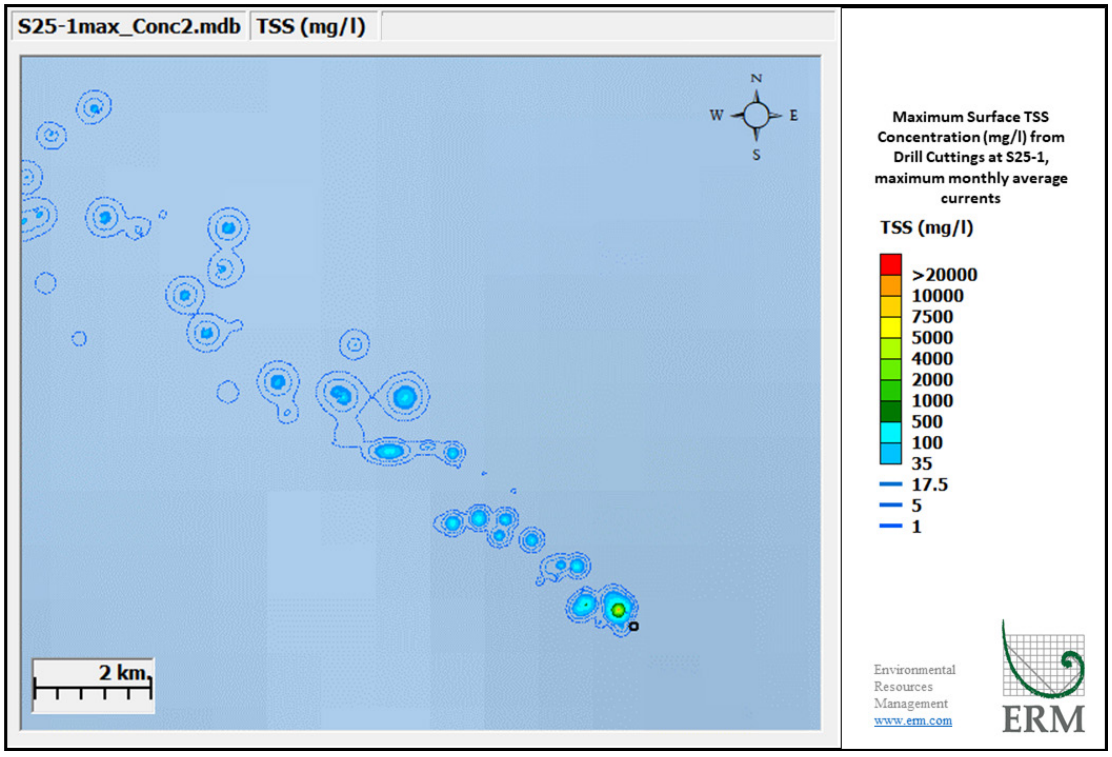


Figure 3-5: Maximum TSS Concentrations at Surface at the Shallow Well under Maximum Currents

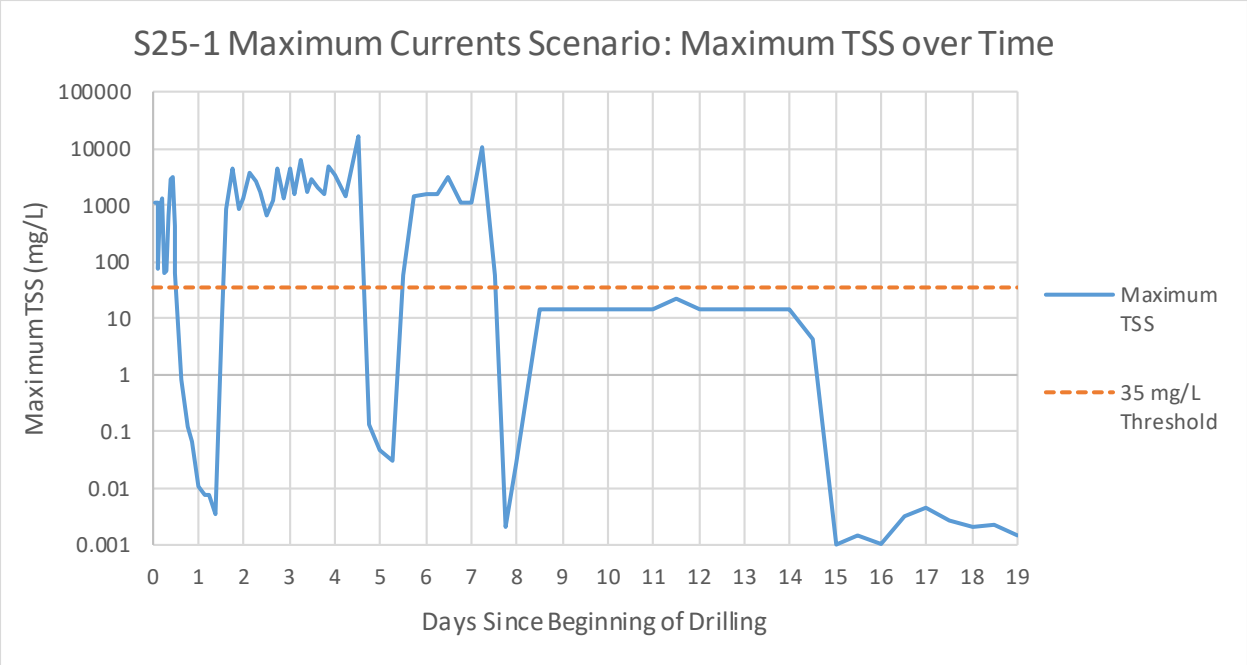


Figure 3-6: Maximum TSS Concentration Peak at Shallow Well Within the Water Column with Time under Maximum Currents

3.1.2 Deep Well (S25-25)

3.1.2.1 Minimum Currents

The minimum currents scenario for the deep well had a maximum TSS concentration of 6,334 mg/L, which occurred near the sea bottom. Figure 3-7 shows the maximum TSS concentration near the sea bottom and Figure 3-8 shows maximum TSS concentration near the surface. The area exceeding 35 mg/L is larger at the surface and covers 0.21 km². As with the shallow well, the TSS peaks are temporary in nature as shown in Figure 3-9, which depicts maximum TSS concentrations within the water column over time. The peak TSS levels (within the water column) stay above the impact threshold (35 mg/L) for no more than about 3 days at any one time.

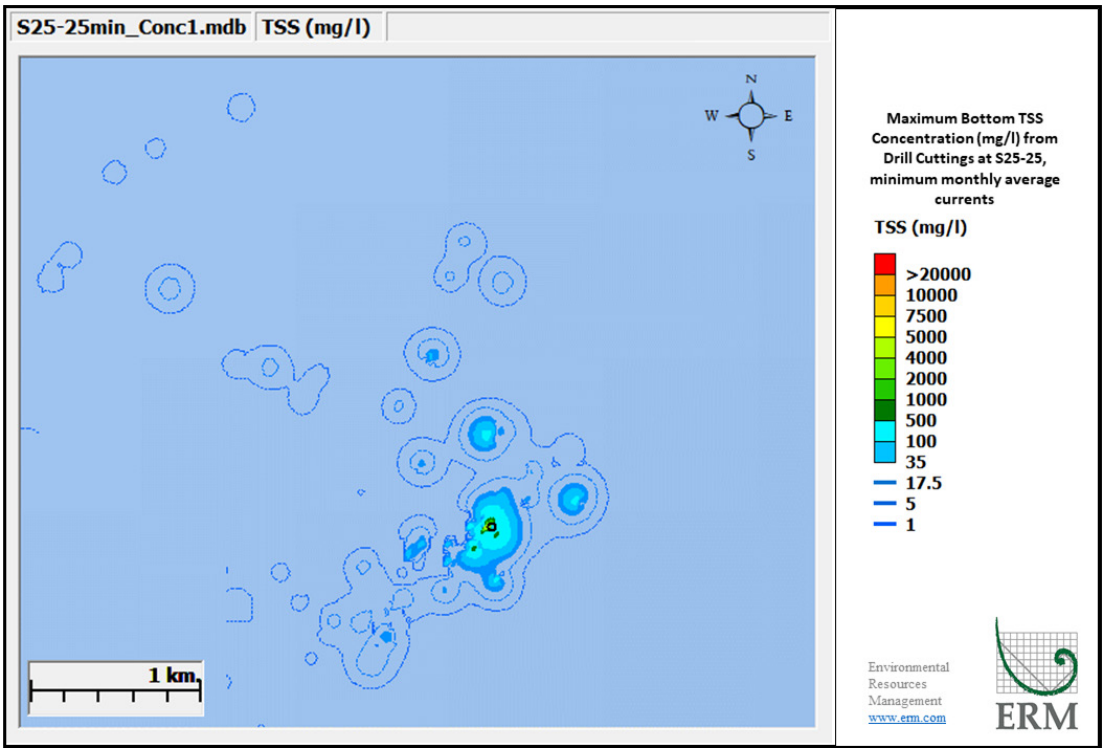


Figure 3-7: Maximum TSS Concentrations at Sea Bottom at the Deep Well under Minimum Currents

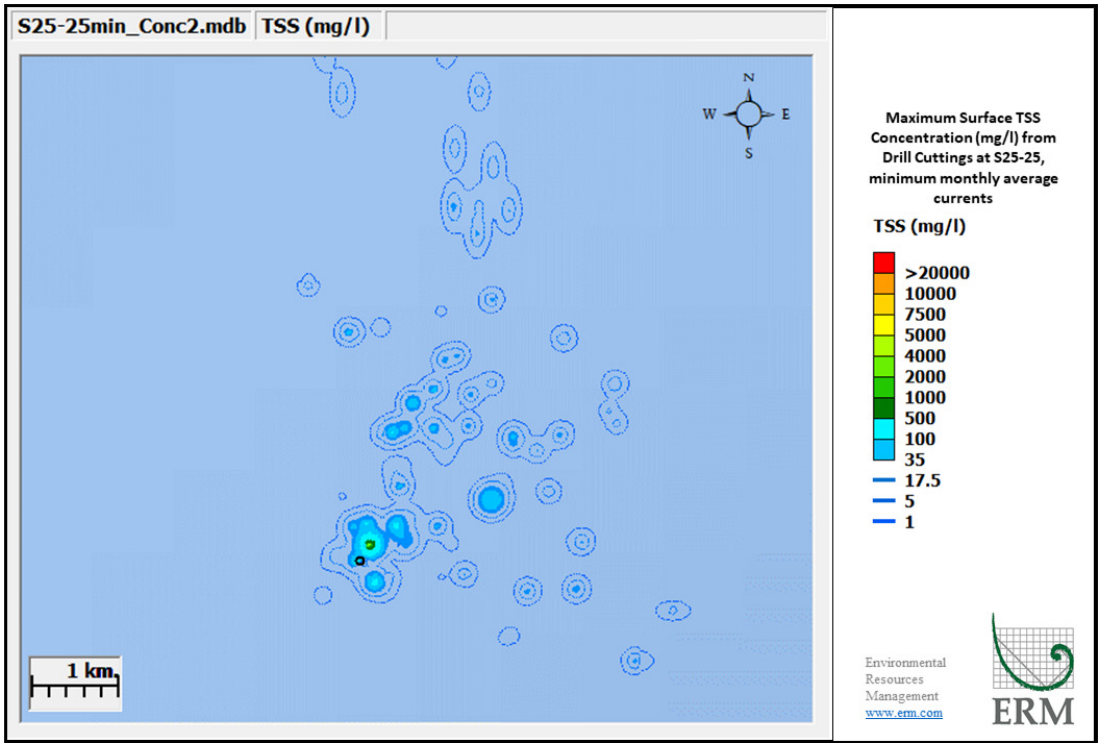


Figure 3-8: Maximum TSS Concentrations at Surface at the Deep Well under Minimum Currents

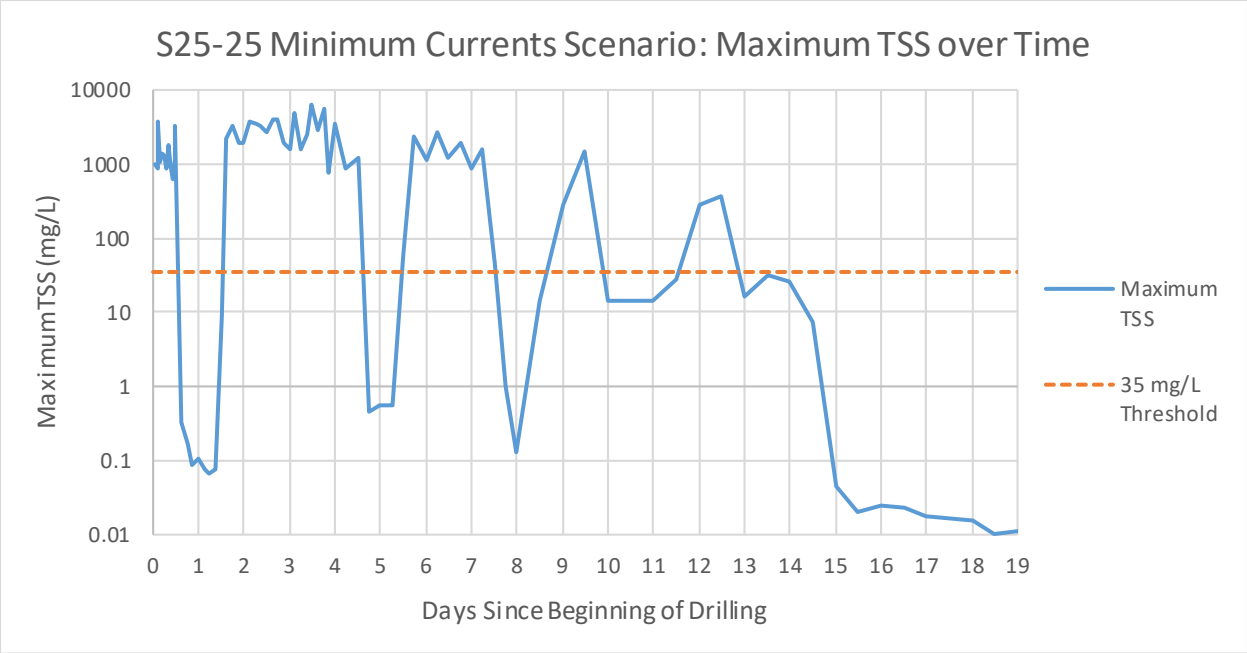


Figure 3-9: Maximum TSS Concentration Peak at Deep Well Within the Water Column with Time under Minimum Currents

3.1.2.2 Maximum Currents

The maximum currents scenario for the deep well had a maximum TSS concentration of 11,419 mg/L, which occurs near the sea bottom, as shown in Figure 3-10. Figure 3-11 shows maximum TSS concentrations near the surface. The area exceeding 35 mg/L is larger at the surface and covers 0.55 km². As noted for the other scenarios, the TSS peaks are temporary in nature, as shown in Figure 3-12, which shows maximum TSS concentrations within the water column over time. The peak TSS levels (within the water column) stay above the impact threshold (35 mg/L) for no more than about 3 days at any one time.

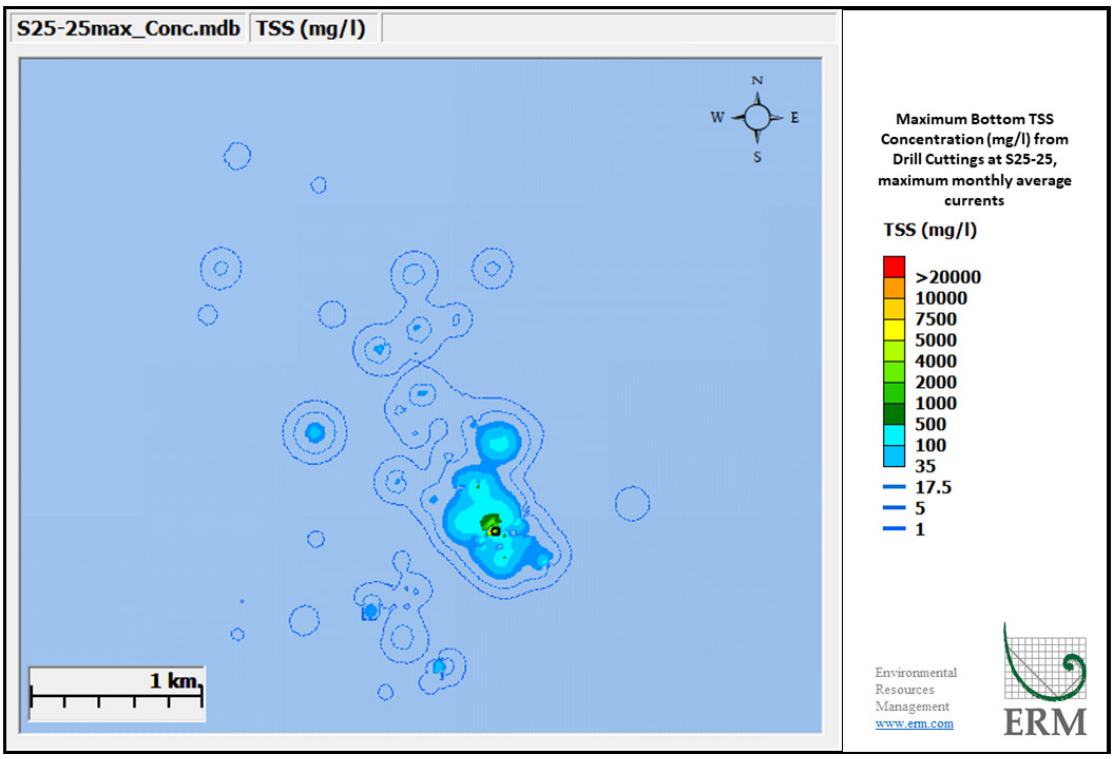


Figure 3-10: Maximum TSS Concentrations at Sea Bottom at the Deep Well under Maximum Currents

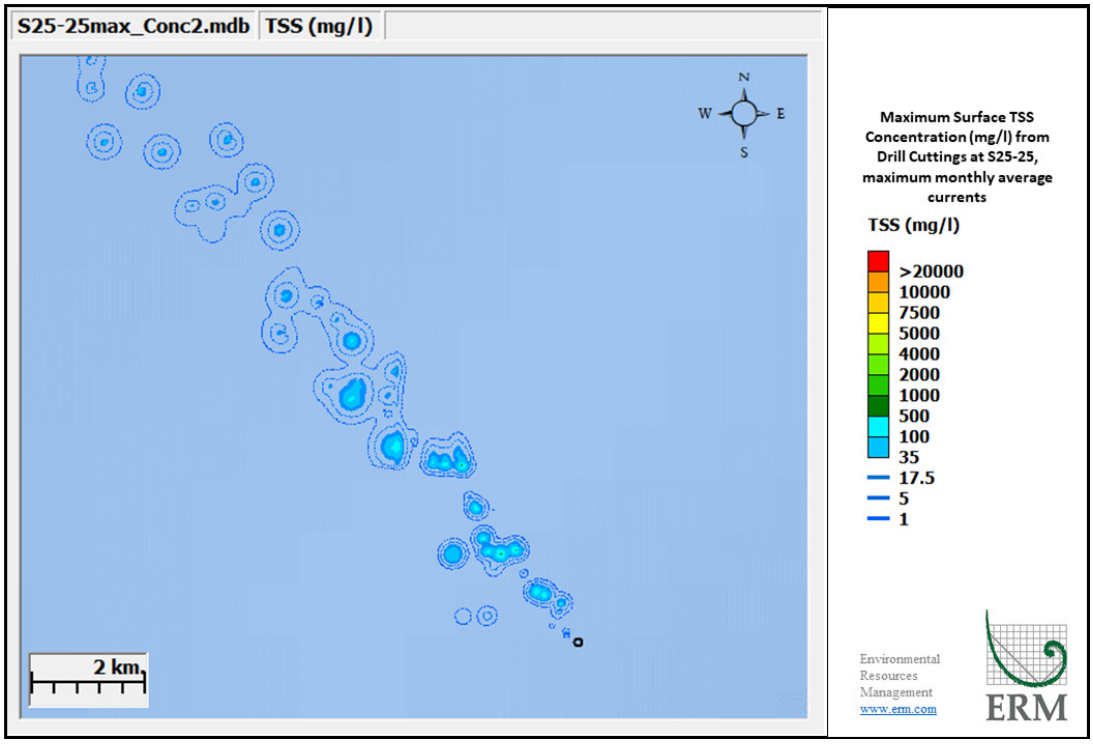


Figure 3-11: Maximum TSS Concentrations at Surface at the Deep Well under Maximum Currents

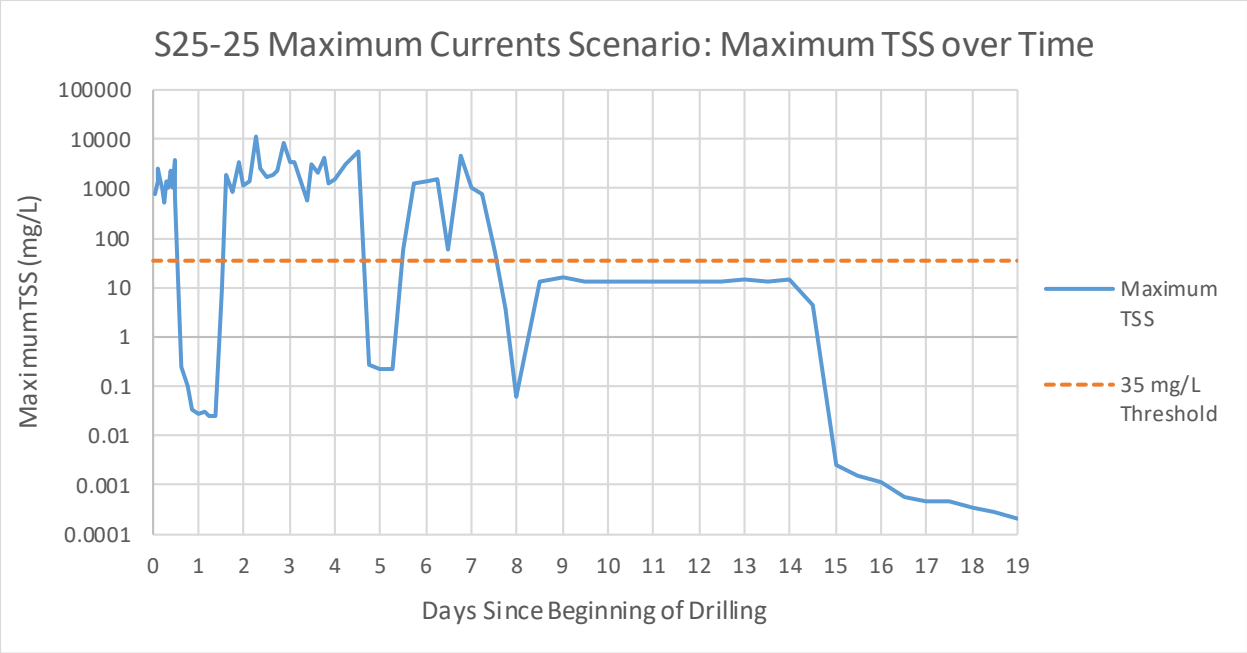


Figure 3-12: Maximum TSS Concentration Peak at Deep Well Within the Water Column with Time under Maximum Currents

3.1.3 Summary

Table 3-1 summarizes the results found in the TSS analysis for the two well locations under minimum and maximum currents scenarios.

Table 3-1: Summary of Results for Deep and Shallow Wells Under Different Currents at Time of Maximum TSS Occurrence

	Sections 1 and 2 (Seabed Release)		Sections 3 and 4 (Surface Release)	
Scenario	Maximum Bottom TSS (mg/L)	Area (km^2) with TSS > 35 mg/L Threshold	Maximum Surface TSS (mg/L)	Area (km^2) with TSS > 35 mg/L Threshold
S25-1 min. currents	5,358	0.20	5,743	0.33
S25-1 max. currents	16,322	0.18	10,877	0.48
S25-25 min. currents	6,334	0.12	2,759	0.21
S25-25 max. currents	11,419	0.19	770	0.55

3.2 Drill Cuttings Depositional Thickness

3.2.1 Shallow Well (S25-1)

3.2.1.1 Minimum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 5 centimeters threshold was 0.0048 km^2 as shown in Figure 3-13. The maximum length of this mound in any direction was 100 meters.

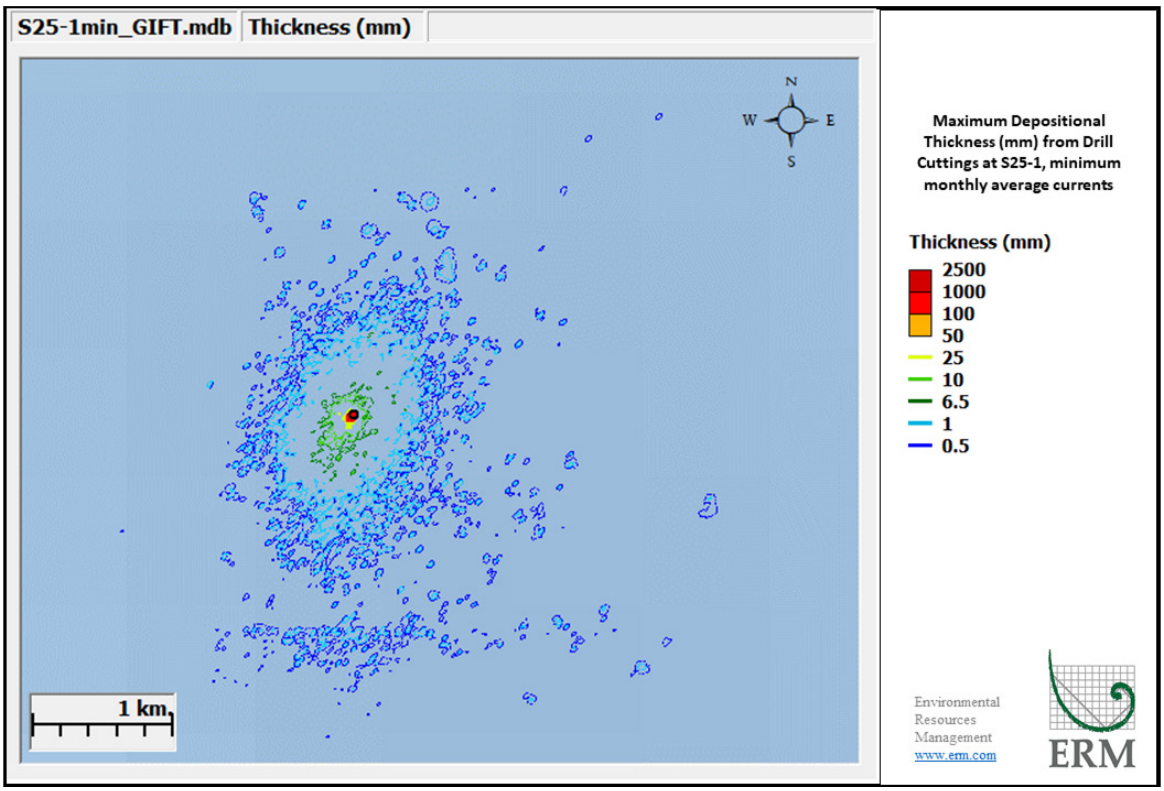


Figure 3-13: Maximum Cuttings Deposition Thickness for Shallow Well Under Minimum Currents

3.2.1.2 Maximum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 5 centimeters (50 millimeters) threshold was 0.0048 km^2 as shown in Figure 3-14. The maximum length of this mound in any direction was 100 meters.

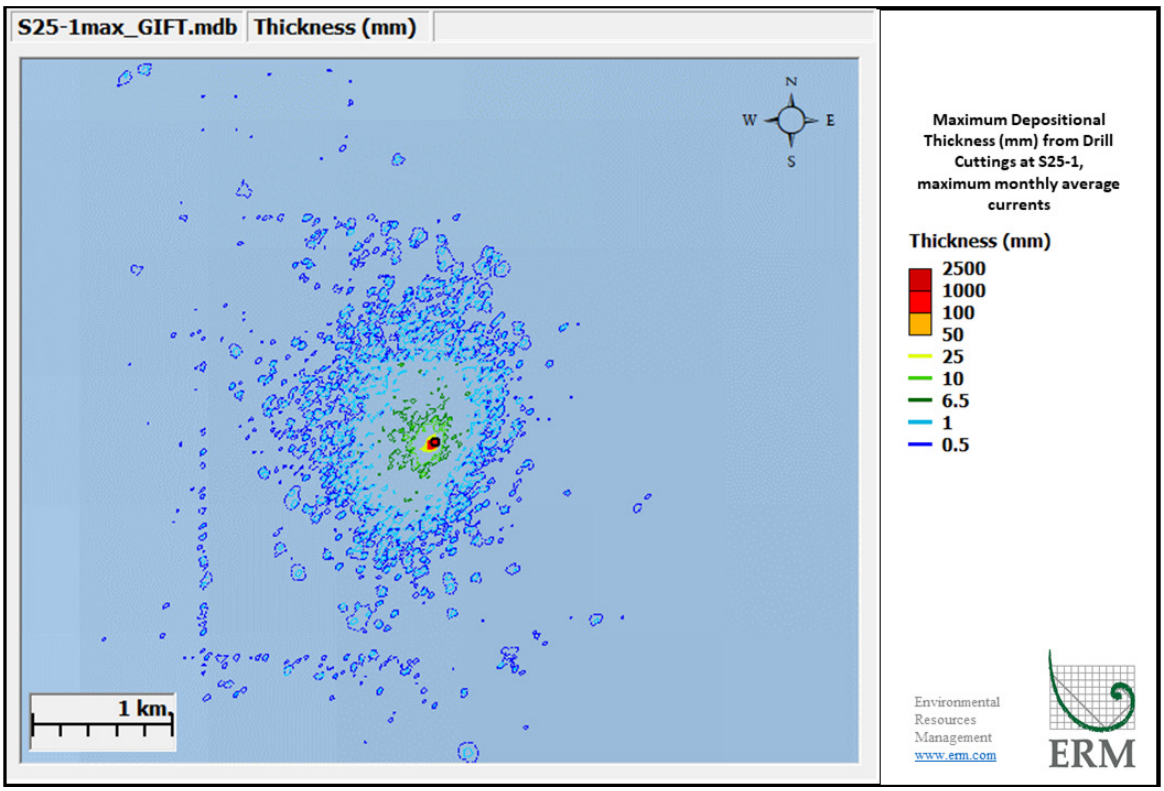


Figure 3-14: Maximum Cuttings Deposition Thickness for Shallow Well Under Maximum Currents

3.2.2 Deep Well (S25-25)

3.2.2.1 Minimum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 5 centimeters (50 millimeters) threshold was 0.0049 km², as shown in Figure 3-15. The maximum length of this mound in any direction was 105 meters.

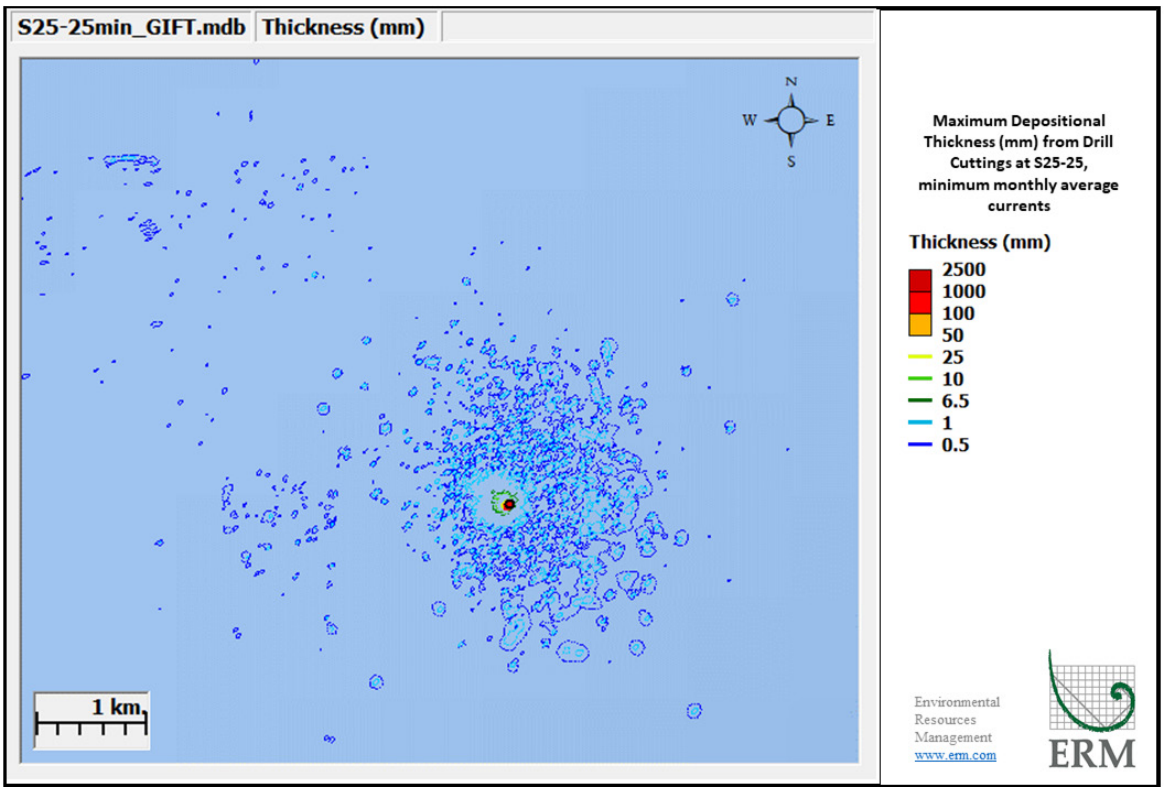


Figure 3-15: Maximum Cuttings Deposition Thickness for Deep Well Under Minimum Currents

3.2.2.2 Maximum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 5 centimeters (50 millimeters) threshold was 0.0054 km² as shown in Figure 3-16. The maximum length of this mound in any direction was 100 meters.

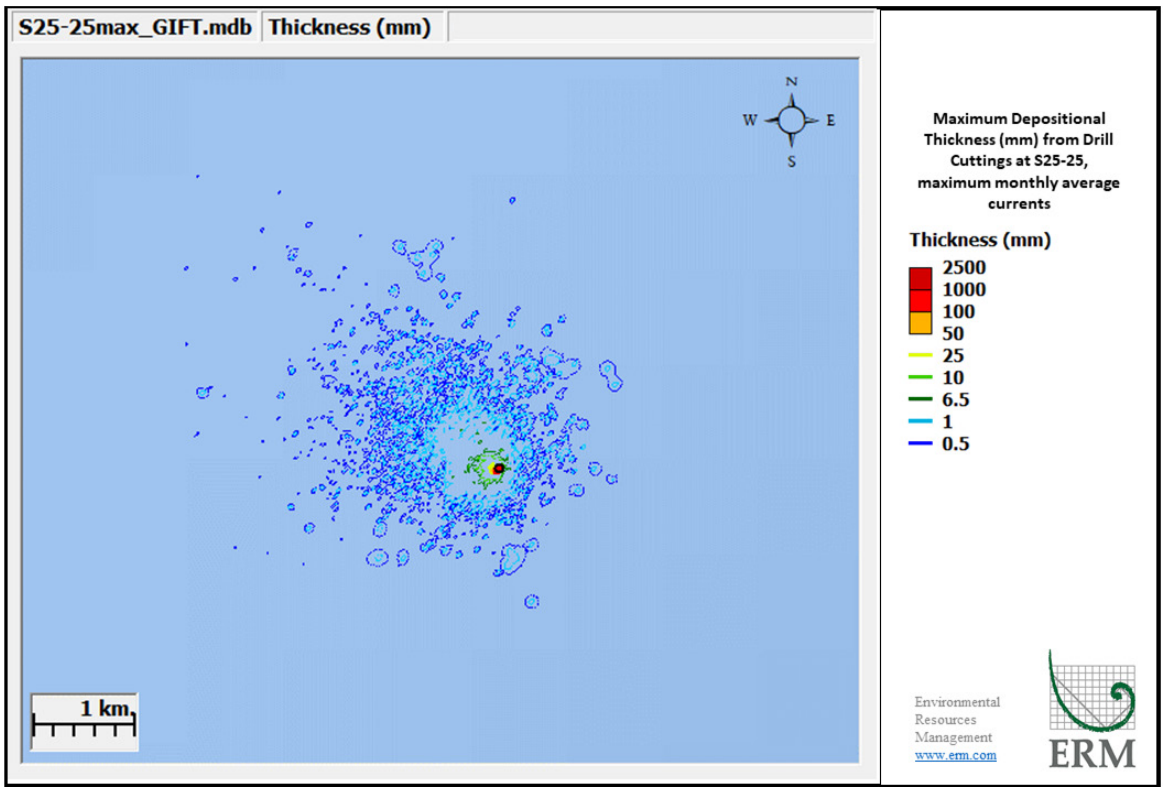


Figure 3-16: Maximum Cuttings Deposition Thickness for Deep Well Under Maximum Currents

3.2.3 Summary

Table 3-2 shows the cuttings accumulation (depositional thickness) analysis for the two well locations under minimum and maximum currents scenarios. Note that the table presents the area and maximum length across the depositional mound with accumulation over the depositional threshold (5 centimeters).

Table 3-2: Summary of Cuttings Deposition Results for Deep and Shallow Wells under Different Currents

Scenario	Area (km^2) with Thickness > 5 Centimeters Threshold	Maximum Length of Mound(s) with Threshold Exceedance (meters)
S25-1 min. currents	0.0048	100
S25-1 max. currents	0.0048	100
S25-25 min. currents	0.0049	105
S25-25 max. currents	0.0054	100

4. CUMULATIVE IMPACT ASSESSMENT RESULTS

4.1 Assessment of Cumulative Impacts within the Project

Cumulative impacts from multiple Project wells could occur if the TSS or cuttings deposition mounds from these wells were to overlap. The depositional mound persists for a longer duration compared to the TSS plume, which is very short lived. The TSS plume, as modeled and discussed in earlier sections, dissipates to less than the 35 mg/L threshold within 4 days after drill cutting discharge ends. For the Project exploration wells to result in cumulative impacts on the water column or seabed as a result of drilling of multiple Project wells, the distance from a well to half of the respective thresholds (17.5 mg/L for TSS and 2.5 centimeters for depositional thickness) would need to exceed the separation distance between any two wells. Additionally, this scenario would have to occur at the same time, as the impacts are only relevant in a specific timeframe. The maximum extents of the “one-half threshold” TSS plumes for the various scenarios are shown in Table 4-1 and the maximum extents of the “one-half threshold” cuttings deposition mounds for the various scenarios are shown in Table 4-2.

Table 4-1: Summary of TSS Results for Deep and Shallow Modeled Project Well Locations under Different Currents with Respect to the "One-Half Threshold"

	Sections 1 and 2 (Seabed Release)				Sections 3 and 4 (Surface Release)			
Scenario	Maximum Bottom TSS Concentration (mg/L)	Area (km^2) with TSS > 17.5 mg/L [a]	Farthest Distance (m) from Well to Edge of 17.5 mg/L Plume	Approximate Width (m) of Plume at Edge of 17.5 mg/L Plume	Maximum Surface TSS Concentration (mg/L)	Area (km^2) with TSS > 17.5 mg/L	Farthest Distance (m) from Well to Edge of 17.5 Plume	Approximate Width (m) of Plume at Edge of 17.5 mg/L Plume
S25-1 min. current	5,358	0.3112	1,700	130	5,743	0.6291	4,500	45
S25-1 max. current	16,322	0.3025	1,800	100	10,877	0.9333	12,000	130
S25-25 min. current	6,334	0.1982	1,100	70	2,759	0.439	4,000	45
S25-25 max. current	11,419	0.3001	1,200	50	770	1.0884	12,600	50

m = meters
[a] One-half of the threshold of 35 mg/L

Table 4-2: Summary of Cuttings Deposition Results for Deep and Shallow Modeled Project Well Locations Under Different Currents with Respect to "One-Half Threshold"

Scenario	Area (km^2) with Thickness > 2.5 centimeters [a]	Maximum Length (m) of Mound Exceeding 2.5 centimeters
S25-1 min. currents	0.0084	135
S25-1 max. currents	0.0083	140
S25-25 min. currents	0.0065	100
S25-25 max. currents	0.0088	120

[a] One-half of the threshold of 5 centimeters

4.1.1 Total Suspended Solids

As discussed previously, due to the short-lived nature of TSS plumes, intra-Project cumulative impacts from TSS are highly unlikely because TSS plumes will not persist beyond about 3 days after the drill cuttings discharges end, as shown previously in Figure 3-3, Figure 3-6, Figure 3-9, and Figure 3-12. From a spatial perspective, the maximum distance from a potential Project well location to the edge of a 17.5 mg/L TSS plume exceeding 17.5 mg/L was modeled at 4.5 kilometers for the minimum currents scenario and 12.6 kilometers for the maximum currents scenario. Figure 4-1 shows that the closest distance between two potential Project well locations is 5.2 kilometers. This indicates that there is theoretically potential for TSS plumes from two Project wells to overlap and result in areas with a combined TSS concentration exceeding 35 mg/L, but only in situations where the currents are similar to the maximum monthly averaged, depth-averaged currents scenario and only in situations where the two wells were being drilled at the same time.

While this scenario is theoretically possible, it is unlikely. Beyond the first few kilometers from a well, the TSS plume is extremely spotty and fragmented. For any overlap to occur spatially, the individual patches of higher TSS would need to occur at the same exact location, and at the same time, which is also unlikely. Note also that at any given time, the currents will move the TSS plume in the same direction for all wells (if drilled at the same time). For instance, an easterly current will move the patches of high TSS concentrations to the east, in the same manner for both wells, not in opposite directions (which would be necessary to facilitate overlapping of the plumes). This means that the separation distance between the plumes will, to a large extent, be maintained at the separation distances of the wells themselves, further reducing the potential for overlap. Furthermore, as discussed above, the short-term existence of the elevated TSS plumes further reduces the possibility of overlap occurring, as the individual spots of high TSS would need to occur within the same timeframe (i.e., within the same few days as seen from temporal plots). Beyond these limited timeframes, suspended solids would continue to disperse and settle, thus reducing the potential for a cumulative impact.

4.1.2 Cuttings Depositional Thickness

The maximum modeled length across a Project well sediment deposition mound exceeding 2.5 centimeters is 140 meters, roughly centered on the well. With the smallest distance between two potential Project wells being 5.2 kilometers, it is therefore highly unlikely for any combined exceedance of the 5 centimeters threshold to occur.

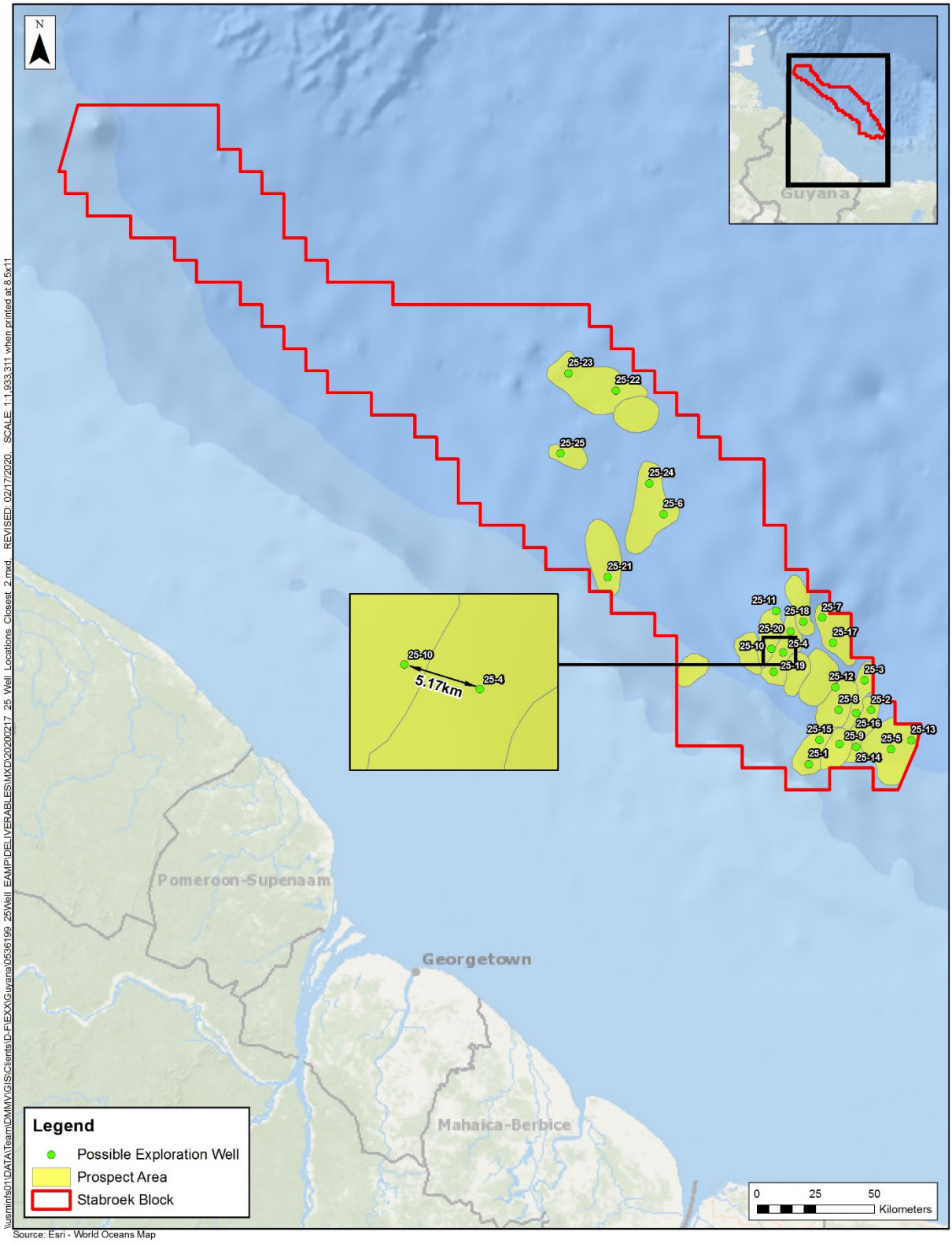


Figure 4-1: Potential Project Well Locations with Distance between Closest Wells

4.2 Assessment of Cumulative Impacts with Other Projects

In addition to assessing the potential for cumulative impacts from wells within the Project, the potential for cumulative impacts to result from Project wells and previously completed exploration wells, other proposed exploration wells, and previously completed or proposed development wells (collectively "other EEPGL drilling") was evaluated. These results are discussed below.

4.2.1 Total Suspended Solids

Cumulative impacts from TSS plumes resulting from the Project and other EEPGL drilling are unlikely due to the reasons discussed in Section 4.1.1. From a spatial perspective, the maximum modeled distance from a potential Project well location to the edge of a 17.5 mg/L TSS plume was 12.6 kilometers. At this distance, the width of the plume is on the order of 50 meters. As shown in Figure 4-2, the potential for overlap between a TSS plume from a Project well and a TSS plume from an EEPGL development well (considering Liza Phase 1, Liza Phase 2, and Payara) is extremely low, because the smallest distance between any two of these well locations is 14.1 kilometers. The distance from a potential Project well location to the nearest actual or potential exploration well location for the Stabroek 12-Well Multiwell Campaign is 6.4 kilometers. Due to the uncertainty in the locations of proposed wells in the Canje and Kaieteur blocks, the "closest" distances from potential Project well locations were measured from the potential Project well locations to the edges of the respective blocks, and were found be 3.3 kilometers and 10.8 kilometers for the Canje and Kaieteur blocks, respectively. This indicates that there is theoretically a potential for TSS plumes to overlap resulting in areas with a combined TSS concentration exceeding 35 mg/L, but only if the wells are actually drilled this close to one another and only in situations where the two wells are being drilled at the same time. When considering the time-varying and depth-varying nature of TSS plumes along with directionality and speed of the currents at a given time, cumulative impacts related to overlapping TSS plumes resulting from Project well drilling and other EEPGL drilling are unlikely.

4.2.2 Cuttings Depositional Thickness

To assess the potential influence of varying water depths of the potential Project well locations when assessing potential cumulative impacts from overlapping cuttings deposition mounds from the Project and other EEPGL drilling, the cuttings deposition modeling results from selected previous modeling efforts (i.e., for separate EEGPL regulatory submittals) were used along with the results from the Project-specific modeling. From EEPGL's 12-Well Stabroek Exploration Campaign Environmental Management Plan, model results from well locations "A" and "F" were used. From EEPGL's Kaieteur Block 1-Well Exploration Campaign Environmental Assessment and Management Plan (EA&MP), model results from the well location "K_Shallow" were used. The detailed results for these modeling efforts are provided in their respective regulatory submittals, but are also provided in Attachment 1, for ease of reference. Figure 4-3 depicts and Table 4-3 summarizes the locations and water depths for the modeled well locations used. Based on the depths at each of the potential Project well locations, the most appropriate 2.5-centimeter ("one-half threshold") cuttings deposition mound results (from the five modeled well locations summarized in Table 4-3) were projected onto each of the potential Project well locations.

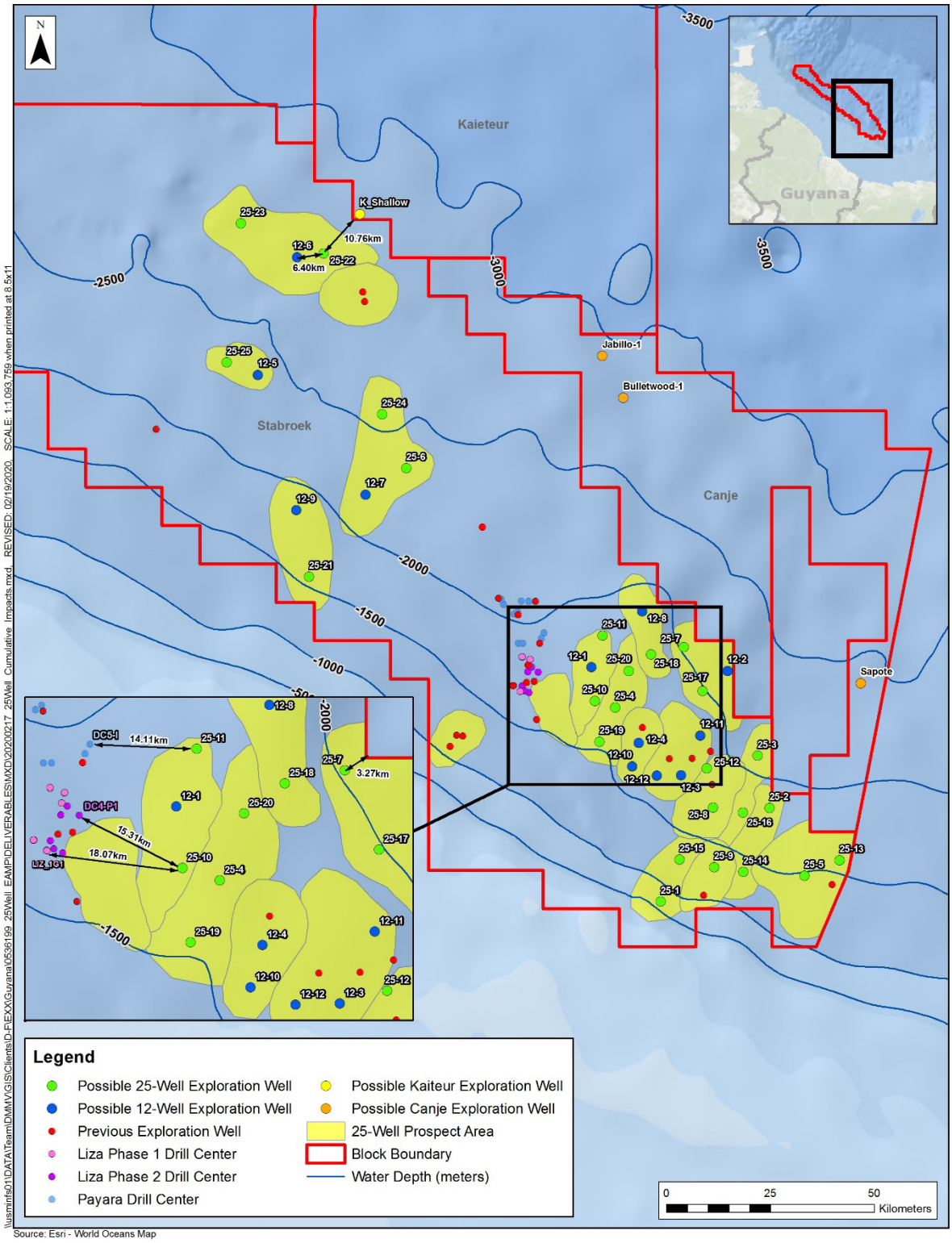


Figure 4-2: Potential Project Well Locations and Other EEPGL Completed or Potential Well Locations with Distances between Closest Wells

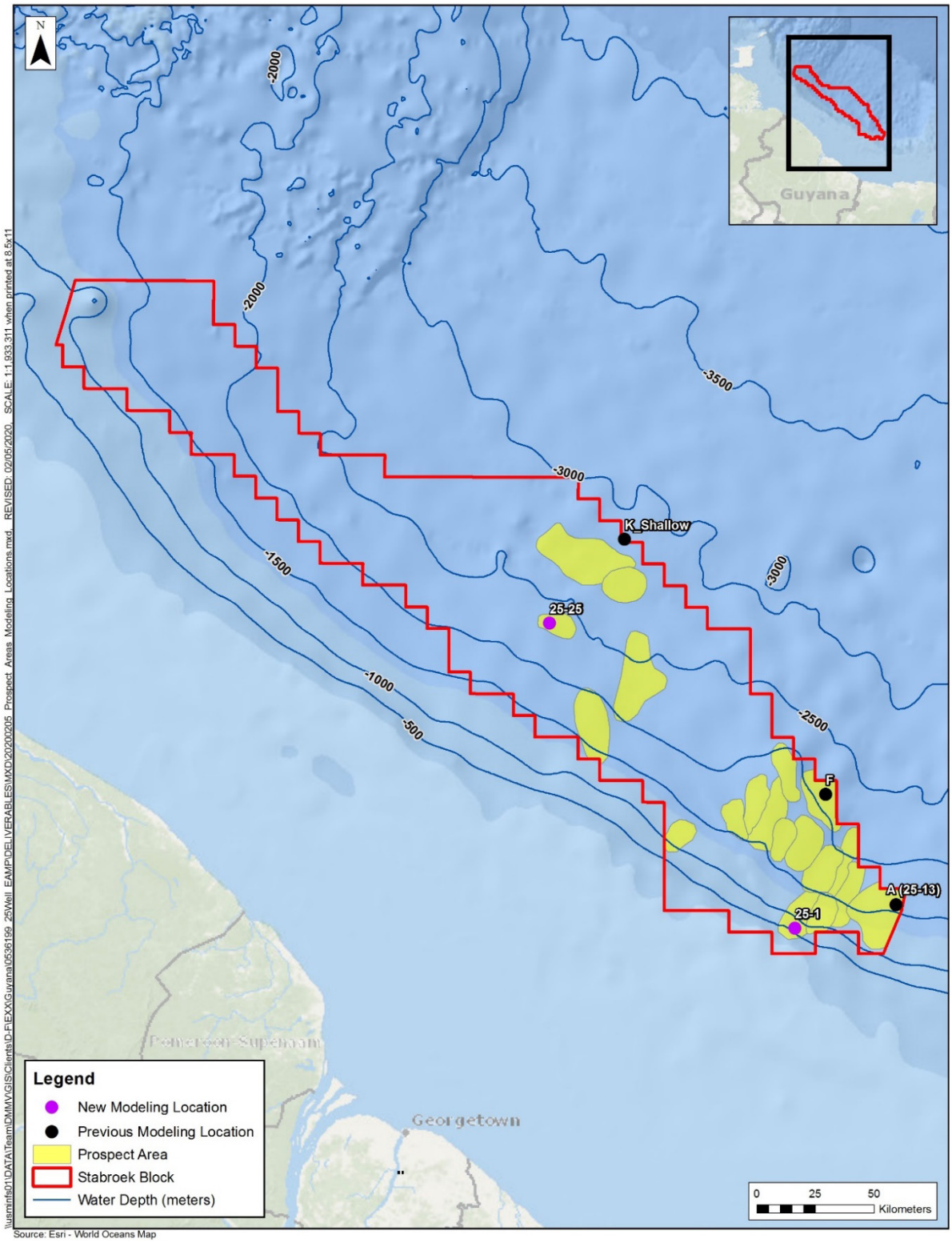


Figure 4-3: Modeling Locations Used to Represent Cuttings Deposition Mounds at the 25 Potential Project Well Locations

Table 4-3: Coordinates and Water Depths for the Modeling Locations Used to Represent Cuttings Deposition Mounds at the 25 Potential Project Well Locations

Location Name	Easting (m)	Northing (m)	Latitude	Longitude	Approximate Water Depth (m)
S25-1	537480	839928	7.598513	-56.6602	717
S25-25	433018	969673	8.771756	-57.609	2,319
A	580500	849912	7.688338	-56.2701	1,579
F	550655	896822	8.113028	-56.5402	2,182
K_Shallow	465041	1005390	9.095177	-57.31814	2,874

For other EEPGL drilling locations, the following representative cuttings deposition modeling results were projected onto the other EEPGL drilling locations based on consideration of proximity, bathymetry, and well profile:

- Liza Phase 1 and Liza Phase 2 Environmental Impact Assessments
- 12-Well Stabroek Exploration Campaign Environmental Management Plan
- Kaieteur Block 1-Well Exploration Campaign EA&MP
- Canje Block 3-Well Exploration Campaign EA&MP

The detailed results for these modeling efforts are provided in Attachment 1. Figure 4-4 and Figure 4-5 show these projected deposition mounds for the minimum and maximum current scenarios, respectively.

As demonstrated in these figures, cumulative impacts due to overlap of cuttings deposition mounds are extremely unlikely. From the modeling results discussed above, the maximum length across a cuttings deposition mound exceeding 2.5 centimeters is 145 meters, roughly centered around the well. This distance is much smaller than the shortest distance between a Project well location and any other EEPGL well location considered (the smallest being 3.3 kilometers from a potential Project well location to the edge of the Canje Block), indicating no possibility of overlap.

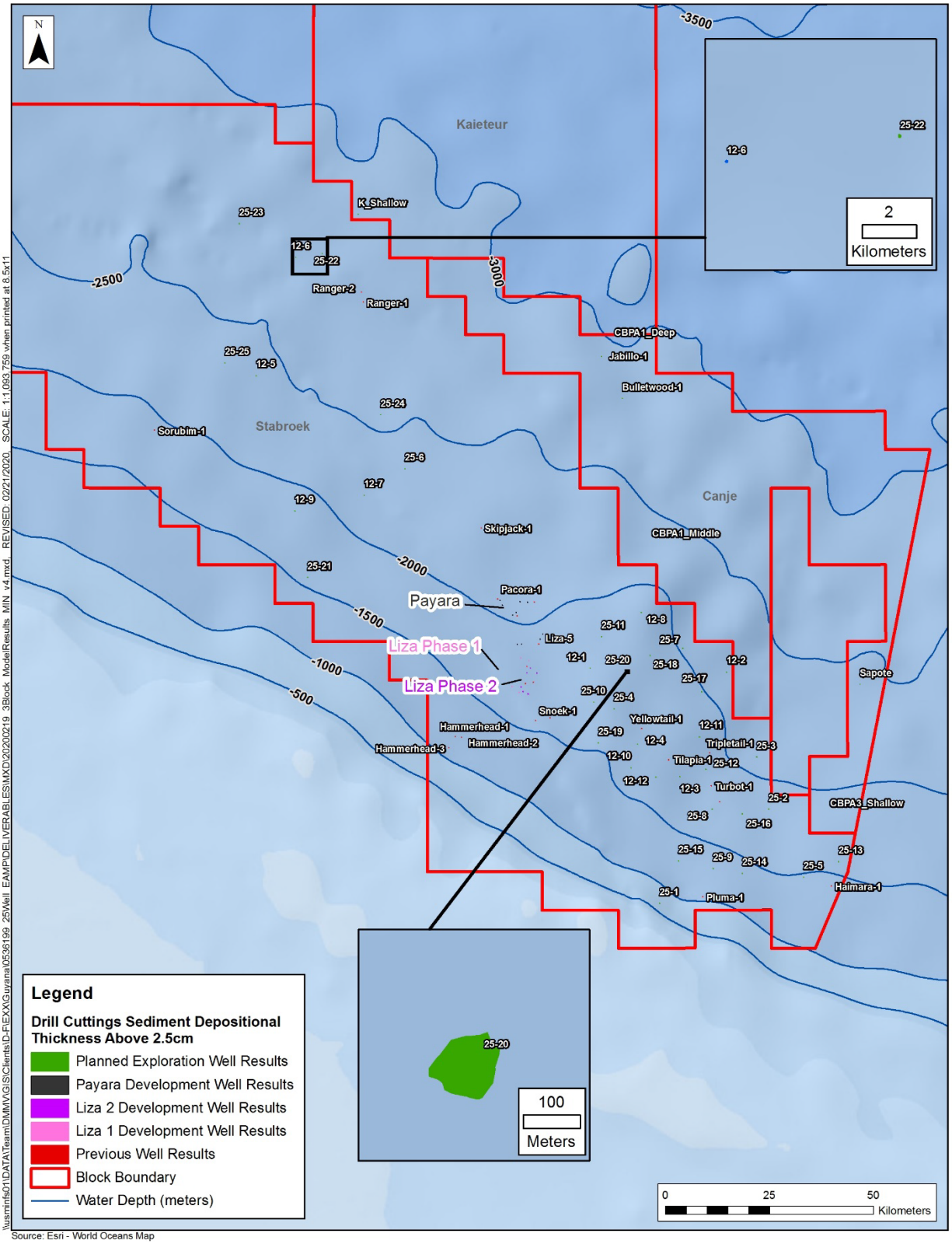


Figure 4-4: Modeling Locations Used to Represent Cuttings Deposition Mounds at the 25 Potential Project Well Locations

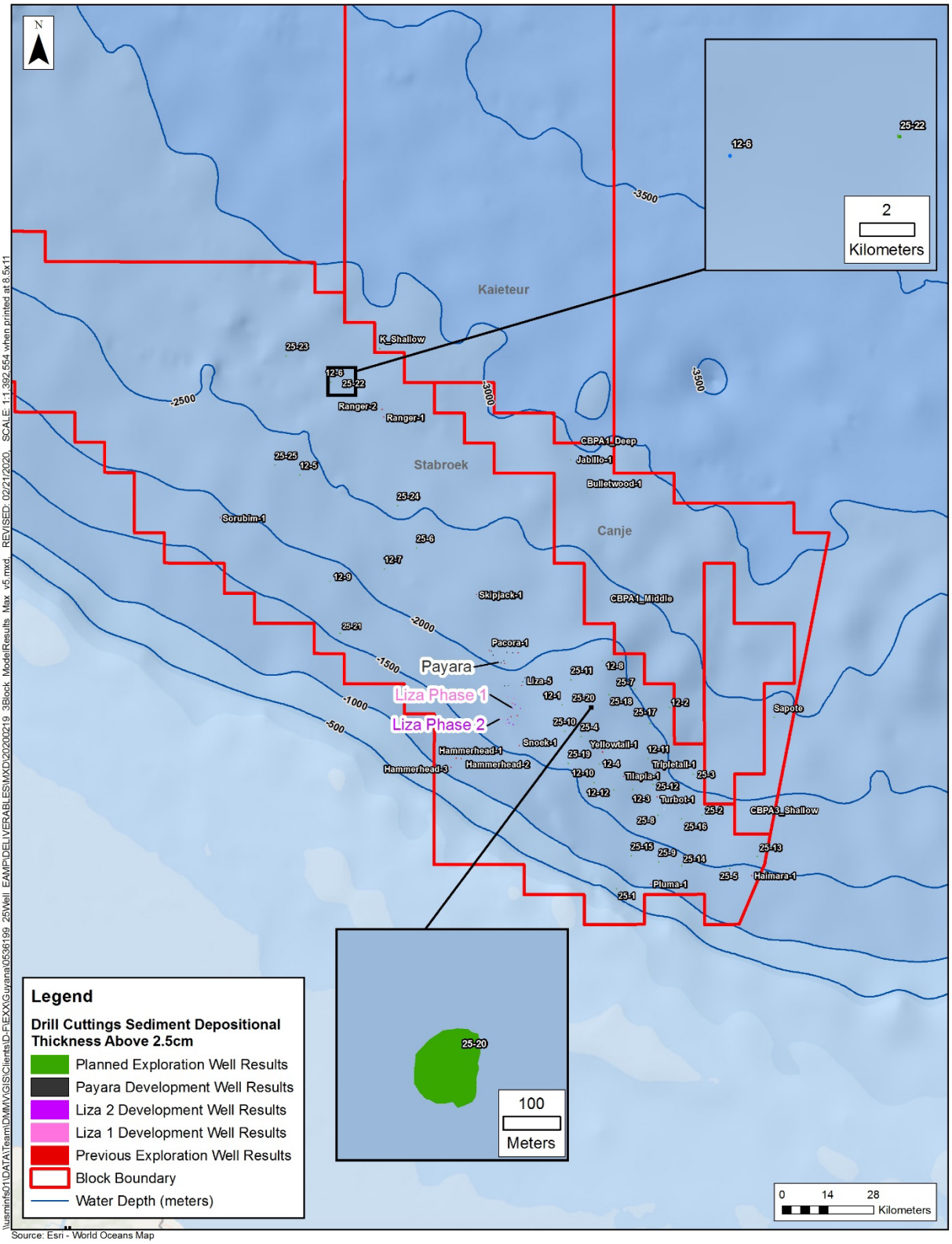


Figure 4-5: Modeling Locations Used to Represent Cuttings Deposition Mounds at the 25 Potential Project Well Locations

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ATTACHMENT 1 DRILL CUTTINGS MODELING FOR PREVIOUS EEPGL PROJECTS

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Esso Exploration and Production Guyana Limited

Drill Cuttings Modeling for Previous EEPGL Projects

Model Results Across all EIAs and EMPs to Date

March 2020

Project No.: 0536199

The business of sustainability

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March 2020

Drill Cuttings Modeling for Previous EEPGL Projects

Model Results Across all EIAs and EMPs to Date



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Acronyms and Abbreviations

Name	Description
ºC	degrees Celsius
°F	degrees Fahrenheit
2-D	two-dimensional
3-D	three-dimensional
bbl	barrel
BFROC	base fluid retention on cuttings
BML	Below mud line
BPD	barrels per day
cm	centimeter
cm/s	centimeters per second
EA&MP	Environmental Assessment and Management Plan
EEPGL	Esso Exploration and Production Guyana Limited
EIA	Environmental Impact Assessment
ERM	Environmental Resources Management
FPSO	Floating Production, Storage, and Offloading (vessel)
g/m²	grams per square meter
GEBCO	General Bathymetric Chart of the Oceans
GEMSS	Generalized Environmental Modeling System for Surfacewaters
GIFT	Generalized Integrated Fate and Transport
GLLVHT	Generalized, Longitudinal-Lateral-Vertical Hydrodynamic and Transport
HYCOM	HYbrid Coordinate Ocean Model
km^2	square kilometers
m	meter
m^2	square meters
m/s	meters per second
MARPOL 73/78	International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978
mg/L	milligrams per liter
mi^2	square miles
mm	millimeter
MSL	mean sea level
NA	not applicable
NABF	non-aqueous base fluid
NADF	non-aqueous drilling fluid
ppg	pounds per gallon
ppm	parts per million
SOBM	synthetic oil-based mud
TSS	total suspended solids
TD	total depth
USEPA	U.S. Environmental Protection Agency
UTM	Universal Transverse Mercator
WBDF	water-based drilling fluids
WBM	water-based mud

1. INTRODUCTION

This appendix contains the results of previous drill cuttings discharge modeling conducted by Environmental Resources Management (ERM) for Esso Exploration and Production Guyana Limited (EEPGL) in support of prior regulatory submittals. These results were used to assess the potential for cumulative impacts from overlapping cuttings deposition mounds from the Project wells and other EEPGL drilling. Cuttings deposition modeling results from selected previous modeling efforts (i.e., for separate EEGPL regulatory submittals) were used along with the results from Project-specific modeling to assign representative cuttings deposition "footprints" for each of the 25 potential Project-specific well locations. From EEPGL's 12-Well Stabroek Exploration Campaign Environmental Management Plan (EMP), model results from well locations "A" and "F" were used. From EEPGL's Kaieteur Block 1-Well Exploration Campaign Environmental Assessment and Management Plan (EA&MP), model results from the well location "K_Shallow" were used.

For other EEPGL drilling locations, results from the following reports were utilized to select representative cuttings deposition "footprints" to be projected onto the other EEPGL drilling locations considered in the analysis, based on consideration of proximity, bathymetry, and well profile:

- Liza Phase 1 and Liza Phase 2 Environmental Impact Assessments (EIAs)
- 12-Well Stabroek Exploration Campaign EMP
- Kaieteur Block 1-Well Exploration Campaign EA&MP
- Canje Block 3-Well Exploration Campaign EA&MP

These results have been provided in previous EEPGL regulatory submittals, but for ease of reference are presented again in this attachment.

2. LIZA PHASE I (EIA)

2.1 Approach

In this study, the discharge of drill cuttings is evaluated. It is assumed that there will be a direct discharge of cuttings during drilling of the riserless open hole section followed by discharge near the surface of cuttings with a small fraction of adhered residual base oil from material removed in the lower well sections after treatment on the floating production, storage, and offloading vessel (FPSO).

For the impact assessment, the modeling was performed to determine three key endpoints:

- The amount of suspended sediment concentrations added to water column background concentrations;
- The seabed accumulation (thickness) of the adhered fluids and drill cuttings over an area of seafloor (the footprint) for assessment of impacts to benthic organisms; and
- The amount of hydrocarbons settled upon the seafloor.

2.1.1 Simulation Design

Released material will pass vertically through the water column because cuttings and fluids are denser than the receiving water. Released material will also migrate horizontally due to advection by local and regional currents. The dispersion of cuttings and fluids dispersion therefore is fundamentally a three-dimensional phenomenon requiring three-dimensional hydrodynamic fate and transport modeling.

There are four well center locations. Two of these centers were modeled representing the shallowest and the deepest wells. These are DC1-I at a depth of 1,688 meters and DC2-I at a depth of 1,853 meters.

At each of these wells, the top hole (Section 1) and conductor (Section 2) will be jetted and drilled with water-based drilling fluids (WBDF) to a depth of 956 meters below the mud line (BML; see Table 2-1). The subsequent three sections (with hole diameters sizes 17.5"and 12.25"followed by a hole 8.5 inches by 9.875 inches) will be drilled with non-aqueous drilling fluid (NADF) until a total depth (TD) is reached at approximately 6,628 meters BML. The discharge pipe from the drill platform will release treated cuttings 11 meters below mean sea level (MSL).

Table 2-1: Well Profile

Section	Diameter (inches)	Well Interval (m)
Section 1 – Structural (Top Hole, Jet)	36"	82
Section 2 – Conductor	26"	1,065
Section 3 – Surface	17 ½"	1,530
Section 4 – Production	12 ¼"	3,150
Section 5 - Open	8 ½" x 9 7/8"	1,000

m = meters

To develop the three required endpoints, three model grids were used: a particle grid, a depositional grid, and a concentration grid. The movement of the discharged cuttings and fluids using Lagrangian particles was computed within the particle grid (Figure 2-1). This particle grid is square approximately 55 kilometers on each side, with each cell approximately 50 meters by 50 meters in length and width. Each grid cell contains an interpolated depth value derived from the bathymetry data described in Section 3.1.3.1. Particles are free to move horizontally and vertically within this grid's domain, independently of the grid except for movement past the grid boundaries on the seafloor (as defined by the bathymetry) and shorelines.

For computation of the mass deposition on the seafloor, the model used a smaller and finer square, two-dimensional (2-D) depositional grid, with each grid centered on a well. The depositional grid is a 20 kilometers square grid with 520 cells on each side, each cell approximately 38 meters in length and width (Figure 2-2).

The concentration grid, used for computations of total suspended solids (TSS), is three-dimensional with the same horizontal dimensions as the depositional grid. Vertically, the cells are 10 meters thick at the surface and bottom regions where the maximum suspended solids are predicted to occur. The cell thicknesses expand in size towards the middle of the water column region. See Table 2-2 for a summary of these three grids' dimensions.

Table 2-2: Grid Dimensions

Grid	Horizontal Dimensions	Vertical Dimensions
Particle grid	50 m x 50 m	N/A
Depositional grid	38 m x 38 m	N/A
Concentration grid	Variable – smallest 25 m x 25 m at center	Variable – smallest 10 m at top and bottom

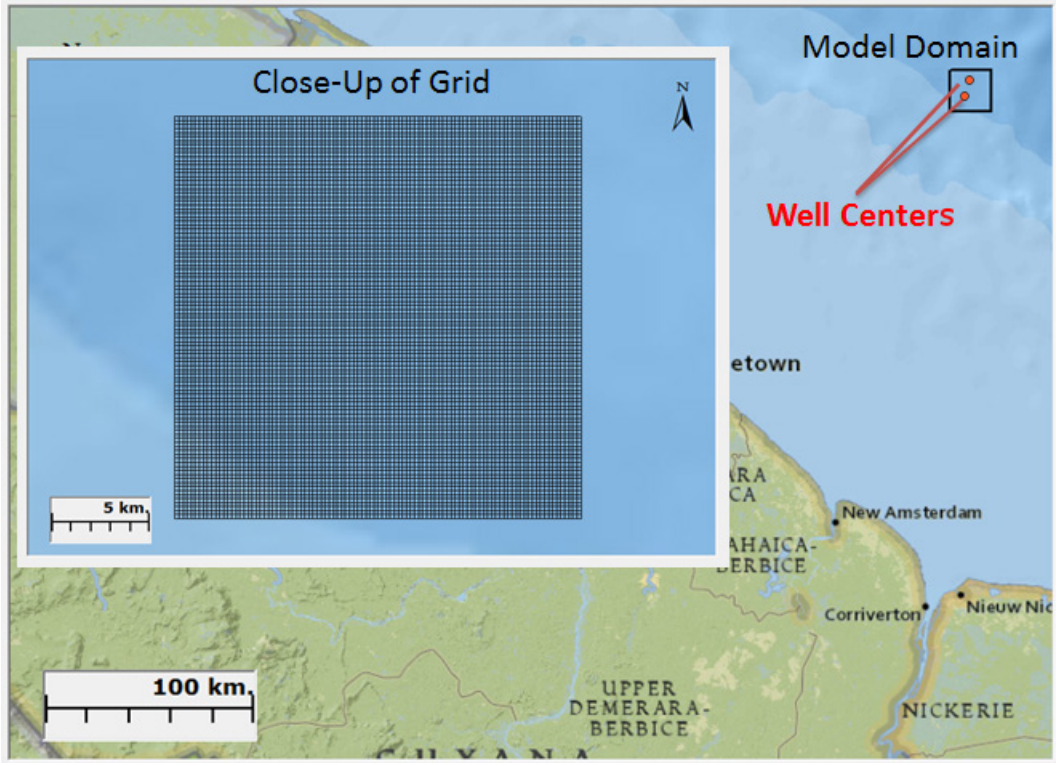


Figure 2-1: Particle Grid

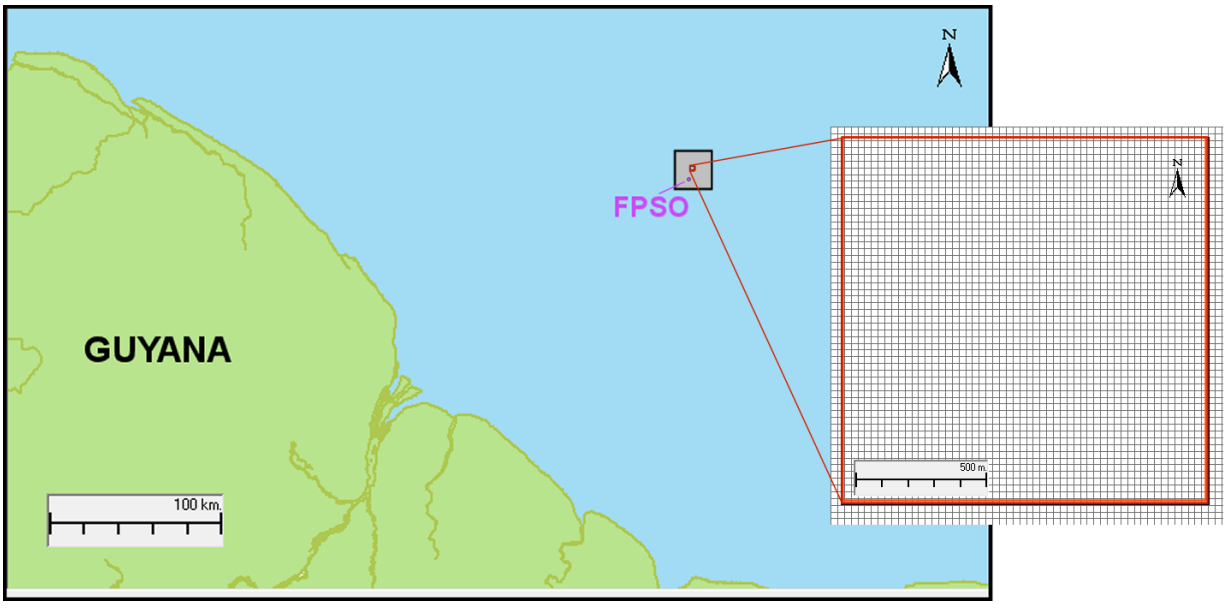


Figure 2-2: Depositional and Concentration Grid

2.1.2 Drill Cuttings and Fluid Deposition Software

The modeling was performed using GEMSS® (Generalized Environmental Modeling System for Surfacewaters) and its drill cuttings and fluids discharge module, GIFT (Generalized Integrated Fate and Transport) (Kolluru and Spaulding 1993; Kolluru, et al. 1998; Fichera and Kolluru 2007; Fichera et al. 2013; Prakash and Kolluru 2014). GIFT simulates the fate of dissolved and particulate material discharged during dredging operations, disposal of mine tailings, well drill cuttings and fluids, and release of produced water. 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. The modeling methodology is based on a deterministic mode of simulation. In deterministic, single event simulations, the starting date and current speed and direction at each time step are chosen from a database of properties in the selected periods.

Drill cuttings and fluids were modeled as particles. Movement in the vertical direction resulted in the settling and deposition of cuttings on the seabed. The combined action of erosion and deposition, based on particle size distribution and the intensity of release, resulted in the net accumulation of drill cuttings on the seabed.

Modeling data requirements included:

- Drill section sizes and schedule
- Drilling fluid types
- Cuttings and fluid grain size distribution
- Fluid and cuttings densities
- Fluid and cuttings release rates, durations, and discharge depths

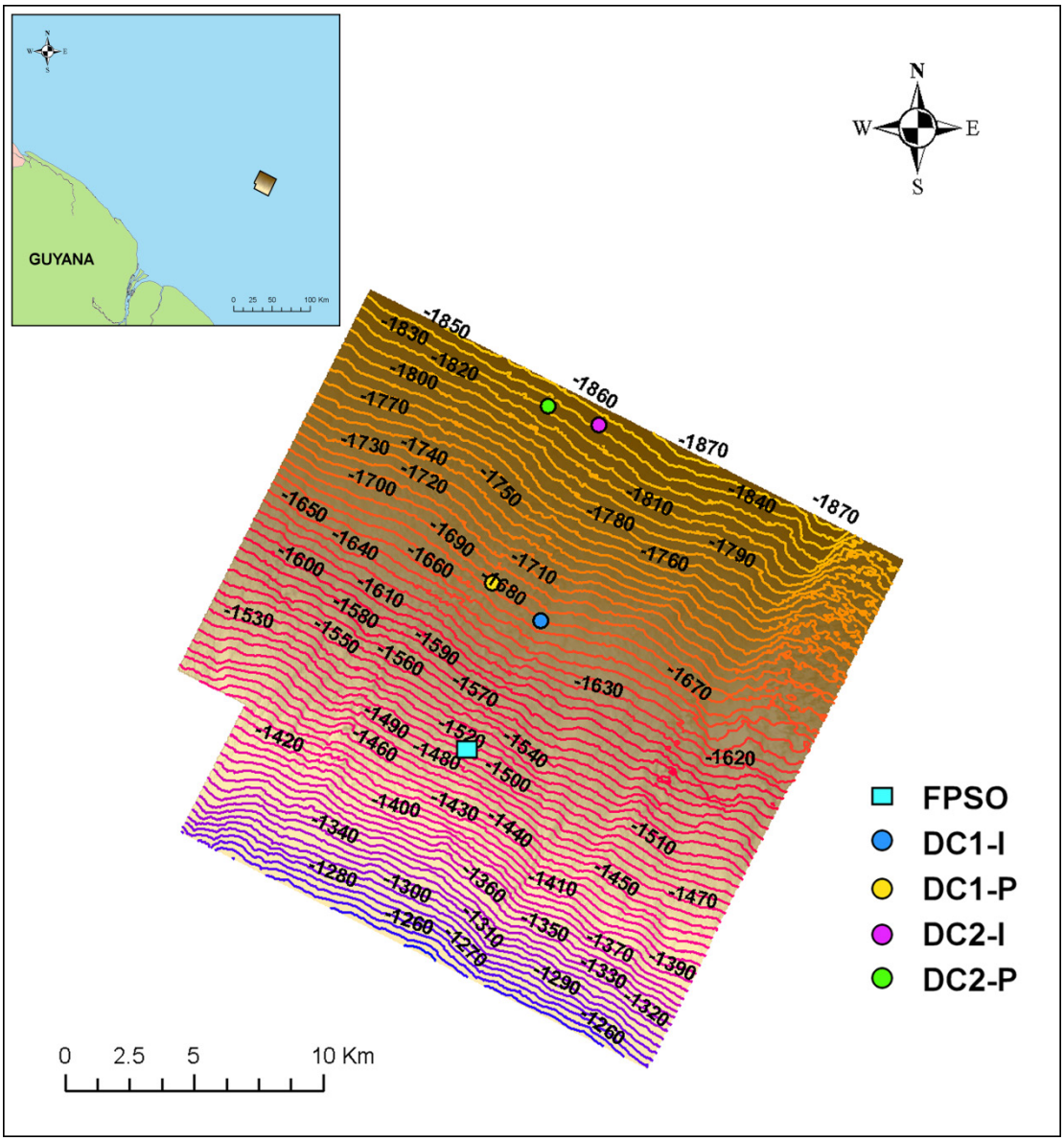
2.1.3 Environmental Data

Model inputs were assembled and formatted for use with GIFT. The environmental data used by the model include bathymetric data, ocean current, water temperature and salinity data. Spatially and temporally varying oceanic data were collected to characterize this area and determine appropriate simulation periods.

2.1.3.1 Bathymetry

The primary spatial dataset is the bathymetric data, used to describe the depth and shape of the seafloor. Bathymetric data are used to develop the shape and depth of the lower boundary of the modeling grids. Two datasets were used. The primary source of bathymetry was the 2016 bathymetric survey performed by Fugro (Fugro 2016). This dataset was provided as a set of depth contour lines covering a region approximately 23 by 22 kilometers within the block (Fugro, 2016

Figure 2-3).



Fugro, 2016

Figure 2-3: Bathymetric Data

The bathymetry data provided by Fugro were supplemented by data from the General Bathymetric Chart of the Oceans (GEBCO), a publicly-available source (BODC 2014). Data from this source provided bathymetric values beyond the Fugro database towards the north. The database used for this study is the GEBCO_08 Grid which has a 30 arc-second resolution. GEBCO bathymetry offshore Guyana is shown in Figure 2-4.

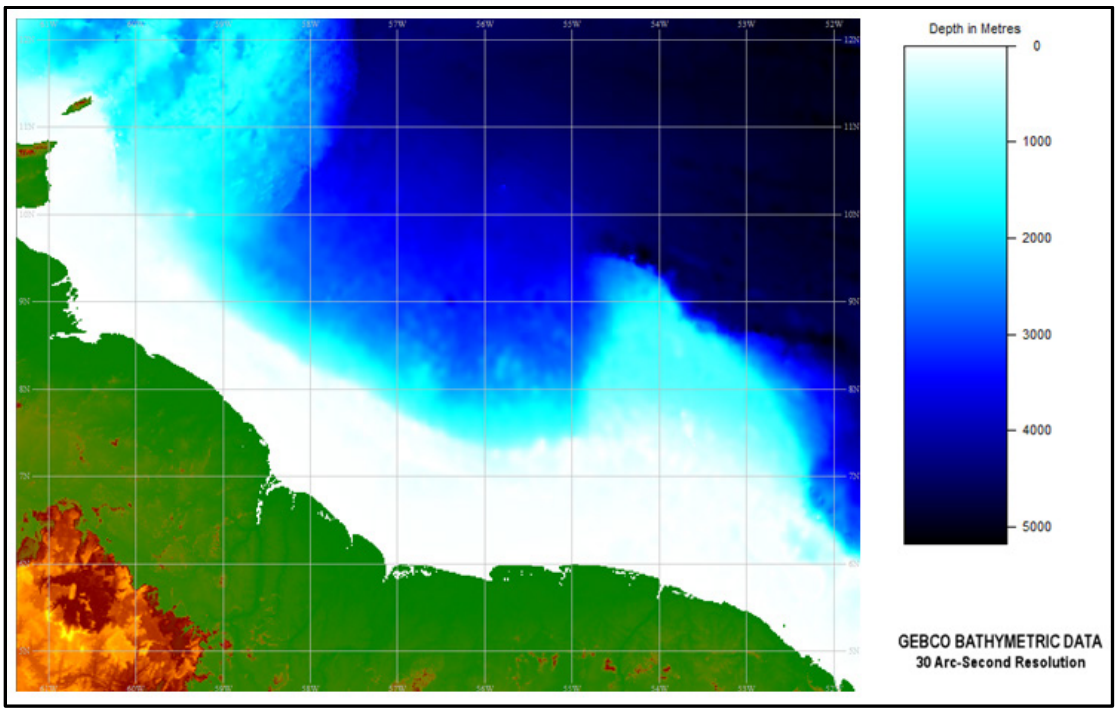


Figure 2-4: GEBCO Data Region

A polyline shapefile of the Guyanese coastline acts as boundary in the model domain between land and water. The coastlines were obtained from Esri's World Boundaries and Places Alternate product.

2.1.3.2 Time Varying Data: Ocean Current, Temperature and Salinity Data

The time-varying data for the drill cuttings deposition modeling include ocean current speed and direction, water temperature, and salinity. Deposition modeling requires time-varying currents on a three-dimensional grid. Hourly depth-varying and spatially-varying currents were obtained from ExxonMobil Upstream Research Company using the SAT-OCEAN model combined with currents from the HYCOM (HYbrid Coordinate Ocean Model) global ocean circulation hindcast model (hycom.org). Currents were obtained every three hours from 2005 through 2014. The model extended from 56º W to 58º W longitude and 7ºN to 11ºN latitude over 128 by 128 grid cells and 22 depth bins at 0, 5, 10, 20, 30, 40, 50, 75, 100, 125, 150, 200, 300, 400, 500, 1000, 1500, 2000, 2500, 3000, 3500,and 4000 meter depths. Depth-varying temperature and salinity values were obtained directly from HYCOM model output.

Monthly-averaged, depth-averaged current speeds were computed across the 2005 to 2014 period of record. Through a statistical analysis of these current speeds at the well locations, the months with the minimum and maximum average current speeds were determined. Modeling was performed assuming drill cuttings deposition occurs starting on the first day of these two months: March 2006 (maximum speed) and August 2013 (minimum speed). Simulations performed during these two months will provide the full range of depositional patterns from a larger and thinner footprint when the current speeds are highest to a thicker, smaller footprint when the speeds are smallest.

Example current vector plots for March 2006 and August 2013 are shown below in Figure 2-5 and Figure 2-7 at the surface (0 meters) and in Figure 2-6 and Figure 2-8 in deeper water (1000 meters).

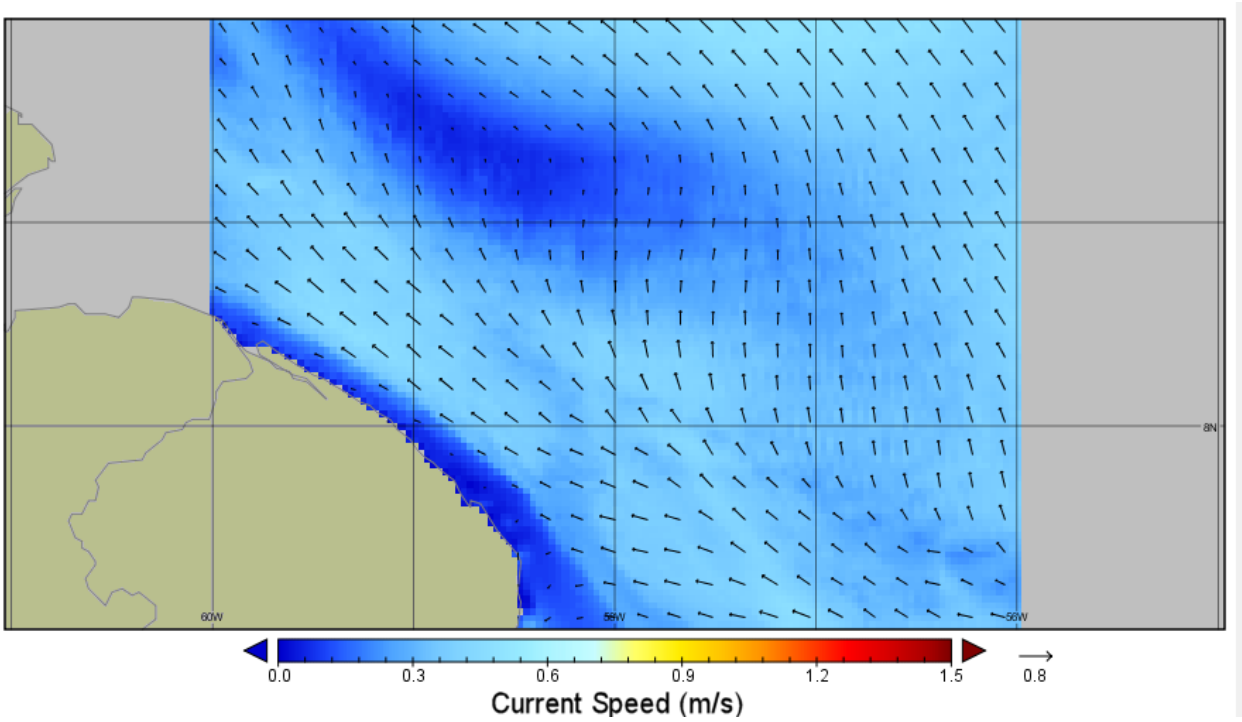


Figure 2-5: Example Current Vector Diagram, March 1, 2006 (surface)

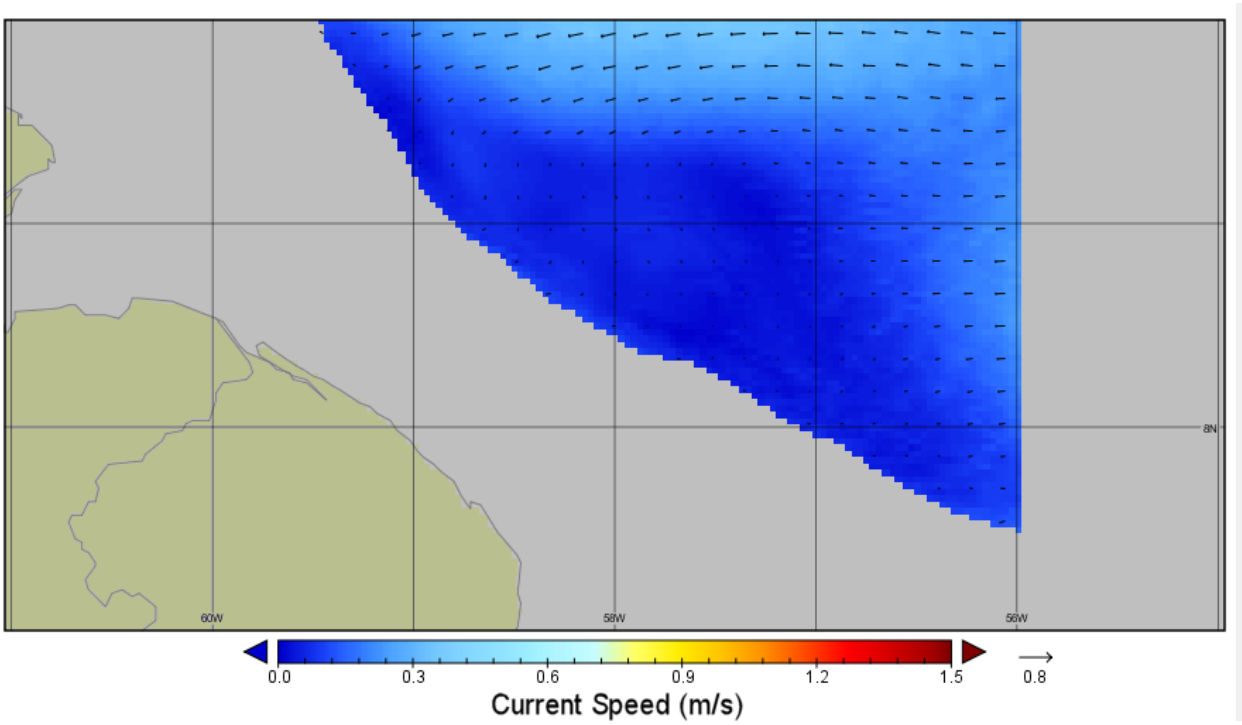


Figure 2-6: Example Current Vector Diagram, March 1, 2006 (1,000 m depth)

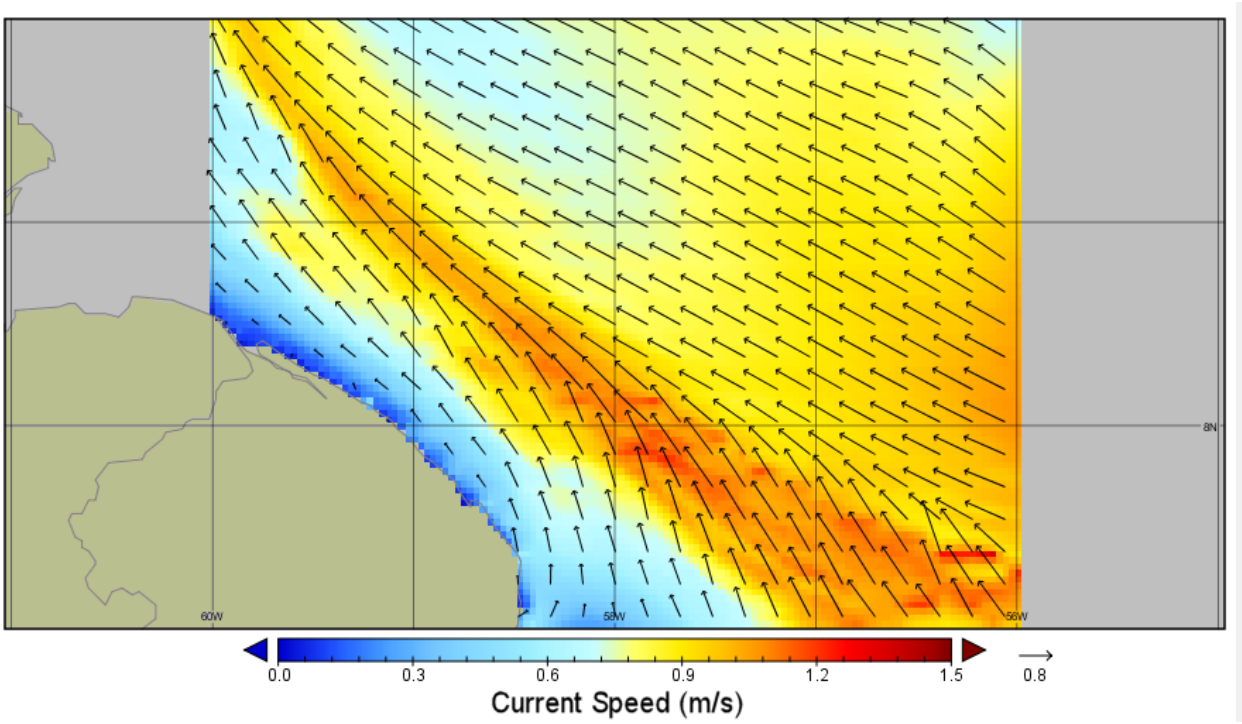


Figure 2-7: Example Current Vector Diagram, August 1, 2013 (surface)

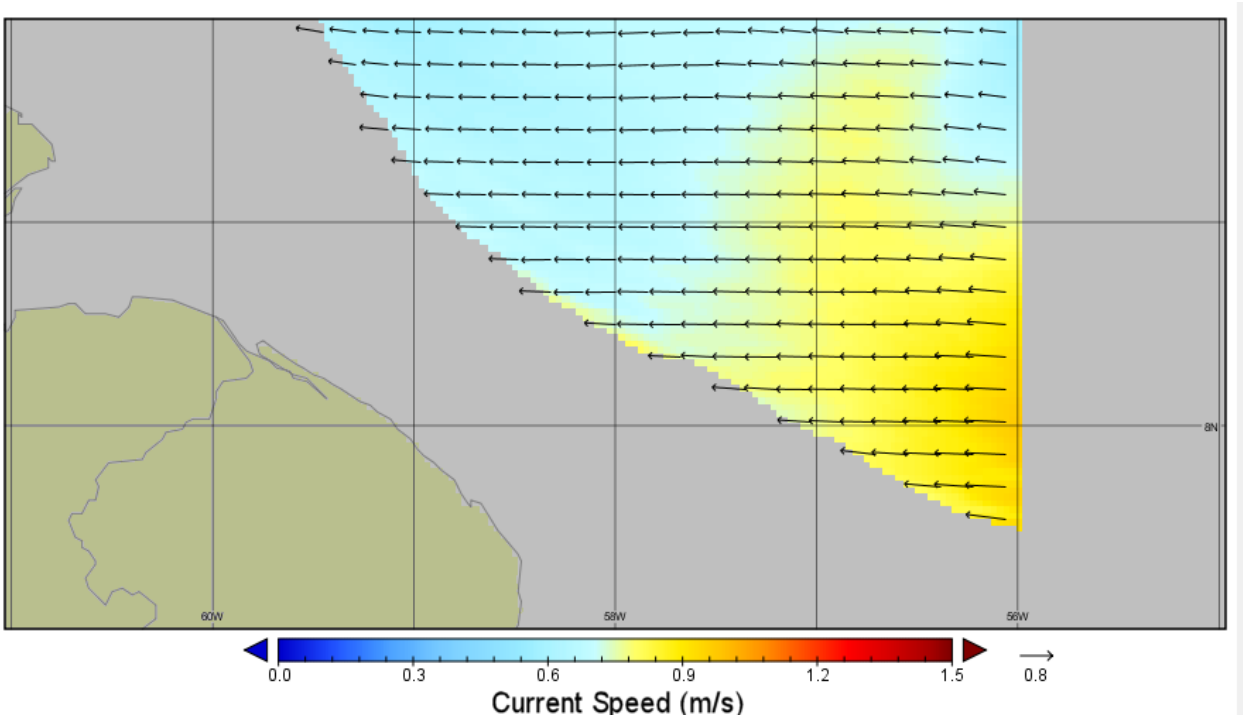


Figure 2-8: Example Current Vector Diagram, August 1, 2013 (1,000 m depth)

2.1.3.3 Drill cuttings and fluid volumes and properties

Estimated quantities of anticipated drill cuttings and fluids to be discharged during drilling are provided in Table 2-3. The estimated times to drill each section were provided by EEPGL. For the top hole sections, only WBDF are expected to be used. The volume of WBDF discharged in Sections 1 and 2 are 5-times and 8-times the volume of the drill cuttings, respectively. In the subsequent sections, the cuttings with a small percentage of adhered non-aqueous fluids will be disposed at 11 meters BSL. No non-aqueous drilling fluids are to be directly discharged. Adhered fluids will not exceed 6.9 percent of the cuttings mass on average.

Table 2-3: Discharge Description

Hole Diameter (inches)	Volume of Cuttings Discharged (bbl)	Volume of Drilling Fluid to be Discharged (bbl)	Type of Drilling Fluid	Estimated Drilling Duration (days)
36”	339	1,694	WBDF	0.5
26”	2,295	18,356	WBDF	1.5
17 ½”	1,493	248	NADF	3
12 ¼”	1,507	251	NADF	6
8 ½” x 9 7/8”	303	56	NADF	4
TOTAL	5,936	28.5	-	15

Though the actual drilling of the well may take longer to complete, the model simulation of the discharges to the sea was run for 23 days assuming 15 days of drilling with a nominal one-day pause of discharges between well sections for a conservative estimate of TSS, and model performance efficiency.

2.1.3.4 Cuttings and Fluid Volumes and Properties

The grain size properties of the drill cuttings and fluids were provided by EEPGL. The distribution of particle sizes and associated fall velocities used in this study are listed in Table 2-4 for cuttings in Section 1 and 2, Table 2-5 for WBDF and Table 2-6 for treated cuttings released from Section 3 through 5 with adhered NADF. Cuttings density was assumed to be 2.6 g/mL. The WBDF density was assumed to be 11 ppg. The density of NADF was reported by EEPGL to range between 9 and 13.2 ppg; 9 ppg was used for a conservative assumption since it would result in slower settling and a larger footprint of deposition.

Table 2-4: Cuttings When Water-Based Fluid is Used

Mass Fraction (wt %)	Fall Velocity (cm/s)	Estimated Diameter (cm)
2	0.00003	0.00005
3	0.0001	0.0001
5	0.0003	0.0002
10	0.0046	0.0006
10	0.0695	0.0007
20	0.4460	0.0059
20	1.8300	0.0363
10	6.9300	0.1350
10	14.3000	0.3730
5	19.8000	0.6680
3	23.4000	0.9510
2	26.1000	1.2200

Table 2-5: WBDF Grain Size Distribution

Mass Fraction (wt %)	Fall Velocity (cm/s)	Estimated Diameter (cm)
7	0.0027	0.0005
8	0.0061	0.0007
5	0.0148	0.0011
10	0.0300	0.0015
13.3	0.0434	0.0018
13.3	0.0511	0.0020
19.2	0.0640	0.0007
19.2	0.0823	0.0008
4	0.4270	0.0058
1	1.1200	0.0250

Table 2-6: Treated Cuttings with Adhered NADF Grain Size Distribution

Mass Fraction (wt %)	Fall Velocity (cm/s)	Estimated Diameter (cm)
43	0.02	0.00
1.01	0.20	0.01
4.99	2.00	0.04
5.55	8.00	0.16
7.99	14.00	0.36
10.99	19.00	0.62
13.01	21.99	0.83
6.81	23.99	1.00
3.69	26.99	1.32
2.47	30.97	1.89
0.49	124.97	*

* Fall velocity outside the range of available correlations; computed by GIFT model

2.2 Scenarios

Modeling was performed for four scenarios representing the shallowest and deepest wells (DC1-I and DC2-I, respectively) and for the minimum and maximum of the monthly-averaged, depth-averaged current speeds (Table 2-7). The water depth at the two well varied between 1,688 meters at DC1-I and 1,853 meters at DC2-I. The same drilling and fluid discharge schedule described in Table 2-3 was assumed at both wells.

Table 2-7: Drill Cuttings and Fluid Deposition Scenarios

Well Center	Scenario Name	Ambient Currents	Water Depth (m)
DC1-I	1a	Minimum Monthly Average	1,688
	1b	Maximum Monthly Average	1,688
DC2-I	2a	Minimum Monthly Average	1,853
	2b	Maximum Monthly Average	1,853

These scenarios provide output that is presented in terms of depositional thickness, TSS concentrations, and deposition of adhered oil.

2.2.1 Depositional Thickness

Drill cuttings and adhered fluid discharges will create a footprint on the seabed. The deposition of cuttings and adhered fluids may result in physical damage and habitat loss or disruption over a defined area of the seabed. The discharge of fluids and cuttings may affect seabed habitats through physical smothering.

Burial by drilling fluids and cuttings may cause physical impacts upon benthic communities. The specific thickness of burial which may cause an impact can vary depending on the benthic species and the amount of oxygen depletion which may occur, causing anoxic conditions beneath the depositional layer.

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 duration of the burial. Thickness thresholds vary by species and sediment impermeability. A suggested threshold thickness value of 5 centimeters above a substratum for a month deposition impacting benthic communities is recommended based on publications by Ellis and Heim (1985) and MarLIN (2011). Smaller threshold values as low as 1 mm have been reported (e.g., Smit et al., 2006), however they are associated with instantaneous burials on benthic species, not gradual smothering effects.

2.2.2 Total Suspended Solids

Increases in concentration of TSS will occur due to discharges of drill cuttings and fluid. The highest concentration increases will exist at the point of discharge from the drillship or at the seafloor during upper well section drilling, and decrease over time and distance as the suspended solids plume dissipates and settles. Larger particles will settle out more quickly than fine particles, such that the TSS plume of tiny particles may linger and travel further than plumes of larger grain-sizes. As such, elevated TSS may form in regions where tiny suspended particles linger in a cloud and mix with subsequent discharges. Impacts related to elevated TSS may occur if light penetration is impeded significantly for long periods of time reducing the ability of plants and phytoplankton to photosynthesize. Increases in TSS may also decrease water clarity and clog fish gills. A commonly used guidance value for TSS effluent discharges in the marine environment recommended by MARPOL of 35 mg/L was used as a threshold (IMO 2006).

2.3 Adhered Oil

Discharges of cuttings after use of NADF must be treated through the on-board systems (shakers and dryers). The non-aqueous base fluid (NABF) portion of the NADF that remains will be reduced to approximately 6.9 percent base fluid retention on cuttings (BFROC) by mass. These hydrocarbons, once settled to the seafloor, can degrade over time, and may enter the pore water within the sediments or become dissolved in the water column, depending on each specific hydrocarbon's tendency to remain partitioned to the solids.

2.4 Results

The results of the modeling are illustrated in the following sections as contour plots. The plots presented indicate the location of the drill cuttings release point, taken at or above the well. The results are presented for the following parameters:

- Bottom thickness at the end of the simulation
- Maximum TSS at any time in the simulation at the surface and bottom
- Mass of hydrocarbons per unit area deposited on the seafloor

Based on the above parameters, the following set of threshold criteria has been applied in this analysis:

- Criterion 1 – The maximum allowable increase in total suspended solids should be no greater than 35 mg/L above ambient
- Criterion 2 – The maximum allowable thickness deposited should not exceed 5 centimeters for the duration of 1 month

There are no available criteria applicable for the mass of hydrocarbons deposited on the seafloor.

2.4.1 Depositional thickness

When the first two sections are jetted and drilled before the riser is installed, cuttings and water based fluids are discharged directly to the seabed resulting in mound of material deposited around the well.

The material discharged at the seabed is deposited in the area directly adjacent to the well head and results in the thickest layers of deposited material, which can be described as a footprint of cuttings with the majority of the material above 1 mm thick concentrated in a 1.5 kilometer radius from the well. In three of the four scenarios, a small region close to the well exceeded the depositional thickness threshold value of 50 mm (5 centimeters) during the month. This exceedance ranged from roughly a 21 meters to 43-meter radius around the well. The maximum thickness reached was 753 mm (Scenario 2b: DC2-I, maximum currents), but slope failure (i.e., sudden collapse of the depositional mound) and resuspension of the particles are likely to reduce the height of the deposited materials over time.

Figure 2-9 through Figure 2-12 show the expected thicknesses of the cuttings and adhered fluid layer on the seabed as a result of the drilling activities at the end of the model simulation (when all deposition had occurred) from both surface and bottom releases. Figure 2-9 and Figure 2-10 show the results of Scenario 1a and 1b. Figure 2-11 and Figure 2-12 show the results of Scenario 2a and 2b.

In Scenario 1, at Well DC1-I, the maximum thickness predicted by the model was 660 mm, located in the vicinity surrounding the well. Jetting and top hole drilling deposited the majority of the deposited mound's peak (658.3 mm of the final 660 mm). The majority of the depositions (98.6 percent to 99.6 percent) were 1-centimeter thick or less.

In Scenario 2, at Well DC2-I, the maximum thickness predicted by the model was 753 mm, located in the vicinity surrounding the well. Jetting and top hole drilling deposited the majority of the deposited mound's peak (701.2 mm of the final 703 mm). The majority of the depositions (98.2 percent to 99.8 percent) were 1-centimeter thick or less.

All results are summarized in Table 2-8.

Table 2-8: Depositional Thickness Summary

Scenario	Maximum Depositional Thickness (mm)	Area (m²) with Thickness > 50 mm threshold
1a DC1-I—Min Currents	660	4,575
1b DC1-I—Max Currents	186	5,815
2a DC2-I—Min Currents	703	1,442
2b DC2-I—Max Currents	753	1,590

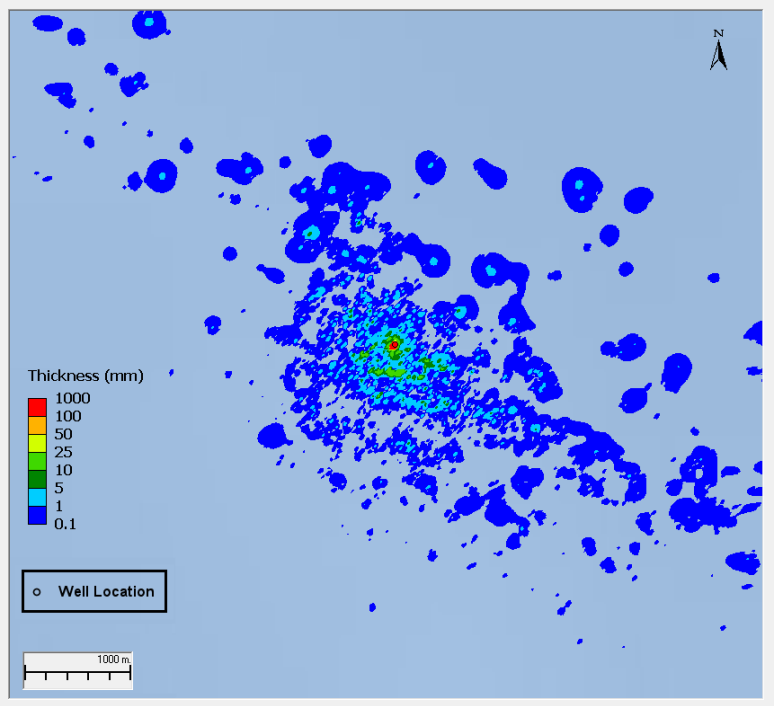


Figure 2-9: Maximum Depositional Thickness – Scenario 1a DC1-I Minimum Currents

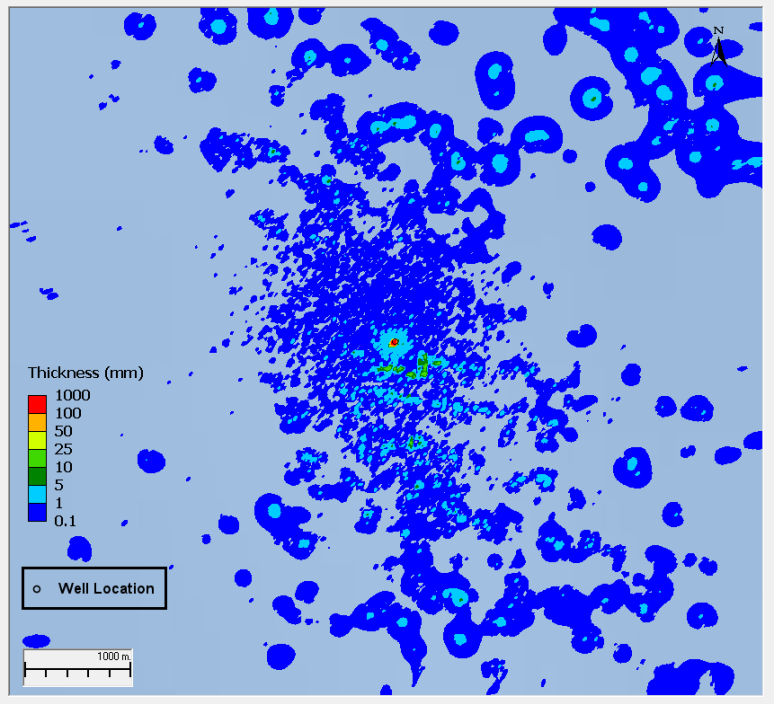


Figure 2-10: Maximum Depositional Thickness – Scenario 1b DC1-I Maximum Currents

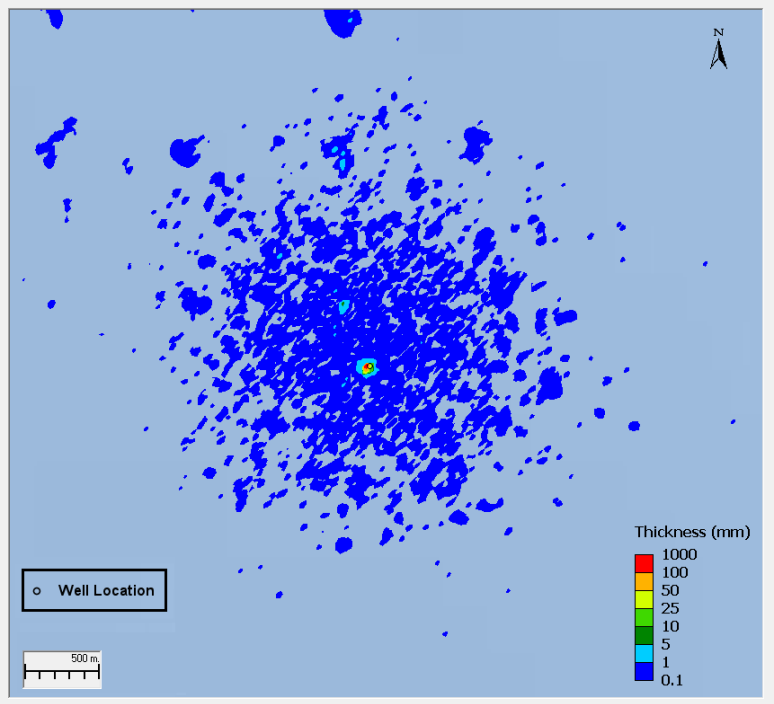


Figure 2-11: Maximum Depositional Thickness – Scenario 2a DC2-I Minimum Currents

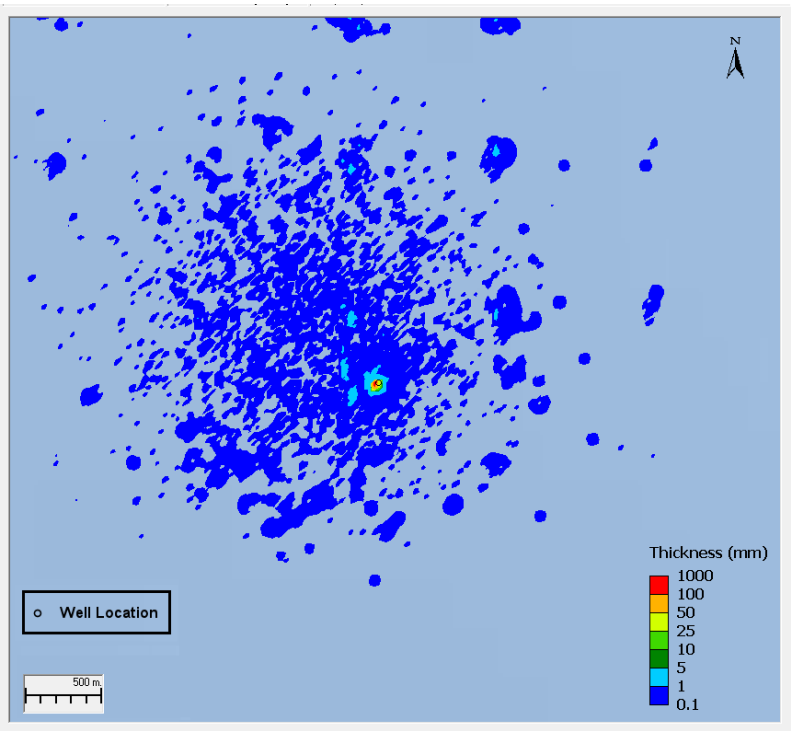


Figure 2-12: Maximum Depositional Thickness – Scenario 2b DC2-I Maximum Currents

2.4.2 Total Suspended Solids

The maximum TSS concentration added above ambient as a result of jetting and top hole drilling near the seafloor was 9,737 mg/L in Scenario 2b. The maximum TSS concentration added above ambient as a result of surface discharges was 5.3 mg/L in Scenario 2b. The 35 mg/L threshold is not predicted to be exceeded at the surface, where inhibition of photosynthesis would be a concern. At the sea floor, a maximum of approximately 0.168 km² of water is predicted to show concentrations that exceed the 35 mg/L threshold during drilling of the first two well sections. These maxima occur at the sea floor and are below the photic zone (the zone where high TSS could impact some organisms). Therefore the inhibition of light is not a concern at these depths.

In Scenario 1 at DC1-I, the maximum TSS ranged between 222 mg/L and 4,323 mg/L at the sea floor. In Scenario 2 at DC2-I, the maximum TSS ranged between 233 mg/L and 5,260 mg/L at the sea floor.

Note that in the following figures, the estimated maximum TSS concentrations may be slightly offset from the discharge location as the simulation's floating small particles suspended in the water column may concentrate together at various locations. Larger particles do not remain suspended but quickly settle to the seafloor. Table 2-9 summarizes the maximum TSS modeled and area exceeding the 35 mg/L threshold under minimum and maximum current conditions at each drill center, and detailed results are also presented in Figure 2-13 through Figure 2-20.

Table 2-9: Total Suspended Solids Summary

Scenario	Maximum TSS (mg/L)		Area (km²) with TSS > 35 mg/L threshold	
	Surface	Bottom	Surface	Bottom
1a DC1-I Min Currents	2.1	4,323	0	0.094
1b DC1-I Max Currents	2.9	5,517	0	0.168
2a DC2-I Min Currents	1.6	5,260	0	0.091
2b DC2-I Max Currents	5.3	9,737	0	0.088

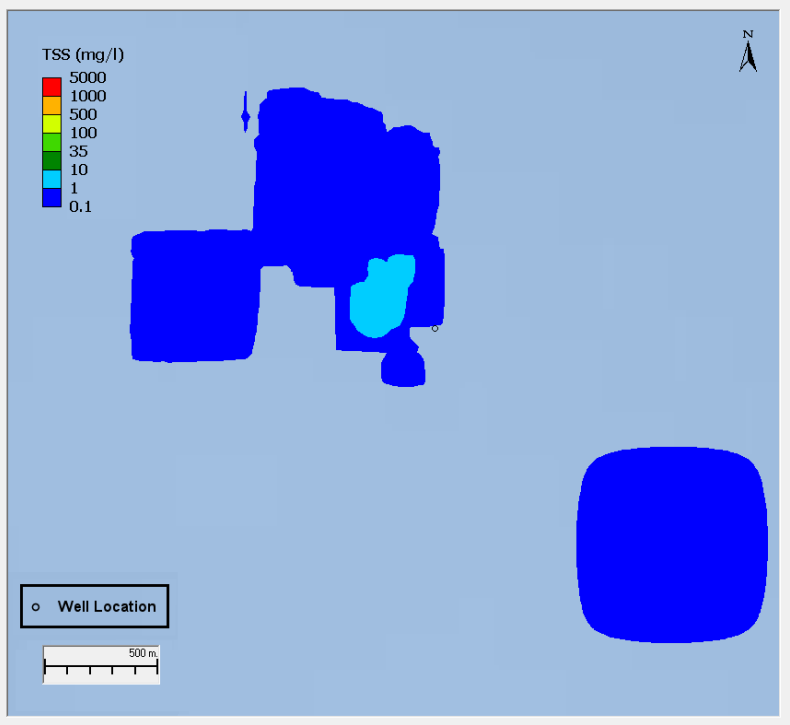


Figure 2-13: Maximum TSS at Surface – Scenario 1a DC1-I Minimum Currents

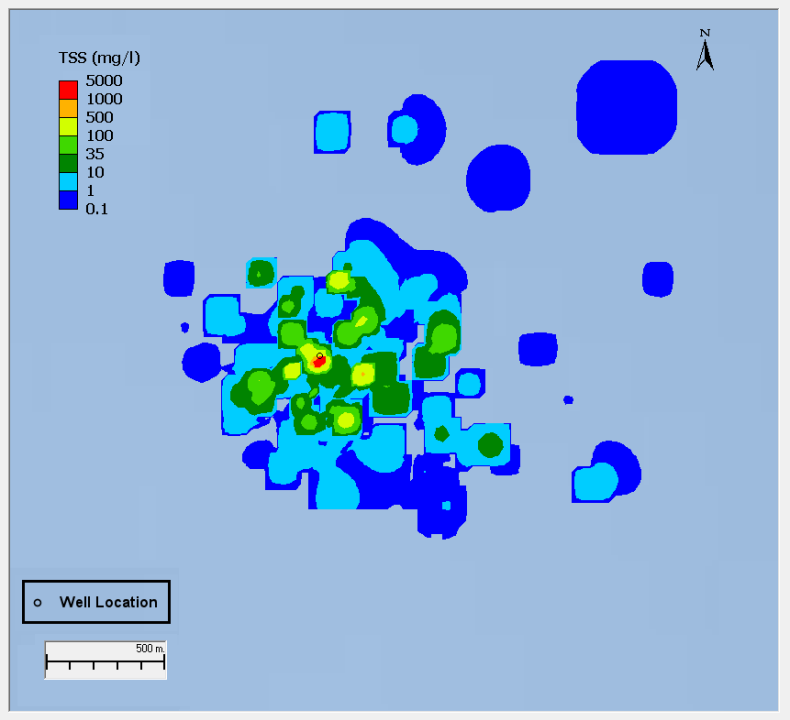


Figure 2-14: Maximum TSS at Bottom – Scenario 1a DC1-I Minimum Currents

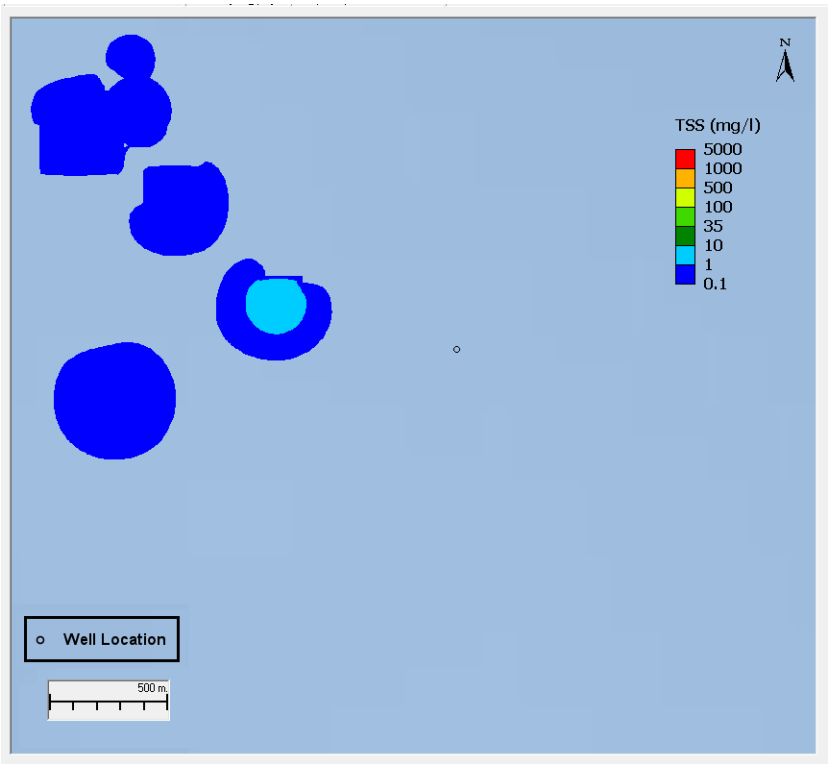


Figure 2-15: Maximum TSS at Surface – Scenario 1b DC1-I Maximum Currents

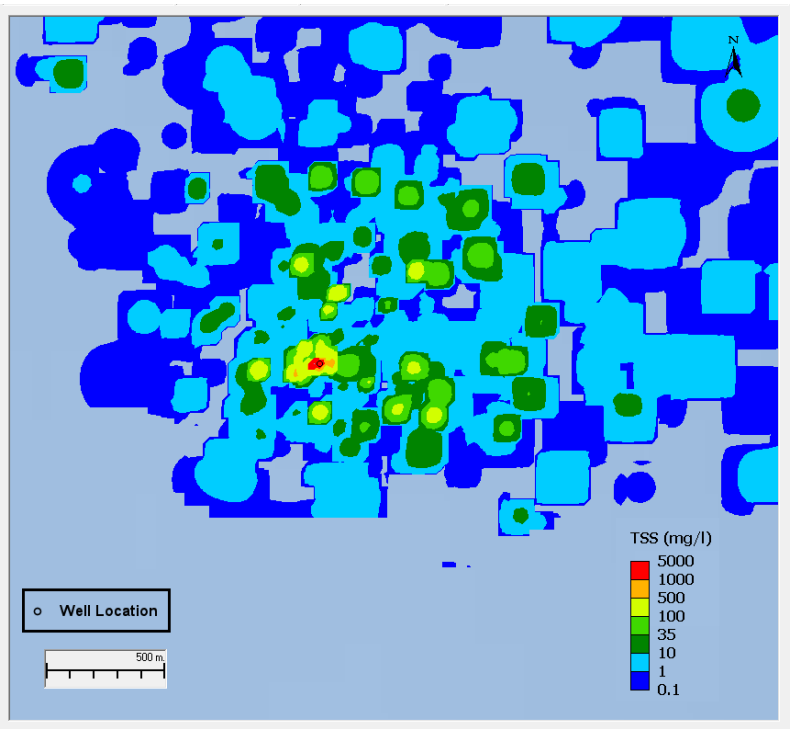


Figure 2-16: Maximum TSS at the Bottom – Scenario 1b DC1-I Maximum Currents

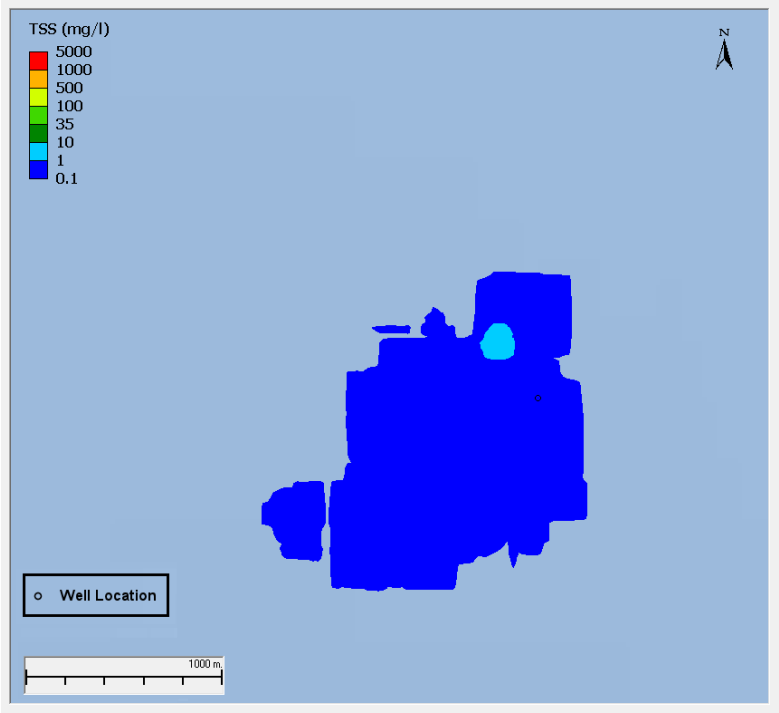


Figure 2-17: Maximum TSS at Surface – Scenario 2a DC2-I Minimum Currents

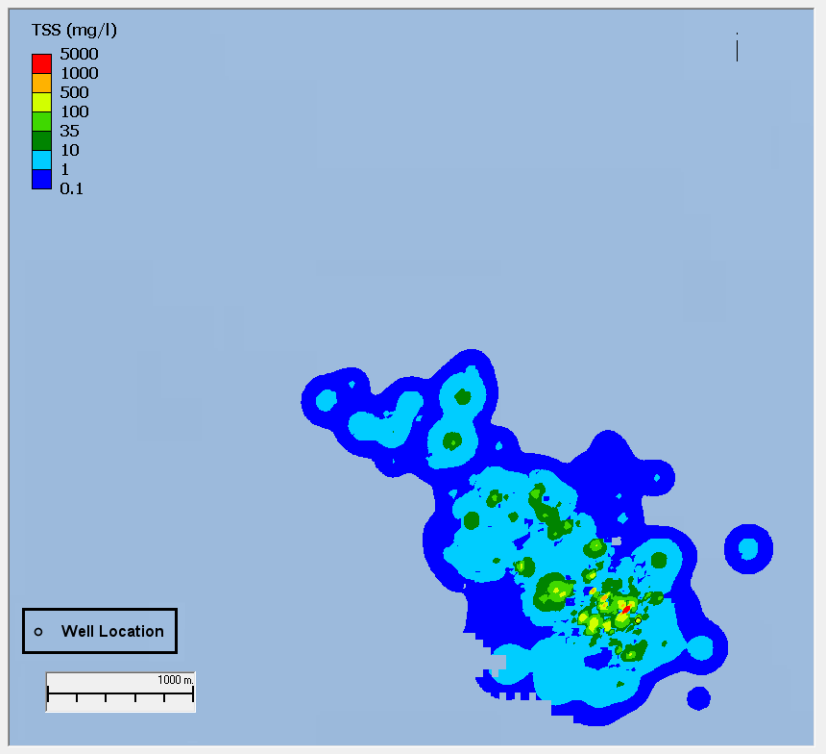


Figure 2-18: Maximum TSS at the Bottom– Scenario 2a DC2-I Minimum Currents

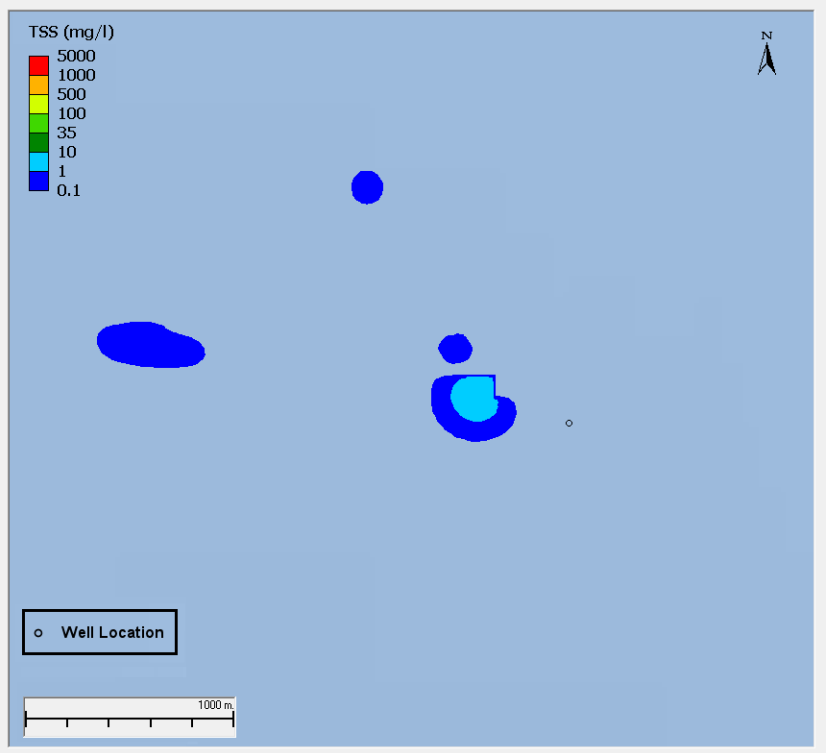


Figure 2-19: Maximum TSS at Surface – Scenario 2b DC2-I Maximum Currents

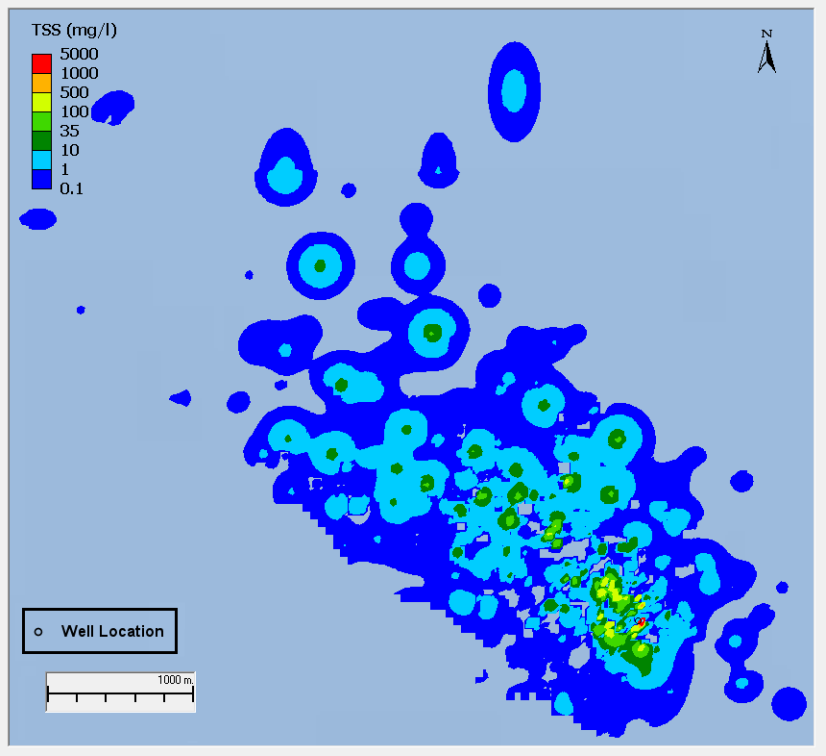


Figure 2-20: Maximum TSS at the Bottom – Scenario 2b DC2-I Maximum Currents

2.4.3 Oil Deposits on the Sediment

At the end of the simulation, NABF adhered to the cuttings settled primarily within approximately a 2-kilometer radius region in all four scenarios. Within that region, the total hydrocarbon concentration reached a maximum of 334.7 g/m² in Scenario 1b.

In Scenario 1 at DC1-I, concentrations above 5 g/m² occupied an area between 10.4 km² and 10.6 km². In Scenario 2 at DC2-I, concentrations above 5 g/m² occupied an area between 8.0 km² and 10.1 km². Table 2-10 summarizes the maximum residual hydrocarbons modeled and area exceeding the 5 g/m^2 threshold under minimum and maximum current conditions at each drill center, and Figure 2-21 through Figure 2-24 present the detailed results as plots.

Table 2-10: Hydrocarbon Deposition Summary

Scenario	Maximum Hydrocarbon Deposition (g/m²)	Area (km²) with Hydrocarbons > 5 g/m²
1a DC1-I—Min Currents	278.5	10.4
1b DC1-I—Max Currents	334.7	10.6
2a DC2-I—Min Currents	307.9	8.0
2b DC2-I—Max Currents	234.4	10.1

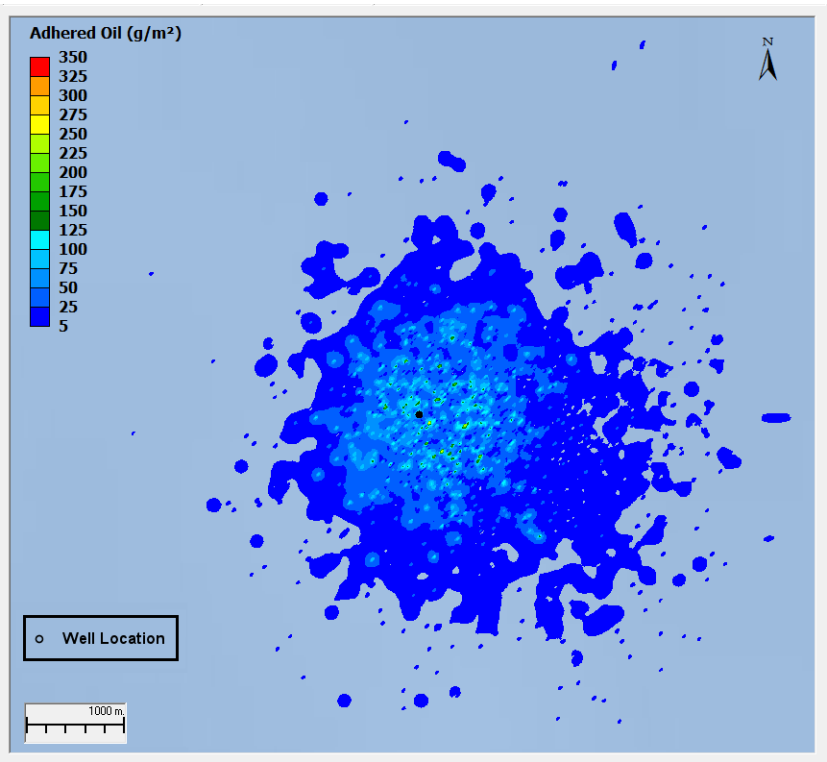


Figure 2-21: Total Deposited Adhered Oil – Scenario 1a DC1-I Minimum Currents

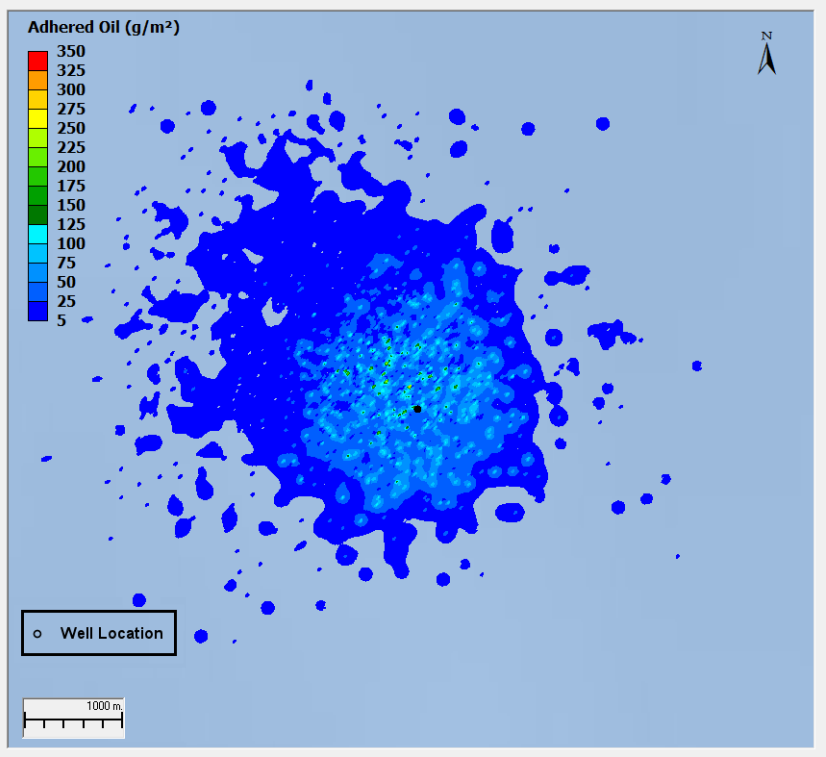


Figure 2-22: Total Deposited Adhered Oil – Scenario 1b DC1-I Maximum Currents

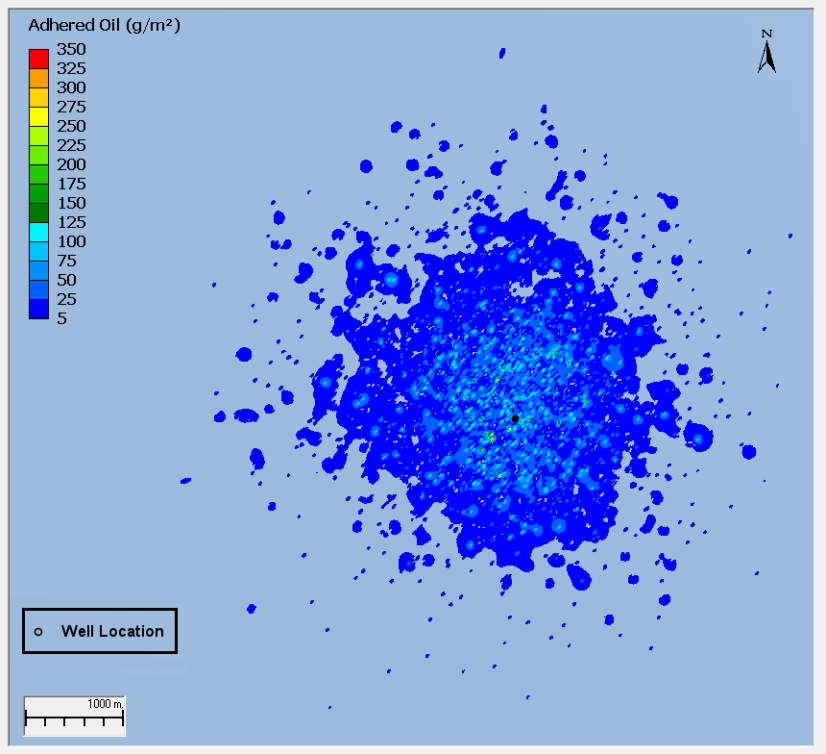


Figure 2-23: Total Deposited Adhered Oil – Scenario 2a DC2-I Minimum Currents

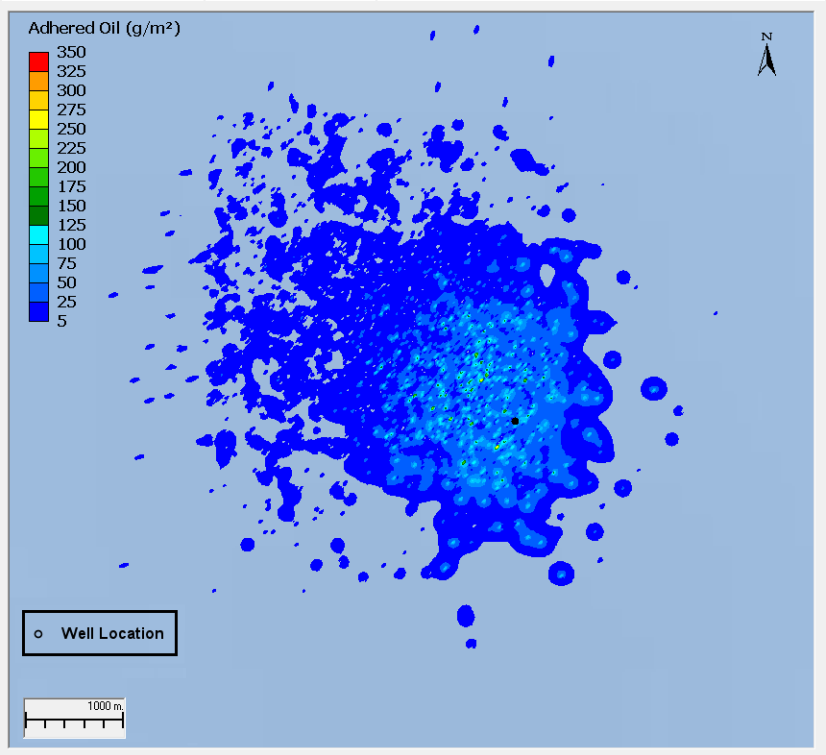


Figure 2-24: Total Deposited Adhered Oil – Scenario 2b DC2-I Maximum Currents

2.5 Conclusions

Modeling was performed using GEMSS® and its drill cuttings and fluids deposition module, GIFT. Four simulations were made representing the shallowest and deepest well locations (DC1-I and DC2-I, respectively) and two ambient current conditions (minimum and maximum monthly-averaged, depth-averaged current speeds over a ten year period of record). At the beginning of the simulation, during a two day period, cuttings and WBDF were discharged directly at the seabed while jetting and drilling the first two well sections. Drill cuttings and adhered NADF from the subsequent three sections were simulated to be release 11 meters below sea level over 13 days.

Output from the drill cutting modeling included estimations of the total thickness of materials deposited on the sea floor, and maximum increased total suspended solids concentrations above ambient conditions. The concentration of hydrocarbons adhered to the cuttings that deposited on the sea floor was estimated in terms of mass per unit area. The results of the modeling are shown below in Table 2-11.

Table 2-11: Model Results Summary

Scenario	Maximum Depositional Thickness (mm)	Area (m^2) with Thickness > 50 mm threshold	Maximum TSS (mg/L) Surface/Bottom	Area (km^2) with TSS > 35 mg/L threshold Surface/Bottom	Maximum Adhered Oil Deposition (g/m^2)	Area (km^2) with Adhered Oil > 5 g/m^2
1a DC1-I Min Currents	660	4,575	2.1 / 4,323	0 / 0.094	278.5	10.4
1b DC1-I Max Currents	186	5,815	2.9 / 5,517	0 / 0.168	334.7	10.6
2a DC2-I Min Currents	703	1,442	1.6 / 5,260	0 / 0.091	307.9	8.0
2b DC2-I Max Currents	753	1,590	5.3 / 9,737	0 / 0.088	234.4	10.1

According to the model results, the thickness of drill cuttings and adhered fluids deposited on the seafloor may exceed the threshold value of 50 mm within a 43-meter radius from the well. This depositional mound is primarily due to the cuttings and fluids discharged during the jetting and drilling of the top two sections. The maximum TSS concentration in the water column directly above the well during the bottom releases may be initially high (over 9,700 mg/L) at the point of release, although in water depths below the photic zone in areas where light inhibition is not a concern and the population of biota is relatively low. At the surface where photosynthesis inhibition is more of a concern, TSS increases from discharges were below the 35 mg/L threshold. The maximum TSS concentration in the water column from the surface release is 5.3 mg/L. Hydrocarbons deposited on the seafloor had a maximum concentration of 334.7 g/m^2 with deposits generally settled in an area 10.4 km^2 at concentrations over 5 g/m^2.

Note that the variations in the current speeds are the primary cause for the variations in the model results provided. Scenario 2 has a higher maximum thickness and higher bottom TSS concentrations compared to the pair of simulations in Scenario 1. At the bottom depth of DC2-I, the currents are slower than at DC1-I allowing for a higher peak deposition, more compact deposition area, and more concentrated TSS. Though Scenario 2b had higher average currents compared to Scenario 2a, the bottom currents where most of the deposition occurs during drilling of the riserless sections were slower in Scenario 2b. Higher in the water column the current speeds in Scenario 2b were higher than in Scenario 2a. The areas of deposits with adhered oil show the opposite effect as the near surface currents in Scenario 1 were higher

than in Scenario 2, causing a larger scatter of particles and resulting footprint area of the oily SOBM particles once they reached the seafloor.

3. LIZA PHASE 2 (EIA)

3.1 Approach

In this study, the discharge of drill cuttings is evaluated. It is assumed that there will be a direct discharge (i.e., near the seabed) of cuttings with water-based drilling fluids during drilling of the riserless open hole section at each well and, for all other well sections, a discharge near the sea surface of cuttings with a small fraction of adhered residual base oil from material removed in the lower well sections after treatment on the FPSO.

Modeling was performed to predict the following as a result of cuttings discharge:

- The TSS concentrations in the water column;
- The seabed accumulation (thickness) of the adhered muds and drill cuttings over an area of seafloor (the footprint); and
- The mass of hydrocarbons settled upon the seafloor.

3.1.1 Simulation Design

Released material will pass vertically through the water column because cuttings and muds are denser than the receiving water. Released material will also migrate horizontally due to advection by local and regional currents. The dispersion of cuttings and muds is fundamentally a three-dimensional phenomenon requiring three-dimensional hydrodynamic fate and transport modeling.

Wells will be drilled from four main drill centers, planned as pairs of drill centers at each of two locations (Figure 3-1). A well at each of the drill centers (one production well drill and one injection well) was modeled.

Coordinates of the drill center locations and the depths of water at these locations are presented in Table 3-1.

Table 3-1: Drill Center Locations and Water Depths

Drill Center	Longitude (degrees)	Latitude (degrees)	X coordinate in UTM 21N (meters)	Y coordinate in UTM 21N (meters)	Water Depth (meters)
DC3-I	56° 56’ 45.88”	8° 03’ 06.40”	505,941	890,022	1,692
DC3-P1	56° 57’ 32.69”	8° 03’ 44.32”	504,509	891,187	1,680
DC4-I	56° 55’ 40.98”	8° 06’ 20.85”	507,927	895,994	1,845
DC4-P1	56° 56’ 09.76”	8° 07’ 21.15”	507,046	897,846	1,830

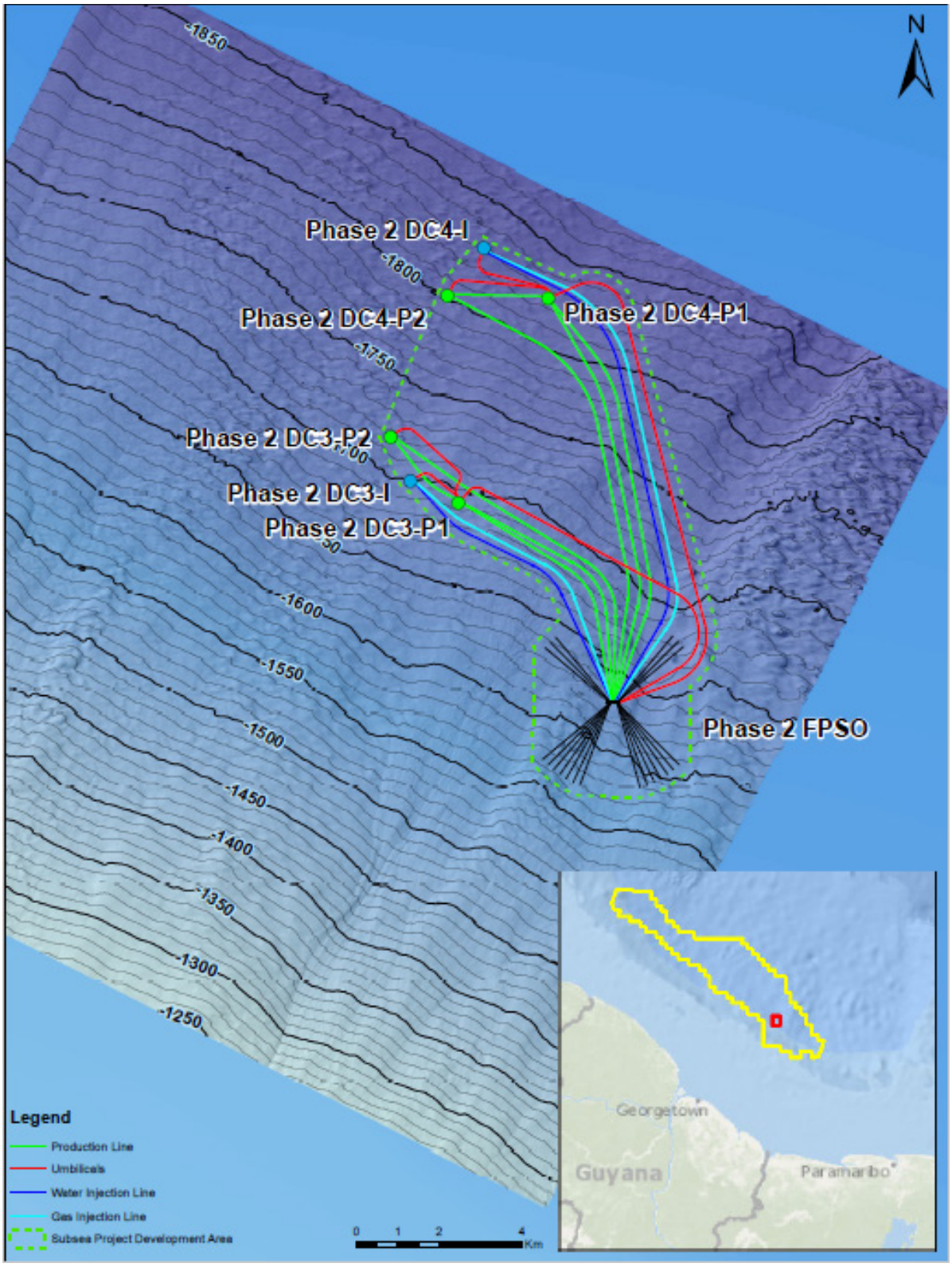


Figure 3-1: Locations of Planned Phase 2 Drill Centers

At each of these drill centers, the top hole (Section 1) and conductor (Section 2) will be jetted and drilled with water-based muds (WBM) to a depth of 1,219 meters below the mud line. The subsequent three sections (with hole diameters sizes 17.5 inches and 12.25 inches followed by a hole 8.5 inches by 9.875 inches) will be drilled with NADF until a total depth is reached at approximately 6,816.2-meters below the mud line. Details of these sections are presented in Table 3-2.

The discharge pipe from the drill platform will release treated cuttings at a depth of 11 meters below mean sea level.

Table 3-2: Well Profile

Section	Diameter (inches)	Well Interval (meters)
Section 1 – Structural (Top Hole, Jet)	36	87
Section 2 – Conductor	26	1,132
Section 3 – Surface	17 ½	1,751
Section 4 – Production	12 ¼	3,292
Section 5 - Open	8 ½ x 9 7/8	554

Three model grids were used: a particle grid, a depositional grid, and a concentration grid.

The movement of the discharged cuttings and muds using Lagrangian particles was computed within the particle grid (Figure 3-2). This particle grid is a square approximately 55 kilometers on each side, with each cell approximately 50 meters by 50 meters. Each grid cell contains an interpolated depth value derived from the bathymetry data described in Section 3.1.3.1. Particles are free to move horizontally and vertically within this grid's domain, independently of the grid, except for movement past the grid boundaries representing the seafloor (as defined by the bathymetry) and shorelines.

For computation of the deposition on the seafloor, the model used a smaller, more finely-spaced two-dimensional (2-D) depositional grid, with each grid centered on a drill center. The depositional grid is a square approximately 20 kilometers on each side. Cell sizes vary in size from 25 meters by 25 meters near the center to 50 meters by 50 meters at the edge of the grid. Figure 3-3 shows the (more tightly spaced) portion of the depositional grid in the vicinity of the FPSO.

The concentration grid, used for computation of TSS concentrations in the water column, is three-dimensional, with the same horizontal dimensions as the depositional grid. Vertically, the cells are 10 meters thick at the surface and bottom regions, where the maximum suspended solids are predicted to occur. The cell thicknesses expand in size towards the middle of the water column region.

A summary of the dimensions of these grids is presented in Table 3-3.

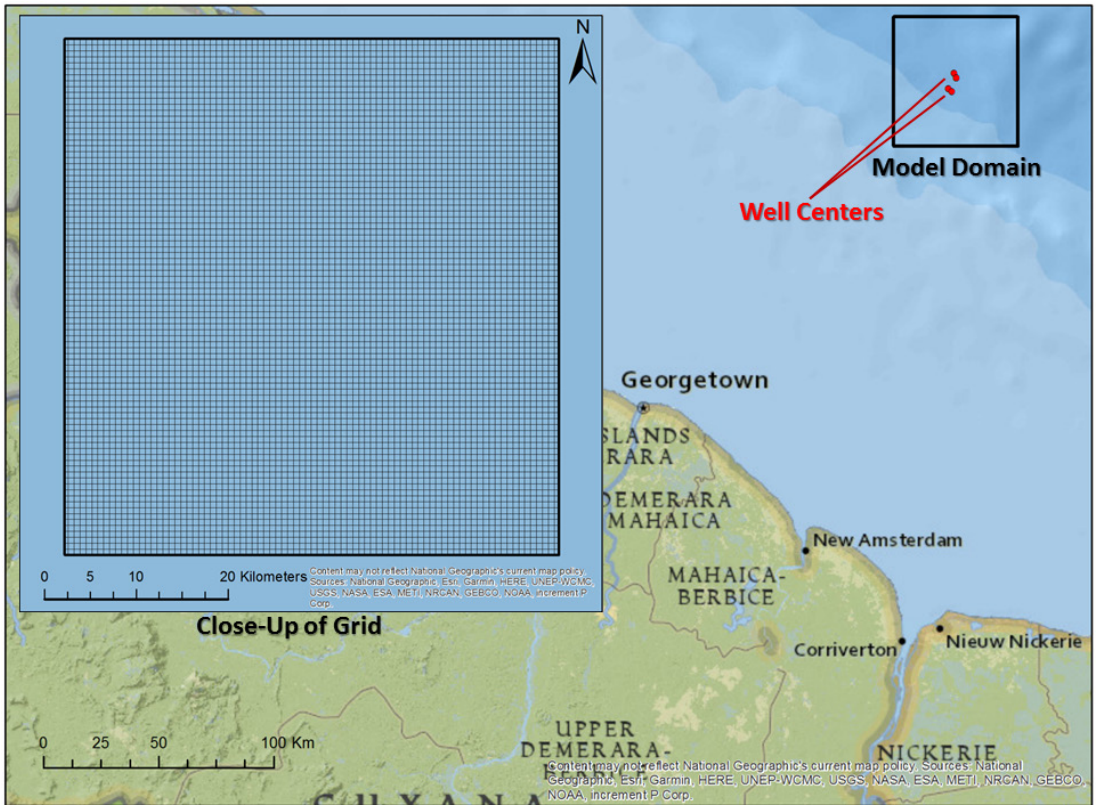


Figure 3-2: Particle Grid

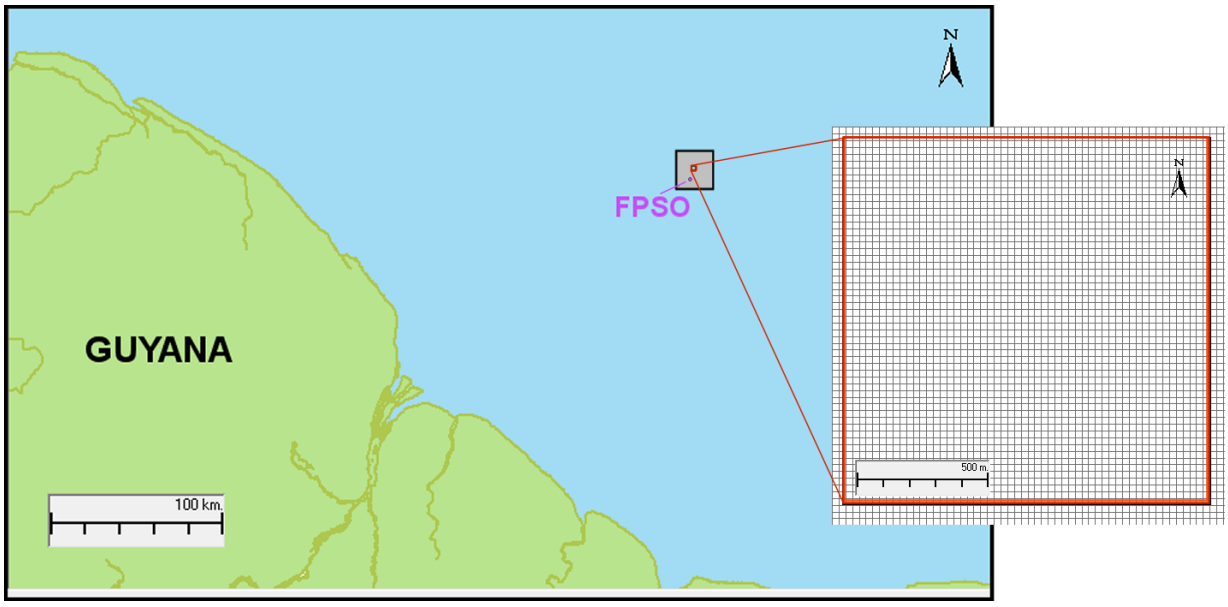


Figure 3-3: Depositional and Concentration Grid

Table 3-3: Grid Dimensions

Grid	Horizontal Dimensions (meters)	Vertical Dimensions
Particle grid	50 x 50	NA
Depositional grid	Variable – smallest 25 x 25 at center	NA
Concentration grid	Variable – smallest 25 x 25 at center	Variable – smallest 10 meters at top and bottom

NA = not applicable

3.1.2 Drill Cuttings and Mud Deposition Software

The modeling was performed using the software package GEMSS® and its drill cuttings and muds discharge module, GIFT (Kolluru and Spaulding 1993; Kolluru et al. 1998; Fichera and Kolluru 2007; Fichera et al. 2013; Prakash and Kolluru 2014). GIFT can simulate the fate of dissolved and particulate material discharged from a range of sources, including drill cuttings and muds and produced water. 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. The modeling methodology is based on a deterministic mode of simulation. In deterministic, single event simulations, the starting date and current speed and direction at each time step are chosen from a database of properties in the selected periods.

Drill cuttings and muds were modeled as particles. Movement in the vertical direction resulted in the settling and deposition of cuttings on the seabed. The combined action of erosion and deposition, based on particle size distribution and the intensity of release, results in the predicted net accumulation of drill cuttings on the seabed.

Modeling data inputs included:

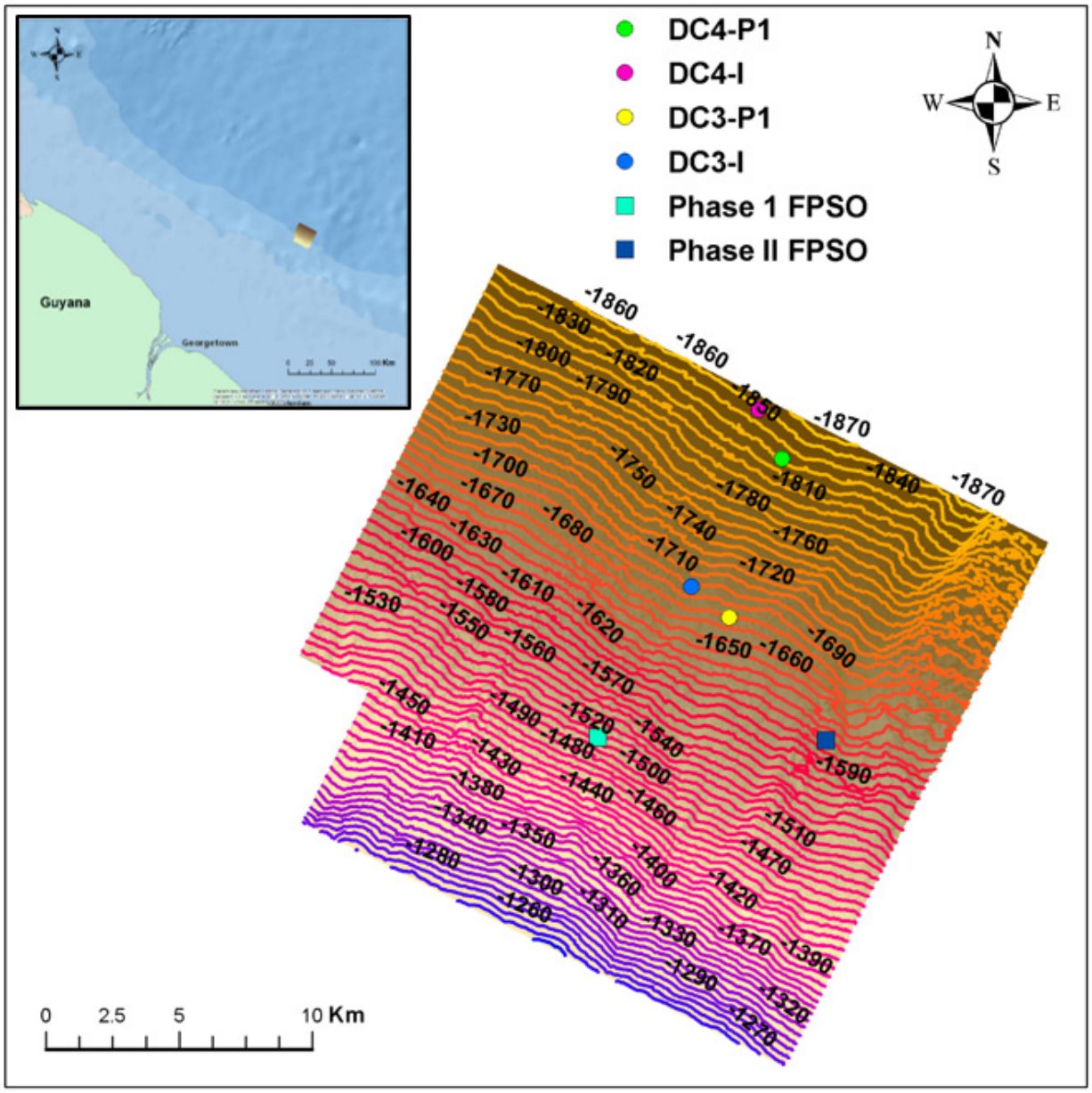
- Drill section sizes and schedule
- Drilling mud types
- Cuttings and mud grain size distribution
- Mud and cuttings densities
- Mud and cuttings release rates, durations, and discharge depths

3.1.3 Environmental Data

Model inputs were assembled and formatted for use with GIFT. The environmental data used by the model included bathymetry, ocean current, water temperature and salinity data. Spatially and temporally varying oceanic data were collected to characterize the area in which the discharges will occur and determine appropriate simulation periods to represent the range of potential results. Additionally, data used for modeling are described in the following sections.

3.1.3.1 Bathymetry

The primary spatial dataset is the bathymetry data, used to describe the depth and shape of the seafloor. Bathymetry data are used to develop the shape and depth of the lower boundary of the modeling grids. Two datasets were used. The primary source of bathymetry was the 2016 bathymetric survey performed by Fugro (Fugro 2016). This dataset was provided as a set of depth contour lines covering a region approximately 23 kilometers by 22 kilometers within the Stabroek Block (Figure 3-4).



Source: Fugro 2016

Figure 3-4: Bathymetry Data

The bathymetry data provided by Fugro were supplemented by data from the GEBCO, a publicly-available source (BODC 2014). Data from this source provided bathymetry values beyond the extent of the Fugro data, toward the north. The database used for this study is the GEBCO_08 Grid which has a 30 arc-second resolution. GEBCO bathymetry offshore Guyana is shown in Figure 3-5.

A polyline shapefile of the Guyana coastline was used as a boundary in the model domain between land and water. The coastlines were obtained from Esri's World Boundaries and Places Alternate product.

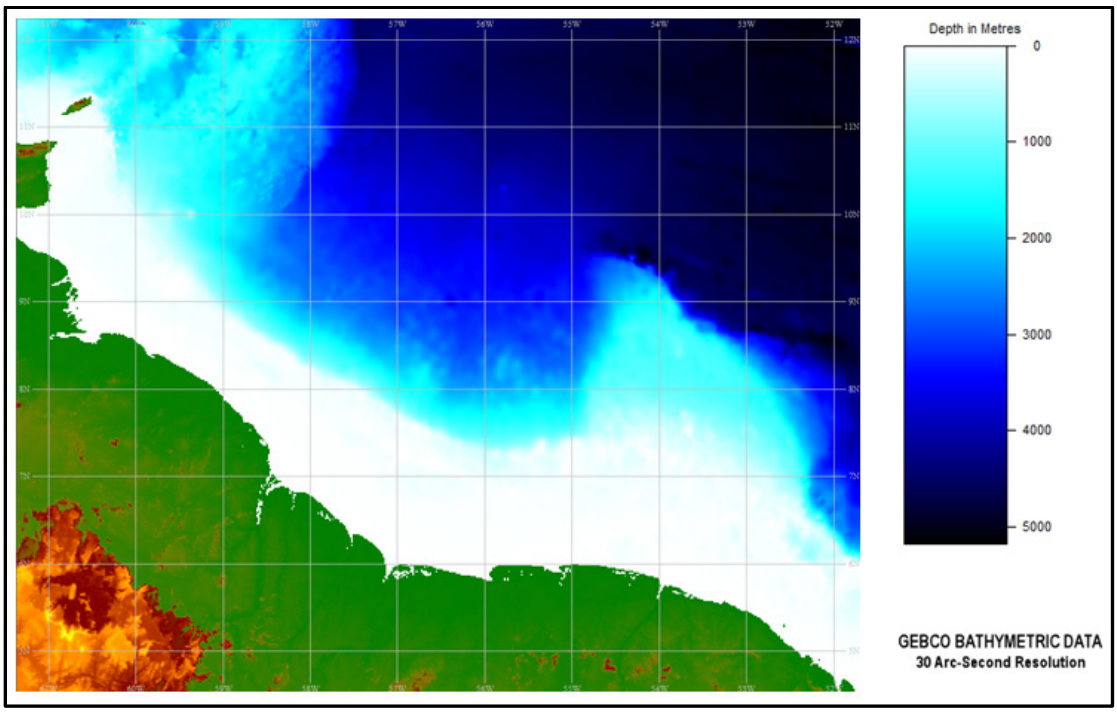


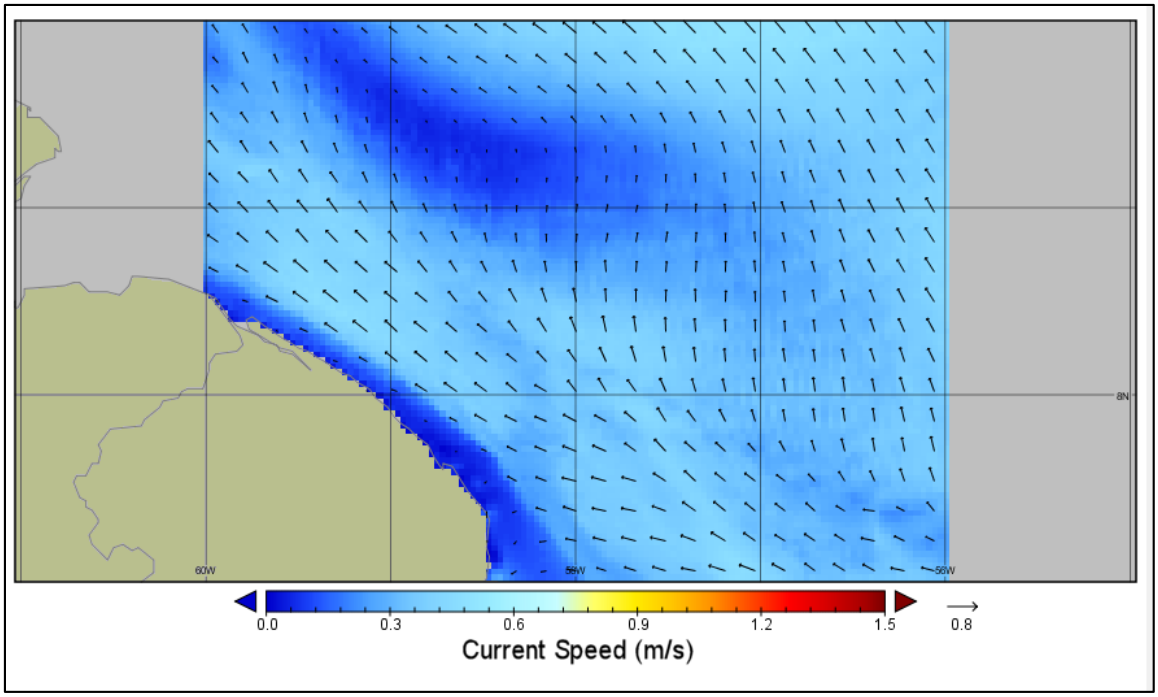
Figure 3-5: GEBCO Bathymetry Data Offshore Guyana

3.1.3.2 Time Varying Data: Ocean Current, Temperature and Salinity Data

The time-varying data used for the drill cuttings deposition modeling included ocean current speed and direction, water temperature, and salinity. Deposition modeling requires time-varying currents on a three-dimensional grid. Hourly depth-varying and spatially-varying currents were obtained from ExxonMobil Upstream Research Company using the SAT-OCEAN model combined with currents from the HYCOM global ocean circulation hindcast model (hycom.org). Currents were obtained every three hours from 2005 through 2014. The model extended from 56º W to 58º W longitude and 7ºN to 11ºN latitude over 128 by 128 grid cells and 22 depth bins at 0, 5, 10, 20, 30, 40, 50, 75, 100, 125, 150, 200, 300, 400, 500, 1000, 1500, 2000, 2500, 3000, 3500, and 4000-meter depths. Depth-varying temperature and salinity values were obtained directly from HYCOM model output.

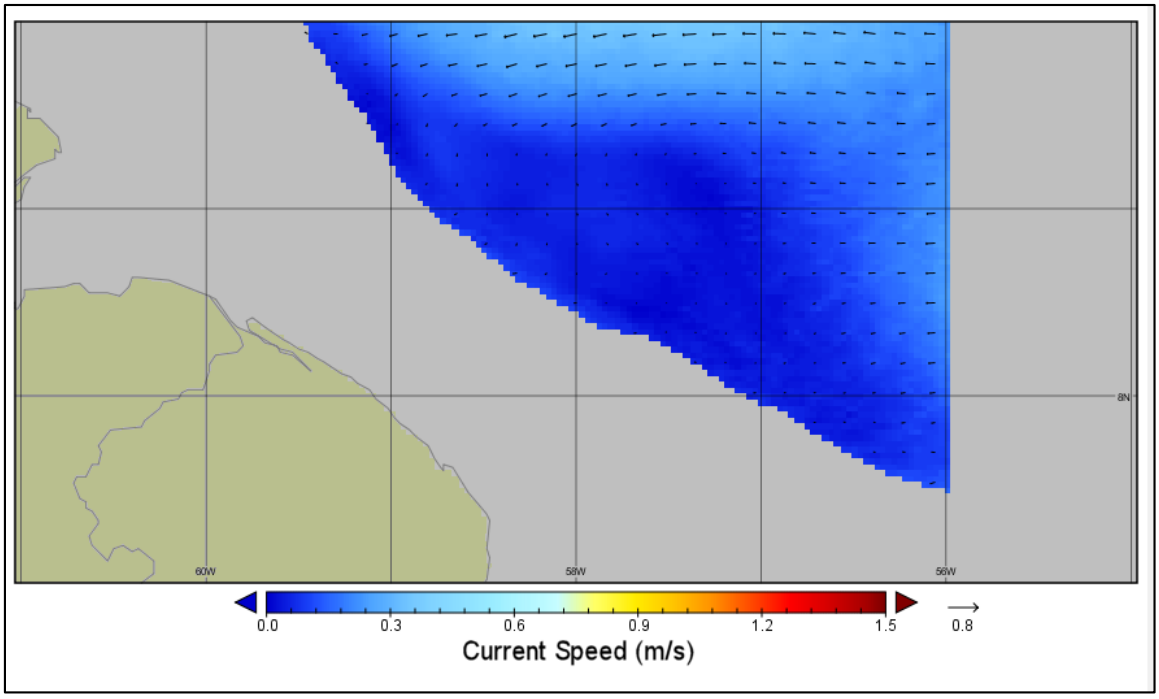
Monthly-averaged, depth-averaged current speeds were computed across the 2005 to 2014 period of record. Through a statistical analysis of these current speeds at the well locations, the months with the minimum and maximum average current speeds were determined. Modeling was performed assuming drill cuttings deposition occurs starting on the first day of these two months: March 2006 (maximum speed) and August 2013 (minimum speed). Simulations performed during these two months will provide the extremes of the full range of depositional patterns (i.e., from a larger and thinner footprint when the current speeds are highest to a smaller and thicker footprint when the current speeds are lowest).

Example current vector plots for March 2006 and August 2013 are shown below in Figure 3-6 and Figure 3-8 (showing current speeds and directions at the sea surface) and in Figure 3-7 and Figure 3-9 (showing current speeds and directions at a depth of 1,000 meters).



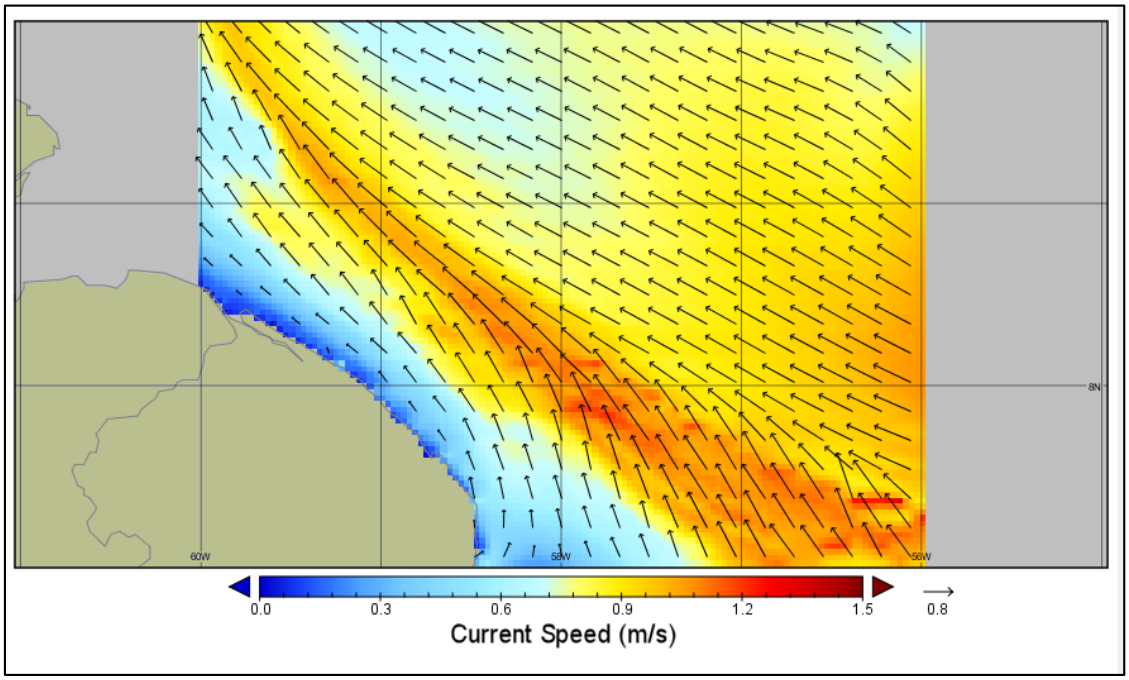
m/s = meters per second

Figure 3-6: Example Current Vector Diagram, 1 March 2006 (Surface)



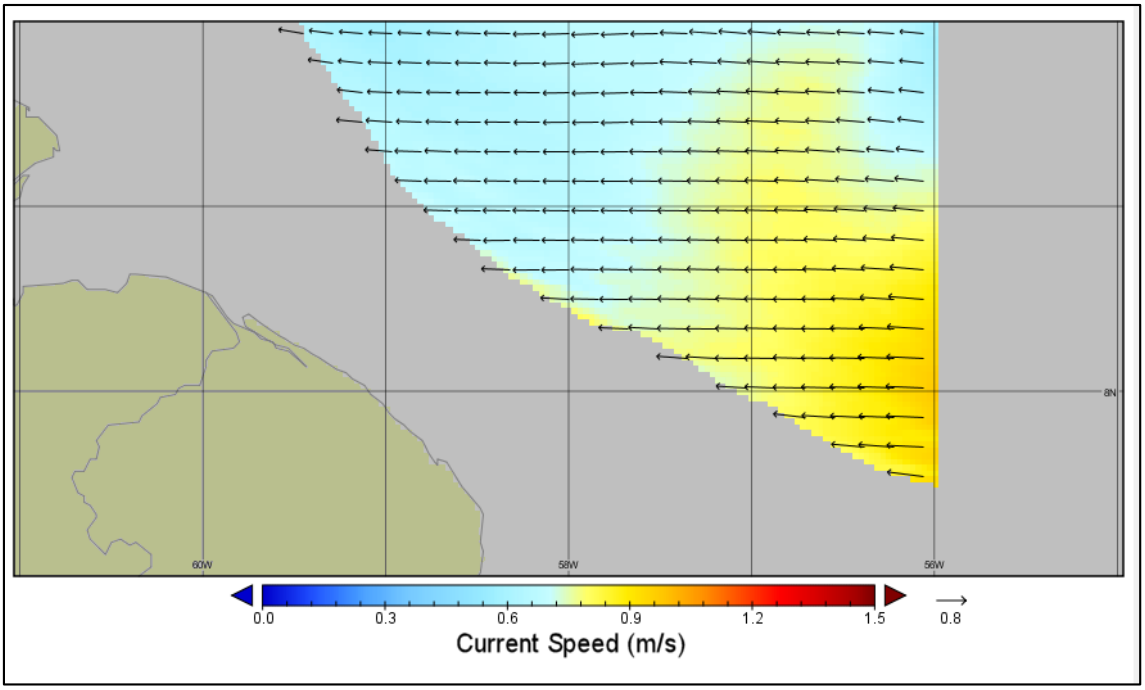
m/s = meters per second

Figure 3-7: Example Current Vector Diagram, 1 March 2006 (1,000-meter Depth)



m/s = meters per second

Figure 3-8: Example Current Vector Diagram, 1 August 2013 (Surface)



m/s = meters per second

Figure 3-9: Example Current Vector Diagram, 1 August 2013 (1,000-meter Depth)

3.1.3.3 Drill cuttings and mud volumes and properties

Estimated quantities of drill cuttings and fluids to be discharged during drilling are provided in Table 3-4. The estimated times to drill each section were provided by EEPGL. For the top hole sections, only WBM are expected to be used. The volume of WBM discharged in Sections 1 and 2 are 5-times and 8-times the volume of the drill cuttings, respectively. In the subsequent sections, the cuttings with a small percentage of adhered non-aqueous muds will be discharged at a depth of 11 meters BSL. No non-aqueous drilling muds will be directly discharged (i.e., before treatment). Solids control and cuttings drying equipment will be installed on the drill ships to process and reduce the percentage of NABF retained on cuttings, such that NABF retained on discharged cuttings will not exceed 6.9 percent (by mass) on average. Accordingly, the modeling assumed an NABF content of 6.9 percent by mass for all discharged cuttings.

Table 3-4: Discharge Description

Hole Diameter (inches)	Volume of Cuttings Discharged (bbl)	Volume of Drilling Fluid to be Discharged (bbl)	Type of Drilling Fluid	Estimated Drilling Duration (days)
36	359	1,797	WBM	0.5
26	2,830	22,636	WBM	1.5
17 ½	1,709	284	NADF	3
12 ¼	1,574	262	NADF	6
8 ½ x 9 $^{7/8}$	159	26	NADF	4
TOTAL	6,632	25,006	-	15

bbl = barrel

Though the actual drilling of the well may take longer to complete, the model simulation of the discharges to the sea was run for 23 days, assuming only 15 days of continuous drilling time for the entire well (inclusive of an assumed one-day pause between well sections) and providing another eight days for settling after cessation of discharges. This provided for a conservative estimate of predicted TSS concentrations.

3.1.3.4 Cuttings and Mud Properties

The grain size properties of the drill cuttings and muds were provided by EEPGL. The distribution of particle sizes and associated fall velocities used in this study are listed in Table 3-5 for cuttings discharged from Section 1 and 2, in Table 3-6 for WBM and in Table 3-7 for treated cuttings with NADF discharged from Sections 3 through 5. Cuttings density was assumed to be 2.6 kilograms per liter. The WBM density was assumed to be 11 pounds per gallon (ppg). The density of NADF was reported by EEPGL to range between 9 and 13.2 ppg; 9 ppg was used for a conservative assumption since it would result in slower settling and a larger footprint of deposition.

Table 3-5: Properties of Cuttings for Well Sections 1 and 2 (Water-Based Fluid)

Estimated Diameter (cm)	Mass Fraction (wt%)	Fall Velocity (cm/s)
0.00005	2	0.00003
0.0001	3	0.0001
0.0002	5	0.0003
0.0006	10	0.0046
0.0007	10	0.0695
0.0059	20	0.4460
0.0363	20	1.8300
0.1350	10	6.9300
0.3730	10	14.3000
0.6680	5	19.8000
0.9510	3	23.4000
1.2200	2	26.1000

cm = centimeter; cm/s = centimeters per second

Table 3-6: WBM Grain-Size Distribution

Estimated Diameter (cm)	Mass Fraction (wt%)	Fall Velocity (cm/s)
0.0005	7	0.0027
0.0007	8	0.0061
0.0011	5	0.0148
0.0015	10	0.0300
0.0018	13.3	0.0434
0.0020	13.3	0.0511
0.0007	19.2	0.0640
0.0008	19.2	0.0823
0.0058	4	0.4270
0.0250	1	1.1200

cm = centimeter; cm/s = centimeters per second

Table 3-7: Properties of Treated Cuttings for Well Sections 3-5 (with Adhered NADF)

Estimated Diameter (cm)	Mass Fraction (wt%)	Fall Velocity (cm/s)
0.001	43	0.02
0.01	1.01	0.20
0.04	4.99	2.00
0.16	5.55	8.00
0.36	7.99	14.00
0.62	10.99	19.00
0.83	13.01	21.99
1.00	6.81	23.99

Estimated Diameter (cm)	Mass Fraction (wt %)	Fall Velocity (cm/s)
1.32	3.69	26.99
1.89	2.47	30.97
*	0.49	124.97

cm = centimeter; cm/s = centimeters per second

* Fall velocity outside the range of available correlations; size computed internally by GIFT model1

3.2 Scenarios

Modeling was performed for eight scenarios: for a well at each of four drill centers (DC3-I, DC3-P1, DC4-I and DC4-P1), for the minimum and maximum of the monthly-averaged, depth-averaged current speeds (Table 3-8). The water depth at the four drill centers varied between 1,680 meters at DC3-P1 and 1,845 meters at DC4-I. The same drilling and mud discharge schedule described in Table 3-4 was assumed at all wells.

Table 3-8: Drill Cuttings and Fluid Deposition Scenarios

Drill Center	Scenario Name	Ambient Current Scenario	Water Depth (meters)
DC3-I	1a	Minimum Monthly Avg.	1,692
	1b	Maximum Monthly Avg.	
DC3-P1	2a	Minimum Monthly Avg.	1,680
	2b	Maximum Monthly Avg.	
DC4-I	3a	Minimum Monthly Avg.	1,845
	3b	Maximum Monthly Avg.	
DC4-P1	4a	Minimum Monthly Avg.	1,830
	4b	Maximum Monthly Avg.	

These scenarios provide predicted cuttings depositional thickness on the seabed on a 2-D basis, TSS concentrations in the water column on a three-dimensional basis, and mass of deposited hydrocarbons on a 2-D basis.

3.2.1 Cuttings Depositional Thickness

Burial by drilling muds and cuttings may cause physical impacts upon benthic communities on the seabed. The potential severity of burial impacts depends on the sensitivity of the benthic organism, the thickness of deposition, the amount of oxygen depleting material, and the duration of the burial. Thickness thresholds vary by species and sediment impermeability. A suggested threshold deposition rate of 5 centimeters per month is recommended based on publications by Ellis and Heim (1985) and MarLIN (2011). Smaller threshold values as low as 1 millimeter have been reported (e.g., Smit et al. 2006); however, they are associated with instantaneous burials on benthic species, not gradual smothering effects. Accordingly, for the purpose of modeling, results are presented in terms of the lateral extent of deposition exceeding 5 centimeters in thickness.

[1] Fall velocities were based on experiments. These velocities were directly used in the GIFT model to estimate settlement. Estimated diameter sizes are only for reference and do not affect GIFT computations.

3.2.2 Total Suspended Solids

Increases in TSS concentrations in the water column will occur due to discharges of drill cuttings and mud. The highest concentration increases will occur at the point of discharge (i.e., at the seafloor for top sections of the well and near the surface for subsequent sections of the well), and will decrease over time and distance as the TSS plume dissipates and settles. Larger particles will settle out more quickly than finer particles, such that smaller particles may stay suspended longer and travel further than larger particles. As such, elevated TSS concentrations may form in regions where tiny suspended particles linger in a cloud and mix with particles from subsequent discharges.

Impacts on marine organisms related to elevated TSS may occur if light penetration in photic zones is impeded significantly for long periods of time (reducing the ability of plants and phytoplankton to photosynthesize). Increases in TSS may also decrease water clarity and clog fish gills. A commonly used guidance value for TSS effluent discharges in the marine environment recommended by MARPOL 73/78[2] is 35 milligrams per liter (mg/L) (IMO 2006). Accordingly, for the purpose of modeling, results are presented in terms of the lateral area with TSS concentrations exceeding 35 mg/L.

3.3 Results

The results of the modeling are illustrated in the following sections as contour plots. The plots presented indicate the location of the drill cuttings release point. Results are presented for each of the following parameters:

- Cuttings deposition thickness at the end of the simulation;
- Maximum TSS concentration in the water column at any time in the simulation (at the surface and at the bottom, representing the surface and seabed discharges, respectively); and
- Mass of hydrocarbons per unit area deposited on the seafloor.

As discussed above, the following threshold criteria were applied for the purpose of reporting results:

- Criterion 1 – Cuttings deposition rate less than 5 centimeters per month; and
- Criterion 2 - Recommended TSS concentrations no greater than 35 mg/L.

There are no available criteria applicable for the mass of hydrocarbons deposited on the seafloor.

3.3.1 Cuttings Depositional Thickness

When the first two sections are jetted and drilled before the riser is installed, cuttings and WBMs are discharged directly to the seabed, resulting in a mound of material deposited around the well.

The material discharged at the seabed is deposited in the area directly adjacent to the well head and results in the thickest layers of deposited material. For DC4-I and DC4-P1, results indicate a footprint of cuttings with the majority of the depositional thickness greater than 1 millimeter concentrated in a 0.5-kilometer radius from the drill centers. For DC3-I and DC3-P1, higher thicknesses are also concentrated around the drill center, but discontinuous patches of depositional thicknesses greater than 1 millimeter are present within a 5-kilometer radius of the drill centers. In all scenarios, a small region close to the well exceeded the depositional thickness threshold value of 50 millimeters (5 centimeters). Releases from near the seafloor at DC4 were predicted to travel a shorter distance, and therefore result in a smaller depositional footprint near DC4 than at DC3, because the bulk of the deposition results from

[2] International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978

near-seafloor releases and modeled currents near the seafloor at DC4 were slower than the modeled currents near the seafloor at DC3.

The lateral extent of thicknesses exceeding this value ranged from roughly a 28-meter to 62-meter radius around the drill center. The maximum thickness predicted was 983 millimeters (Scenario 2a: DC3-P1 minimum currents), but slope failure (i.e., collapse of the depositional mound) and resuspension of the particles are likely to reduce the height of this thickness of deposited materials over time (see Table 3-9).

Figure 3-10 through Figure 3-17 present the predicted distribution of depositional thicknesses at the time when the maximum thickness is accumulated on the ocean floor during the 23 day simulation period. The model simulates releases over 15 days, and then continues to track settling for another 8 after cessation of discharges. Additionally, the model includes a re-suspension function to simulate the natural process of re-suspension. The results presented reflect the maximum deposited thickness for each location at any one time over the 23 day simulation (which would not happen at the same time at all locations). Usually, the maximum thickness and the largest area above 1 millimeter thickness occur soon after the first two sections are drilled, where drill cuttings and mud are discharged near the ocean floor. Maximum thickness and the area above 1 millimeter thickness may reduce with time due to the resuspension of deposited materials as a result of ocean currents.

The maximum depositional thicknesses predicted by the model ranged from 98.3 centimeters in Scenario 2a (at Well DC3-P1 with minimum currents) to 16.2 centimeters in Scenario 3a (at Well DC4-I with minimum currents).

In Scenario 2a, the maximum thickness of 98.3 centimeters was located in the immediate vicinity of the drill center. Parsing the data, jetting and top hole drilling contributed most of the deposited thickness (98.0 centimeters of the ultimate thickness of 98.3 centimeters). At the end of the simulation period (23 days), the majority of the depositions within the model domain were 1 centimeter thick or less (99.82 percent of the deposited area[3]).

In Scenario 3a, the maximum thickness of 16.2 centimeters was also located in the immediate vicinity of the drill center. Parsing the data, jetting and top hole drilling contributed all of the deposited thickness (16.2 centimeters of the ultimate thickness of 16.2 centimeters). At the end of the simulation period (23 days), the majority of the depositions within the model domain were 1-centimeter thick or less (99.5 percent of the deposited area).

Table 3-9: Summary of Results – Cuttings Depositional Thickness

Scenario	Maximum Depositional Thickness (cm)	Area (m²) with Thickness > 5 cm threshold
1a DC3-I—Min Currents	58.5	5,961
1b DC3-I—Max Currents	20.5	3,210
2a DC3-P1—Min Currents	98.3	7,386
2b DC3-P1—Max Currents	25.2	6,347
3a DC4-I—Min Currents	16.2	1,468
3b DC4-I—Max Currents	17.3	1,759
4a DC4-P1—Min Currents	20.8	1,483
4b DC4-P1—Max Currents	19.1	1,773

[3] Region where any incremental deposition occurs regardless of the magnitude

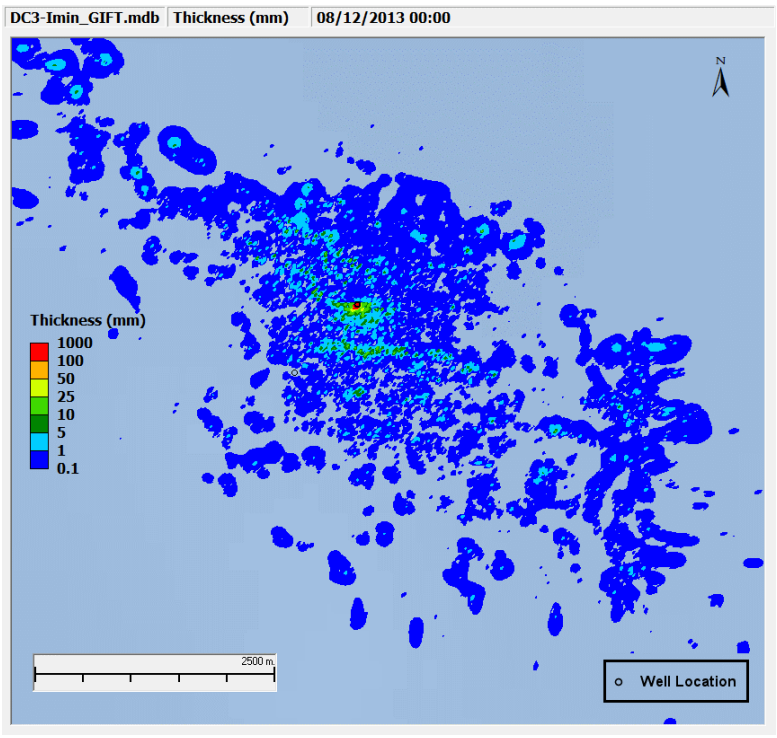


Figure 3-10: Maximum Depositional Thickness—Scenario 1a DC3-I Minimum Currents

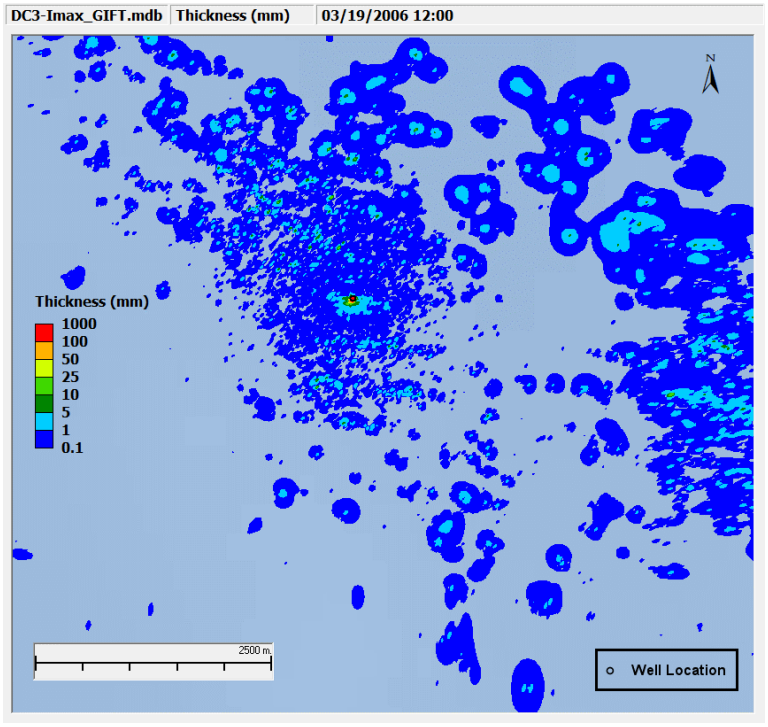


Figure 3-11: Maximum Depositional Thickness—Scenario 1b DC3-I Maximum Currents

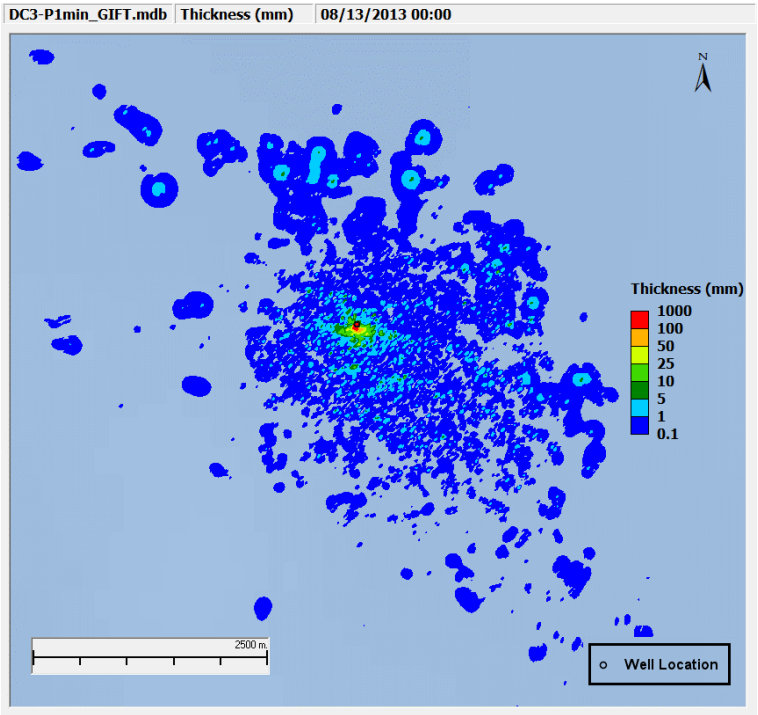


Figure 3-12: Maximum Depositional Thickness—Scenario 2a DC3-P1 Minimum Currents

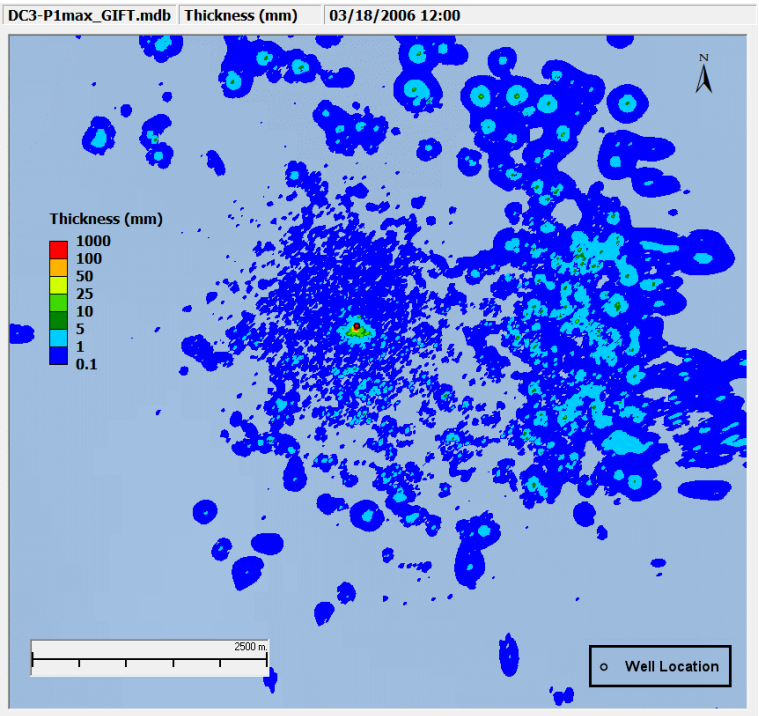


Figure 3-13: Maximum Depositional Thickness—Scenario 2b DC3-P1 Maximum Currents

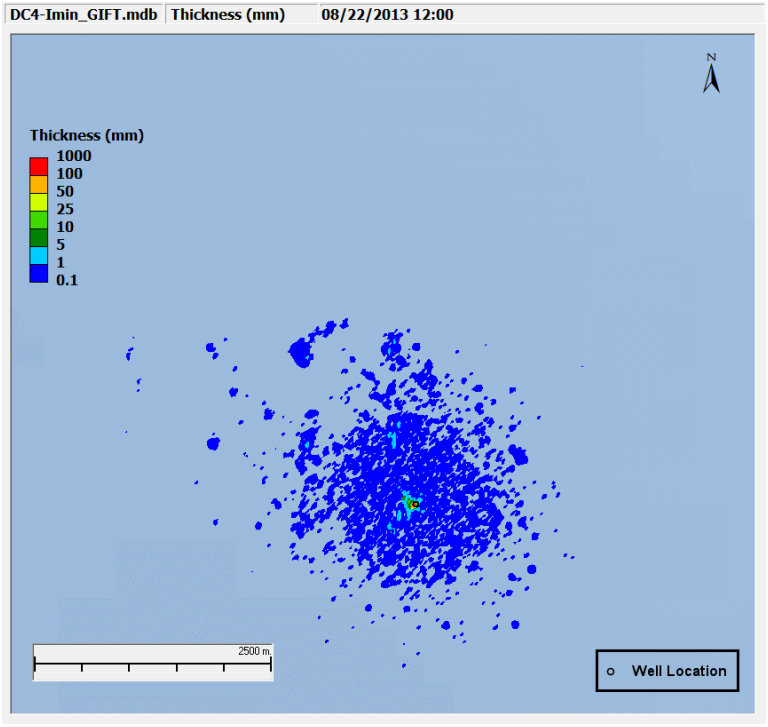


Figure 3-14: Maximum Depositional Thickness—Scenario 3a DC4-I Minimum Currents

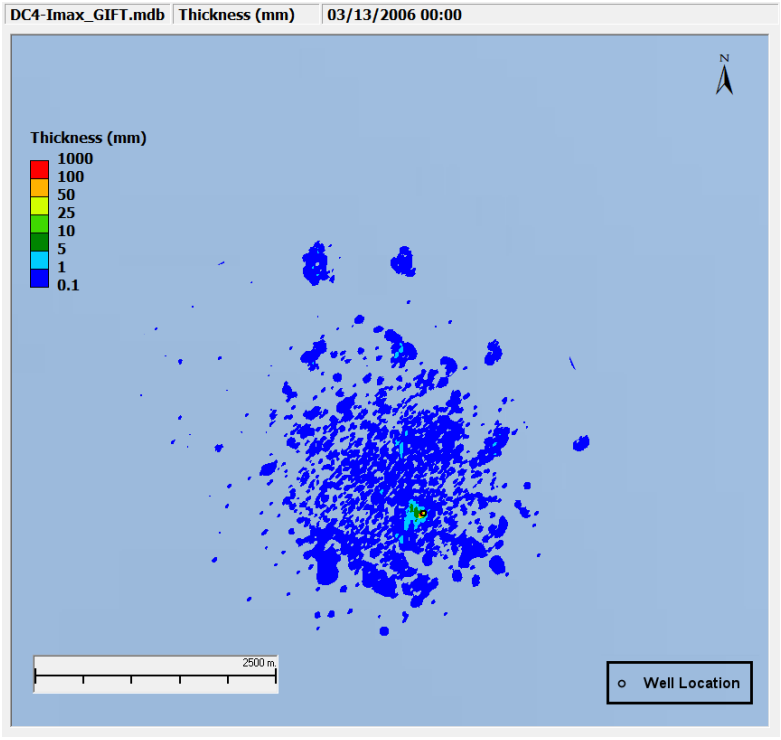


Figure 3-15: Maximum Depositional Thickness—Scenario 3b DC4-I Maximum Currents

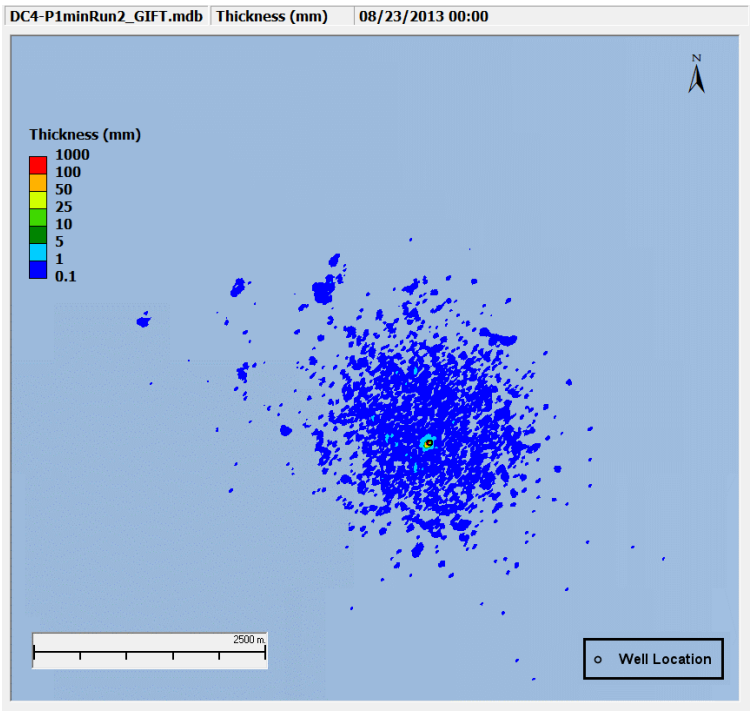


Figure 3-16: Maximum Depositional Thickness—Scenario 4a DC4-P1 Minimum Currents

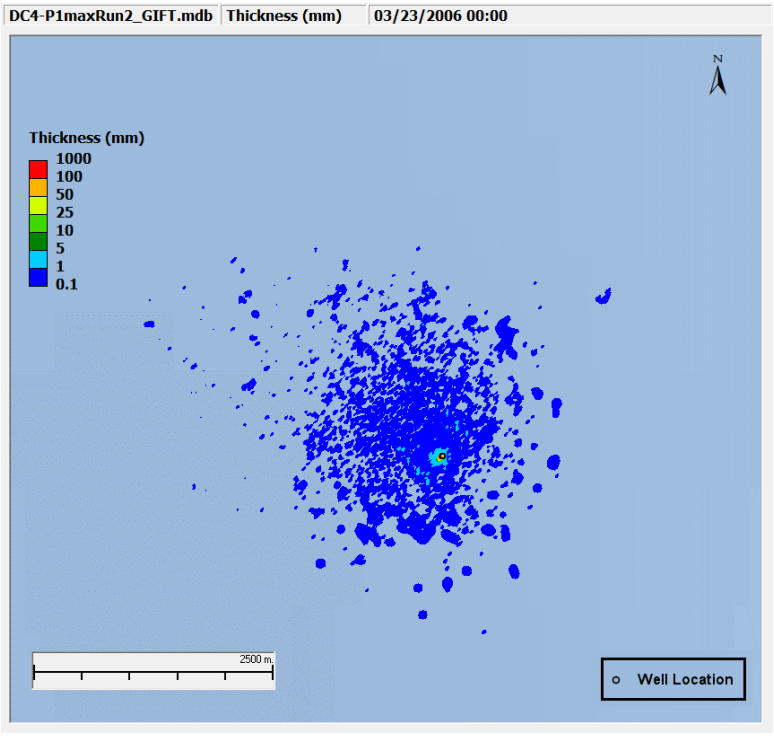


Figure 3-17: Maximum Depositional Thickness—Scenario 4b DC4-P1 Maximum Currents

3.4 Conclusions

Drill cuttings deposition modeling was performed using GEMSS® and its drill cuttings and muds deposition module, GIFT. Eight simulations were modeled, representing at well at each of four different drill center locations (DC3-I, DC3-P1, DC4-I and DC4-P1), each under two ambient current conditions (minimum and maximum monthly-averaged, depth-averaged current speeds over a ten year period of record). At the beginning of the simulation, during a two-day period, cuttings and WBM were discharged directly at the seabed while jetting and drilling the first two well sections. After a one day break, drill cuttings and adhered NADF muds from the subsequent three sections were simulated to be released 11 meters below sea level over the following 13 days.

Output from the drill cutting modeling included estimations of the lateral distribution of deposited cuttings thickness on the sea floor, the maximum increase in TSS concentrations above ambient conditions, and the lateral distribution of mass of hydrocarbons adhered to cuttings deposited on the sea floor. The results of the modeling are shown below in Table 3-10.

Table 3-10: Model Results Summary

Scenario	Maximum Depositional Thickness (cm)	Area (m^2) with Thickness > 5 cm Threshold	Maximum TSS (mg/L) Surface/ Bottom	Area (km^2) with TSS > 35 mg/L Threshold Surface/ Bottom	Maximum Adhered Oil Deposition (g/m^2)	Area (km^2) with Adhered Oil Deposition > 5 g/m^2
1a DC3-I Min Currents	58.5	5,961	7.2/12,591	0/0.080	355.1	10.2
1b DC3-I Max Currents	20.5	3,210	14.1/9,801	0/0.282	280.7	10.1
2a DC3-P1 Min Currents	98.3	7,386	6.3/5,783	0/0.069	280.8	9.9
2b DC3-P1 Max Currents	25.2	6,347	6.9/7,269	0/0.208	272.7	9.8
3a DC4-I Min Currents	16.2	1,468	6.0/39,613	0/0.405	354.9	9.9
3b DC4-I Max Currents	17.3	1,759	3.1/19,857	0/0.521	322.2	8.6
4a DC4-P1 Min Currents	20.8	1,483	8.1/41,055	0/0.325	247.7	9.9
4b DC4-P1 Max Currents	19.1	1,773	10.4/15,690	0/0.475	246.5	8.0

According to the model results, the thickness of drill cuttings and adhered muds deposited on the seafloor may exceed the threshold value of 5 centimeters within as much as a 62-meter radius from the drill center. The bulk of the depositional mound results from the cuttings and muds discharged during the jetting and drilling of the top two sections. The maximum TSS concentration of ambient in the bottom of the water column are predicted to be as much as 41,000 mg/L at the point of release; however, these concentrations will occur at water depths below the photic zone, in areas where photosynthesis inhibition is not a concern. At the surface, where photosynthesis inhibition is more of a concern, TSS increases above ambient from discharges were predicted to be below the 35 mg/L threshold. The maximum TSS concentration increases above ambient in the shallow water column is 14.1 mg/L. Hydrocarbon deposition on the seafloor had a maximum predicted value of 355.1 g/m^2, with deposition over 5 g/m^2 within an area no more than 10.2 km^2.

Variations in the current speeds are the primary cause for the variations in the model results provided. In general, scenarios with minimum currents have higher maximum cuttings deposition thicknesses and higher bottom TSS concentrations compared to the scenarios with maximum currents. Slower currents allow for a more laterally-concentrated deposition and more concentrated TSS. Though Scenario 3a has lower monthly and depth-averaged currents compared to Scenario 3b, the bottom currents where most of the deposition occurs during drilling of the riserless sections were higher in Scenario 3a, allowing lower depositional thickness in Scenario 3a compared to Scenario 3b. In addition, Scenario 2a with minimum currents showed lower TSS concentrations compared to Scenario 2b with maximum currents, because currents near the bottom in Scenario 2a are significantly lower than those for Scenario 2b, causing faster deposition of cuttings without causing larger TSS concentrations. Higher bottom currents result in a larger depositional area during drilling of the first two sections, with near-seabed discharges causing cuttings to settle across a larger area, and reducing the maximum depositional thickness in Scenario 3a and Scenario 4a with minimum currents versus Scenario 3b and Scenario 4b with maximum currents.

Similar to the depositional thickness, scenarios with minimum currents have higher maximum hydrocarbon deposition compared to scenarios with maximum currents. Slower currents allow for a more laterally concentrated deposition of hydrocarbon-containing cuttings.

4. PAYARA (EIA)

4.1 Approach

In this study, the discharge of drill cuttings is evaluated. It is assumed that there will be a direct discharge (i.e., near the seabed) of cuttings with water-based drilling fluids during drilling of the riserless open-hole section at each well and, for all other well sections, a discharge near the sea surface of cuttings with a small fraction of adhered residual base oil from material removed in the lower well sections after treatment on the FPSO.

Modeling was performed to predict the following as a result of cuttings discharge:

- The total suspended solids (TSS) concentrations in the water column;
- The seabed accumulation (thickness) of the adhered muds and drill cuttings over an area of seafloor (the footprint); and
- The mass of hydrocarbons settled upon the seafloor.

4.1.1 Scenario Design

Released material will pass vertically through the water column because cuttings and muds are denser than the receiving water. Released material will also migrate horizontally due to advection by local and regional currents. The dispersion of cuttings and muds is fundamentally a three-dimensional (3-D) phenomenon requiring 3-D hydrodynamic fate and transport modeling.

For modeling purposes, two drill center locations were selected at extreme ends of the range of water depths across the Project drill centers (see Table 4-1 and Figure 4-1). Location PY1-P represents a production well cluster at drill center PY1-P and location PY3-I represents an injection well cluster at drill center PY3-I. Coordinates of the main drill centers and the depths of water at these locations are presented in Figure 4-1.

Table 4-1: Modeled Well Locations and Water Depths

Well Location	Longitude	Latitude	X Coordinate in UTM 21N (meters)	Y Coordinate in UTM 21N (meters)	Water Depth (meters)
PY1-P	-56.970533	8.161038	503,246	902,101	1,900
PY3-I	-56.947871	8.252458	505,741	912,208	2,119

UTM = Universal Transverse Mercator

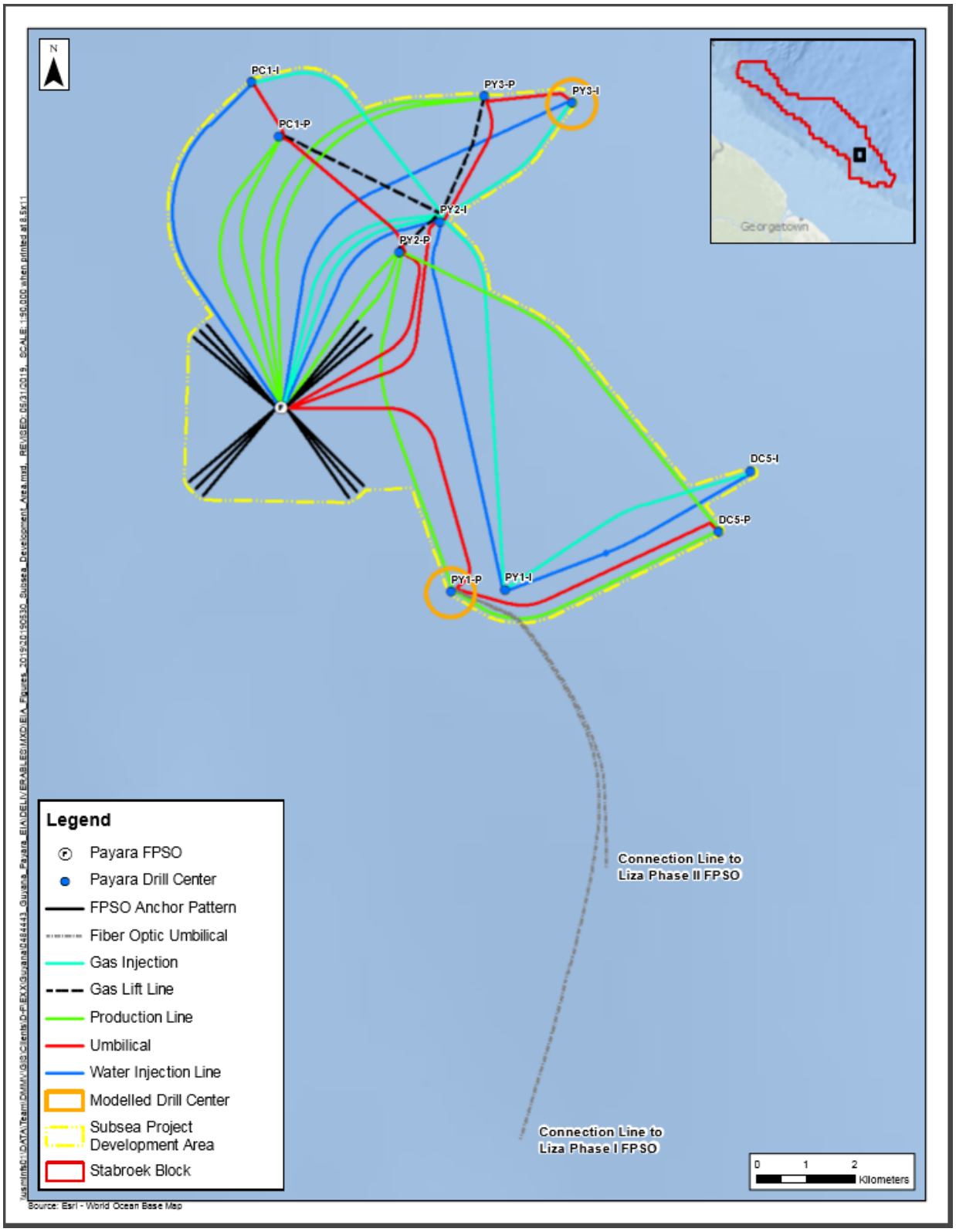


Figure 4-1: Locations of Planned Drill Centers in the Payara Subsea Project Development Area

4.1.1.1 Location PY1-P

For modeling purposes, it is assumed that a cluster of four wells will be drilled within <20 meters (65.6 feet) of the drill center at PY1-P. Each well will consist of five sections. At each of these well locations, the top hole (Section 1) and conductor (Section 2) will be jetted and drilled with water-based muds (WBM) to a depth of 1,539 meters (5,049.2 feet) below the mud line. The subsequent three sections - with hole diameters sizes 44.5 centimeters (17.5 inches), 31.1 centimeters (12.25 inches), and 24.1 centimeters (9.5 inches) - will be drilled with non-aqueous drilling fluid (NADF) until a total depth of approximately 6,083 meters (19,957 feet) below the mud line is reached. Details of these sections are presented in Table 4-2. The discharge pipe from the drill platform will release treated cuttings from Sections 3 through 5 at a depth of 11 meters (36 feet) below mean sea level.

Table 4-2: Well Profile at Location PY1-P

Section	Diameter (inches)	Section Length (meters)	Modeled Cuttings Discharge Duration (days)
Section 1—Structural (Top Hole, Jet)	36	120	0.5
Section 2—Conductor	28	1,419	1.6
Section 3—Surface	17 ½	946	3.5
Section 4—Production	12 ¼	2,554	8.1
Section 5—Open	9 ½	1,044	6.8

4.1.1.2 Location PY3-I

For modeling purposes, it is assumed that a cluster of four wells will be drilled within <20 meters (65.6 feet) of the drill center at PY3-I. Each well will consist of five sections. At each of these well locations, the top hole (Section 1) and conductor (Section 2) will be jetted and drilled with WBM to a depth of 1,539 meters (5,049.2 feet) below the mud line. The subsequent three sections - with hole diameters sizes 44.5 centimeters (17.5 inches), 31.1 centimeters (12.25 inches), and 24.1 centimeters (9.5 inches) - will be drilled with NADF until a total depth of approximately 6,049 meters (19,845.9 feet) below the mud line is reached. Details of these sections are presented in Table 4-3. The discharge pipe from the drill platform will release treated cuttings from Section 3 through 5 at a depth of 11 meters (36.1 feet) below mean sea level.

Table 4-3: Well Profile at Location PY3-I

Section	Diameter (inches)	Section Length (meters)	Modeled Cuttings Discharge Duration (days)
Section 1—Structural (Top Hole, Jet)	36	120	0.5
Section 2—Conductor	28	1,292	1.6
Section 3—Surface	17 ½	930	3.5
Section 4—Production	12 ¼	2,664	8.1
Section 5—Open	9 ½	1,034	6.8

4.1.1.3 Model Scenarios

The model simulations for drill cuttings included three scenarios at each drill center location. These are described below.

Scenario 1

Scenario 1 evaluated the impacts from sequentially jetting and drilling two top-hole sections (Sections 1 and 2) at each of the four well locations at PY1-P and PY3-I. This represents the most likely maximum number of top holes (eight; four wells and two top-hole sections each) that will be drilled sequentially at any time from a drill center (PY1-P or PY3-I) within a 30-day time period (the time period relevant for the 5 centimeters (2 inches) per month deposition standard used). Table 4-2 and Table 4-3 show that the actual drilling duration based on continuous drilling are 0.5 day and 1.6 days for Section 1 and Section 2 respectively. However, from an operational standpoint, the total duration of the jetting/drilling of these top-hole sections (Section 1 and 2) will each take approximately 1 week, considering breaks and labor shifts. In addition, jetting/drilling of any top-hole section (Sections 1 and 2) will be followed by at least a 4-day rest period prior to starting the jetting/drilling of the next top-hole. Considering these breaks and rest periods, in addition to the actual drilling/jetting period, this results in a total operational period of 40 days for all four locations, with two top-hole sections at each location.

The resting/break period of 4 days between the sections and wells will allow releases to settle without initiation of a new release from a subsequent well. For conservativeness in the model, the model simulations assumed only a 1-day resting/break period, while preserving the actual continuous drilling duration. This conservative assumption significantly compresses the overall drilling schedule from a total of 40 days to a total of 19 days. The modeled drilling schedule is shown in Table 4-4.

Table 4-4: Scenario 1 Simulation Schedule

Drilling Action	Duration (days)
Well 1—Section 1	0.5
Break	1
Well 1—Section 2	1.6
Break	1
Well 2—Section 1	0.5
Break	1
Well 2—Section 2	1.6
Break	1
Well 3—Section 1	0.5
Break	1
Well 3—Section 2	1.6
Break	1
Well 4—Section 1	0.5
Break	1
Well 4—Section 2	1.6
Additional Modeled Period for Particle Settling	3.6
Total Simulation Days	**19**

Scenario 2

Scenario 2 evaluated the sequential jetting and drilling of two top-hole sections (Sections 1 and 2) at two of the well locations (PY1-P and PY3-I) followed by the change-out of the drill ship to NADF drilling and the drilling of Sections 3 and 4 at the second well location for which top-hole sections were drilled. This represents the most likely maximum number of top holes (two wells with two top-hole sections each) and

bottom holes (one well with two bottom-hole sections) that will be drilled sequentially at any time from a drill center (PY-P or PY3-I) within a 30-day time period (the time period relevant for the 5 centimeters (2 inches) per month deposition standard used). Table 4-2 and Table 4-3 show that the actual drilling duration based on continuous drilling are 0.5 days and 1.6 days for Section 1 and Section 2 respectively. Actual drilling duration based on continuous drilling is 3.5 days for Section 3 and 8.1 days for Section 4. However, from an operational standpoint, the total duration of the jetting/drilling operation of these top-hole sections (Section 1 or 2) will take approximately 1 week, considering breaks and labor shifts. Once the top-hole sections of the second well have been drilled (approximately 7 days), WBM drilling equipment will be changed to NADF equipment over a rest period of approximately 7 days. Following this change out, Sections 3 and 4 of the second well will be drilled over a period of approximately 15 days. Considering these breaks and rest periods, in addition to actual drilling/jetting period, this results in a total operation period of approximately 40 days.

The resting/break period of 4 to 7 days between the sections and wells will allow all releases to settle without any new release starting from the subsequent section. For conservativeness in the model, the model simulations only assumed a 1-day resting/break period, while preserving the actual continuous drilling duration. This conservative assumption significantly compresses the overall drilling schedule from a total of 40 days to a total of 21.5 days. The modeled drilling schedule is shown in Table 4-5.

Table 4-5: Scenario 2 Simulation Schedule

Drilling Action	Duration (days)
Well 1—Section 1	0.5
Break	1
Well 1—Section 2	1.6
Break	1
Well 2—Section 1	0.5
Break	1
Well 2—Section 2	1.6
Break	1
Well 2—Section 3	3.5
Break	1
Well 2—Section 4	8.1
Additional Modeled Period for Particle Settling	0.7
Total Simulation Days	**21.5**

Scenario 3

Scenario 3 assesses hydrocarbon deposition from topside discharges of treated drill cuttings with adhered oil from sequentially drilling three bottom-hole sections (Sections 3, 4, and 5) at each of four well locations at a drill center. Table 4-2 and Table 4-3 show that the actual drilling duration based on continuous drilling are 3.5 days, 8.1 days, and 6.8 days for Section 3, 4, and 5, respectively. However, from an operational standpoint, the drilling of Sections 3 to 5 of the a well will be drilled over a period of approximately 25 days, followed by a period of approximately 14 days before beginning drilling of Sections 3 to 5 of a subsequent well. The drilling of Sections 3 to 5 of the subsequent well will require another approximately 25 days to complete, followed by a period of approximately 14 days before drilling the next well's bottom-hole sections. Drilling of the third and fourth wells will take another approximately 64 days. In total, it is estimated that this drilling operation will take approximately 140 days.

The resting/break period ranging from 4 to 7 days to multiple weeks between the sections and wells will allow all releases to settle without any new release initiating. For conservativeness in the model, the model simulations only assumed a 1-day resting/break period while preserving the actual continuous drilling duration. This conservative assumption significantly compresses the overall drilling schedule from a total of more than 140 days to a total of 87 days. The modeled drilling schedule is shown in Table 4-6.

Table 4-6: Scenario 3 Simulation Schedule

Drilling Action	Duration (days)
Well 1—Section 3	3.5
Break	1
Well 1—Section 4	8.1
Break	1
Well 1—Section 5	6.8
Break	1
Well 2—Section 3	3.5
Break	1
Well 2—Section 4	8.1
Break	1
Well 2—Section 5	6.8
Break	1
Well 3—Section 3	3.5
Break	1
Well 3—Section 4	8.1
Break	1
Well 3—Section 5	6.8
Break	1
Well 4—Section 3	3.5
Break	1
Well 4—Section 4	8.1
Break	1
Well 4—Section 5	6.8
Additional Modeled Period for Particle Settling	2.4
Total Simulation Days	**87**

4.1.1.4 Particle Grids

Three model grids were used: a particle grid, a depositional grid, and a concentration grid. The movement of the discharged cuttings and muds using Lagrangian particles was computed within the particle grid (Table 4-2 and Figure 4-2). This particle grid is a square approximately 50 kilometers (31 miles) on each side, with each cell approximately 50 meters (164 feet) by 50 meters (164 feet). Each grid cell contains an interpolated depth value derived from the bathymetry data described in Section 4.1.3. Particles are free to move horizontally and vertically within this grid's domain, independently of the grid, except for movement past the grid boundaries representing the seafloor (as defined by the bathymetry) and shorelines.

For computation of the deposition on the seafloor, the model used a smaller, more finely spaced two-dimensional (2-D) depositional grid, with each grid centered on a drill center. The depositional grid is a square approximately 20 kilometers (12.4 miles) on each side. Cell sizes vary in size from 10 meters (32.8 feet) by 10 meters (32.8 feet) near the center to 100 meters (328 feet) by 100 meters (328 feet) at the edge of the grid. Figure 4-3 shows the (more tightly spaced) portion of the depositional grid in the vicinity of the FPSO.

The concentration grid, used for computation of TSS concentrations in the water column, is 3-D, with the same horizontal dimensions as the depositional grid. Vertically, the cells are 10 meters (32.8 feet) thick at the surface and bottom regions, where the maximum suspended solids are predicted to occur. The cell thicknesses expand in size towards the middle of the water column region.

A summary of the dimensions of these grids is presented in Table 4-7.

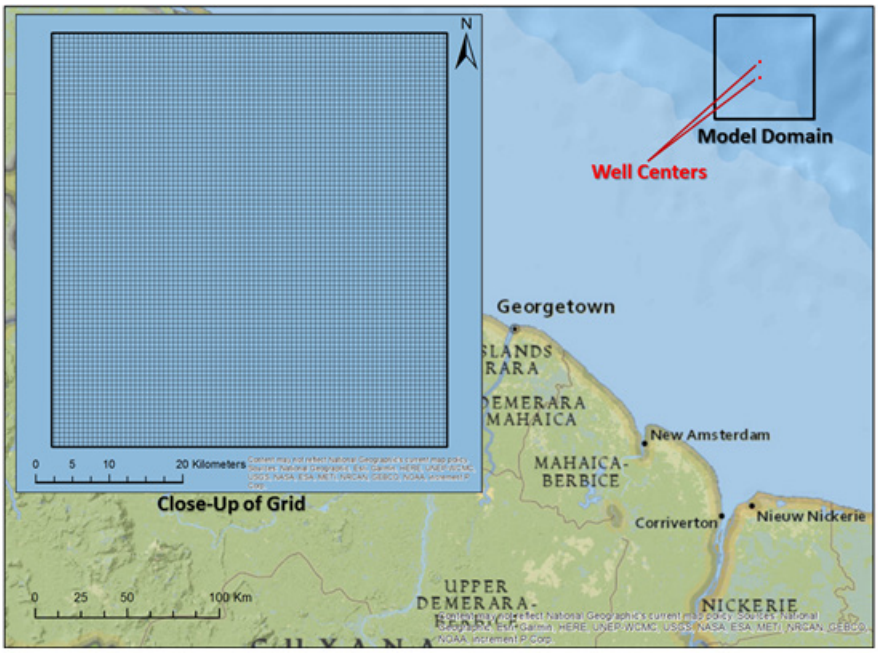


Figure 4-2: Particle Grid

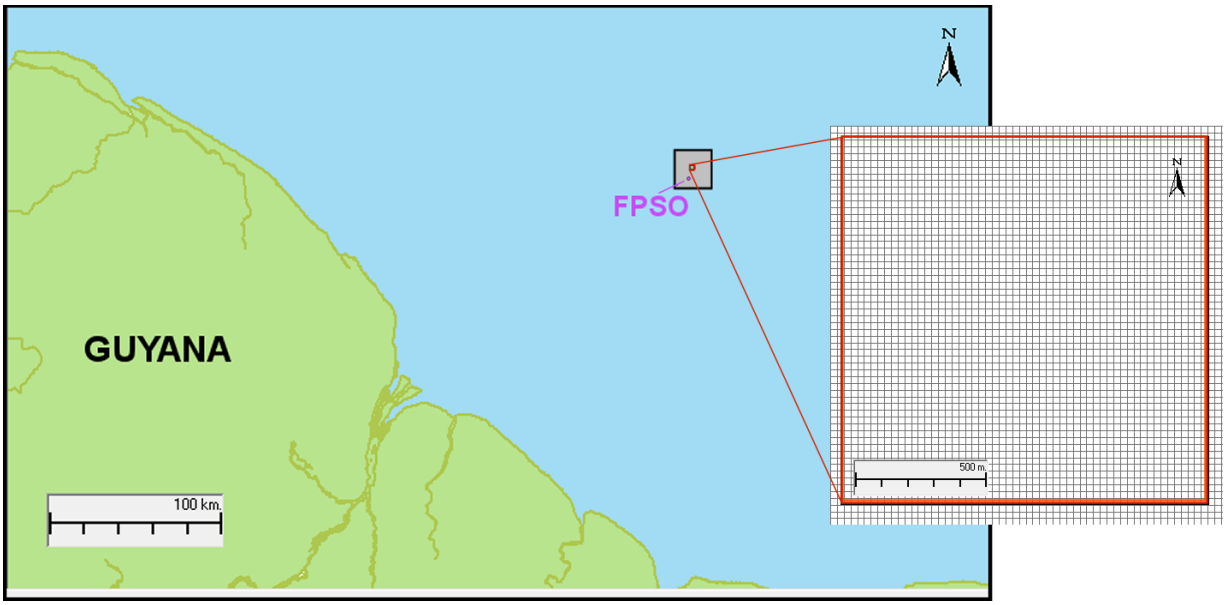


Figure 4-3: Depositional and Concentration Grid

Table 4-7: Grid Dimensions

Grid	Horizontal Dimensions (meters)	Vertical Dimensions
Particle grid	50 x 50	NA
Depositional grid	Variable—smallest 10 x 10 at center	NA
Concentration grid	Variable—smallest 10 x 10 at center	Variable—smallest 10 meters at top and bottom

NA = not applicable

4.1.2 Drill Cuttings and Mud Deposition Software

The modeling was performed using the software package GEMSS® and its drill cuttings and muds discharge module, GIFT (Kolluru and Spaulding 1993; Kolluru, et al. 1998; Fichera and Kolluru 2007; Fichera et al. 2013; Prakash and Kolluru 2014). GIFT can simulate the fate of dissolved and particulate material discharged from a range of sources, including drill cuttings and muds and produced water. This 3-D 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. The modeling methodology is based on a deterministic mode of simulation. In deterministic, single event simulations, the starting date and current speed and direction at each time step are chosen from a database of properties in the selected periods.

Drill cuttings and muds were modeled as particles. Movement in the vertical direction resulted in the settling and deposition of cuttings on the seabed. The deposition, based on particle size distribution and the intensity of release, results in the predicted accumulation of drill cuttings on the seabed.

Modeling data inputs included:

- Drill section sizes and schedule
- Drilling mud types
- Cuttings and mud grain size distribution
- Mud and cuttings densities

- Mud and cuttings release rates, durations, and discharge depths

4.1.3 Environmental Data

Model inputs were assembled and formatted for use with GIFT. The environmental data used by the model included bathymetry, ocean current, water temperature, and salinity data. Spatially and temporally varying oceanic data were collected to characterize the area in which the discharges will occur and determine appropriate simulation periods to represent the range of potential results (see Project EIA Section 6.4.2, Existing Conditions—Marine Water Quality).

4.1.3.1 Bathymetry

The primary spatial dataset is the bathymetric data, used to describe the depth and shape of the seafloor. Bathymetric data are used to develop the lower boundary of the modeling grids. The GEBCO, a publicly available source, was used to extract seafloor bathymetry at the study site (IOC et al. 2003). The database used for this study is the GEBCO_08 Grid, which has a 30-arc-second resolution. GEBCO bathymetry offshore of Guyana is shown in Figure 4-4.

A polyline shapefile of the Guyana coastline was used as a boundary in the model domain between land and water. The coastline boundary was obtained from Esri's World Boundaries and Places Alternate product.

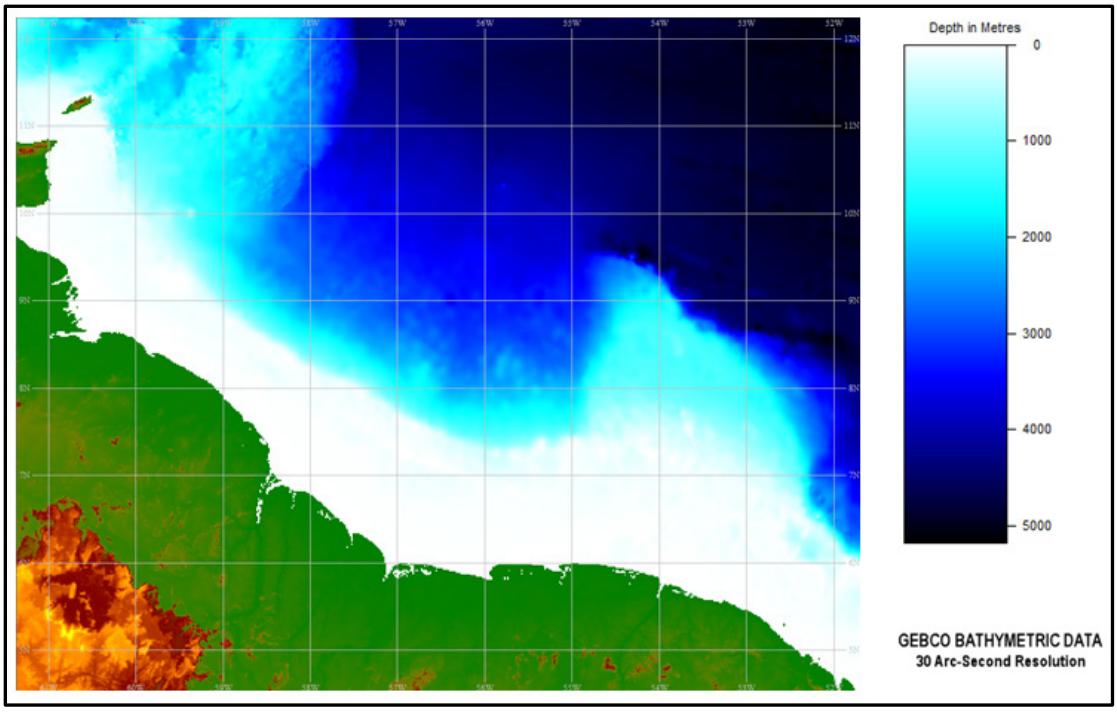


Figure 4-4: GEBCO Bathymetry Data Offshore Guyana

4.1.3.2 Time Varying Data: Ocean Current, Temperature, and Salinity Data

The time-varying data used for the drill cuttings deposition modeling included ocean current speed and direction, water temperature, and salinity. Deposition modeling requires time-varying currents on a 3-D grid. Hourly depth-varying and spatially varying currents were obtained from ExxonMobil Upstream Research Company using the SAT-OCEAN model combined with currents from the HYCOM global ocean

circulation hindcast model. Currents were obtained every three hours from 2005 through 2014. The model extended from 56ºW to 58ºW longitude and 7ºN to 11ºN latitude over 128 by 128 grid cells and 22 depth bins at 0-, 5-, 10-, 20-, 30-, 40-, 50-, 75-, 100-, 125-, 150-, 200-, 300-, 400-, 500-, 1,000-, 1,500-, 2,000-, 2,500-, 3,000-, 3,500-, and 4,000-meter (0-, 16.4-, 32.8-, 65.6-, 98.4-, 131.2-, 164-, 246.1-, 328.1-, 410.1-, 492.1-, 656.2-, 984.3-, 1,312.3-, 1,640.4-, 3,280.8-, 4,921.3-, 6,561.7-, 8,202.1-, 9,842.5-, 11,482.9-, and 13,123.4-foot) depths. Depth-varying temperature and salinity values were obtained directly from HYCOM model output.

Monthly averaged, depth-averaged current speeds were computed across the 2005 to 2014 period of record. Through a statistical analysis of these current speeds at the well locations, the months with the minimum and maximum average current speeds were determined. Modeling was performed assuming drill cuttings deposition occurs starting on the first day of these 2 months: March 2006 (maximum speed) and August 2013 (minimum speed). Simulations performed during these 2 months will provide the extremes of the full range of depositional patterns (i.e., from a larger and thinner footprint when the current speeds are highest to a smaller and thicker footprint when the current speeds are lowest).

Example current vector plots for March 2006 and August 2013 are shown below in Figure 4-5 and Figure 4-7 (showing current speeds and directions at the sea surface) and in Figure 4-6 and Figure 4-8 (showing current speeds and directions at a depth of 1,000 meters [3,280.8 feet]).

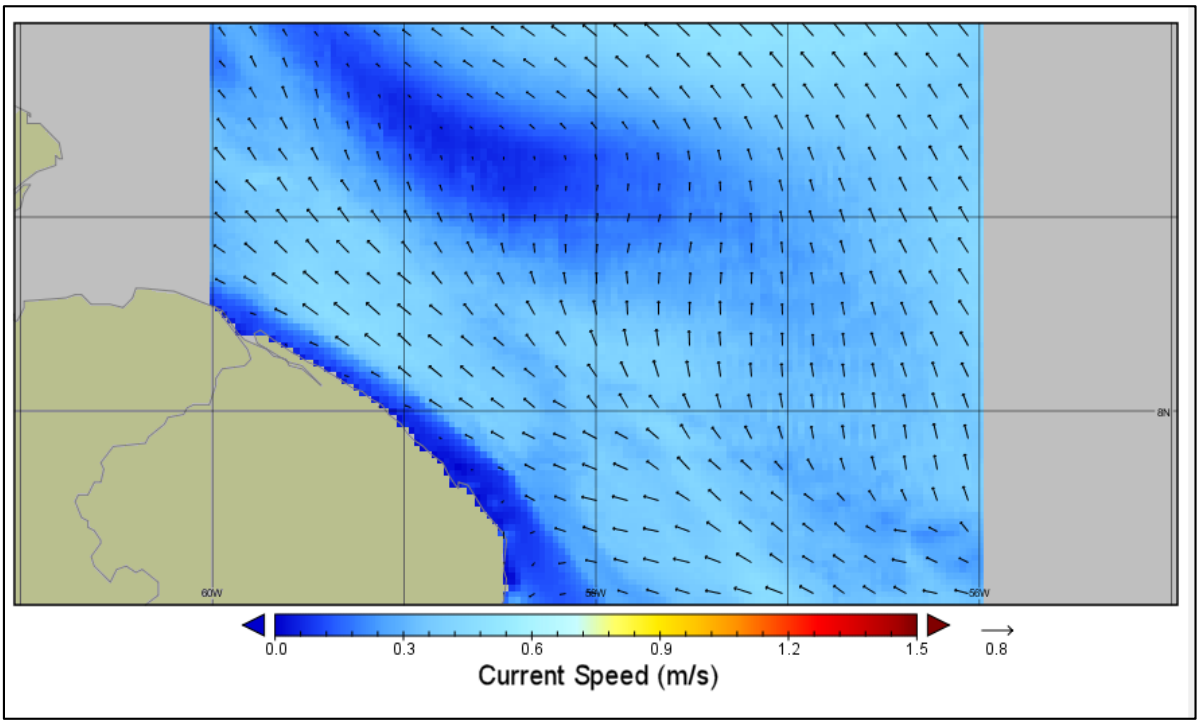


Figure 4-5: Example Current Vector Diagram, 1 March 2006 (Surface)

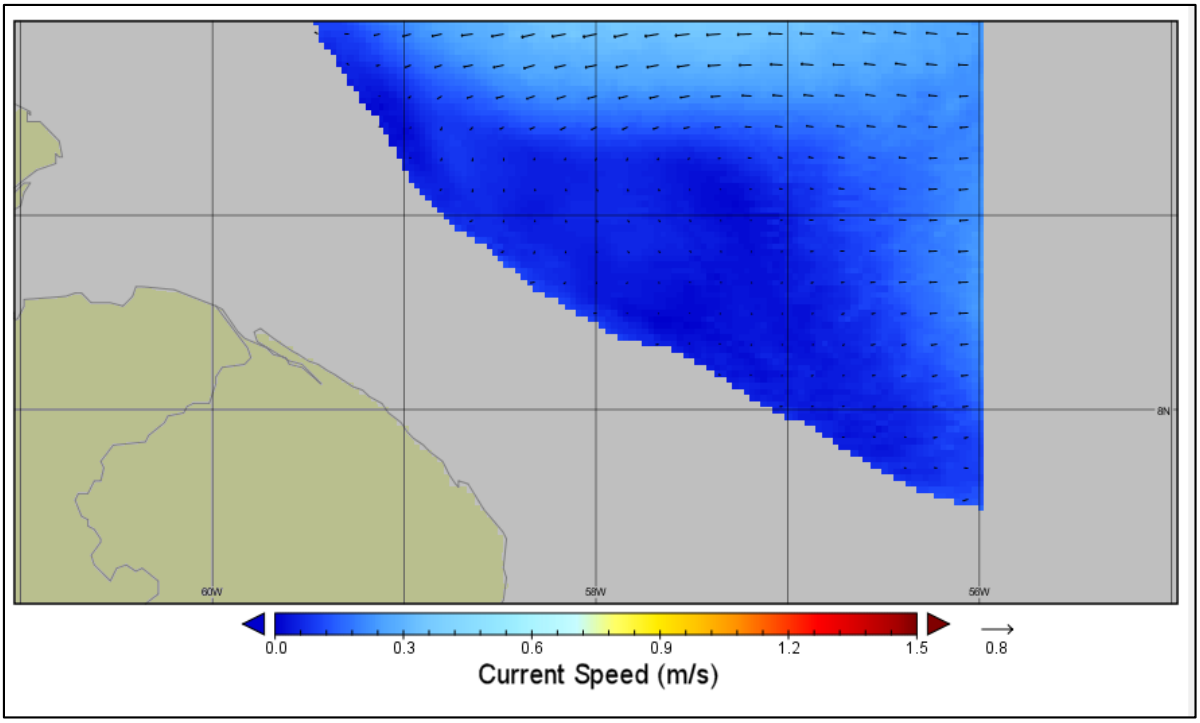


Figure 4-6: Example Current Vector Diagram, 1 March 2006 (1,000-meter Depth)

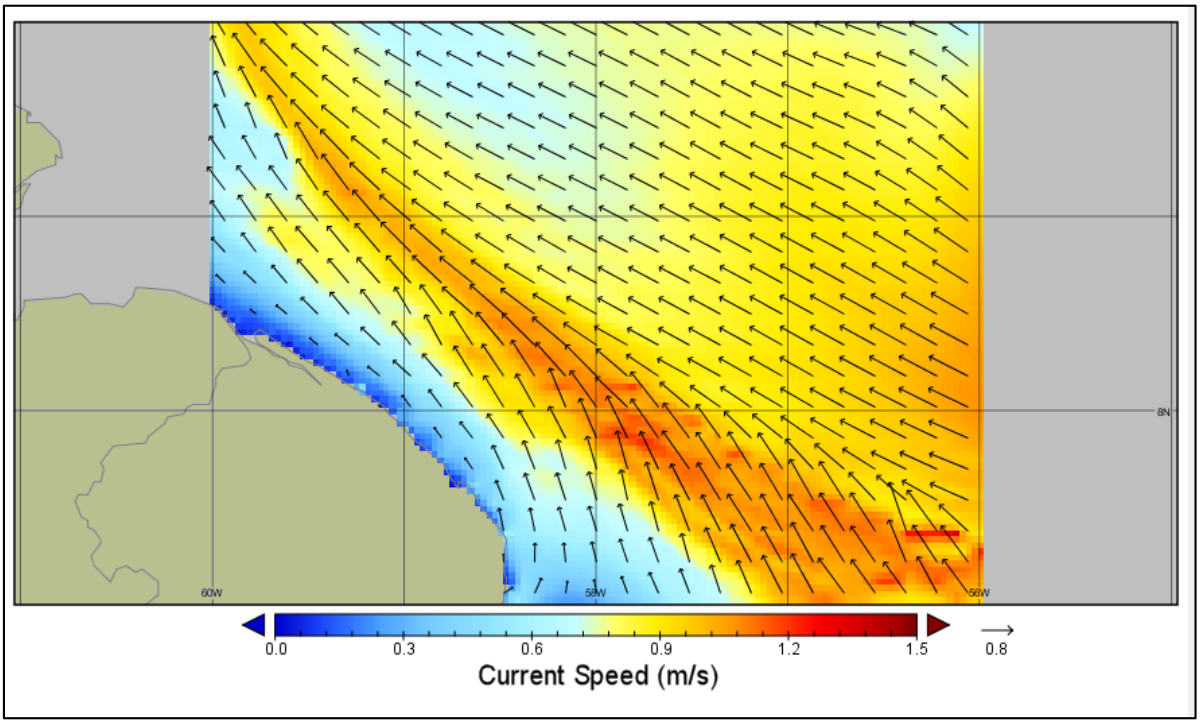


Figure 4-7: Example Current Vector Diagram, 1 August 2013 (Surface)

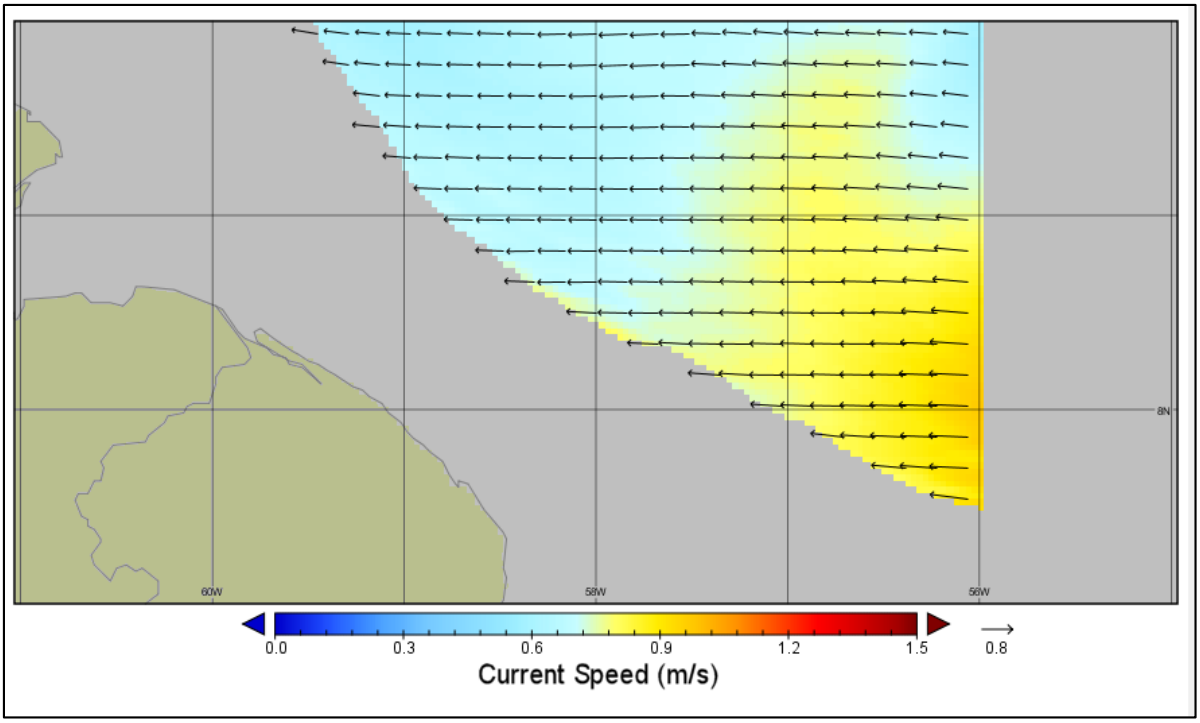


Figure 4-8: Example Current Vector Diagram, 1 August 2013 (1,000-meter Depth)

4.1.3.3 Drill Cuttings and Mud Volumes and Properties

Estimated quantities of drill cuttings and fluids to be discharged during drilling are provided for locations PY1-P and PY3-I in Table 4-8 and Table 4-9, respectively. The estimated times to drill each section were provided by EEPGL. For the top-hole sections (Sections 1 and 2), only WBM is expected to be used and cuttings will be discharged at the seafloor. For Sections 3 through 5, the cuttings with a small percentage of adhered non-aqueous muds will be discharged at a depth of 11 meters (36.1 feet) below sea level. No non-aqueous drilling muds will be directly discharged (i.e., before treatment). Solids control and cuttings drying equipment will be installed on the drill ships to process and reduce the percentage of NADF retained on cuttings, such that NADF retained on discharged cuttings will not exceed 6.9 percent (by mass) on average. Accordingly, the modeling assumed an NADF content of 6.9 percent by mass for all discharged cuttings.

Table 4-8: Discharge Description for Location PY1-P

Hole Diameter (inches)	Volume of Cuttings Discharged (bbl)	Volume of Drilling Fluid to be Discharged (bbl)	Type of Drilling Fluid	Modeled Cuttings Discharge Duration (days)
36	496	668	WBM	0.5
26	4,077	9,729	WBM	1.6
17 ½	894	143	NADF	3.5
12 ¼	1,256	201	NADF	8.1
9 ½	309	49	NADF	6.8
TOTAL	**7,032**	**10,790**	**-**	**20.5**

bbl = barrel

Table 4-9: Discharge Description for Location PY3-I

Hole Diameter (inches)	Volume of Cuttings Discharged (bbl)	Volume of Drilling Fluid to be Discharged (bbl)	Type of Drilling Fluid	Modeled Cuttings Discharge Duration (days)
36	533	668	WBM	0.5
26	3,713	9,729	WBM	1.6
17 ½	879	141	NADF	3.5
12 ¼	1,310	210	NADF	8.1
9 ½	306	49	NADF	6.8
TOTAL	**6,740**	**10,796**	**-**	**20.5**

bbl = barrel

4.1.3.4 Cuttings and Mud Properties

The grain size properties of the drill cuttings and muds were provided by EEPGL. The distribution of particle sizes and associated fall velocities used in this study are listed in Table 4-10 for cuttings discharged from Section 1 and 2, in Table 4-11 for WBM, and in Table 4-12 for treated cuttings with NADF discharged from Sections 3 through 5. Cuttings density was assumed to be 2.6 kilograms per liter. The WBM density was assumed to be 11 pounds per gallon (ppg). The density of NADF was reported by EEPGL to range between 9 and 13.2 ppg; 9 ppg was used as a conservative assumption, since it would result in slower settling and a larger footprint of deposition.

Table 4-10: Properties of Cuttings for Well Sections 1 and 2 (Water-Based Fluid)

Estimated Diameter (cm)	Mass Fraction (wt %)	Fall Velocity (cm/s)
0.00005	2	0.00003
0.0001	3	0.0001
0.0002	5	0.0003
0.0006	10	0.0046
0.0007	10	0.0695
0.0059	20	0.4460
0.0363	20	1.8300
0.1350	10	6.9300
0.3730	10	14.3000
0.6680	5	19.8000
0.9510	3	23.4000
1.2200	2	26.1000

cm = centimeter; cm/s = centimeters per second

Table 4-11: WBM Grain-Size Distribution

Estimated Diameter (cm)	Mass Fraction (wt %)	Fall Velocity (cm/s)
0.0005	7	0.0027
0.0007	8	0.0061
0.0011	5	0.0148

Estimated Diameter (cm)	Mass Fraction (wt %)	Fall Velocity (cm/s)
0.0015	10	0.0300
0.0018	13.3	0.0434
0.0020	13.3	0.0511
0.0007	19.2	0.0640
0.0008	19.2	0.0823
0.0058	4	0.4270
0.0250	1	1.1200

cm = centimeter; cm/s = centimeters per second

Table 4-12: Properties of Treated Cuttings for Well Sections 3 through 5 (with Adhered NADF)

Estimated Diameter (cm)	Mass Fraction (wt %)	Fall Velocity (cm/s)
0.001	43	0.02
0.01	1.01	0.20
0.04	4.99	2.00
0.16	5.55	8.00
0.36	7.99	14.00
0.62	10.99	19.00
0.83	13.01	21.99
1.00	6.81	23.99
1.32	3.69	26.99
1.89	2.47	30.97
Note a	0.49	124.97

cm = centimeter; cm/s = centimeters per second

[a] Fall velocity outside the range of available correlations; size computed internally by GIFT model. Fall velocities were based on experiments. These velocities were directly used in the GIFT model to estimate settlement. Estimated diameter sizes are only for reference and do not affect GIFT computations.

4.2 Simulations

Modeling was performed for 12 simulations: for each of three scenario at each of the two modeled locations (PY1-P and PY3-I), at each of the minimum and maximum ambient current scenarios determined by the monthly averaged, depth-averaged currents analysis (see Table 4-13).

Table 4-13: Drill Cuttings and Fluid Deposition Simulations

Drill Center	Scenario	Parameter(s) Evaluated	Ambient Current Scenario
PY1-P	1	Depositional Thickness Bottom TSS	Minimum Monthly Average
			Maximum Monthly Average
	2	Depositional Thickness Bottom TSS Surface TSS	Minimum Monthly Average
			Maximum Monthly Average
	3	Hydrocarbon Mass Deposition	Minimum Monthly Average
			Maximum Monthly Average
PY3-I	1	Depositional Thickness Bottom TSS	Minimum Monthly Average
			Maximum Monthly Average
	2	Depositional Thickness Bottom TSS Surface TSS	Minimum Monthly Average
			Maximum Monthly Average
	3	Hydrocarbon Mass Deposition	Minimum Monthly Average
			Maximum Monthly Average

Because Scenario 1 results in only bottom discharges from the sequential jetting/drilling of the top-hole sections of four wells, the simulations include predicted cuttings depositional thickness on the seabed on a 2-D basis and TSS concentrations in the water column on a 3-D basis. Scenario 2 drilling results in both bottom and surface discharges. Consequently, depositional thickness as well as surface and bottom TSS concentrations were evaluated. Scenario 3 evaluated the sequential drilling of bottom holes (Sections 3 through 5) for four wells, which represents the worst case for hydrocarbon deposition (from the perspective of temporal overlap) resulting from surface discharges of treated drill cuttings. For this scenario, the mass of deposited hydrocarbons on a 2-D basis was evaluated.

4.2.1 Cuttings Depositional Thickness

Burial by drilling muds and cuttings may cause physical impacts on benthic communities on the seabed. The potential severity of burial impacts depends on the sensitivity of the benthic organism, the thickness of deposition, the amount of oxygen-depleting material, and the duration of the burial. Thickness thresholds vary by species and sediment impermeability. A suggested threshold deposition rate of 5 centimeters (2 inches) per month is recommended based on Ellis and Heim (1985) and MarLIN (2011). Smaller threshold values as low as 1 millimeter (0.04 inches) have been reported (e.g., Smit et al. 2006); however, they are associated with instantaneous burials on benthic species, not gradual smothering effects. Accordingly, for the purpose of modeling, results are presented in terms of the lateral extent of deposition exceeding 5 centimeters (2 inches) in thickness. Simulations were designed with consideration to the temporal aspect of the threshold.

4.2.2 Total Suspended Solids

Increases in TSS concentrations in the water column will occur due to discharges of drill cuttings and mud. The highest concentration increases will occur at the point of discharge (i.e., at the seafloor for top sections of the well and near the sea surface for subsequent sections of the well), and will decrease over time and distance as the TSS plume dissipates and settles. Larger particles will settle out more quickly than finer particles, such that smaller particles may stay suspended longer and travel laterally further than larger particles. As such, elevated TSS concentrations may form in regions where tiny suspended particles linger in a cloud and mix with particles from subsequent discharges.

Impacts on marine organisms related to elevated TSS may occur if light penetration in photic zones is impeded significantly for long periods of time (reducing the ability of plants and phytoplankton to photosynthesize). Increases in TSS may also decrease water clarity and clog fish gills. A commonly used guidance value for TSS from effluent discharges in the marine environment recommended by MARPOL 73/78[4] is 35 milligrams per liter (mg/L) (IMO 2006). Accordingly, for the purpose of modeling, results are presented in terms of the lateral area with TSS concentrations exceeding 35 mg/L.

4.3 Mass of Oil Deposition

Cuttings containing NADF will be treated through the FPSO onboard systems (shakers and dryers). The non-aqueous base fluid portion of the NADF that remains will be reduced to no more than 6.9 percent base fluid retention on cuttings (average, by mass). These hydrocarbons, once settled to the seafloor, can degrade over time, and may enter the pore water within the sediments or become dissolved in the water column, depending on each specific hydrocarbon's tendency to remain partitioned to the solids.

4.4 Results

The results of the modeling are illustrated in the following sections as contour plots. The plots presented indicate the location of the drill cuttings release point. Results are presented for each of the following parameters for the appropriate scenarios:

- Cuttings deposition thickness at the end of the simulation;
- Maximum TSS concentration in the water column at any time in the simulation (at the surface and at the bottom, representing the surface and seabed discharges, respectively); and
- Mass of hydrocarbons per unit area deposited on the seafloor.

As discussed above, the following threshold criteria were applied for the purpose of reporting results:

- Criterion 1—Cuttings deposition rate less than 5 centimeters (2 inches) per month
- Criterion 2—Recommended TSS concentrations no greater than 35 mg/L

There are no available criteria applicable for the mass of hydrocarbons deposited on the seafloor.

4.4.1 Cuttings Depositional Thickness

4.4.1.1 Scenario 1

When the first two (top-hole) sections of a well are jetted and drilled (prior to the installation of a riser), cuttings and WBMs are discharged directly to the seabed, resulting in a mound of material deposited closely around the well. The material discharged at the seabed is mostly deposited in the area directly adjacent to each wellhead and results in the thick layers of deposited material.

Figure 4-9 through Figure 4-12 present the depositional thickness for Scenario 1 for drill centers PY1-P and PY3-I. Higher thicknesses are concentrated around the drill center at the well clusters, but some discrete patches of depositional thicknesses greater than 1 millimeter (0.04 inch) are also present at some distance from these wells. For PY3-I, the small regions exceeding 1 millimeter (0.04 inch) thickness were all within a 0.2-kilometer (0.1-mile) radius from the drill center. For PY1-P, the small regions exceeding 1-millimeter (0.04-inch) thickness were all within a 0.5-kilometer (0.3-mile) radius from the drill center.

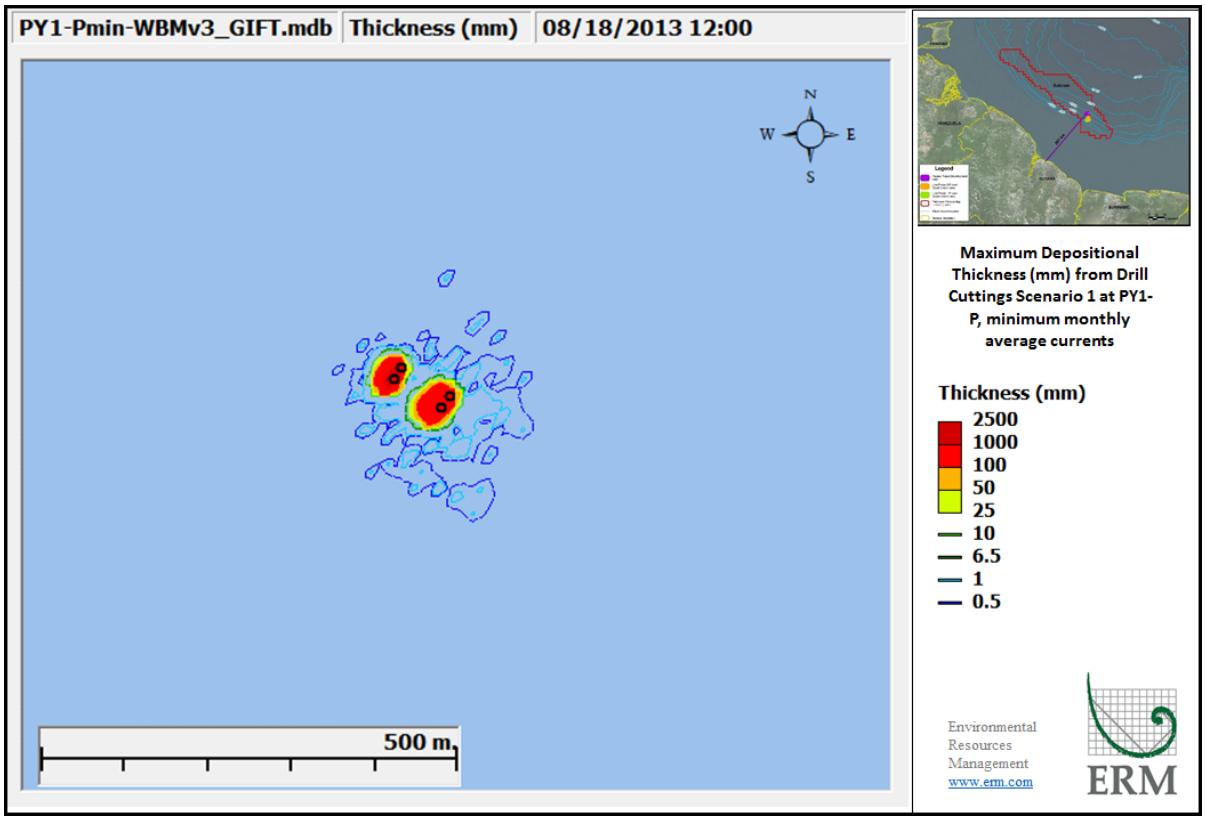
[4] International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978

In all simulations, a small region surrounding the well clusters at the drill centers exceeds the depositional thickness threshold value of 5 centimeters (2 inches). There are two deposition mounds with an approximate lateral extent of 60 meters (164 feet) where the thicknesses exceed this threshold. The maximum depositional thicknesses and areas exceeding the threshold value of 5 centimeters (2 inches) for Scenario 1 are presented in Table 4-14. For drill center PY1-P, the maximum depositional thickness was approximately 239 centimeters (94.1 inches) under the maximum currents simulation. For drill center PY3-I, the maximum depositional thickness was approximately 256 centimeters (100.8 inches) under the maximum currents simulation. It is noted that these are conservatively high estimates, as slope failures (i.e., collapse of the depositional mound) and resuspension of the particles by ocean currents are likely to reduce the height of the deposited materials over time.

Table 4-14: Summary of Results—Cuttings Depositional Thickness: Scenario 1

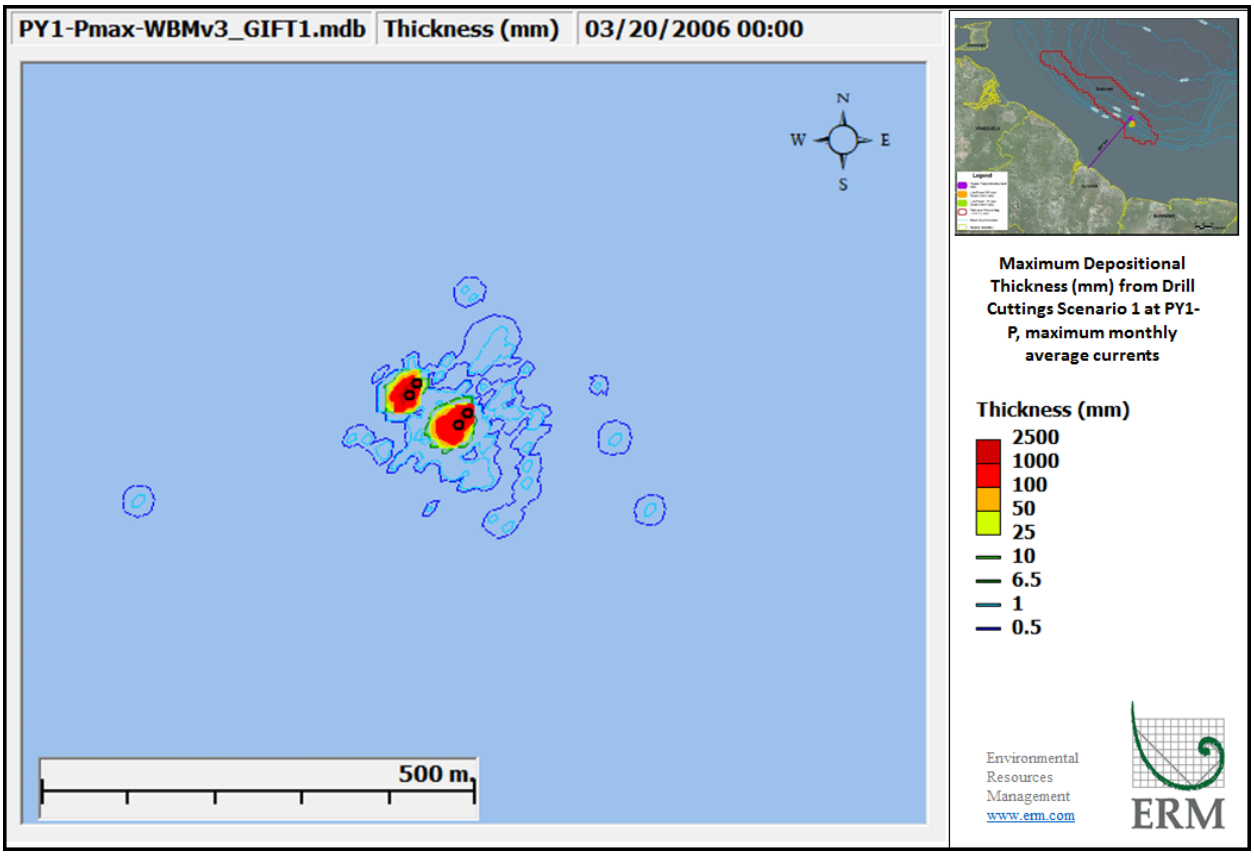
Simulation	Maximum Depositional Thickness (cm)	Area (m^2) with Thickness > 5 cm threshold
PY1-P Scenario 1 Minimum Currents	185.7	3,571
PY1-P Scenario 1 Maximum Currents	238.8	2,874
PY3-I Scenario 1 Minimum Currents	214.2	2,932
PY3-I Scenario 1 Maximum Currents	255.5	2,739

cm = centimeter; m^2 = square meters



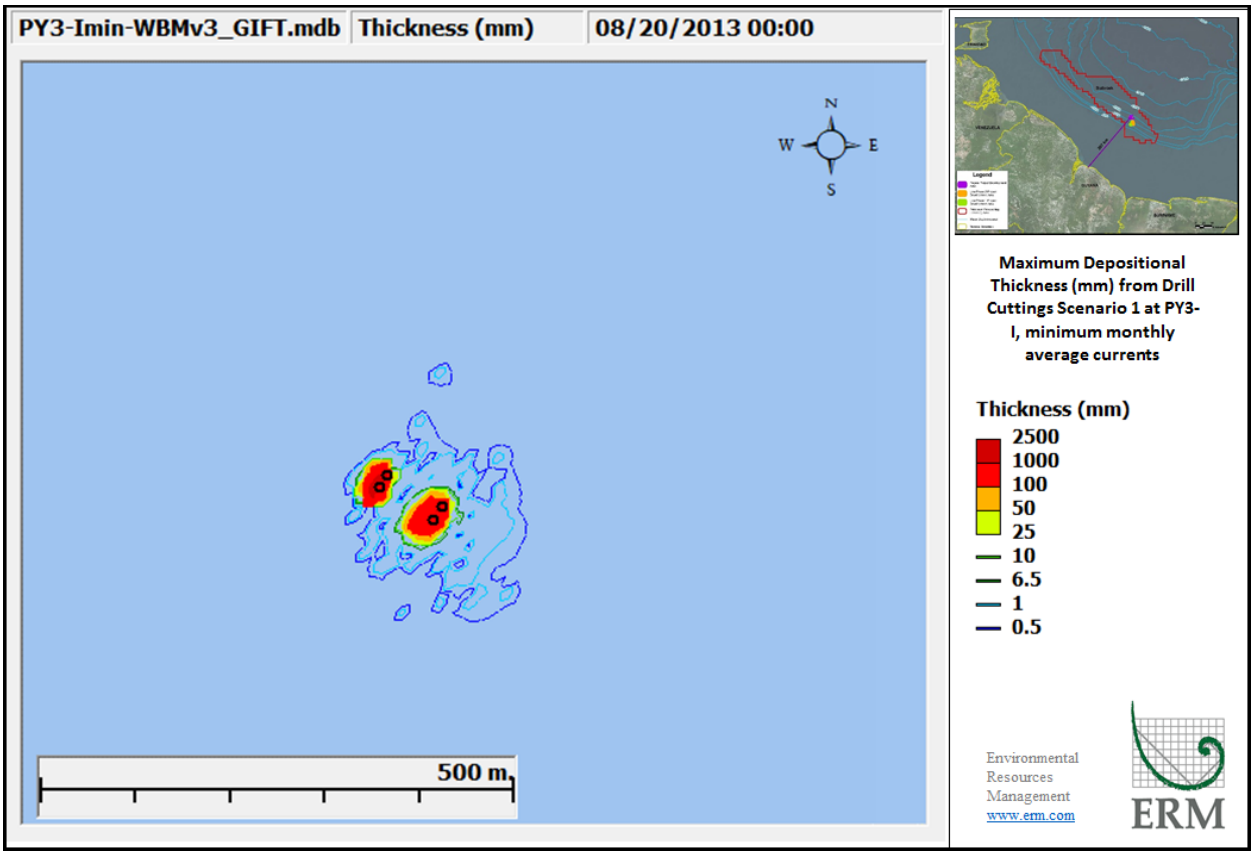
mm = millimeter

Figure 4-9: Maximum Depositional Thickness—Scenario 1 PY1-P: Minimum Currents



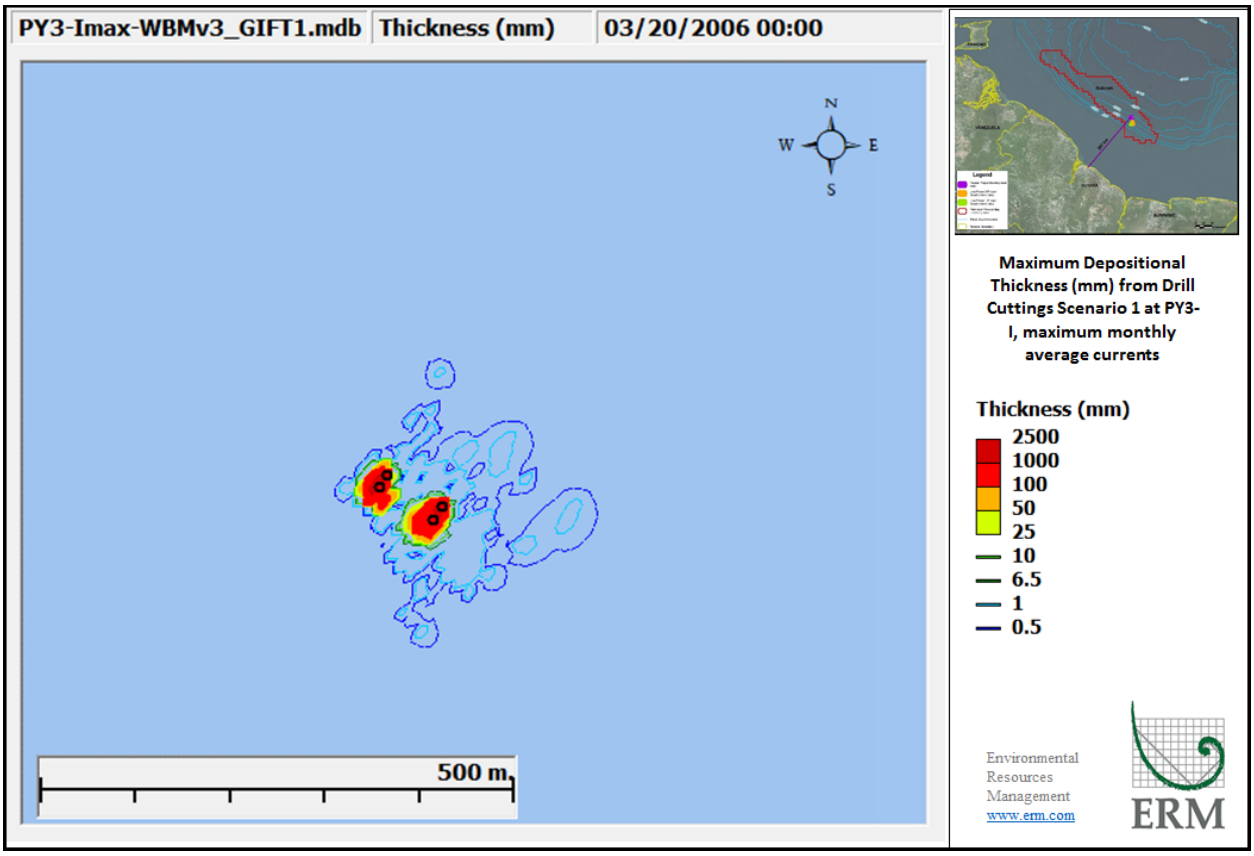
mm = millimeter

Figure 4-10: Maximum Depositional Thickness—Scenario 1 PY1-P: Maximum Currents



mm = millimeter

Figure 4-11: Maximum Depositional Thickness—Scenario 1 PY3-I: Minimum Currents



mm = millimeter

Figure 4-12: Maximum Depositional Thickness—Scenario 1 PY3-I: Maximum Currents

4.4.1.2 Scenario 2

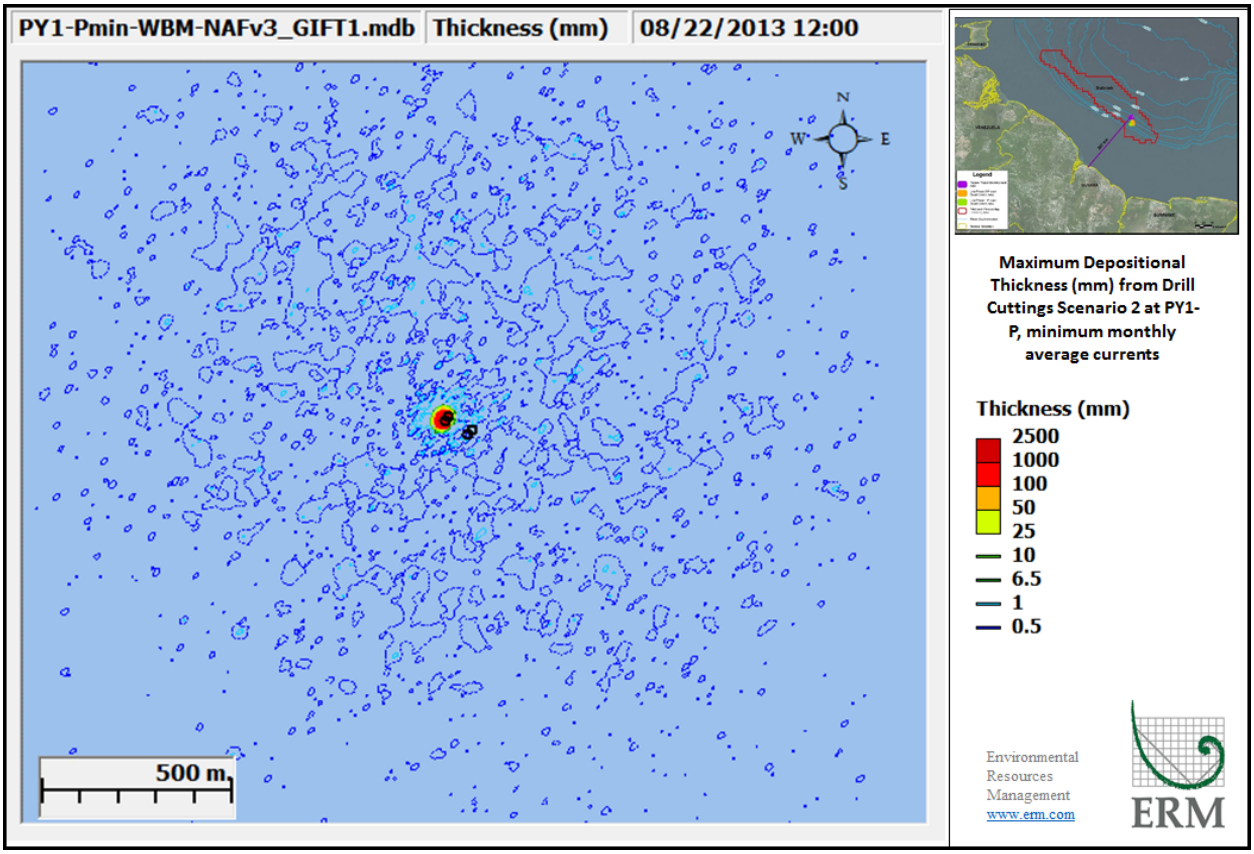
Figure 4-13 through Figure 4-16 present the depositional thickness for Scenario 2 for drill centers PY1-P and PY3-I. For both PY1-P and PY3-I, higher thicknesses are concentrated around the well cluster associated with the drill center, but discrete patches of depositional thicknesses greater than 1 millimeter (0.04 inch) thickness are also present within a 0.2-kilometer (0.1-mile) radius of the drill centers. In all simulations, a small region close to the drill centers exceeded the depositional thickness threshold value of 5 centimeters (2 inches). There is one deposition mound with an approximate lateral extent of 60 meters (164 feet) where the thicknesses exceed this threshold.

The maximum depositional thicknesses and areas exceeding the threshold value of 5 centimeters (2 inches) for Scenario 2 are presented in Table 4-15. For drill center PY1-P, the maximum depositional thickness was approximately 178 centimeters (70 inches) under the maximum current simulation. For drill center PY3-I, the maximum depositional thickness was approximately 179 centimeters (70.5 inches) under the maximum current simulation. It is noted that these are conservatively high estimates, as slope failures (i.e., collapse of the depositional mound) and resuspension of the particles by ocean currents are likely to reduce the height of the deposited materials over time.

Table 4-15: Summary of Results—Cuttings Depositional Thickness: Scenario 2

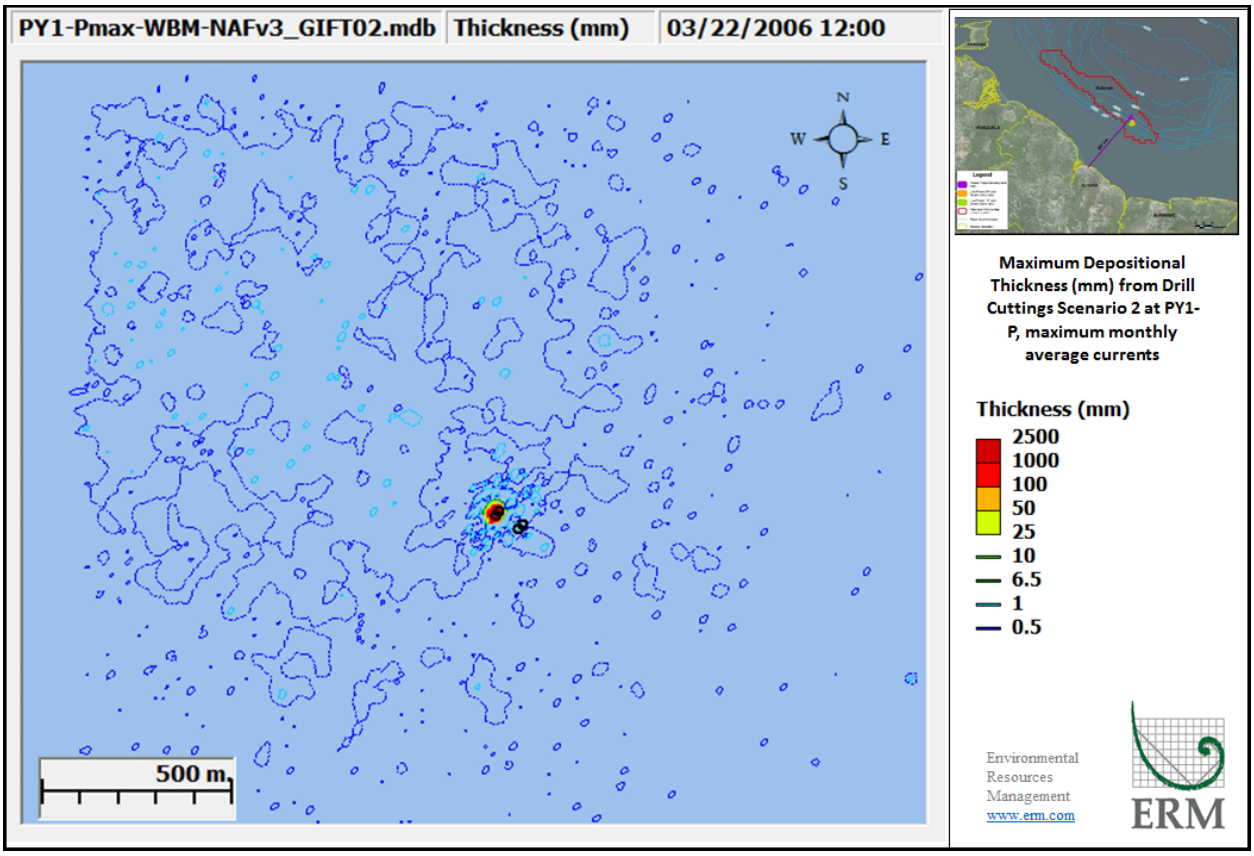
Simulation	Maximum Depositional Thickness (cm)	Area (m^2) with Thickness > 5 cm threshold
PY1-P Scenario 2 Minimum Currents	116.8	1,976
PY1-P Scenario 2 Maximum Currents	178.3	1,636
PY3-I Scenario 2 Minimum Currents	138.2	1,663
PY3-I Scenario 2 Maximum Currents	179.1	1,455

cm = centimeter; m^2 = square meters



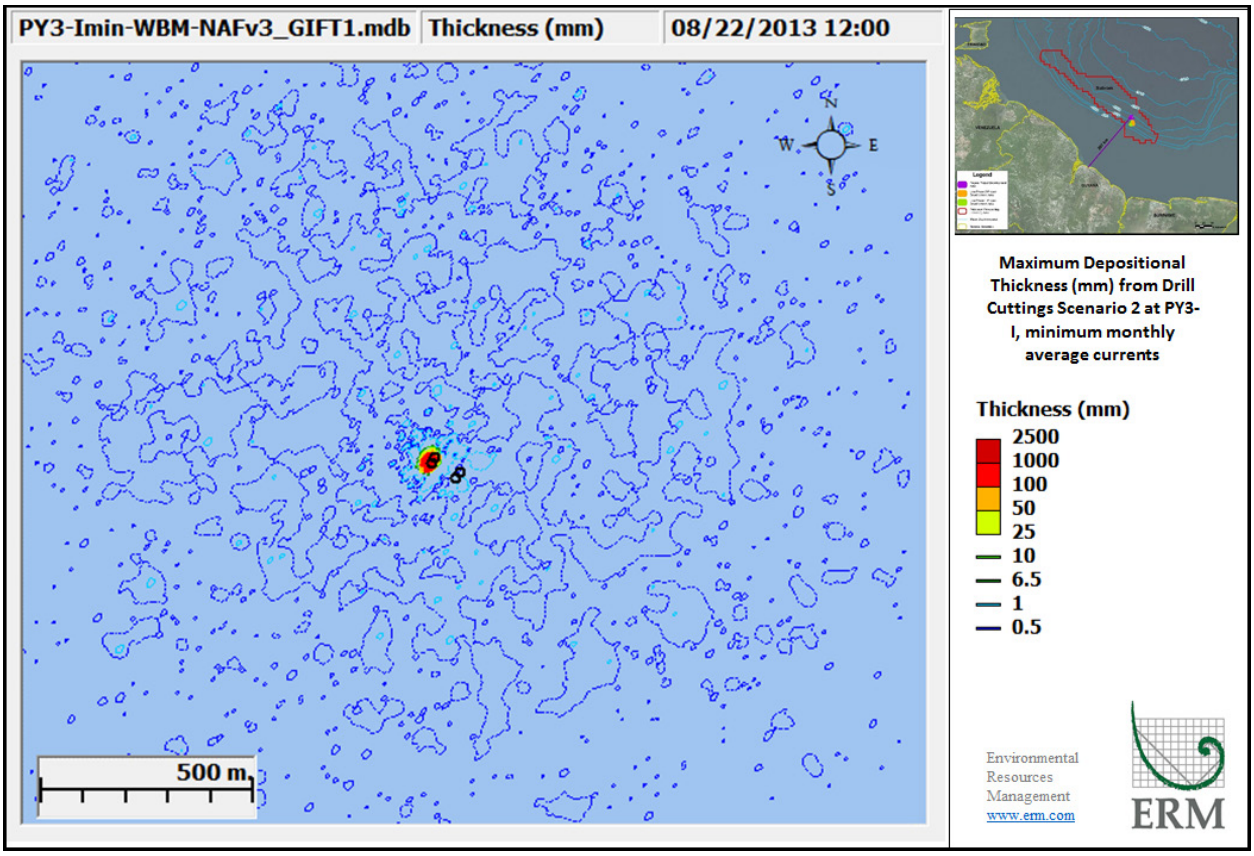
mm = millimeter

Figure 4-13: Maximum Depositional Thickness—Scenario 2 PY1-P: Minimum Currents



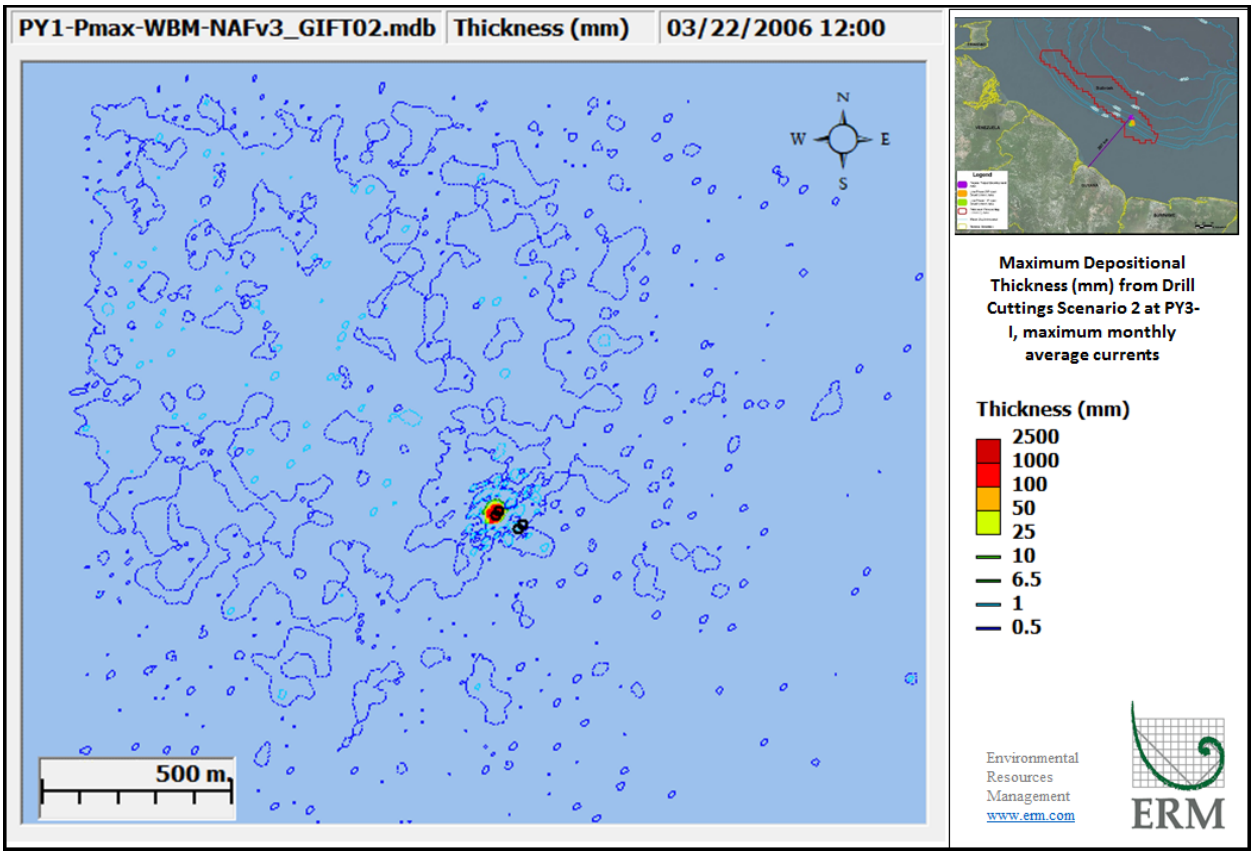
mm = millimeter

Figure 4-14: Maximum Depositional Thickness—Scenario 2 PY1-P: Maximum Currents



mm = millimeter

Figure 4-15: Maximum Depositional Thickness—Scenario 2 PY3-I: Minimum Currents



mm = millimeter

Figure 4-16: Maximum Depositional Thickness—Scenario 2 PY3-I: Maximum Currents

4.4.2 Total Suspended Solids

4.4.2.1 Scenario 1

Figure 4-17 through Figure 4-20 present the predicted TSS concentrations added above ambient levels at the time when the maximum Project-generated TSS concentration occurs at the seabed. A separate "maximum" event was captured for near-seabed concentrations (correlating with direct discharge at the seabed).

Table 4-16 summarizes the maximum predicted surface and bottom TSS concentrations modeled and the lateral areas with TSS concentrations exceeding the 35 mg/L threshold under minimum and maximum current conditions at each drill center.

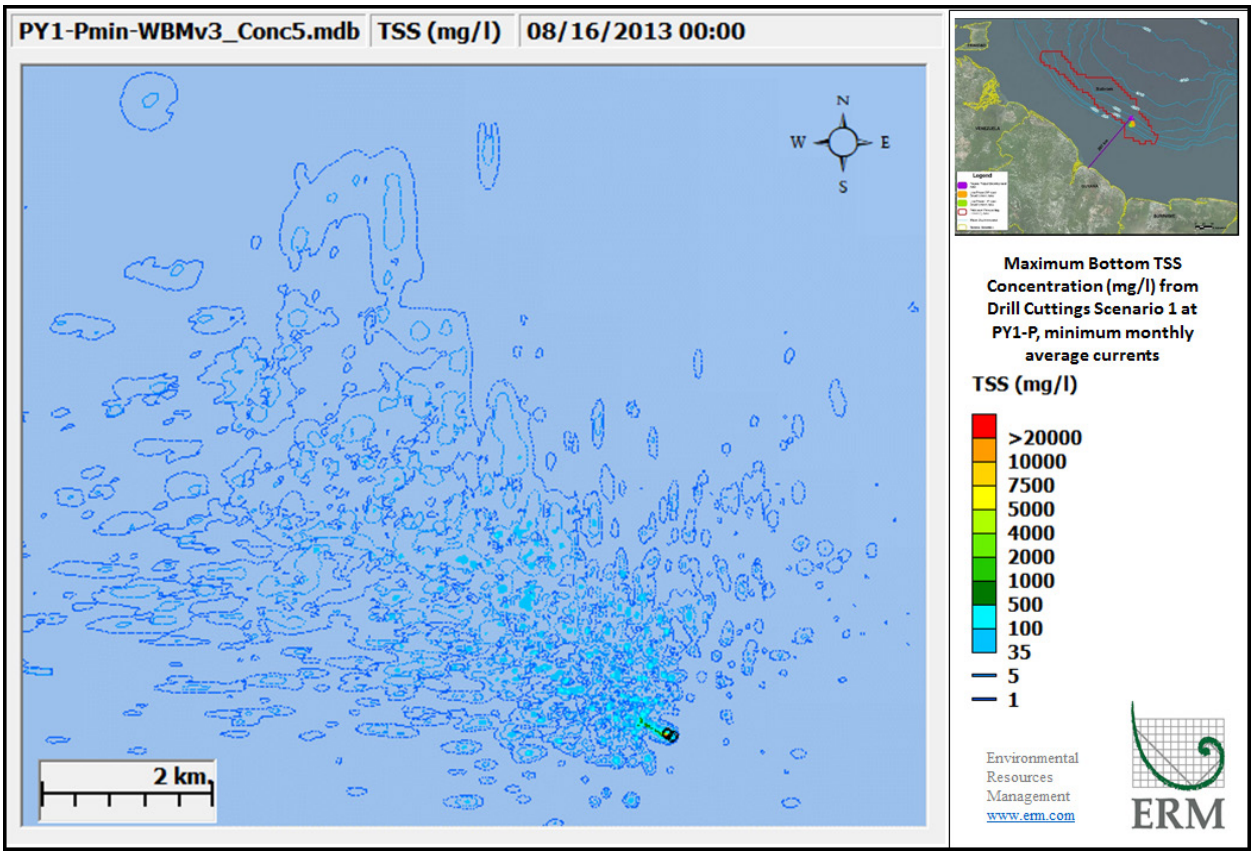
Table 4-16: Total Suspended Solids Summary—Scenario 1

Simulation	Maximum TSS (mg/L)		Area (km²) with TSS >35 mg/L Threshold	
	Surface	Bottom	Surface	Bottom
Scenario 1: PY1-P Minimum Currents	NA	42,796	NA	0.362
Scenario 1: PY1-P Maximum Currents	NA	36,859	NA	0.621
Scenario 1: PY3-I Minimum Currents	NA	51,120	NA	0.170
Scenario 1: PY3-I Maximum Currents	NA	51,164	NA	1.339

NA = not applicable

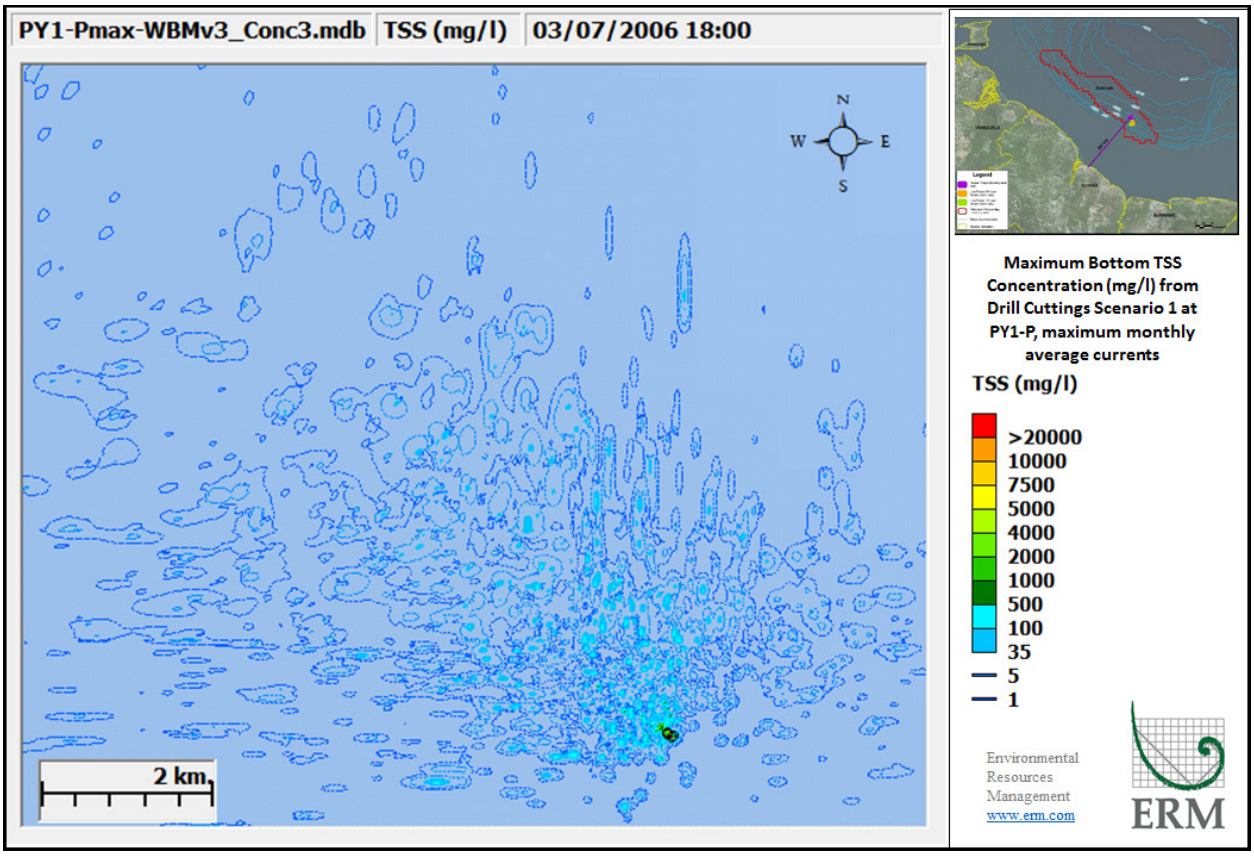
At the PY1-P drill center, the maximum TSS concentration added above ambient as a result of seabed discharges ranged from 36,859 mg/L under maximum monthly averaged currents to 42,796 mg/L under minimum monthly averaged currents. The maximum area with TSS exceeding the 35 mg/L threshold was 0.362 square kilometers (km^2) (0.1 square miles [mi^2]) under minimum currents and 0.621 km^2 (0.2 mi^2) under maximum- currents.

At the PY3-I drill center, the maximum TSS concentration added above ambient as a result of seabed discharges ranged from 51,120 mg/L under minimum currents to 51,164 mg/L under maximum currents. The maximum area with TSS exceeding the 35 mg/L threshold was 0.170 km^2 (0.07 mi^2) under minimum currents and 1.339 km^2 (0.52 mi^2) under maximum currents.



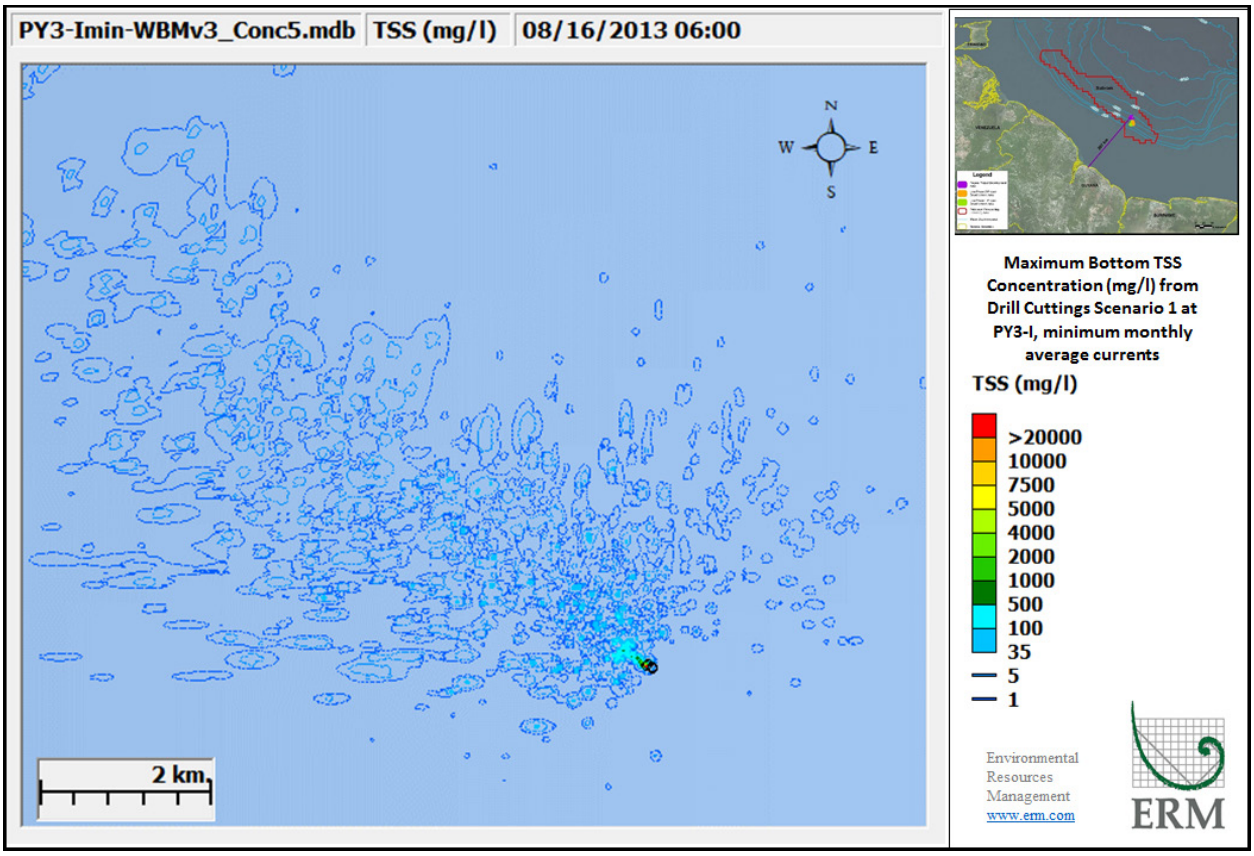
mm = millimeter

Figure 4-17: Maximum TSS Concentrations at the Bottom—Scenario 1 PY1-P: Minimum Currents



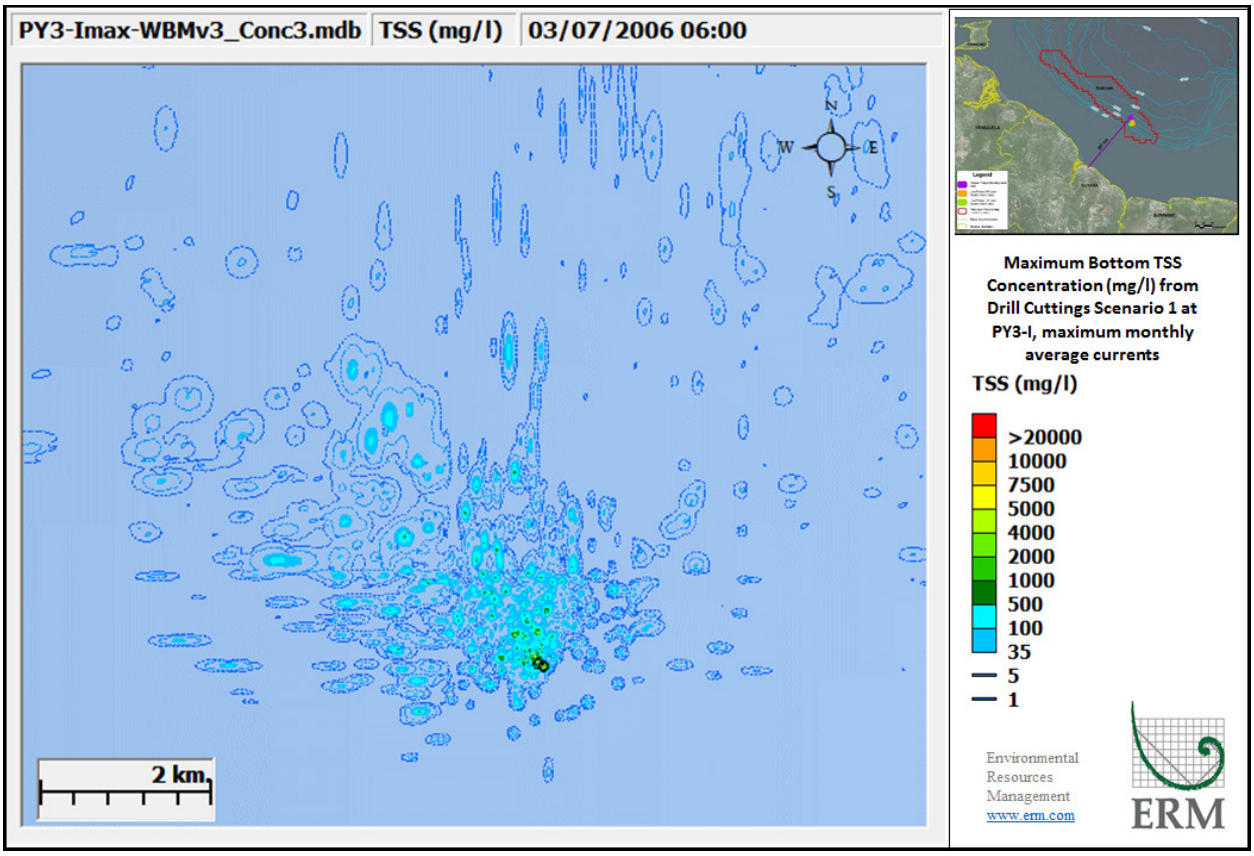
mm = millimeter

Figure 4-18: Maximum TSS Concentrations at the Bottom— Scenario 1 PY1-P: Maximum Currents



mm = millimeter

Figure 4-19: Maximum TSS Concentrations at the Bottom—Scenario 1 PY3-I: Minimum Currents



mm = millimeter

Figure 4-20: Maximum TSS Concentrations at the Bottom—Scenario 1 PY3-I: Maximum Currents

4.4.2.2 Scenario 2

Figure 4-21 through Figure 4-24 present the predicted TSS concentrations added above ambient levels at the time when the maximum Project-generated TSS concentration occurs at the seabed. Figure 4-25 through Figure 4-28 present the predicted TSS concentrations added above ambient levels at the time when the maximum Project-generated TSS concentration occurs from surface discharges. A separate "maximum" event was captured for near-seabed and surface concentrations.

At the PY1-P drill center, the maximum TSS concentration added above ambient as a result of seabed discharges ranged from 18,520 mg/L under minimum currents to 26,149 mg/L under maximum monthly averaged currents. The maximum area with TSS exceeding the 35 mg/L threshold was 0.160 km^2 (0.1 mi^2) under maximum currents and 0.288 km^2 (0.1 mi^2) under minimum currents. For surface discharges, the maximum TSS concentration added above ambient ranged from 23.6 mg/L under minimum currents to 52.8 mg/L under maximum currents. The maximum area of TSS exceeding the 35 mg/L threshold was 0.0065 km^2 (0.003 mi^2) under maximum currents. The threshold was not exceeded under the minimum currents.

At the PY3-I drill center, the maximum TSS concentration added above ambient as a result of seabed discharges ranged from 12,711 mg/L under minimum currents to 45,302 mg/L under maximum currents. The maximum area with TSS exceeding the 35 mg/L threshold was 0.202 km^2 (0.1 mi^2) under maximum currents and 0.259 km^2 (0.1 mi^2) under minimum currents. For surface discharges, the maximum TSS

concentration added above ambient ranged from 23.7 mg/L under minimum currents to 52.4 mg/L under maximum currents. The maximum area of TSS exceeding the 35 mg/L threshold was 0.0065 km^2 (0.003 mi^2) under maximum currents. The threshold was not exceeded under the minimum currents.

Note that on the following figures, the estimated maximum TSS concentrations may be slightly offset from the discharge location as the simulation's floating small particles suspended in the water column may concentrate together at various locations. Larger particles do not remain suspended but quickly settle to the seafloor.

Table 4-17 summarizes the maximum predicted surface and bottom TSS concentrations modeled and the lateral areas with TSS concentrations exceeding the 35 mg/L threshold under minimum and maximum current conditions at each drill center.

Table 4-17: Total Suspended Solids Summary—Scenario 2

Simulation	Maximum TSS (mg/L)		Area (km^2) with TSS >35 mg/L Threshold	
	Surface	Bottom	Surface	Bottom
Scenario 2: PY1-P Minimum Currents	23.65	18,520	0.288	0
Scenario 2: PY1-P Maximum Currents	52.78	26,149	0.160	0.0065
Scenario 2: PY3-I Minimum Currents	23.73	12,711	0.259	0
Scenario 2: PY3-I Maximum Currents	52.42	45,302	0.202	0.0065

NA = not applicable

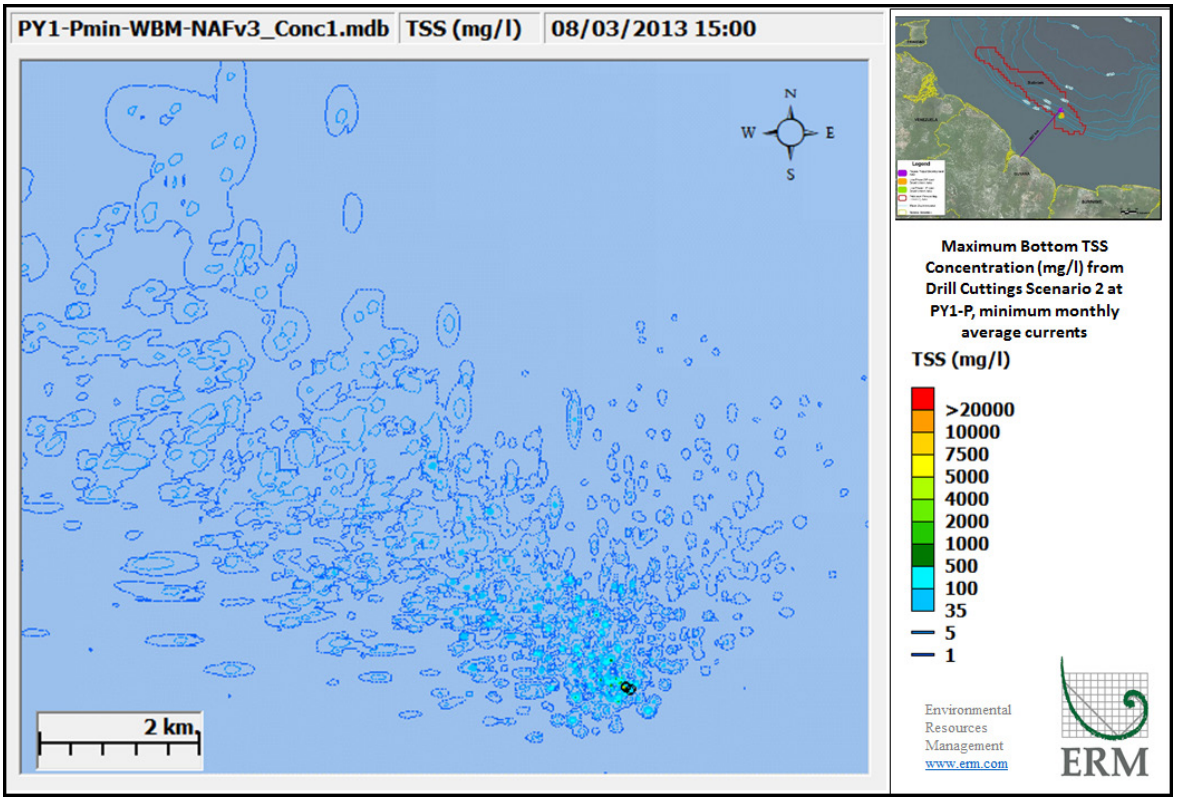


Figure 4-21: Maximum TSS Concentrations at the Bottom—Scenario 2 PY1-P: Minimum Currents

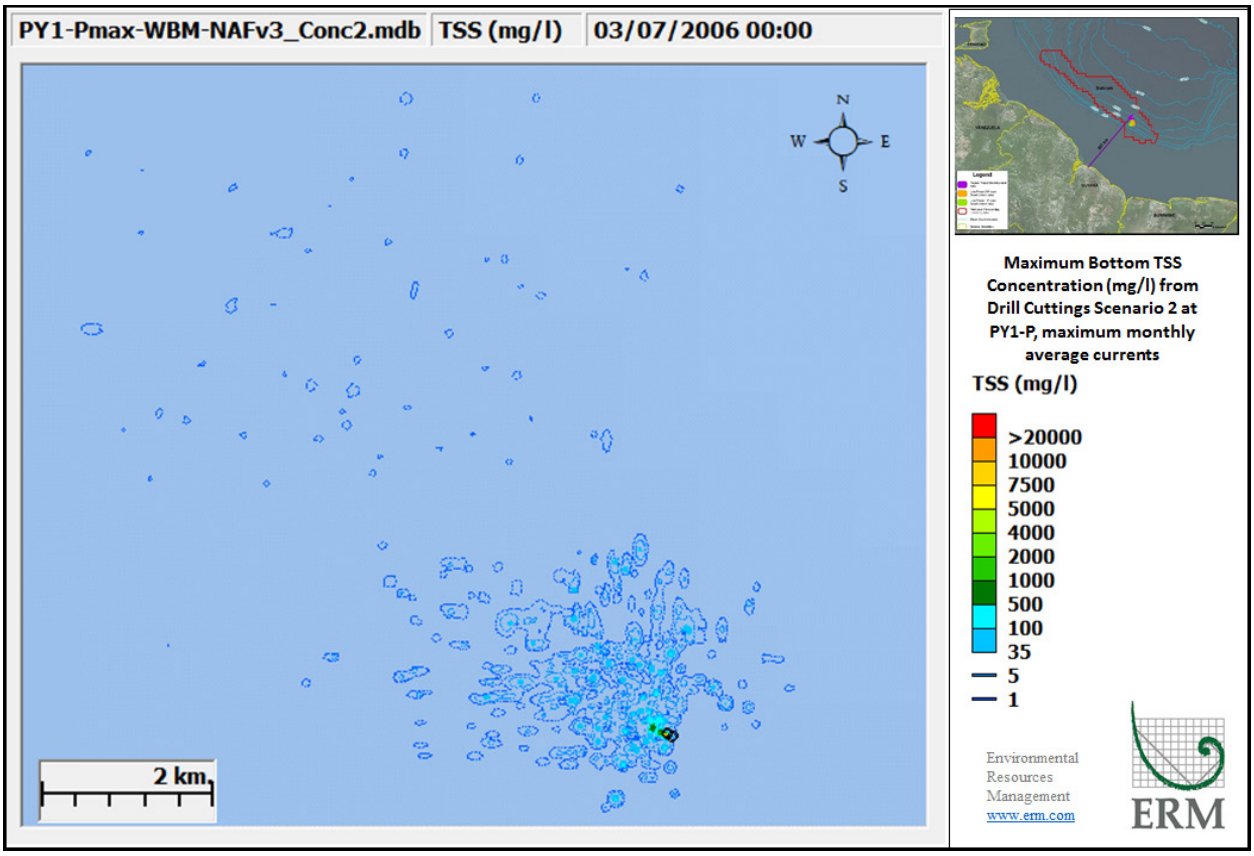


Figure 4-22: Maximum TSS Concentrations at the Bottom—Scenario 2 PY1-P: Maximum Currents

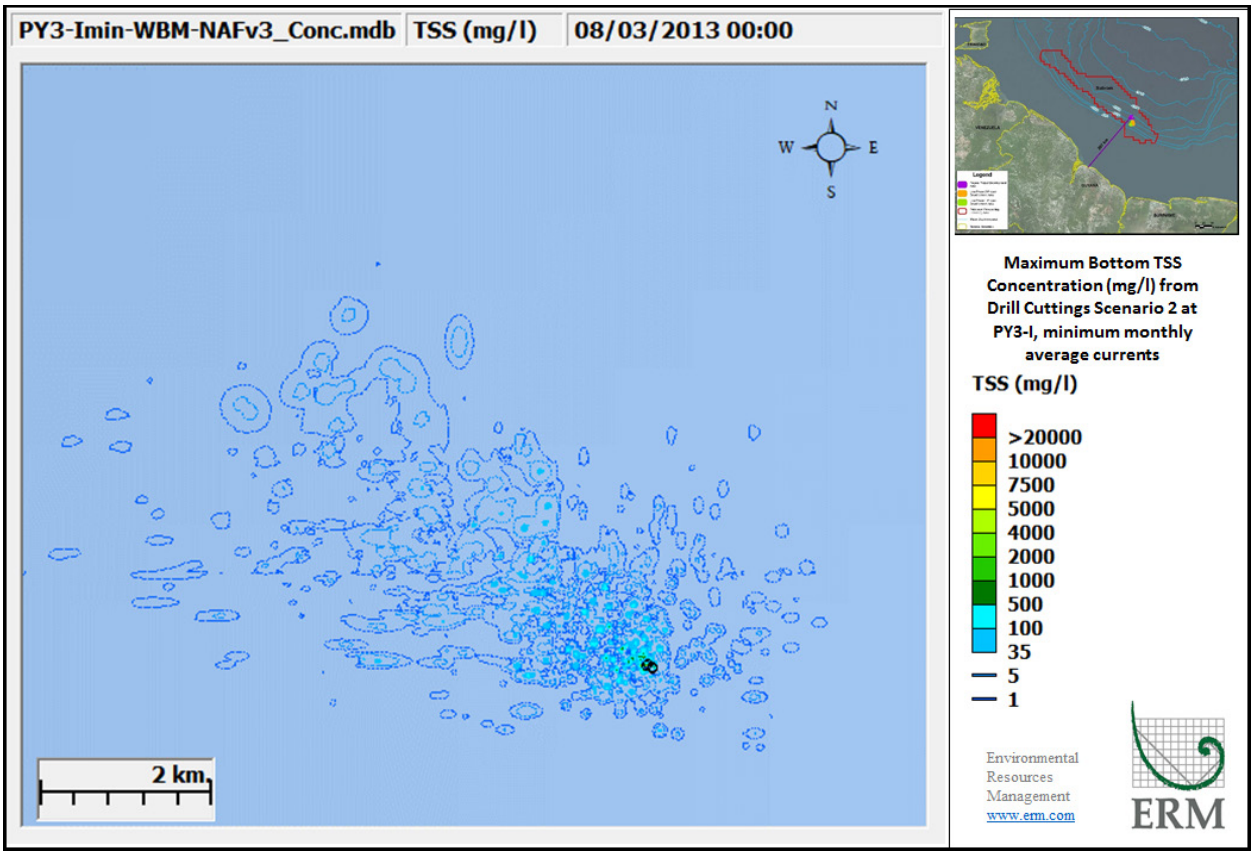


Figure 4-23: Maximum TSS Concentrations at the Bottom—Scenario 2 PY3-I: Minimum Currents

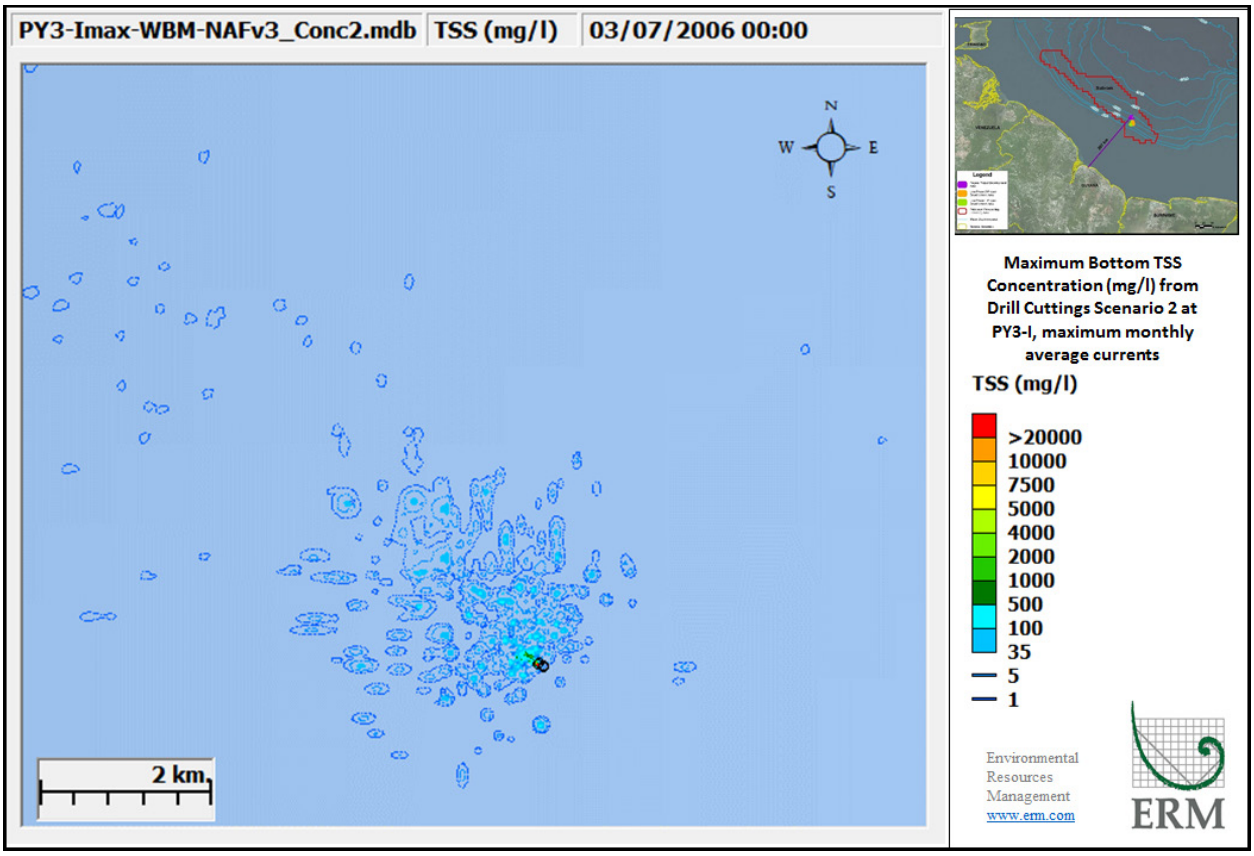


Figure 4-24: Maximum TSS Concentrations at the Bottom—Scenario 2 PY3-I: Maximum Currents

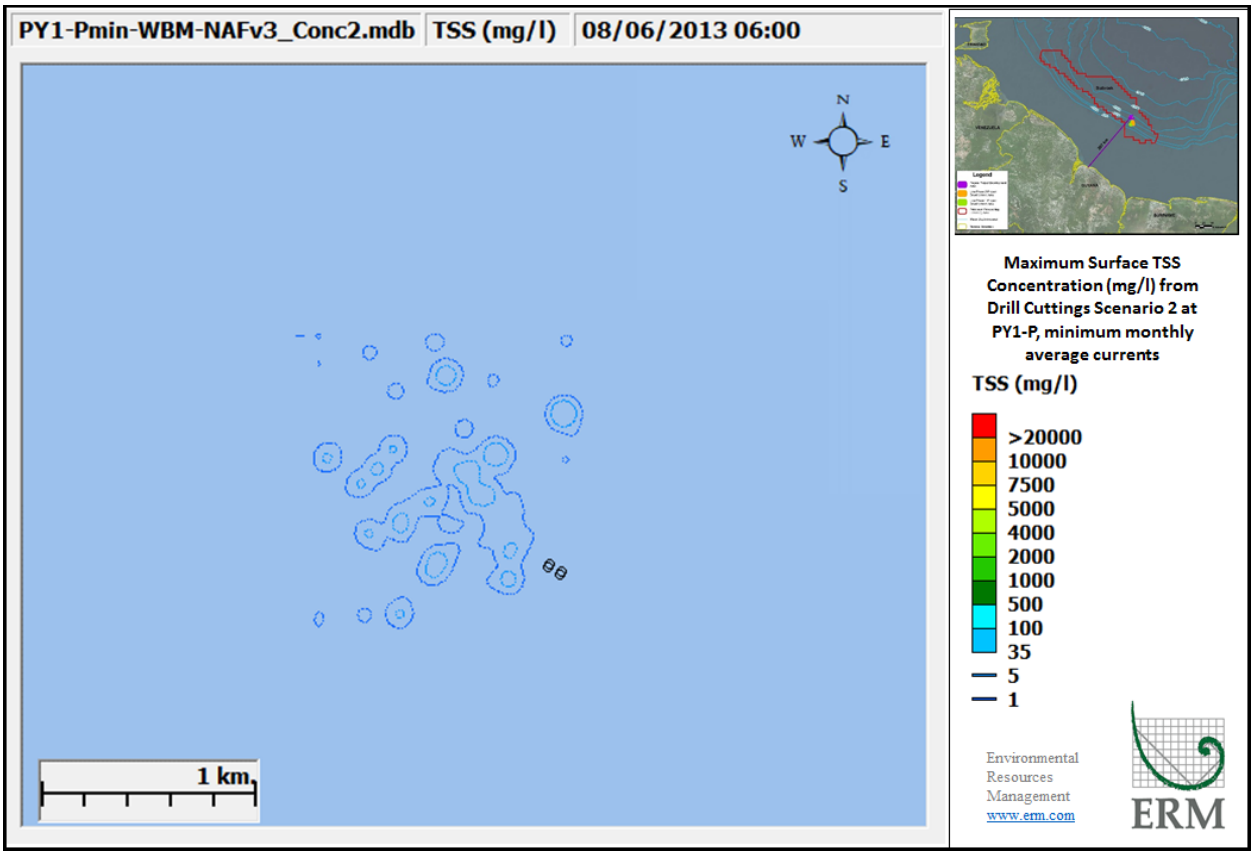


Figure 4-25: Maximum TSS Concentrations at the Surface—Scenario 2 PY1-P: Minimum Currents

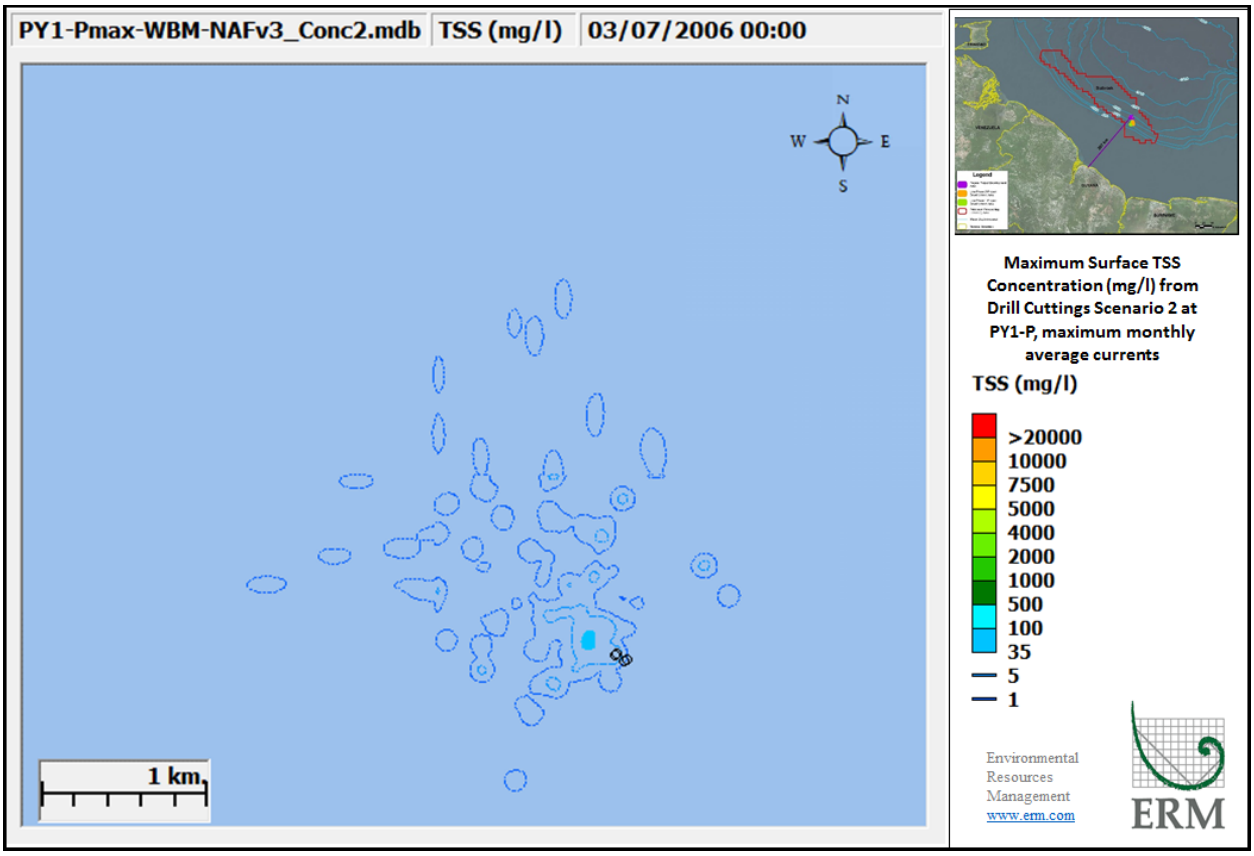


Figure 4-26: Maximum TSS Concentrations at the Surface—Scenario 2 PY1-P: Maximum Currents

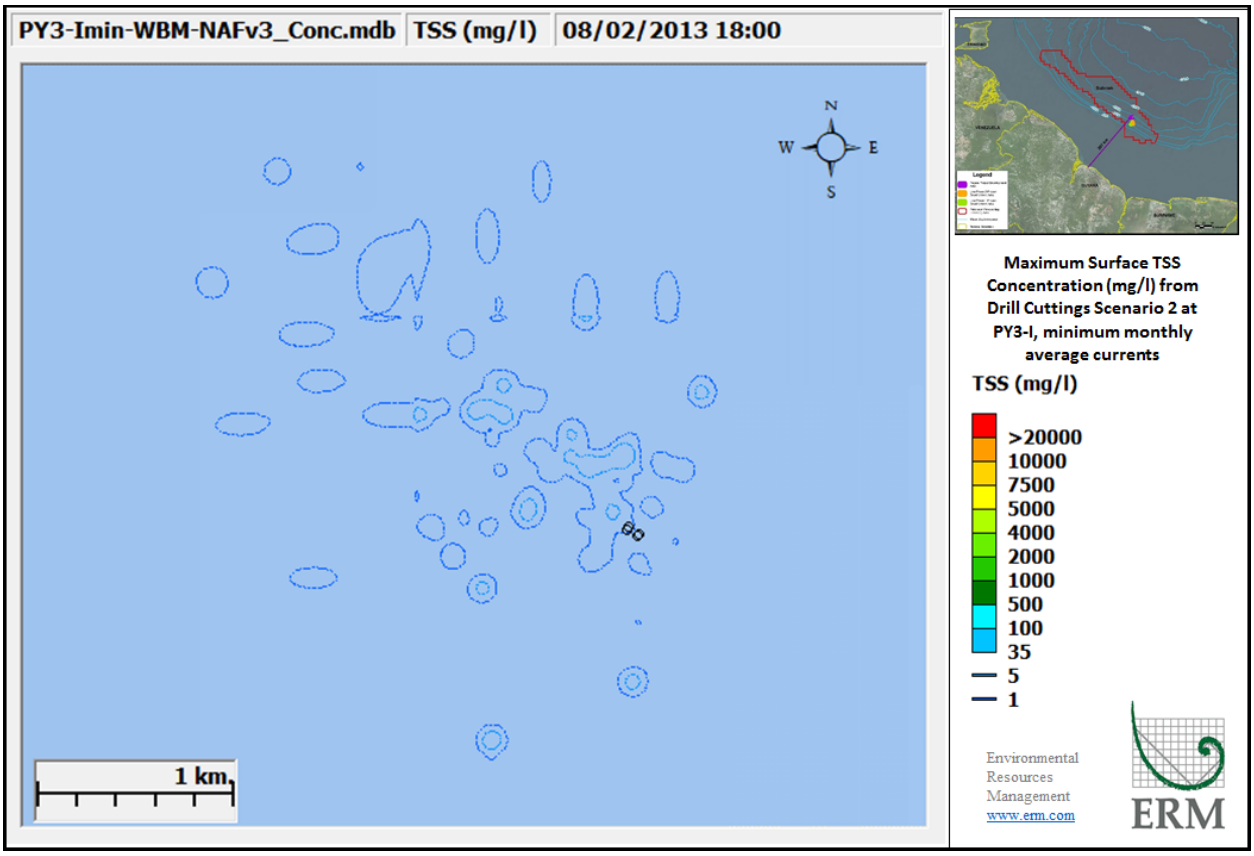


Figure 4-27: Maximum TSS Concentrations at the Surface—Scenario 2 PY3-I: Minimum Currents

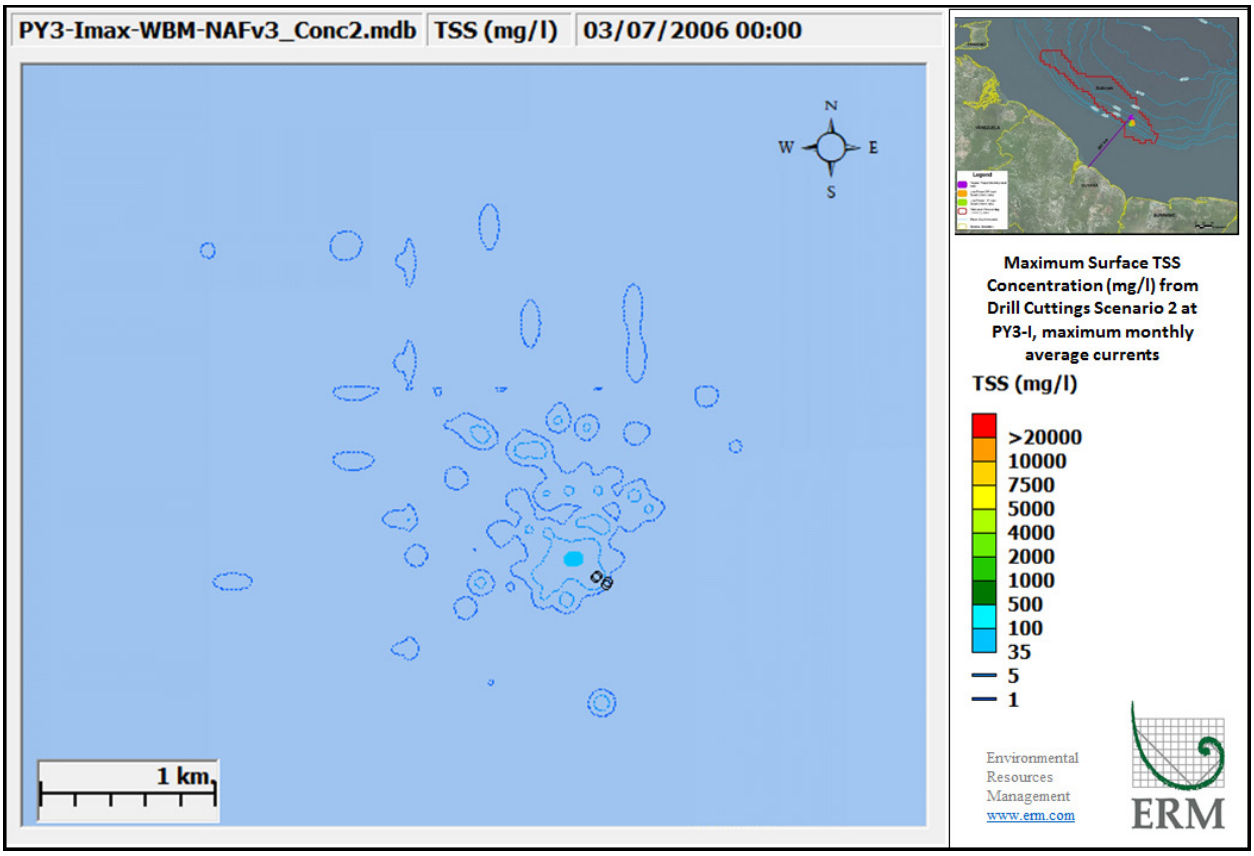


Figure 4-28: Maximum TSS Concentrations at the Surface—Scenario 2 PY3-I: Maximum Currents

4.4.3 Mass of Oil Deposited on the Seabed

Figure 4-29 through Figure 4-32 present the predicted hydrocarbon deposition on the seabed based on the statistical summary identifying the maximum hydrocarbon deposition occurring on the ocean floor during the entire simulation period. At the end of the simulation period (87 days), non-aqueous base fluid adhered to the cuttings settled primarily within an approximately 3-kilometer (1.9-mile) radius of the drill center for all four simulations.

For drill center PY1-P, the maximum hydrocarbon deposition under the minimum monthly averaged current scenario was 952.8 grams per square meter (g/m²) and was 897.7 g/m² under the maximum monthly averaged current scenario.

For drill center PY3-I, the maximum hydrocarbon deposition under the minimum monthly averaged current scenario was 901.9 g/m² and was 689.0 g/m² under the maximum monthly averaged current scenario.

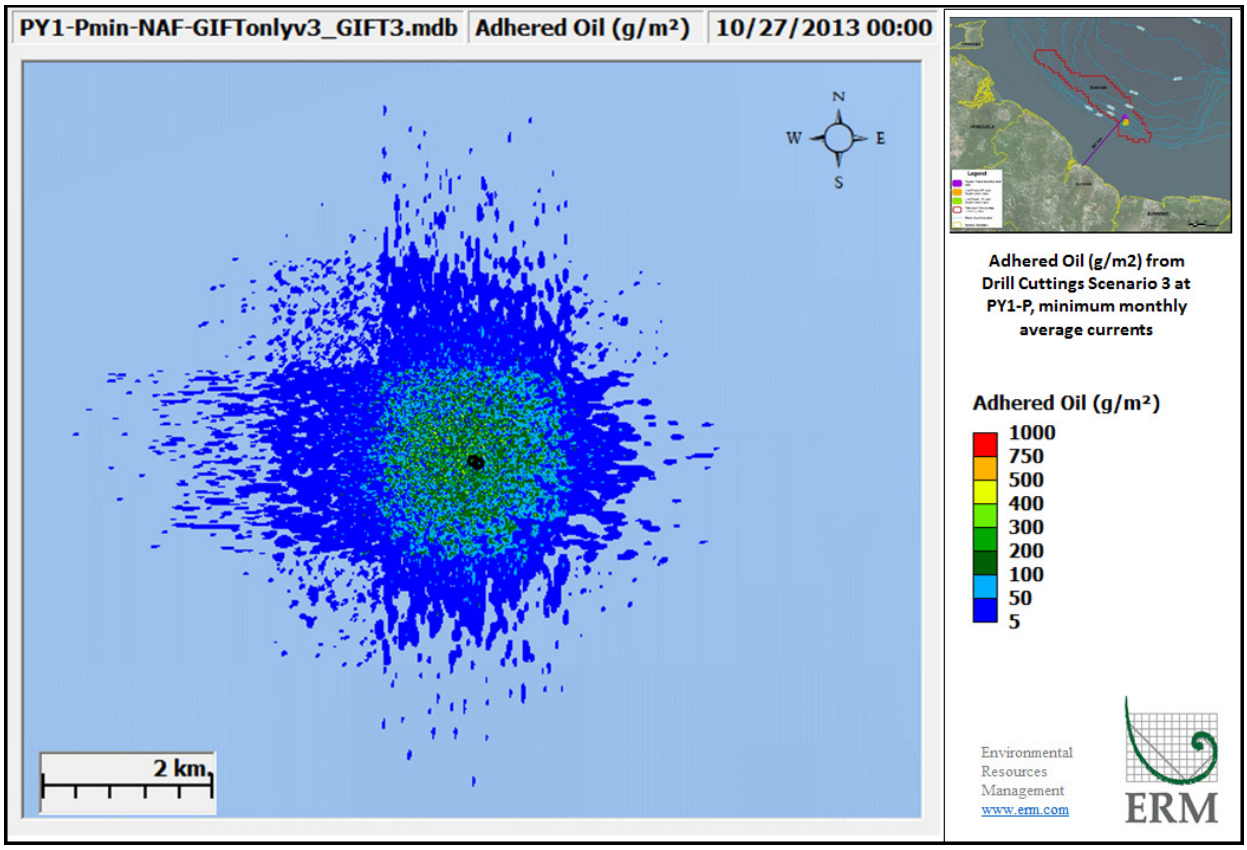


Figure 4-29: Total Deposited Adhered Oil—Scenario 3 PY1-P: Minimum Currents

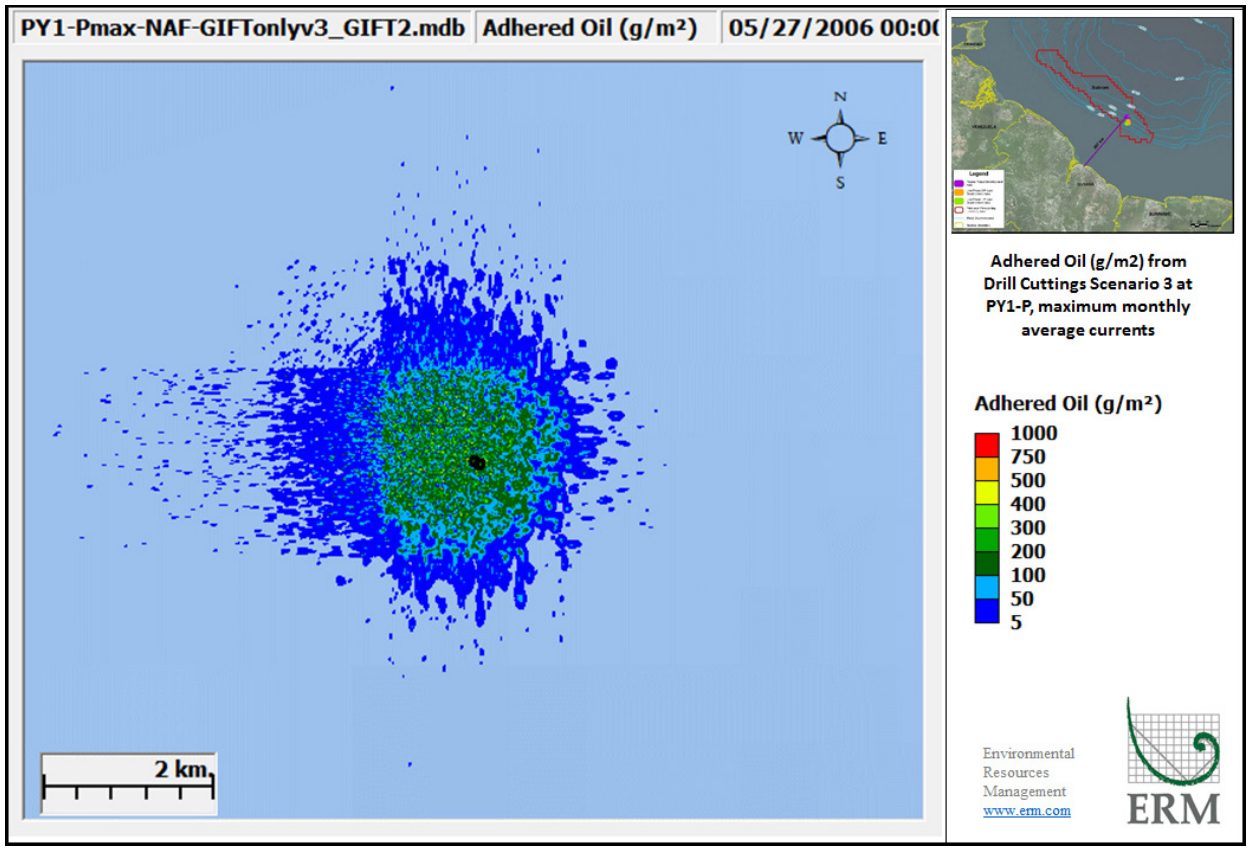


Figure 4-30: Total Deposited Adhered Oil—Scenario 3 PY1-P: Maximum Currents

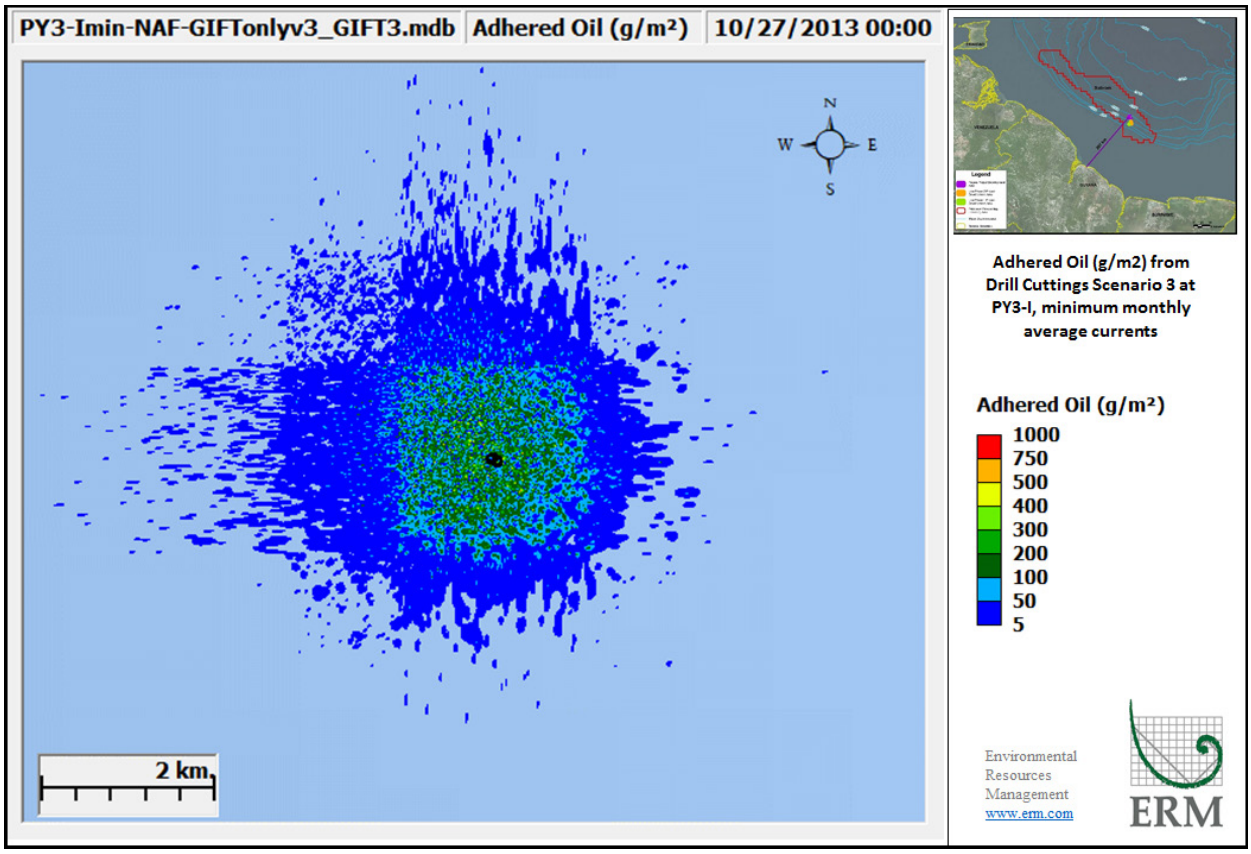


Figure 4-31: Total Deposited Adhered Oil—Scenario 3 PY3-I: Minimum Currents

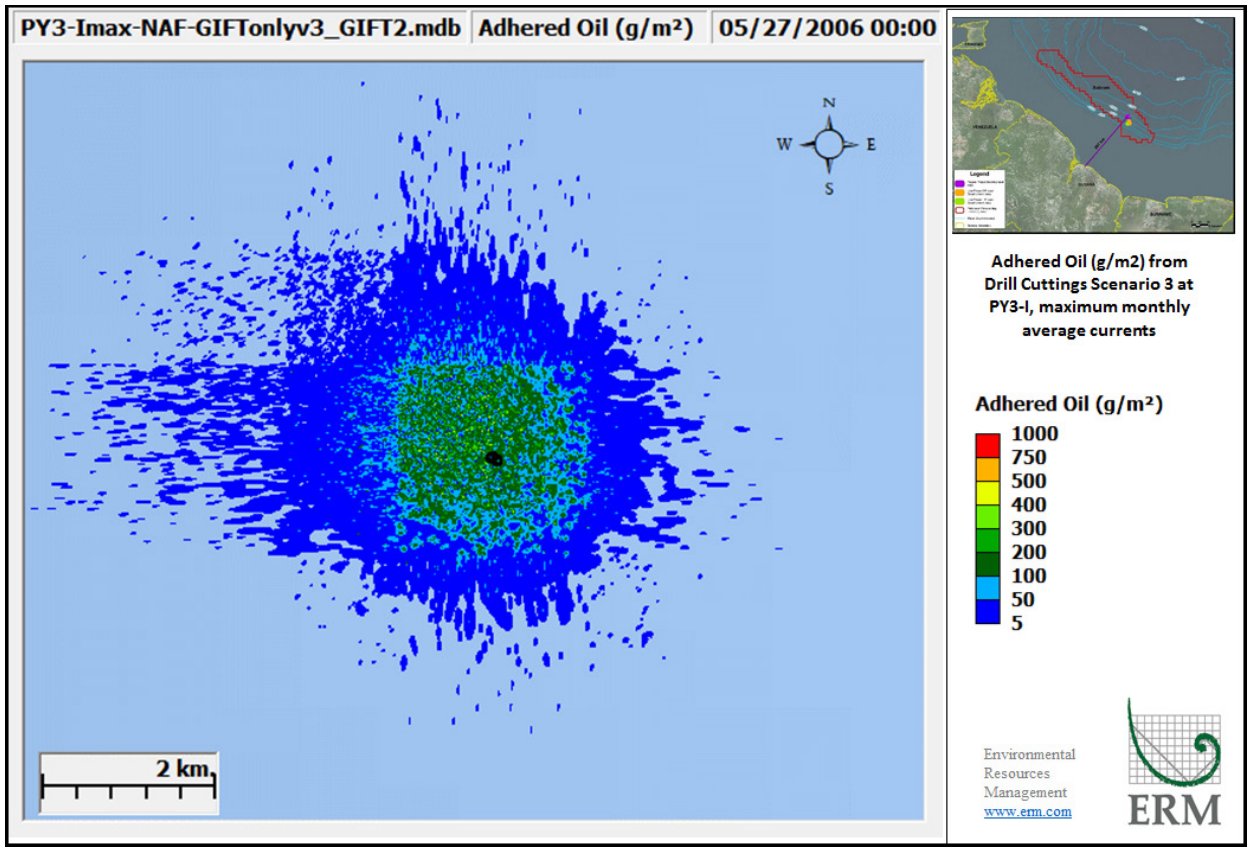


Figure 4-32: Total Deposited Adhered Oil—Scenario 3 PY3-I: Maximum Currents

Table 4-18 summarizes the maximum hydrocarbon deposition modeled at any point for the scenario and the area with hydrocarbon deposition exceeding 5 g/m^2 under minimum and maximum current conditions at each drill center.

Table 4-18: Hydrocarbon Deposition Summary

Simulation	Maximum Hydrocarbon Deposition (g/m²)
Scenario 3: PY1-P Minimum Currents	952.8
Scenario 3: PY1-P Maximum Currents	897.7
Scenario 3: PY3-I Minimum Currents	901.9
Scenario 3: PY1-I Maximum Currents	689

4.5 Cumulative Impacts from Drilling Operations

Similar to the offshore discharge, drilling operations for the Payara Project may occur simultaneously with drilling for other EEPGL development projects as well as EEPGL exploration drilling in the Stabroek Block. Although the footprint of drill cuttings deposition from drilling operations and the extent of associated TSS plumes is very limited, and typically located within close proximity of the drilling locations, an assessment was performed to evaluate the potential for cumulative impacts (overlap) from simultaneous drilling activities.

Figure 4-33 shows the preliminary locations of future exploration wells for which EEPGL has submitted an Environmental Management Plan to the Guyana Environmental Protection Agency in support of a request

for EPA's authorization. Figure 4-33 also shows the Project development well locations, and the development well locations for the Liza Phase 1 and Liza Phase 2 Projects. As shown in Figure 4-34, the closest proposed exploration well to a Project development well is the well labelled "I," which is 13.9 kilometers (8.6 miles) away from the nearest Project development well. Results of the drill cuttings modeling (See Section 2) show that this distance of 13.9 kilometers (8.6 miles) far exceeds the distance that a drill cuttings deposition footprint and TSS plume extend from a well. Similarly, the closest Liza Phase 1 or Liza Phase 2 development well to a Project development well is a Liza Phase 1 well (LIZ_2P4), which is approximately 3.3 kilometers (2.1 miles) away from the nearest Project development well. This distance also is significantly larger than the distance a drill cuttings deposition footprint or TSS plume extends from a well.

Furthermore, temporal behavior should also be considered in evaluation of the cumulative impacts. The threshold of sedimentation is 5 centimeters (2 inches) of deposition over a period of 30 days. Any additional drilling operation in a nearby location would have to produce additional sedimentation within the 30 days that exceeds 5 centimeters (2 inches). It is not likely that two wells closer than 1 kilometer (0.6 miles) would be drilled within a 30-day period. Similarly, the TSS plume is transient and will continue to move under the ambient currents with potential for any overlap with a nearby well unlikely.

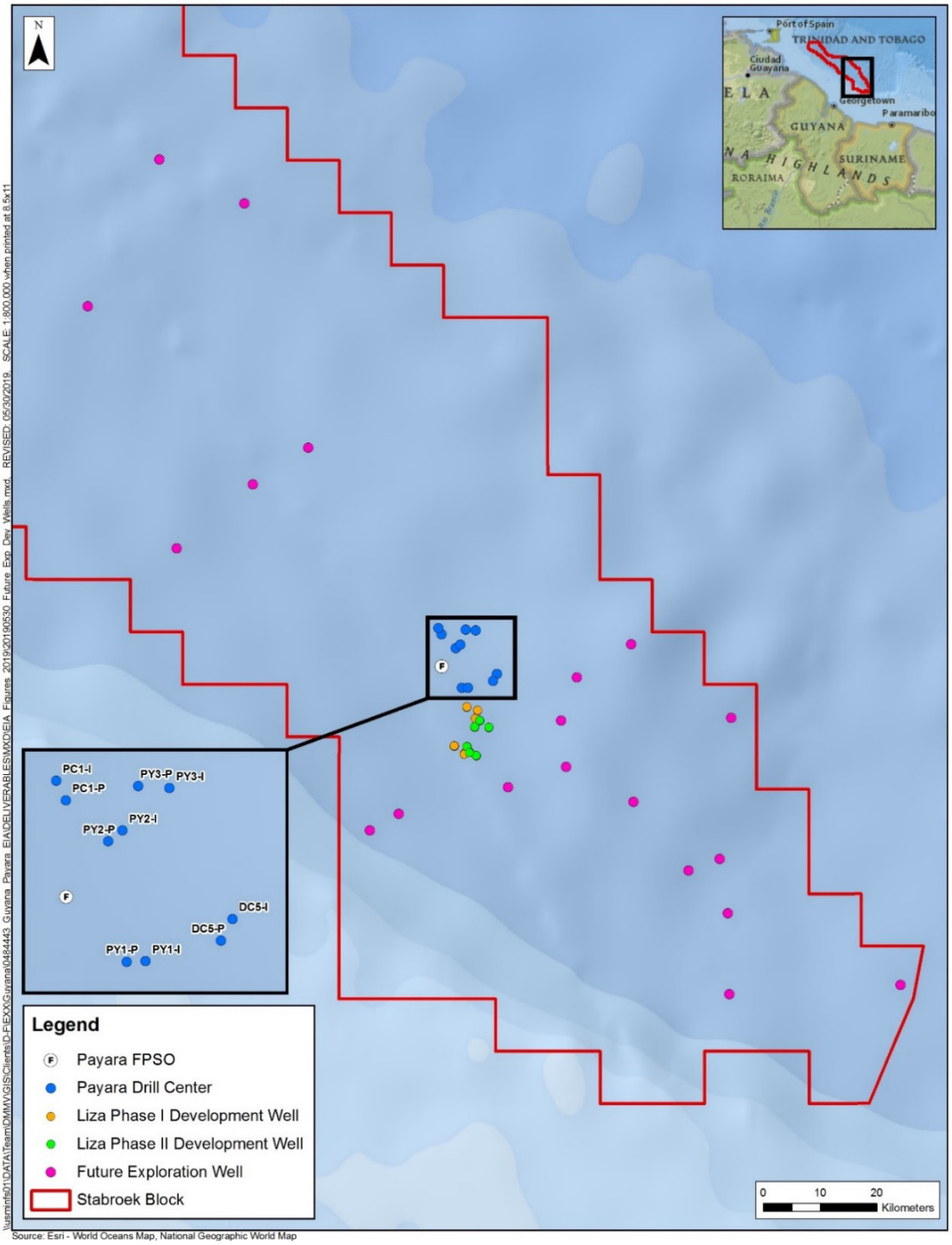


Figure 4-33: Locations of Proposed Exploration Wells Compared to Existing and Proposed Locations of Development Wells (Liza Phase 1, Liza Phase 2, and Payara)

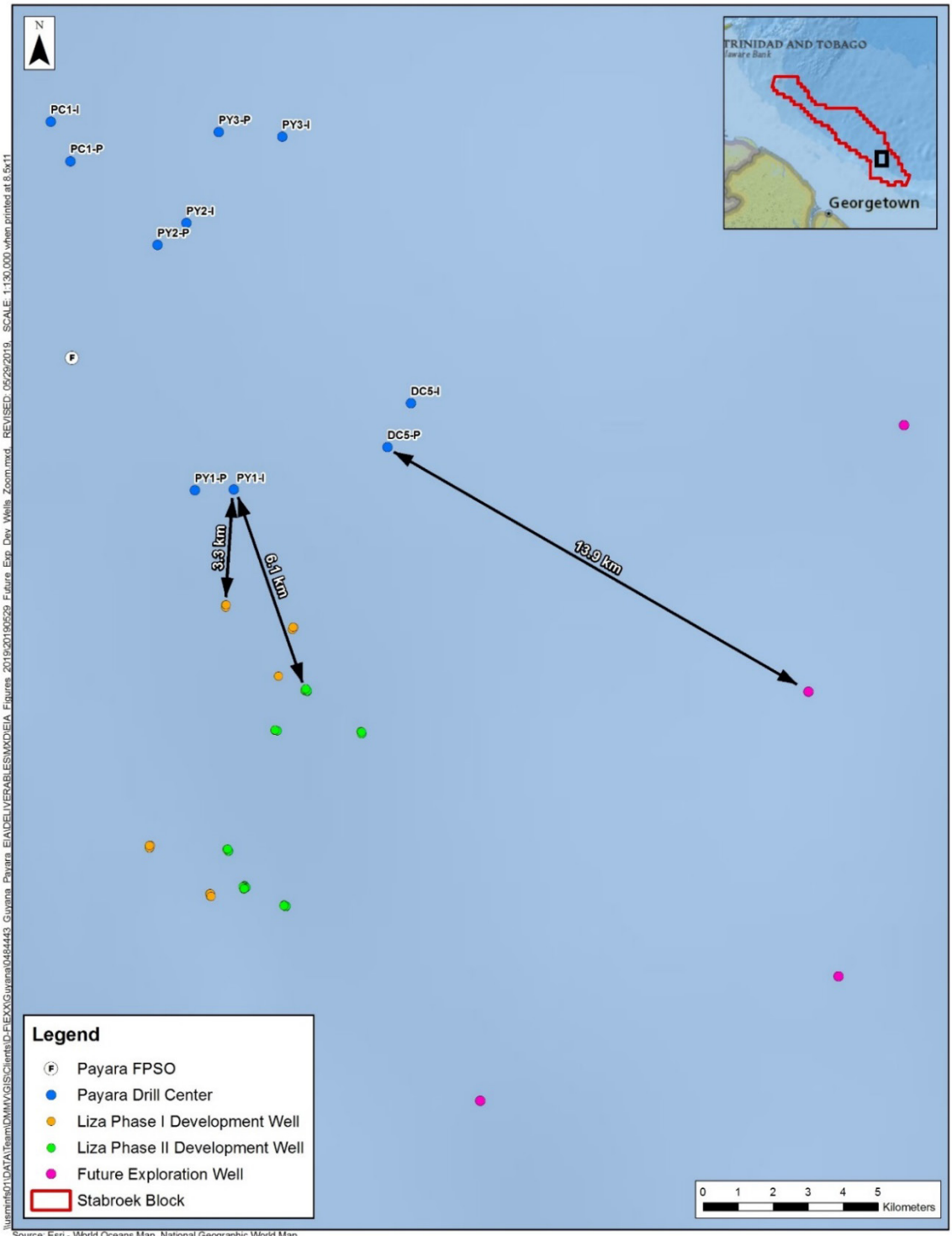


Figure 4-34: Distances from Payara Development Wells Locations to the Closest Proposed Exploration Well and Liza Phase 1 or Liza Phase 2 Development Well Locations

4.6 Conclusions

Drill cuttings deposition modeling was performed using GEMSS® and its drill cuttings and muds deposition module, GIFT. Twelve simulations were modeled, representing two drill centers (PY1-P and PY3-I) and three drilling scenarios under two ambient current conditions (minimum and maximum monthly averaged, depth-averaged current speeds over a 10-year period of record).

Output from the drill cutting modeling included estimations of the lateral distribution of deposited cuttings thickness on the seafloor, the maximum increase in TSS concentrations above ambient conditions, and the lateral distribution of mass of hydrocarbons adhered to cuttings deposited on the seafloor. The results of the modeling are shown below in Table 4-19.

Table 4-19: Model Results Summary

Simulation	Maximum Depositional Thickness (cm)	Area (m²) with Thickness >5 cm Threshold	Maximum TSS (mg/L) Bottom/ Surface	Area (km²) with TSS >35 mg/L Threshold Bottom/ Surface	Maximum Adhered Oil Deposition (g/m²)
Scenario 1—PY1-P Minimum Currents	185.7	3,571	42,796	0.362	NA
Scenario 1—PY1-P Maximum Currents	238.8	2,874	36,859	0.621	NA
Scenario 1—PY3-I Minimum Currents	214.2	2,932	51,120	0.170	NA
Scenario 1—PY3-I Maximum Currents	255.5	2,739	51,164	1.339	NA
Scenario 2—PY1-P Minimum Currents	116.8	1,976	18,520/ 23.6	0.288/0	NA
Scenario 2—PY1-P Maximum Currents	178.3	1,636	26,149/ 52.8	0.160/0.0065	NA
Scenario 2—PY3-I Minimum Currents	138.2	1,663	12,711/ 23.7	0.259/0	NA
Scenario 2—PY3-I Maximum Currents	179.1	1,455	45,302/ 52.4	0.202/0.0065	NA
Scenario 3—PY1-P Minimum Currents	NA	NA	NA	NA	952.8
Scenario 3—PY1-P Maximum Currents	NA	NA	NA	NA	897.7
Scenario 3—PY3-I Minimum Currents	NA	NA	NA	NA	901.9
Scenario 3—PY3-I Maximum Currents	NA	NA	NA	NA	689

cm = centimeter; NA = not applicable

In all simulations, a small region close to the drill centers exceeded the depositional thickness threshold value of 5 centimeters (2 inches). The lateral extent of the deposition mound where thicknesses exceed this threshold was approximately 60 meters (164 feet). The bulk of the depositional mound results from the cuttings and muds discharged during the jetting and drilling of the two top-hole sections. The maximum increase in TSS concentration above ambient conditions in the bottom of the water column is predicted to be as much as 51,164 mg/L at the point of release; however, these concentrations will occur at water depths below the photic zone, in areas where photosynthesis inhibition is not a concern. At the

surface, where photosynthesis inhibition is more of a concern, TSS concentration increases above ambient from discharges were predicted to be below the 35 mg/L threshold for minimum current conditions. For maximum current conditions, the maximum TSS concentration increases above ambient in the shallow water column is 52.8 mg/L. Hydrocarbon deposition on the seafloor had a maximum predicted value of 952.8 g/m².

Variations in the current speeds are the primary cause for the variations in the model results provided. In general, scenarios with minimum currents have higher maximum areas of deposition greater than the 5-centimeter (2-inch) threshold and higher bottom TSS concentrations compared to the scenarios with maximum currents. Slower currents allow for a less dispersed settling and therefore a more laterally concentrated deposition and more concentrated TSS.

Similar to the depositional thickness, scenarios with minimum currents have higher maximum hydrocarbon deposition compared to scenarios with maximum currents. Slower currents allow for a more laterally concentrated deposition of hydrocarbon-containing cuttings.

5. 12-WELL STABROEK EXPLORATION CAMPAIGN (EMP) – APRIL 2019

5.1 Introduction

5.1.1 Approach

In this report, potential impacts to water quality and sediment from the planned discharge of drill cuttings is evaluated. The evaluation is for individual and cumulative impacts during the planned drilling of future exploration wells as part of a proposed 12-well exploration drilling program expansion (hereafter, “the Project”). The exact locations for the 12 wells have not been finalized at this point, but for the purpose of this analysis they are assumed to be completed at 12 of the 20 locations shown on Figure 5-1.

It is assumed that there will be a direct discharge (i.e., near the seabed) of cuttings with water-based drilling fluids during drilling of the initial riserless open hole section at each well and the second section of the well. For the other two (deeper) well sections, it is assumed that cuttings will be discharged from the drill ship with a small fraction of adhered residual base oil from material removed in the lower well sections, after treatment on the drill ship.

Modeling was performed to predict the following as a result of cuttings discharge:

- TSS concentrations in the water column
- Seabed accumulation (thickness) of the adhered muds and drill cuttings on the seafloor

To evaluate cumulative impacts, locations of previously completed exploration wells, potential locations for the proposed exploration wells comprising the Project, and previously completed and to-be-completed development wells were considered to understand the potential cumulative effects resulting from the proximity of these wells to each other. A mapping exercise was then performed to evaluate potential for overlap from these individual discharges.

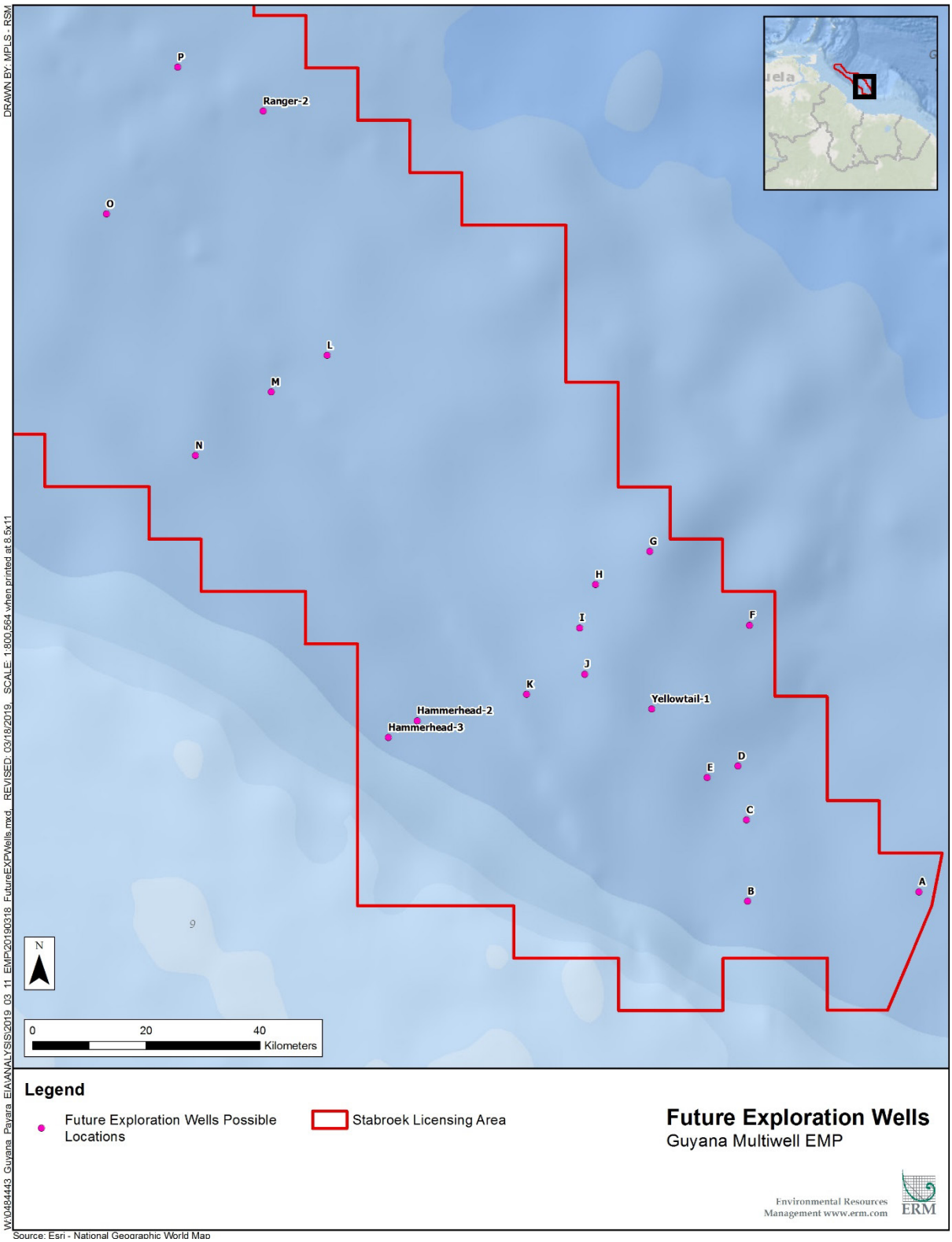


Figure 5-1: Potential Exploration Well Locations

5.1.1.1 Simulation Design

Released material will pass vertically through the water column because cuttings and muds are denser than the receiving water. Released material will also migrate horizontally due to advection by local and regional currents. The dispersion of cuttings and muds is fundamentally a three-dimensional phenomenon requiring three-dimensional hydrodynamic fate and transport modeling.

The possible locations for the proposed Project wells were classified as “shallow” or “deep” using a statistical analysis based on the depths of water at these locations. From the analysis, representative shallow and deep locations were chosen for modeling. Since the released material migrates downwards, the depth that these cuttings and muds have to travel determines how far they spread laterally. A shallow location would result in quicker settling and a consequently smaller lateral spread. At a deeper location, cuttings and muds will take longer to settle, facilitating a larger lateral spread. The representative shallow well location is tentatively named “A” while the representative deep well location is tentatively named “F” (see Table 5-1). The minimum and maximum monthly-averaged, depth-averaged currents scenarios were modeled to represent a range of impacts in seabed cuttings accumulation and TSS concentrations.

Table 5-1: Potential Locations of Project Exploration Wells and Water Column Depths

Name	X	Y	Latitude	Longitude	Approximate Water Depth (meters)
Hammerhead-3	487075	877058	7.934495	-57.1173	-1101
Hammerhead-2	492155	879995	7.961072	-57.0712	-1261
B	550337	848245	7.673637	-56.5436	-1306
A	580500	849912	7.688338	-56.2701	-1579
J	521631	888216	8.035395	-56.8037	-1606
K	511405	884658	8.003245	-56.8965	-1633
I	520778	896347	8.108947	-56.8114	-1705
C	550099	862532	7.802871	-56.5456	-1719
Yellow tail-1	533454	882054	7.934495	-57.1173	-1722
E	543193	869994	7.87043	-56.6082	-1748
N	453103	926667	8.383019	-57.426	-1764
H	523508	903966	8.177852	-56.7866	-1782
G	533074	909792	8.230495	-56.6997	-1795
D	548625	872036	7.888852	-56.5589	-1885
F	550655	896822	8.113028	-56.5402	-2182
M	466466	937861	8.484384	-57.3047	-2276
O	437444	969148	8.767074	-57.5688	-2370
L	476280	944289	8.542586	-57.2155	-2386
P	450007	995009	9.001138	-57.4548	-2736
Ranger-2	465017	987260	7.934495	-57.1173	-2748

5.2 Individual Well Results

5.2.1 Total Suspended Solids (TSS)

MARPOL 73/78 (IMO 2006) recommends a TSS threshold of 35 mg/L for effluent discharges from marine vessels. The model results were evaluated at a threshold of 17.5 mg/L (half of the selected threshold) to take into consideration the possible overlap between two wells.

5.2.1.1 Representative Shallow Well (Well Location A)

Minimum Currents

The minimum currents scenario for the shallow well had a maximum TSS concentration of approximately 3,000 mg/L, which occurred near the sea bottom, as shown in Figure 5-2. Figure 5-3 shows maximum TSS concentrations near the surface. The area exceeding 17.5 mg/L is larger at the surface and covers an area of 0.45 km². The maximum TSS concentration is sustained for a very short time period, as ambient currents tend to further spread and settling tends to remove particles from the water column. The TSS peaks at any depth within the water column with time is shown in Figure 5-4. Within a few days (<3 days), the TSS concentrations drop to below 17.5 mg/l. The farthest distance of the TSS plume exceeding 17.5 mg/L occurs at the surface, about 3.4 kilometers away from the well location, and has an approximate width of only 85 meters.

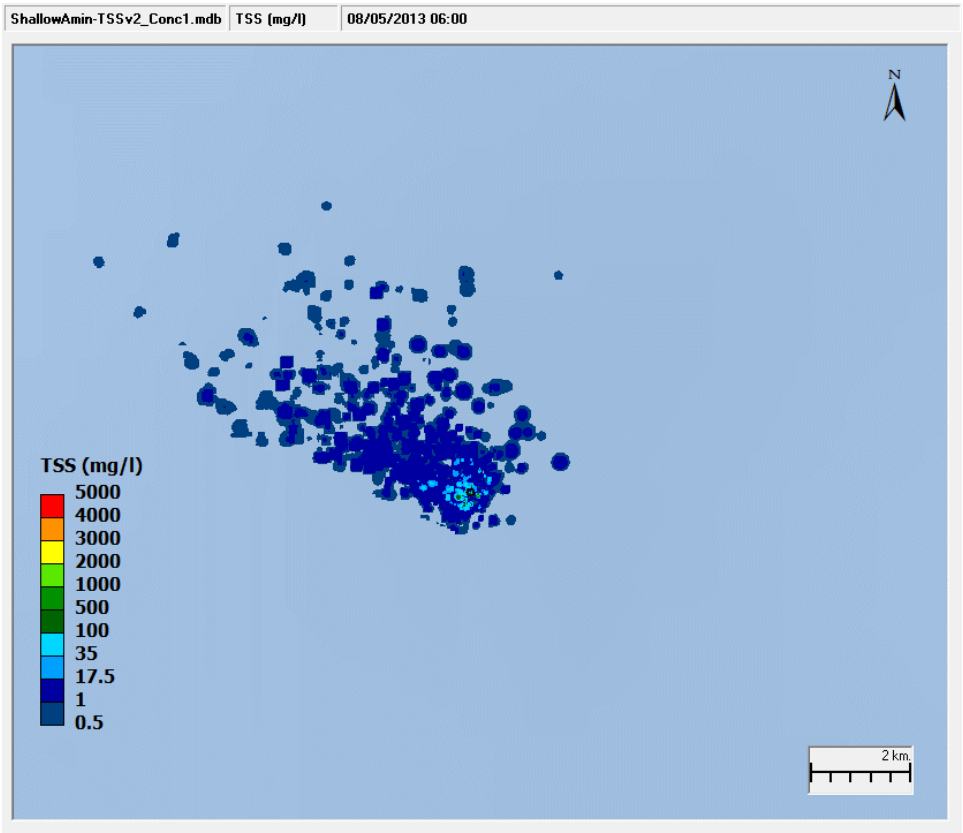


Figure 5-2: Maximum TSS Concentrations at Sea Bottom at the Shallow Well Under Minimum Currents

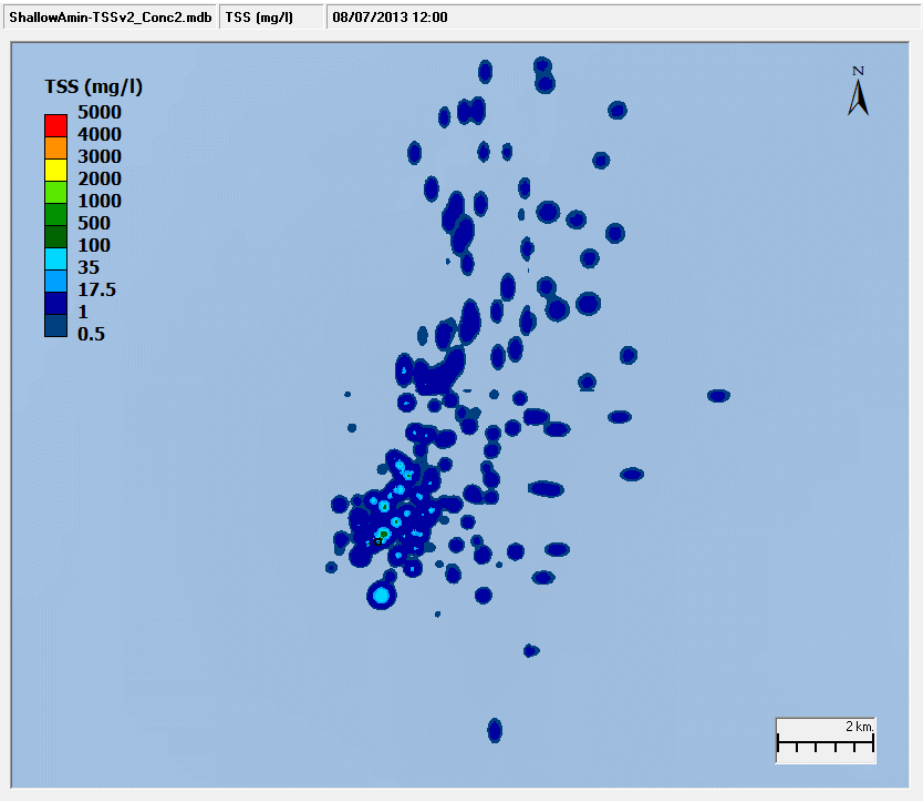


Figure 5-3: Maximum TSS Concentrations at Surface at the Shallow well Under Minimum Currents

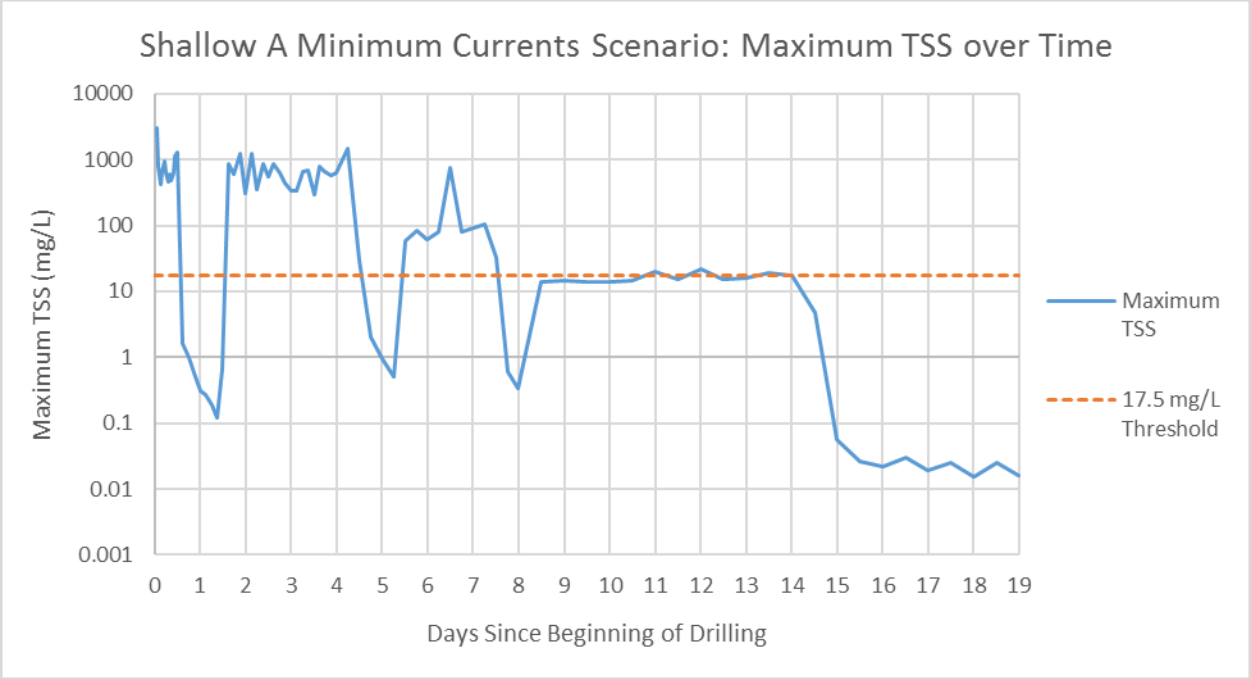


Figure 5-4: Maximum TSS Concentration Peak at Shallow Well at Any Depth with Time Under Minimum Currents

Maximum Currents

The maximum currents scenario for the shallow well had a maximum TSS concentration of approximately 3,600 mg/L, which occurred near the sea bottom as shown in Figure 5-5. Figure 5-6 shows maximum TSS concentrations near the surface. The area exceeding 17.5 mg/L is larger at the sea bottom and covers 0.26 km^2. The farthest distance from the well location of a TSS plume exceeding 17.5 mg/L occurs at the sea bottom about 2 kilometers away. This plume, however, is only 80 meters wide at this point. Temporally, the TSS peaks exist only for a short duration of time as shown in Figure 5-7. The peak TSS levels (at any depth) drops below the half of impact threshold (17.5 mg/L) within 3 days.

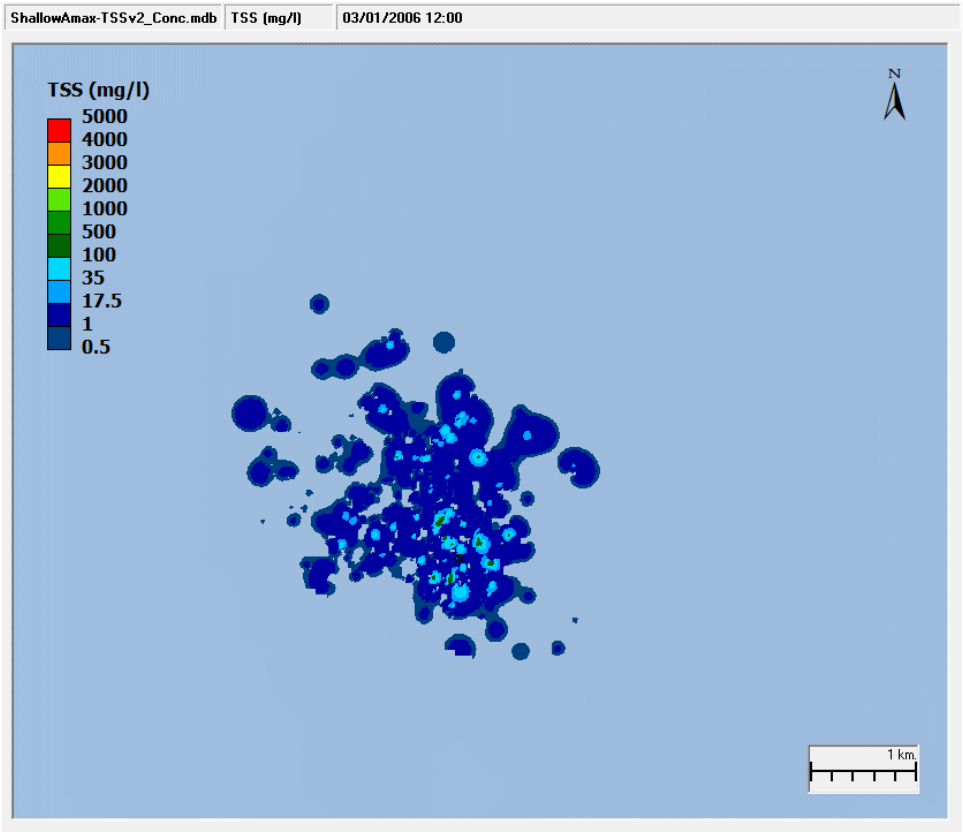


Figure 5-5: Maximum TSS Concentrations at Sea Bottom at the Shallow Well Under Maximum Currents

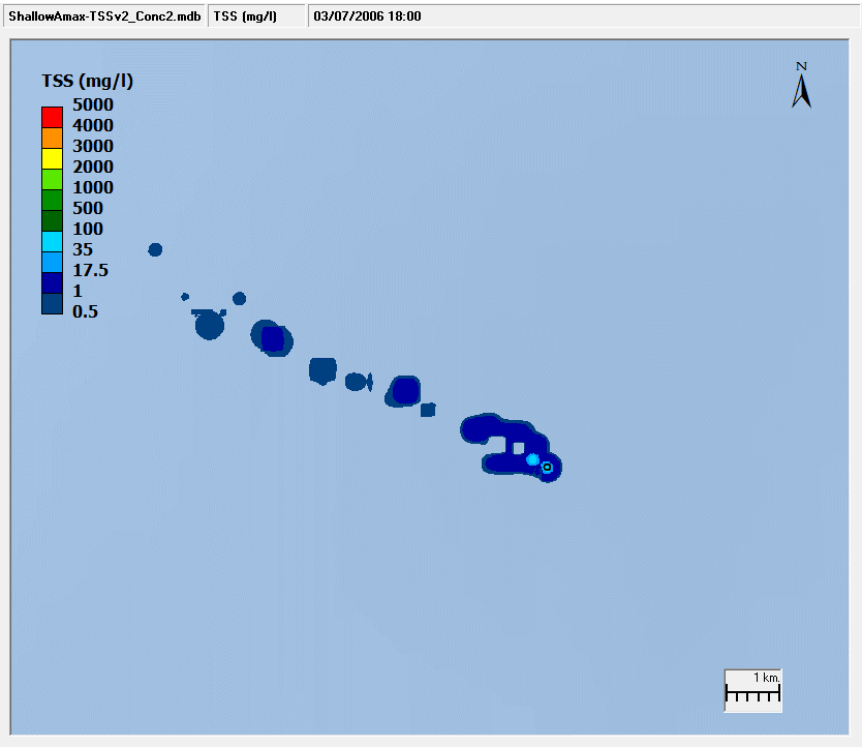


Figure 5-6: Maximum TSS Concentrations at Surface at the Shallow Well Under Maximum Currents

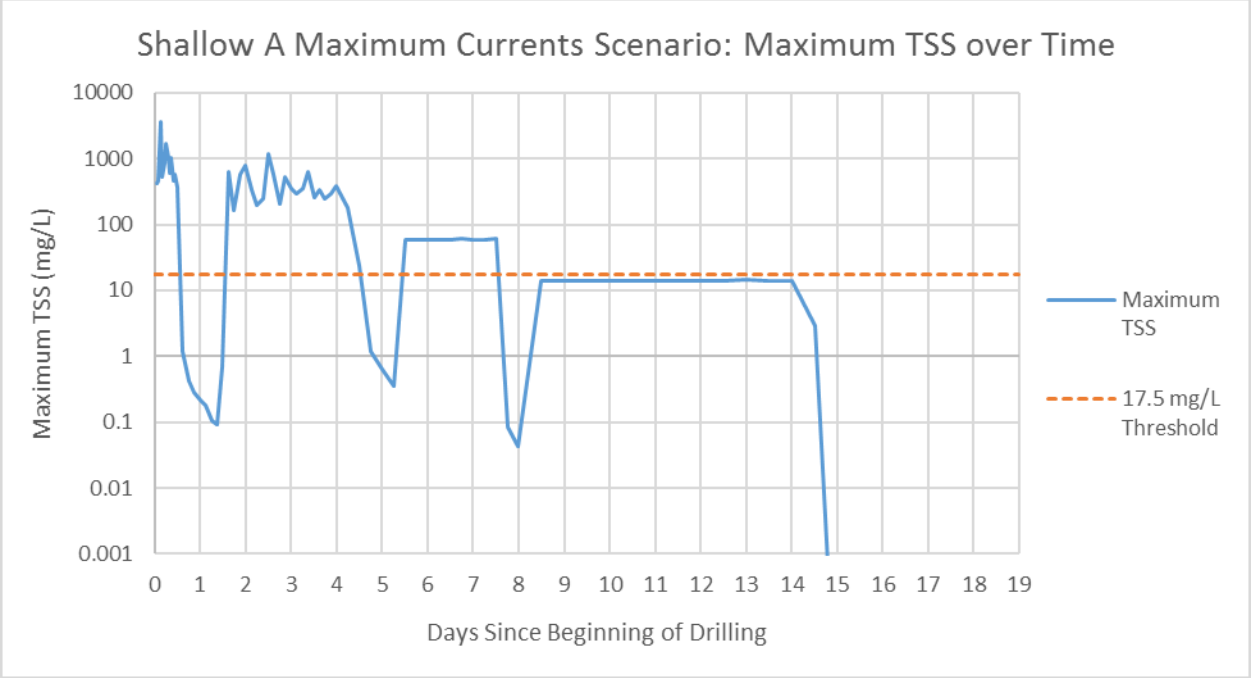


Figure 5-7: Maximum TSS Concentration Peak at Shallow Well at Any Depth with Time Under Minimum Currents

5.2.1.2 Representative Deep Well (Well Location F)

Minimum Currents

The minimum currents scenario for the deep well had a maximum TSS of approximately 3,100 mg/L, which occurred near the sea bottom shown in Figure 5-8. Figure 5-9 shows maximum TSS concentrations near the surface. The area exceeding 17.5 mg/L is larger at the sea bottom and covers 0.23 km². The farthest distance where the TSS plume exceeds 17.5 mg/L occurs at the sea bottom and is about 2 kilometers away from the well location. This plume has an approximate width of 80 meters at this point. As noted for the shallow well, the TSS peaks are temporary in nature as shown in Figure 5-10, which shows maximum TSS concentrations at any depth over time.

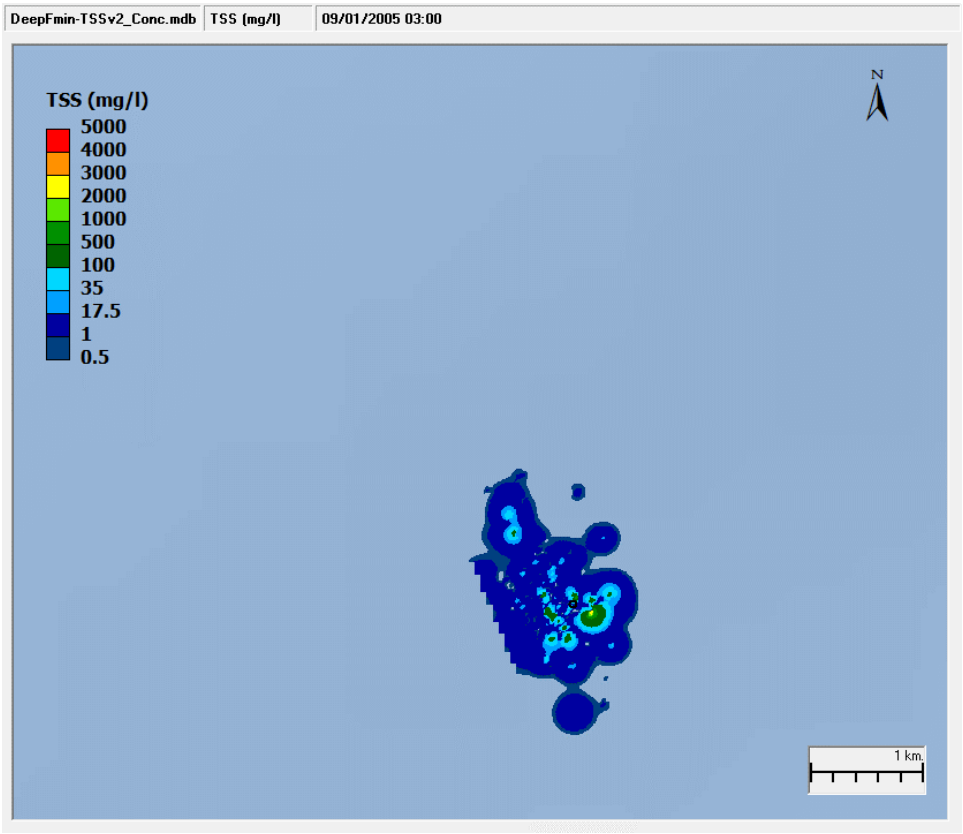


Figure 5-8: Maximum TSS Concentrations at Sea Bottom at the Deep Well Under Minimum Currents

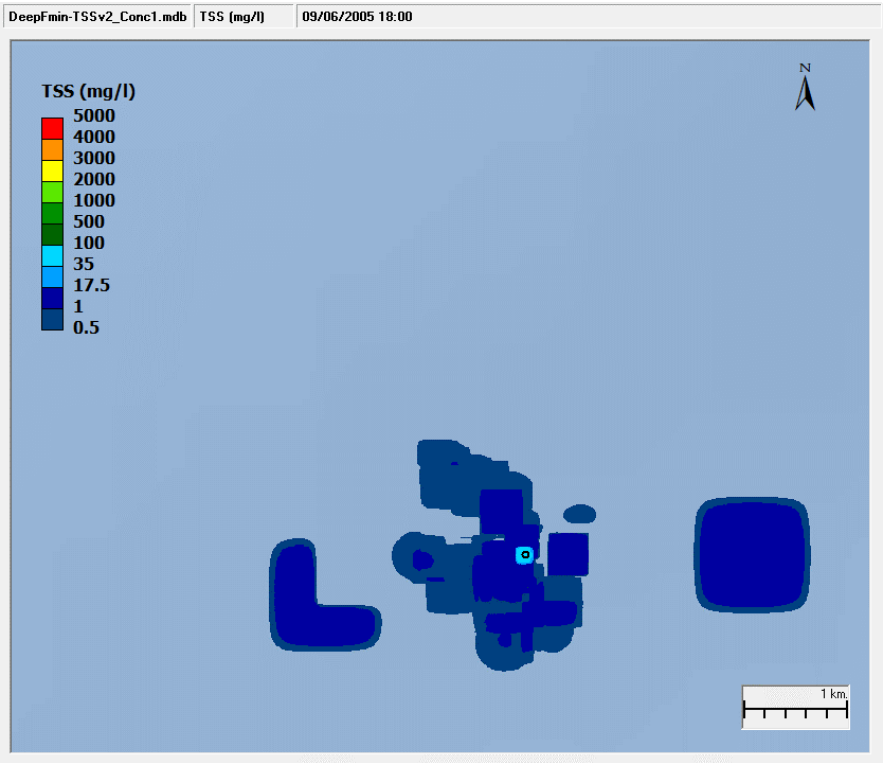


Figure 5-9: Maximum TSS Concentrations at Surface at the Deep Well Under Minimum Currents

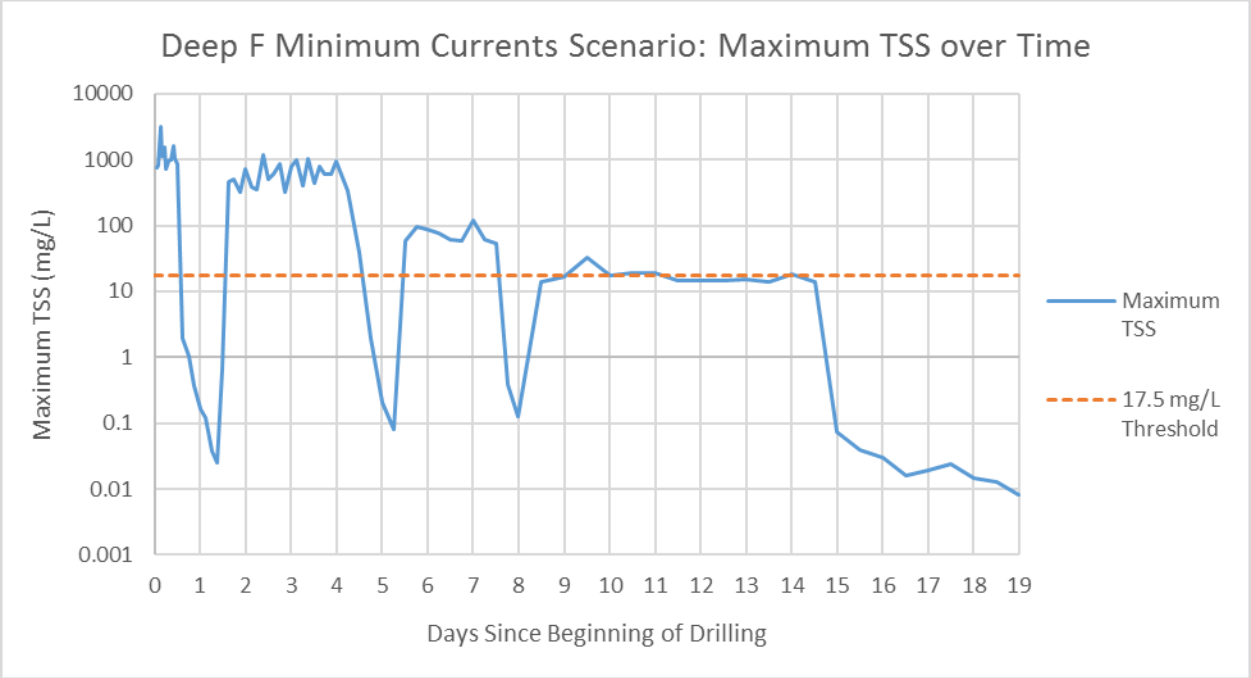
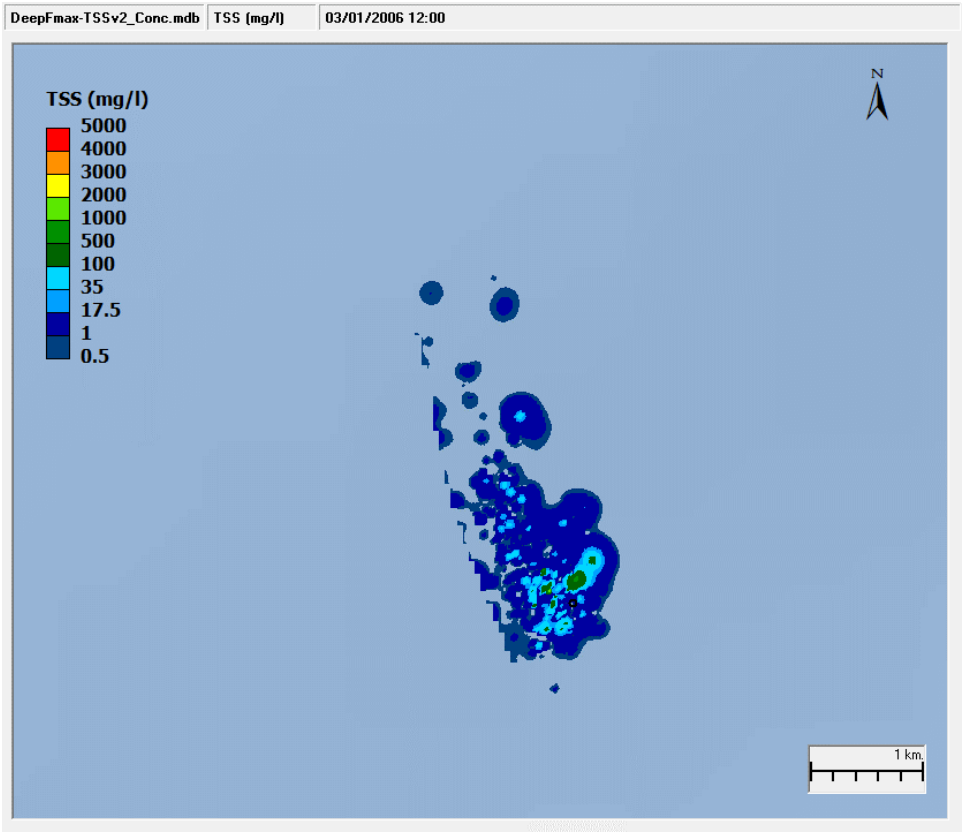


Figure 5-10: Maximum TSS Concentration Peak at Deep Well at Any Depth with Time Under Minimum Currents

Maximum Currents

The maximum currents scenario for the deep well had a maximum TSS of approximately 4,100 mg/L, which occurs near the sea bottom as shown in Figure 5-11. Figure 5-12 shows maximum TSS concentrations near the surface. The area exceeding 17.5 mg/L is larger at the sea bottom and covers 0.23 km². The farthest distance a TSS plume exceeds 17.5 mg/L occurs at the sea bottom about 1.7 kilometers away from the well location. This plume only has an approximate width of 100 meters. As noted for the other scenarios, the TSS peaks are temporary in nature as shown in Figure 5-13, which shows maximum TSS concentrations at any depth over time.



Note: The gridded effect at the bottom layer is due to the shallower bathymetry west of the release location.

Figure 5-11: Maximum TSS Concentrations at Sea Bottom at the Deep Well Under Maximum Currents

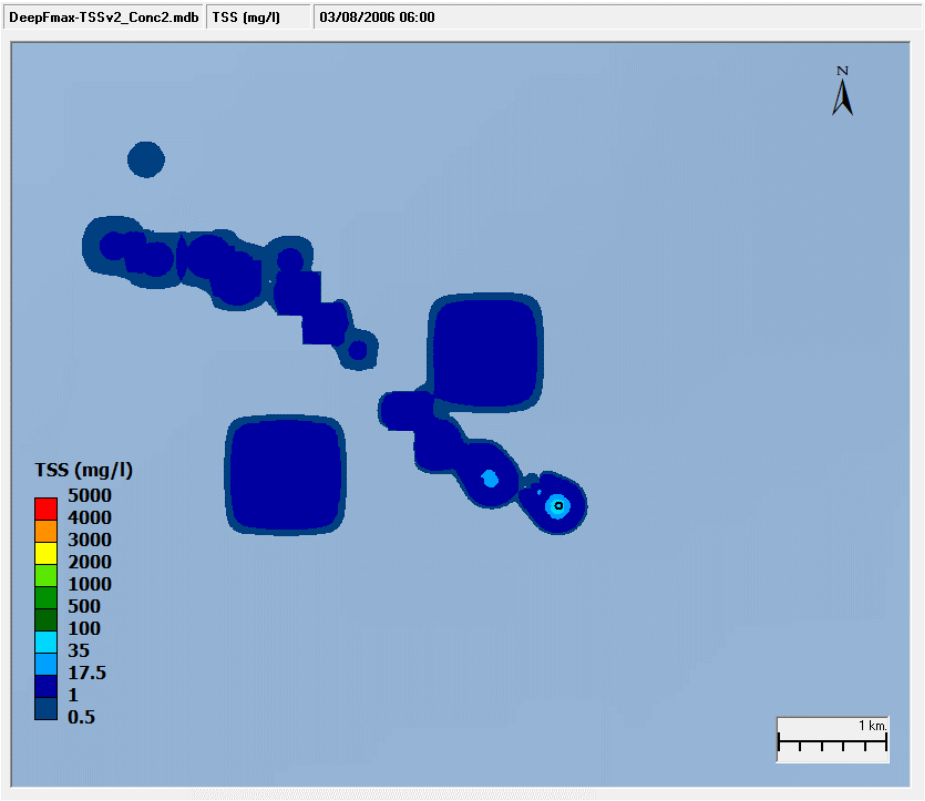


Figure 5-12: Maximum TSS Concentrations at Surface at the Deep Well Under Maximum Currents

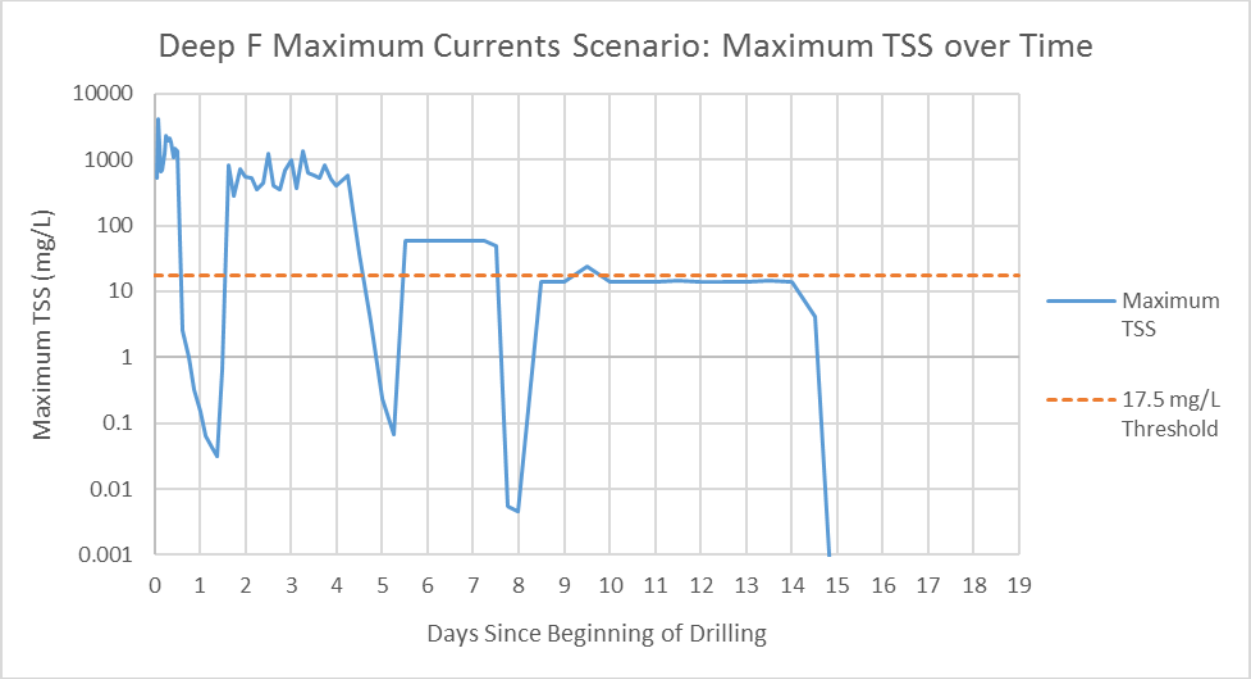


Figure 5-13: Maximum TSS Concentration Peak at Deep Well at Any Depth with Time Under Maximum Currents

5.2.1.3 Summary

Table 5-2 summarizes the results found in the TSS analysis for the two well locations under minimum and maximum currents scenarios.

Table 5-2: Summary of Results for Both Deep and Shallow Wells Under Different Currents

	Sections 1 and 2 - Bottom Release				Sections 3 and 4 - Surface Release			
Scenario	Max TSS (mg/L)	Area (km²) greater than 17.5 mg/L	Farthest distance (m) from well of 17.5 mg/L exceedance	Approximate Width (m) of plume at farthest extent of 17.5 mg/L exceedance	Max TSS (mg/L)	Area (km²) greater than 17.5 mg/L	Farthest distance (m) from well of 17.5 mg/L exceedance	Approximate Width (m) of plume at farthest extent of 17.5 mg/L exceedance
Shallow A-Minimum Currents	2,999	0.27	1,300	105	751	0.45	3400	85
Shallow A- Maximum Currents	3,560	0.26	1,985	80	62	0.07	360	220
Deep F- Minimum Currents	3101	0.23	2,000	80	94	0.02	391	280
Deep F-Maximum Currents	4107	0.23	1,700	104	59	0.05	713	161

5.2.2 Drill Cuttings Depositional Thickness

A threshold of 5 centimeters is suggested by MarLIN (2011) for smothering of benthic species. The model results, therefore, were evaluated at a threshold of 2.5 centimeters (half of the selected threshold value) to take into consideration the possible overlap between two wells.

5.2.2.1 Representative Shallow Well (Well Location A)

Minimum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 2.5-centimeter threshold was 0.01 km^2 as shown in Figure 5-14. The maximum length of this mound in any direction was 130 meters.

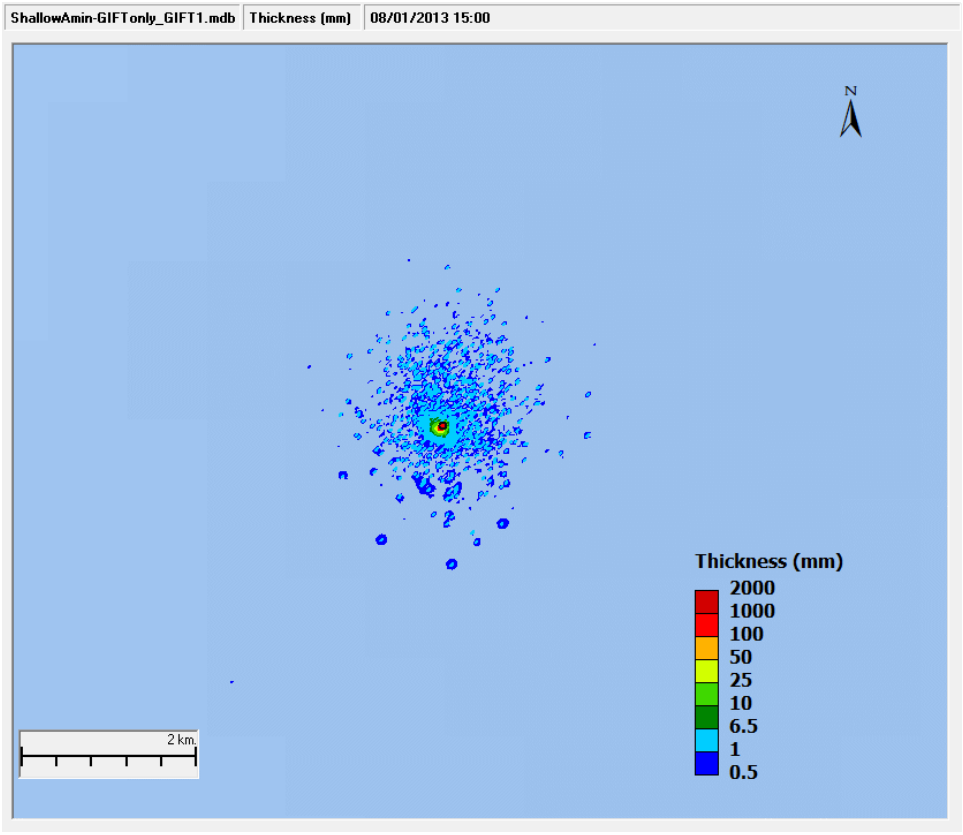


Figure 5-14: Maximum Cuttings Deposition Thickness for Shallow Well Under Minimum Currents

Maximum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 2.5 centimeters threshold was 0.013 km^2 as shown in Figure 5-15. The maximum length of this mound in any direction was 145 meters.

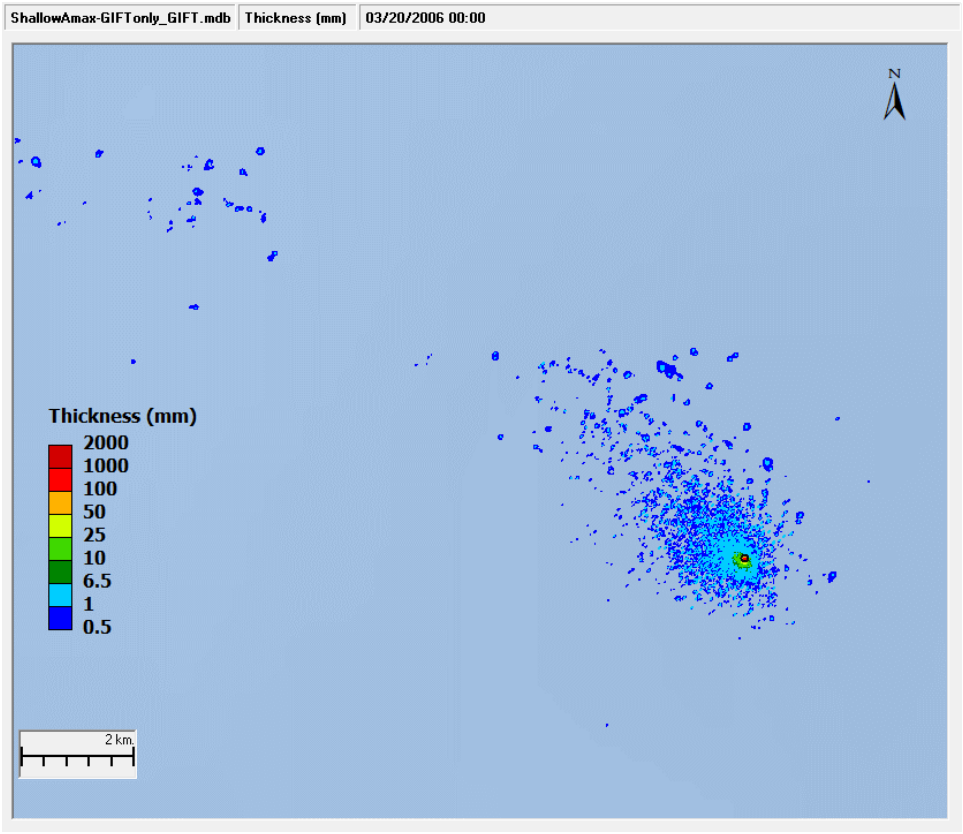


Figure 5-15: Maximum Cuttings Deposition Thickness for Shallow Well Under Maximum Currents

5.2.2.2 Representative Deep Well (Well Location F)

Minimum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 2.5 centimeters threshold was 0.011 km² as shown in Figure 5-16. The maximum length of this mound in any direction was 140 meters.

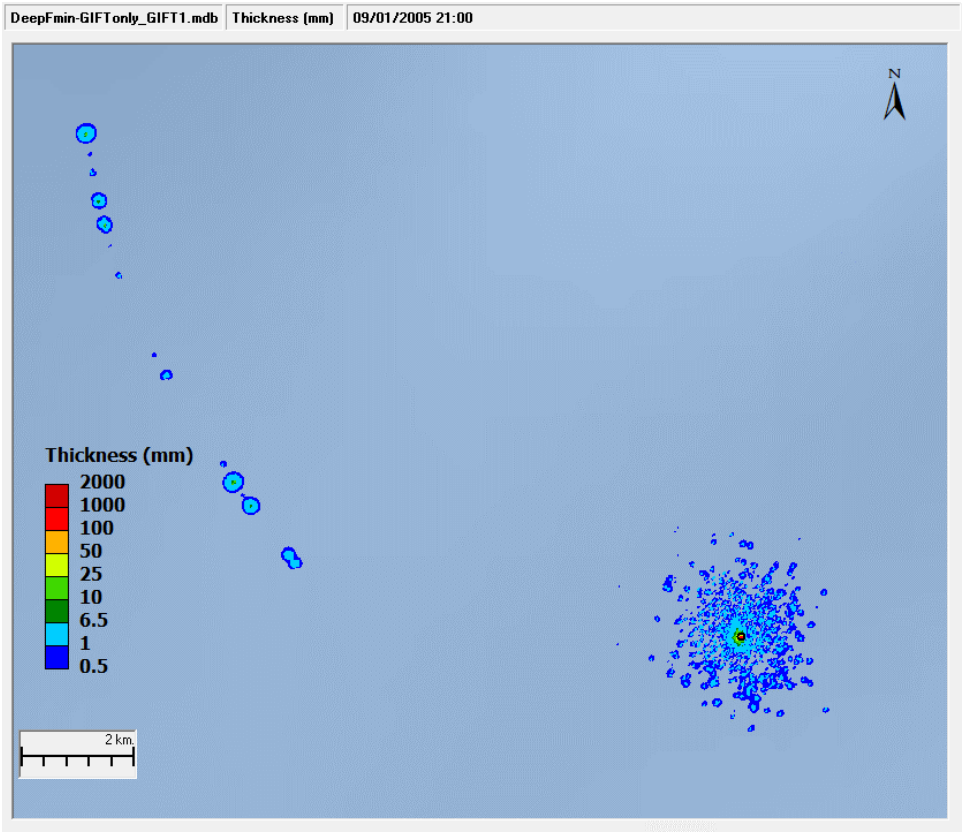


Figure 5-16: Maximum Cuttings Deposition Thickness for Deep Well Under Minimum Currents

Maximum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 2.5 centimeters threshold was 0.01 km² as shown in Figure 5-17. The maximum length of this mound in any direction was 130 meters.

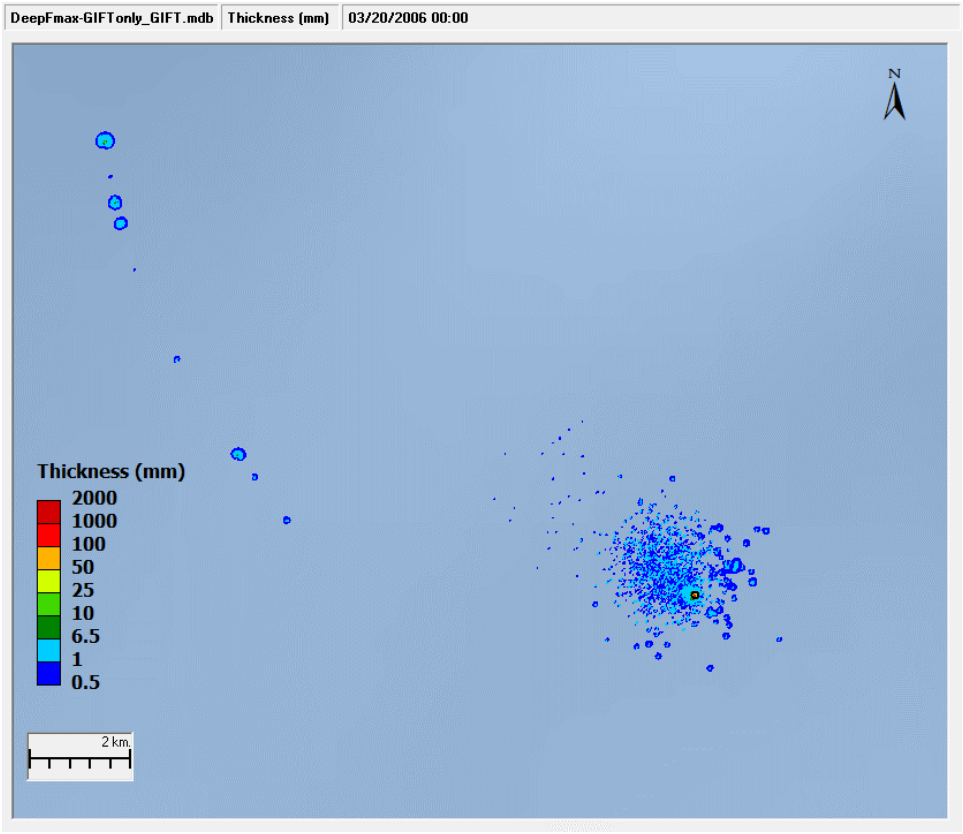


Figure 5-17: Maximum Cuttings Deposition Thickness for Deep Well Under Maximum Currents

5.2.2.3 Summary

Table 5-3 shows the cuttings accumulation (depositional thickness) analysis for the two well locations under minimum and maximum currents scenarios. Note that the table presents the area and length of the depositional mound for the depositional threshold (5 centimeters) and half of the depositional threshold (2.5 centimeters).

Table 5-3: Summary of Cuttings Deposition Results for Both Deep and Shallow Wells Under Different Currents

Scenarios	Area (km²) above 5 cm	Maximum Length (m) of Mound exceeding 5 cm	Area (km²) above 2.5 cm	Maximum Length (m) of mound exceeding 2.5 cm
Shallow A-Minimum Currents	0.0048	100	0.010	130
Shallow A- Maximum Currents	0.0052	100	0.013	145
Deep F- Minimum Currents	0.0048	100	0.011	140
Deep F-Maximum Currents	0.005	100	0.01	130

5.3 Cumulative Impact Assessment Results

5.3.1 Assessment of Cumulative Impacts within the Project

Within the Project, the possible exploration well locations closest together are locations “D” and “E,” as shown in Figure 5-18. These wells are approximately 5.8 kilometers apart from each other, a distance much larger distance than the modeled extent of >17.5 mg/L TSS or >2.5 centimeter cuttings deposition thicknesses. This is discussed further below.

5.3.1.1 Total Suspended Solids

Cumulative impacts from TSS are unlikely. From a temporal perspective, it is highly unlikely that TSS plumes above the threshold will persist beyond the time of drilling, as shown in Figure 5-4, Figure 5-7, Figure 5-10, and Figure 5-13. From a spatial perspective, the maximum distance from a well location of a TSS plume exceeding 17.5 mg/L was 3.4 kilometers. Considering that the two closest of the proposed exploration wells are 5.8 kilometers apart, there will be no cumulative TSS impact.

5.3.1.2 Cuttings Depositional Thickness

Cumulative impacts from seabed accumulation of cuttings are also unlikely. The longest sediment deposition mound exceeding 2.5 centimeters is 145 meters, roughly centered on the well. This distance is much smaller than the smallest distance between the two closest of the proposed wells (at 5.8 kilometers). In Figure 5-19 and Figure 5-20, the model results of the cuttings depositional thickness were applied to each possible well location for the minimum and maximum currents scenarios based on water depth classification. As seen in these figures, there will be no potential overlap and therefore no resulting cumulative impact from the proposed exploration wells.

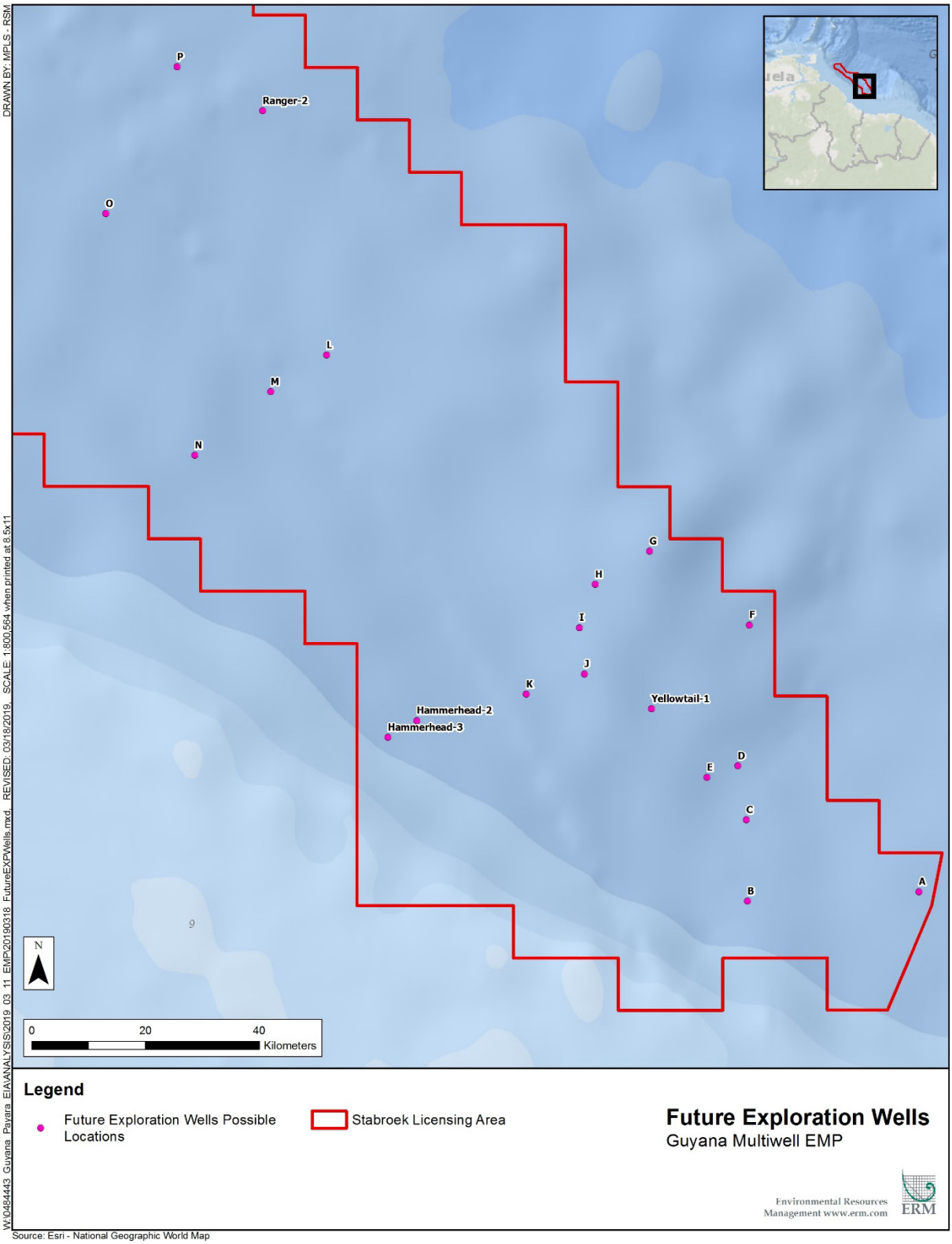


Figure 5-18: Potential Exploration Well Locations

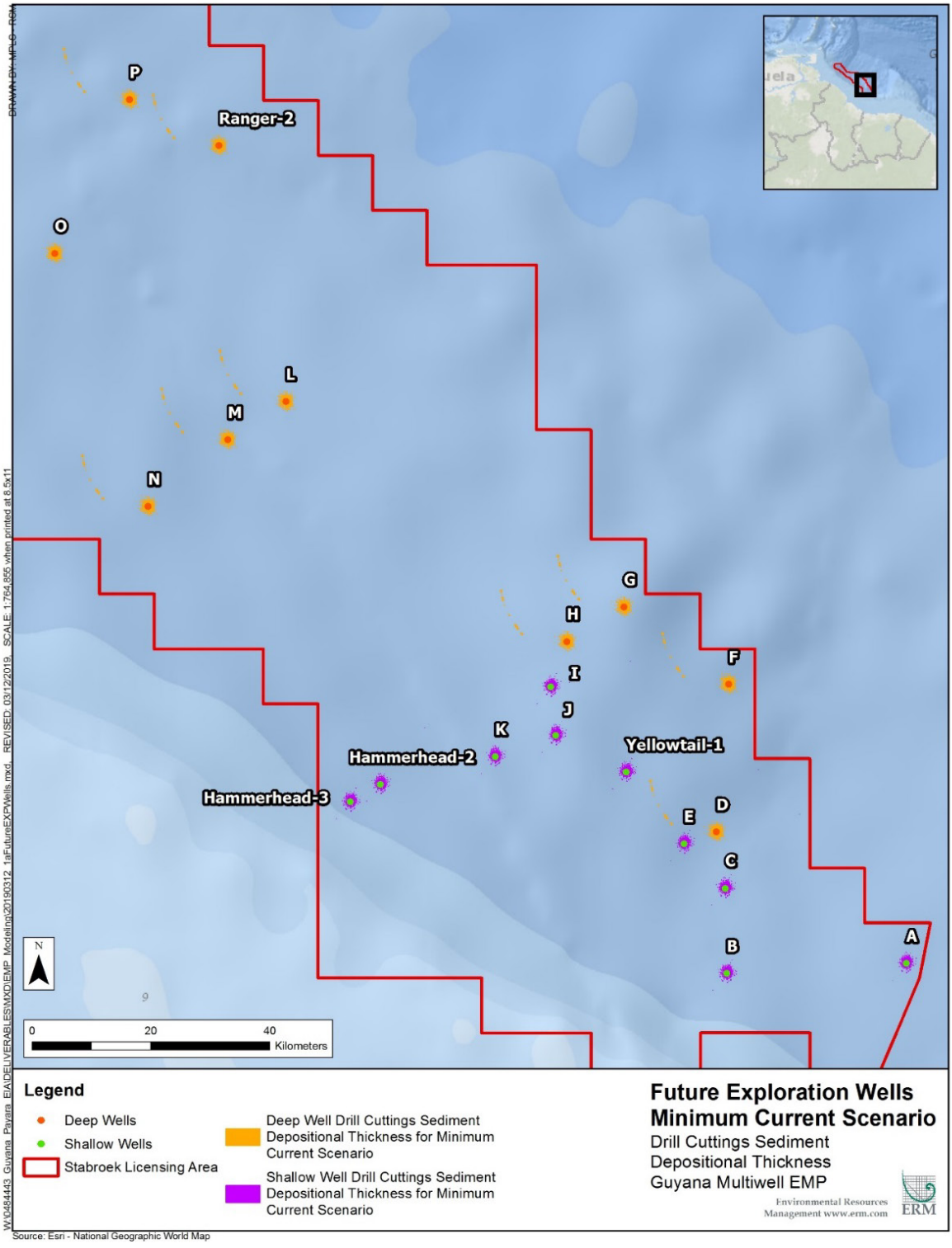


Figure 5-19: Potential Exploration Well Locations with Individual 0.5 mm Cuttings Deposition Extents (Minimum Currents) Overlaid to Demonstrate Lack of Overlap and Resulting Lack of Cumulative Impacts from Sediment Deposition

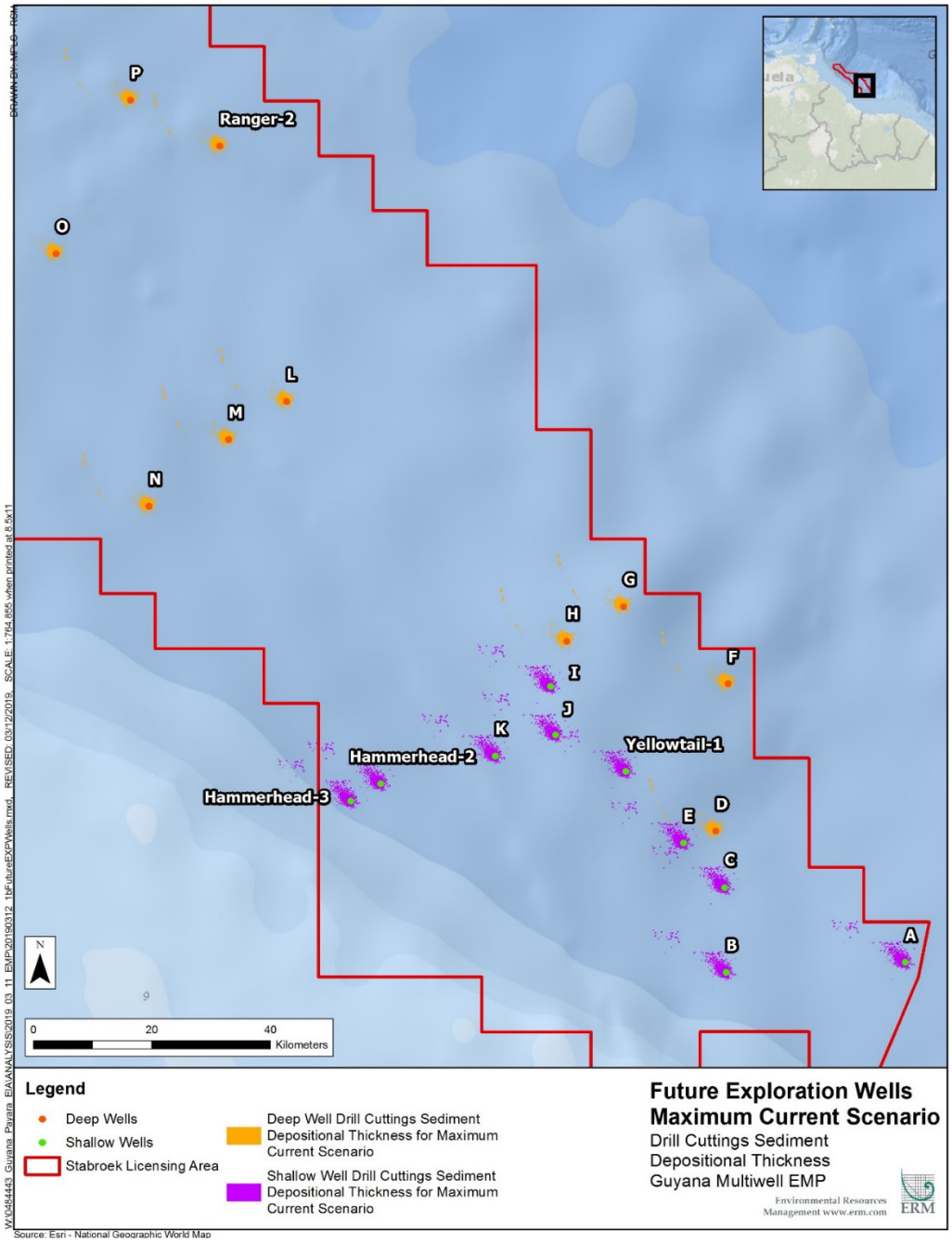


Figure 5-20: Potential Exploration Well Locations with Individual 0.5 mm Cuttings Deposition Extents (Maximum Currents) Overlaid to Demonstrate Lack of Overlap and Resulting Lack of Cumulative Impacts from Sediment Deposition

5.3.2 Assessment of Cumulative Impacts with Other Projects

In addition to assessing the potential for cumulative impacts from wells within the Project, the potential for cumulative impacts from Project wells and development wells for the Liza Phase 1, Liza Phase 2, or Payara Development Projects was completed. The well location tentatively named “K” is the closest possible exploration well location to a Liza Phase 1, Liza Phase 2, or Payara Development well location, as shown in Figure 5-21. Well “K” is 7.9 kilometers from the closest Liza Phase 2 well (DC3-P1_9) and 9.7 kilometers from the closest Liza Phase 1 well (LIZ_1P1).

Figure 5-22 shows that the well location tentatively named “I” is the closest possible exploration well to a planned Payara Development drill center [well locations are not finalized yet] (DC5-P), at 13.9 kilometers away.

5.3.2.1 Total Suspended Solids

Cumulative impacts from TSS are unlikely. From a spatial perspective, the maximum distance from a well location of a TSS plume exceeding 17.5 mg/L was 3.4 kilometers. Considering that the smallest distance between any two well locations (considering proposed exploration wells, Phase 1, Phase 2, and Payara) is 7.9 kilometers, there is no potential for overlap and therefore no resulting cumulative TSS impact.

5.3.2.2 Cuttings Depositional Thickness

Cumulative impacts due to cuttings accumulation overlap (considering proposed exploration wells, Phase 1, Phase 2, and Payara) are also unlikely. The longest cuttings deposition mound exceeding 2.5 centimeters is 145 meters, roughly centered on the well. This distance is much smaller than the smallest distance between any two well locations (7.9 kilometers).

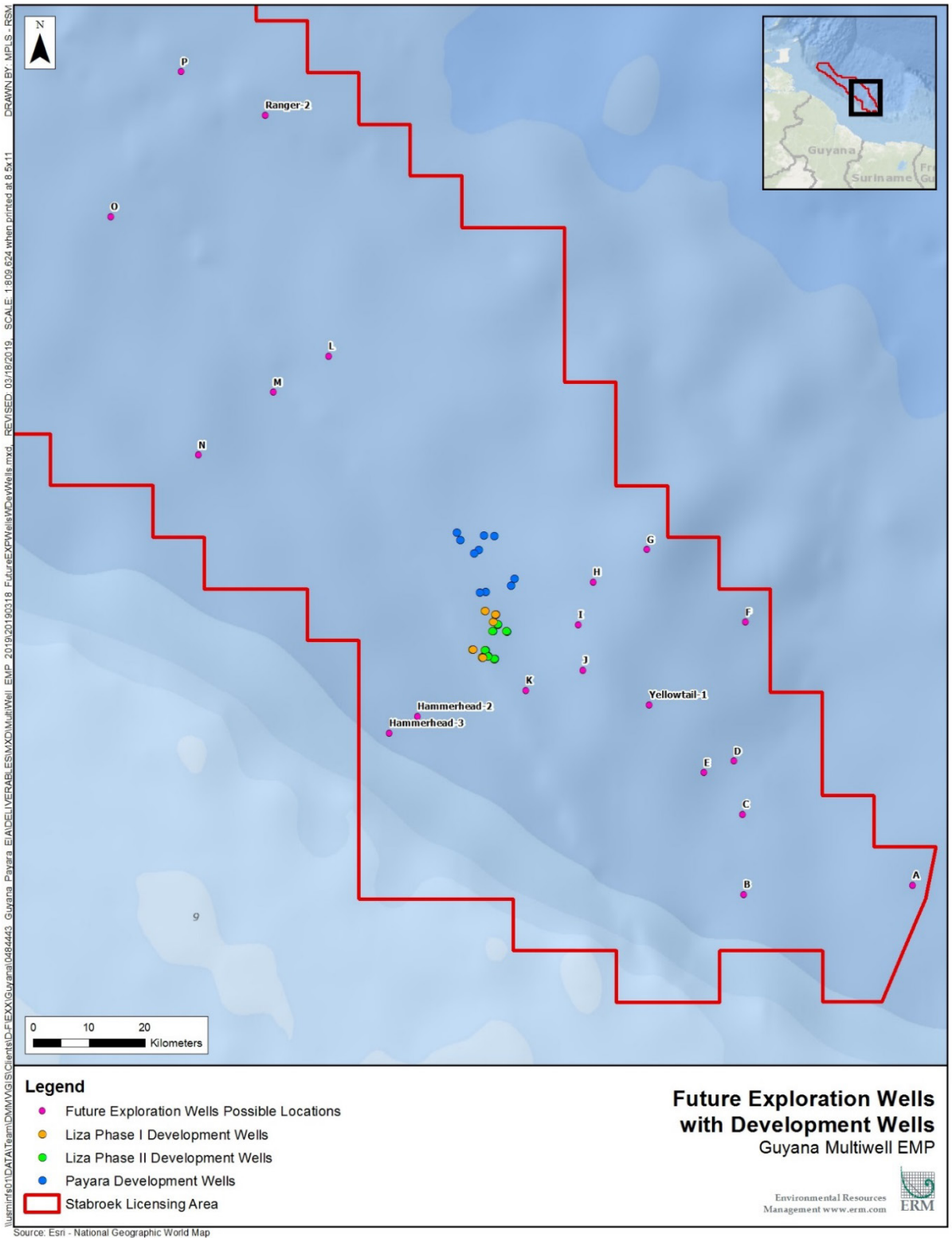


Figure 5-21: Locations of Proposed Exploration Wells Compared to Locations of Existing and Planned Development Wells (Phase 1, Phase 2, and Payara)

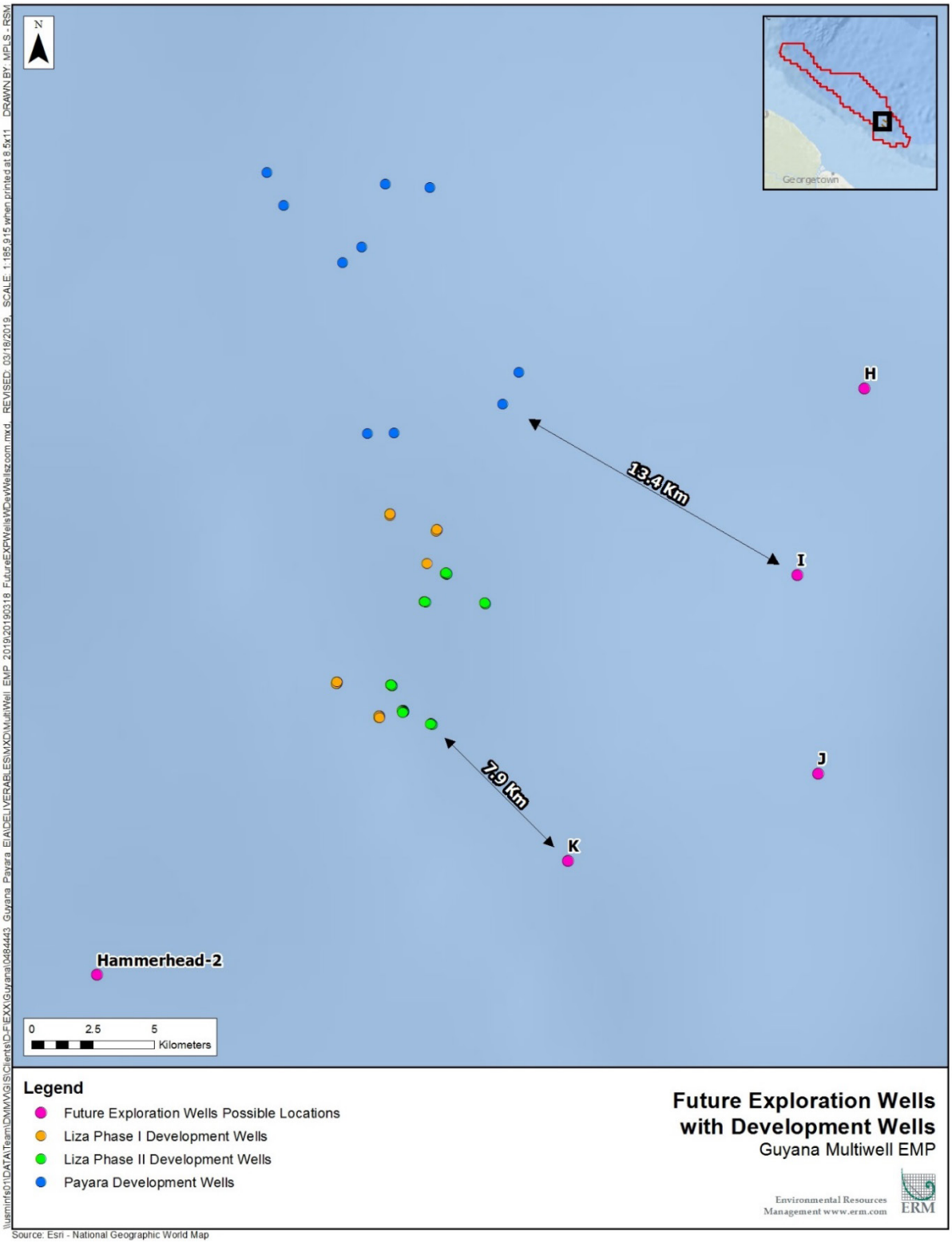


Figure 5-22: Distances of the Closest Proposed Exploration Well Locations to Development Well Locations

6. CANJE 3-WELL EXPLORATION CAMPAIGN (EA&MP)

6.1 Introduction

6.1.1 Approach

In support of the Proposed Canje 3-well Exploration Drilling Project (Project) Environmental Assessment & Management Plan, Esso Exploration and Production Guyana Limited (EEPGL) commissioned Environmental Resources Management (ERM) to model drill cuttings deposition from planned Project activities to evaluate the potential impacts to water quality and sediment. The evaluation is for individual and cumulative impacts during the planned drilling of exploration wells as part of a proposed Canje 3-well exploration drilling program expansion (hereafter referred to as “the Project”). Exact locations for the 3 wells have not been determined, but existing information indicates they will be within Prospect Areas 1 and 3, shown on Figure 6-1.

It is assumed that there will be a direct discharge of cuttings with water-based drilling fluids near the seabed during drilling of the initial riserless open-hole section and the second section at each well. For the remaining two (deeper) well sections, it is assumed that cuttings will be discharged from the drill ship, with a small fraction of adhered non-aqueous drilling fluid from material removed in the lower well sections, after treatment on the drill ship.

Modeling was performed to predict the following as a result of these cuttings and fluids discharge:

- Total suspended solids (TSS) concentrations in the water column; and
- Seabed accumulation (thickness) of the adhered muds and drill cuttings on the seafloor.

To evaluate cumulative impacts, this report considers locations of previously proposed and completed exploration wells, potential locations for the proposed exploration wells comprising the Project, and previously completed and to-be-completed development wells. Proximity of all of these wells to the proposed wells as part of the Project was reviewed to understand the potential cumulative effects. A mapping exercise was then performed to evaluate potential for overlap from these individual discharges.

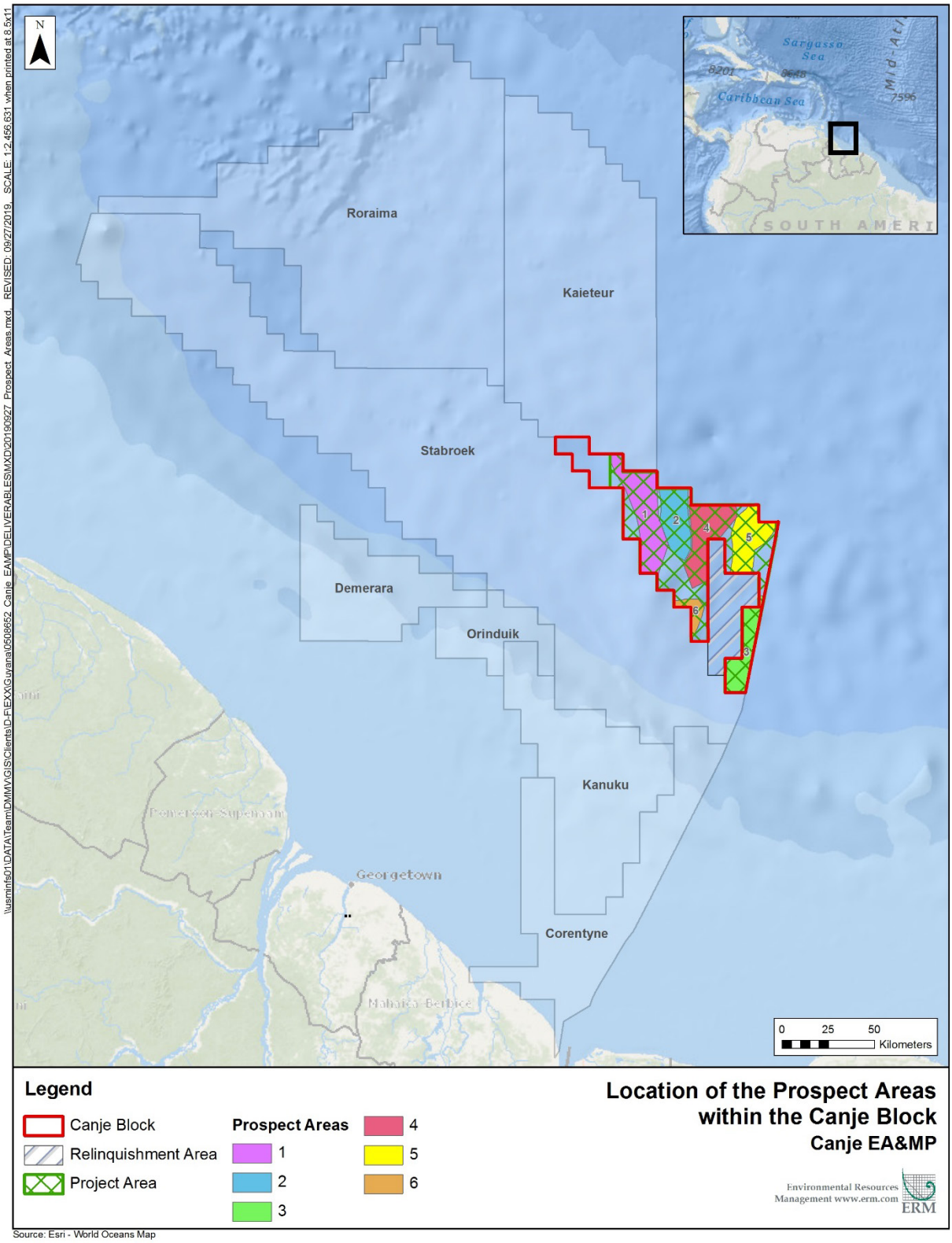


Figure 6-1: Location of the Prospect Areas Within the Canje Block

6.1.1.1 Simulation Design

Released material will pass vertically through the water column because cuttings and muds are denser than the receiving water. Released material will also migrate horizontally due to advection by local and regional currents. The dispersion of cuttings and muds is fundamentally a three-dimensional phenomenon requiring three-dimensional hydrodynamic fate and transport modeling.

The locations of the proposed Project wells were chosen based on the water depths at the two Prospect Areas, and were classified as shallow, middle, and deep. Since the released material migrates downwards, the depth that these cuttings and muds have to travel determines the time they are in suspension, and eventually how far they spread laterally. A shallow location would result in quicker settling and a consequently smaller lateral spread. At a deeper location, cuttings and muds will take longer to settle, facilitating a larger lateral spread. The middle depth location gives an approximation in between. The representative shallow well location is tentatively named “CBPA3_Shallow” while the representative middle depth and deep well locations are tentatively named “CBPA1_Middle” and “CBPA1_Deep,” respectively (see Table 6-1 and Table 5-2). The minimum and maximum monthly-averaged, depth-averaged currents scenarios were modeled to represent a range of impacts in seabed cuttings accumulation and TSS concentrations.

Table 6-1: Selected Modeling Locations of Project Exploration Wells and Water Column Depths

Name	X	Y	Latitude	Longitude	Approximate Water Depth (meters)
CBPA3_Shallow	578533	861265	7.791055	-56.28773	-1,837
CBPA1_Middle	535670	926035	8.377399	-56.67601	-2,418
CBPA1_Deep	526622	974295	8.81398	-56.757916	-3,000

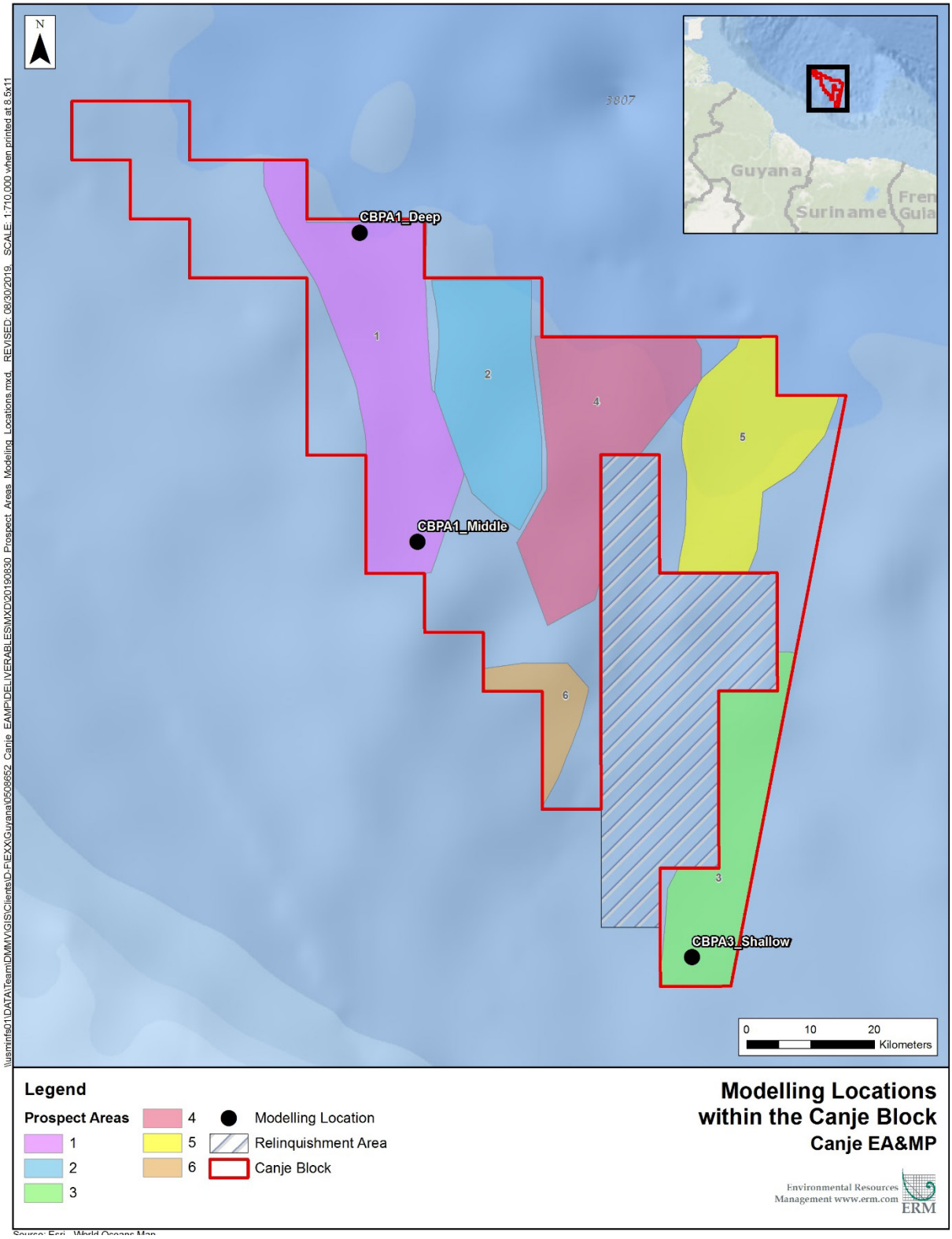


Figure 6-2: Modeling Locations Within the Canje Block

6.2 Individual Well Results

6.2.1 Total Suspended Solids

The International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL 73/78) recommends a TSS threshold of 35 milligrams per liter (mg/L) for effluent discharges from marine vessels.

6.2.1.1 Representative Shallow Well (CBPA3_Shallow)

Minimum Currents

The minimum currents scenario for the shallow well had a maximum TSS concentration of approximately 1,135 mg/L, which occurred near the sea bottom, as shown in Figure 6-3. Figure 6-4 shows maximum TSS concentrations near the surface. The area exceeding 35 mg/L is larger near the sea bottom and covers an area of 0.10 square kilometers (km²). The maximum TSS concentration is sustained for a very short time period, as ambient currents tend to further spread and settling tends to remove particles from the water column. The TSS concentration peaks (within the water column) with time are shown in Figure 6-5. Within a few days (less than 3 days), the TSS concentrations drop to below 35 mg/L.

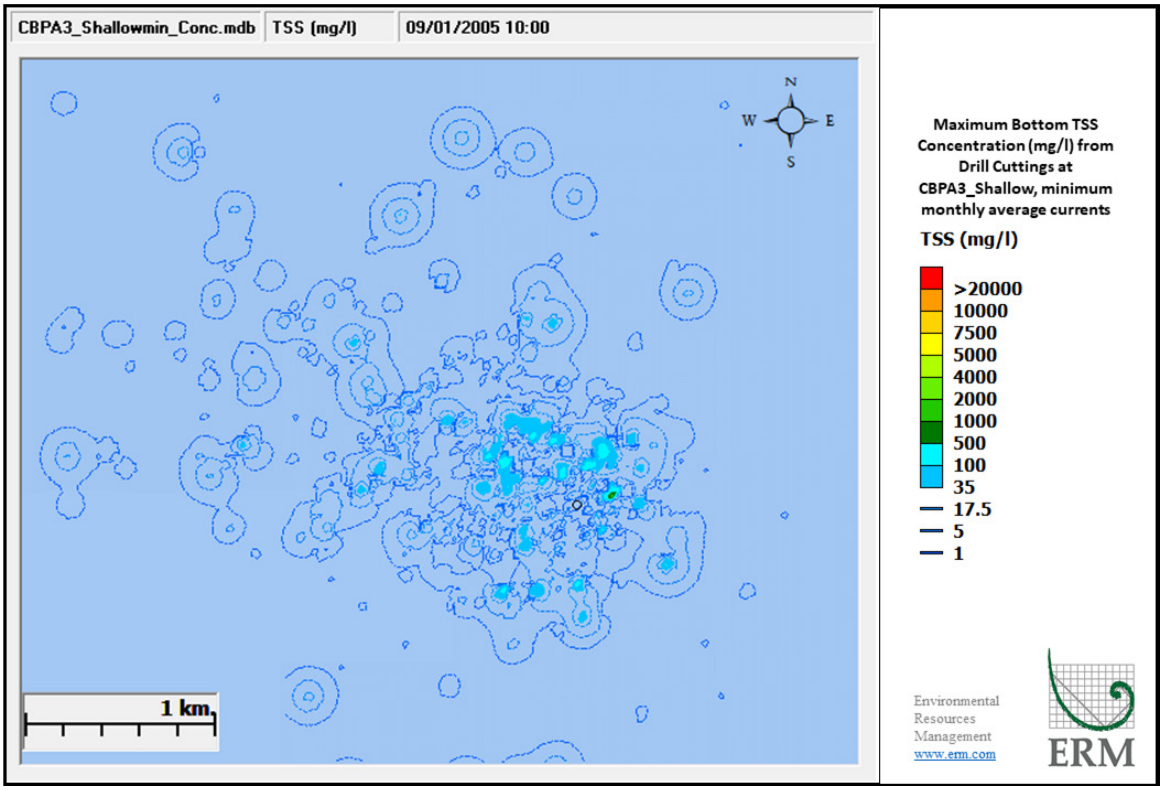


Figure 6-3: Maximum TSS Concentrations at Sea Bottom at the Shallow Well Under Minimum Currents

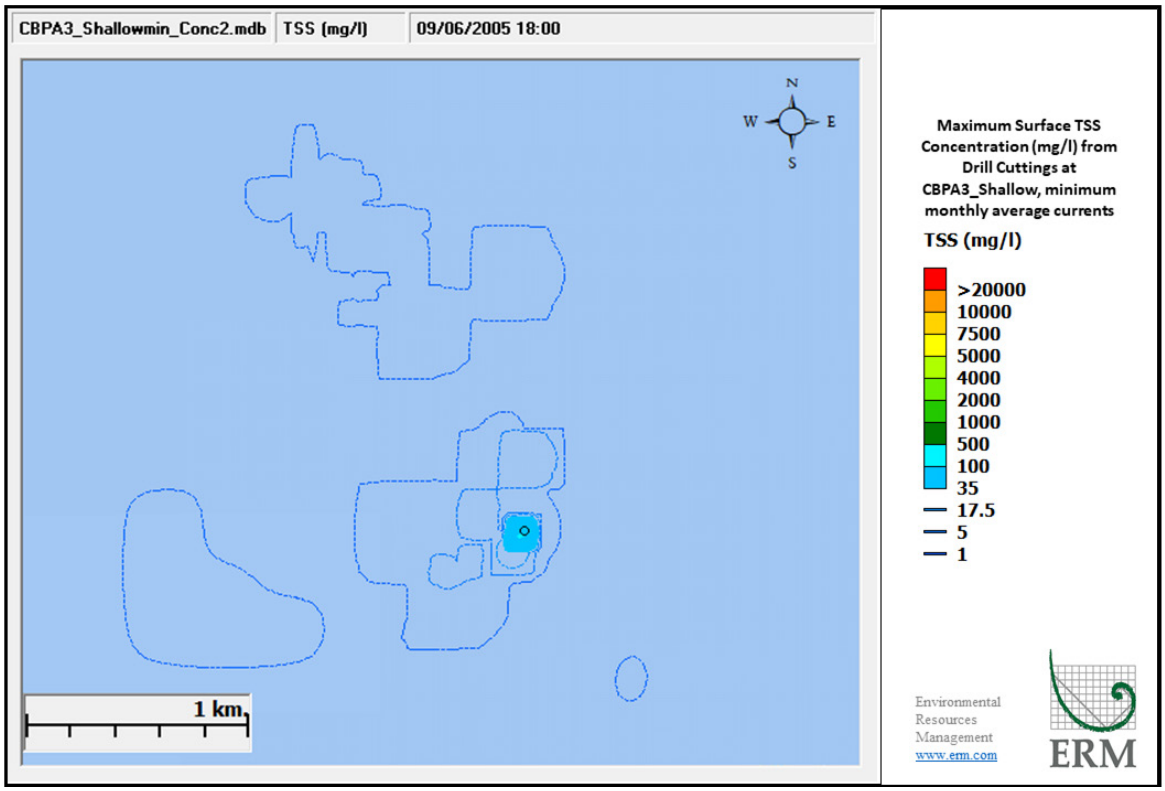


Figure 6-4: Maximum TSS Concentrations at Surface at the Shallow Well Under Minimum Currents

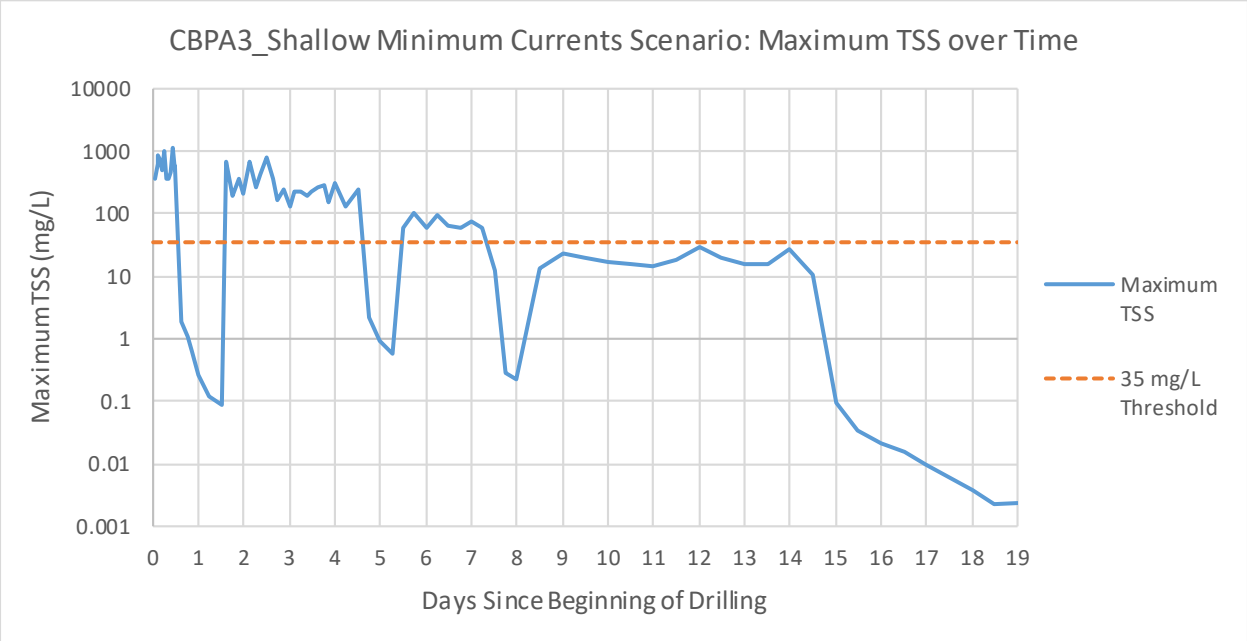


Figure 6-5: Maximum TSS Concentration Peak at Shallow Well Within the Water Column with Time Under Minimum Currents

Maximum Currents

The maximum currents scenario for the shallow well had a maximum TSS concentration of approximately 913 mg/L, which occurred near the sea bottom as shown in Figure 6-6. Figure 6-7 shows maximum TSS concentrations near the surface. The area exceeding 35 mg/L is larger at the sea bottom and covers 0.13 km^2. Temporally, the TSS concentration peaks exist only for a short duration of time as shown in Figure 6-8. The peak TSS concentration levels (within the water column) drop below the impact threshold (35 mg/L) within 3 days.

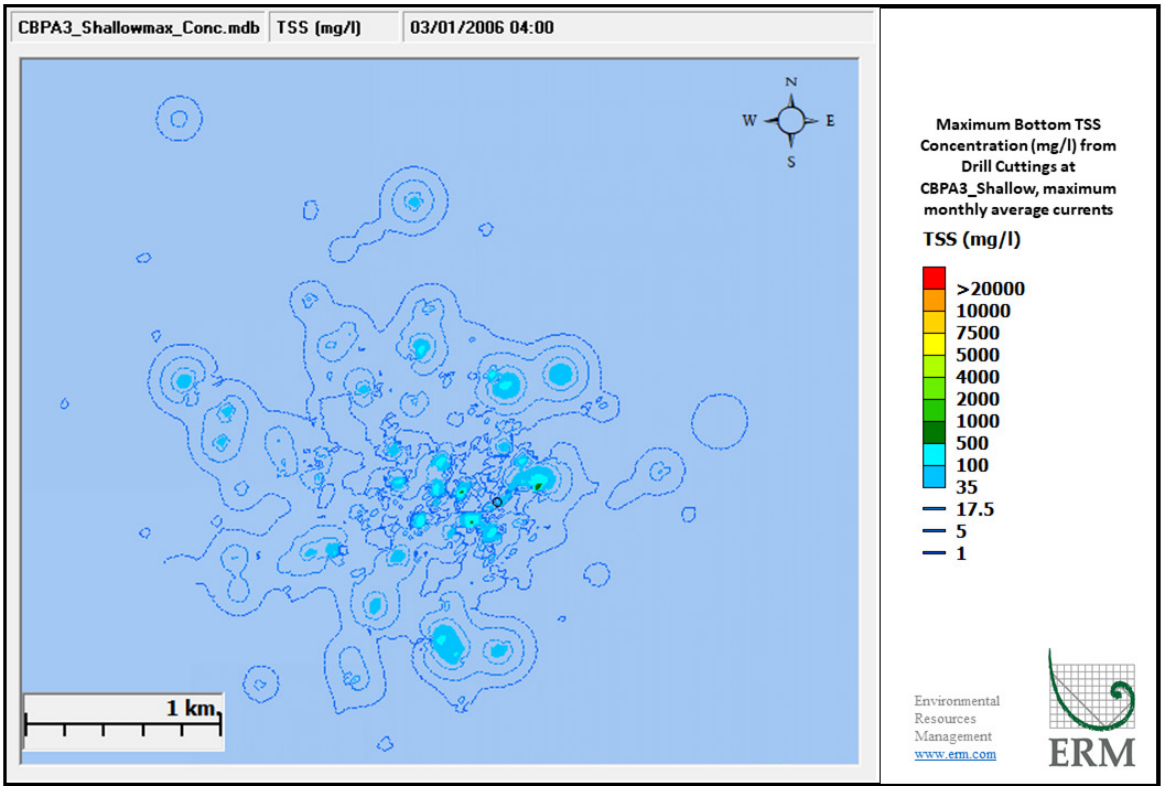


Figure 6-6: Maximum TSS Concentrations at Sea Bottom at the Shallow Well Under Maximum Currents

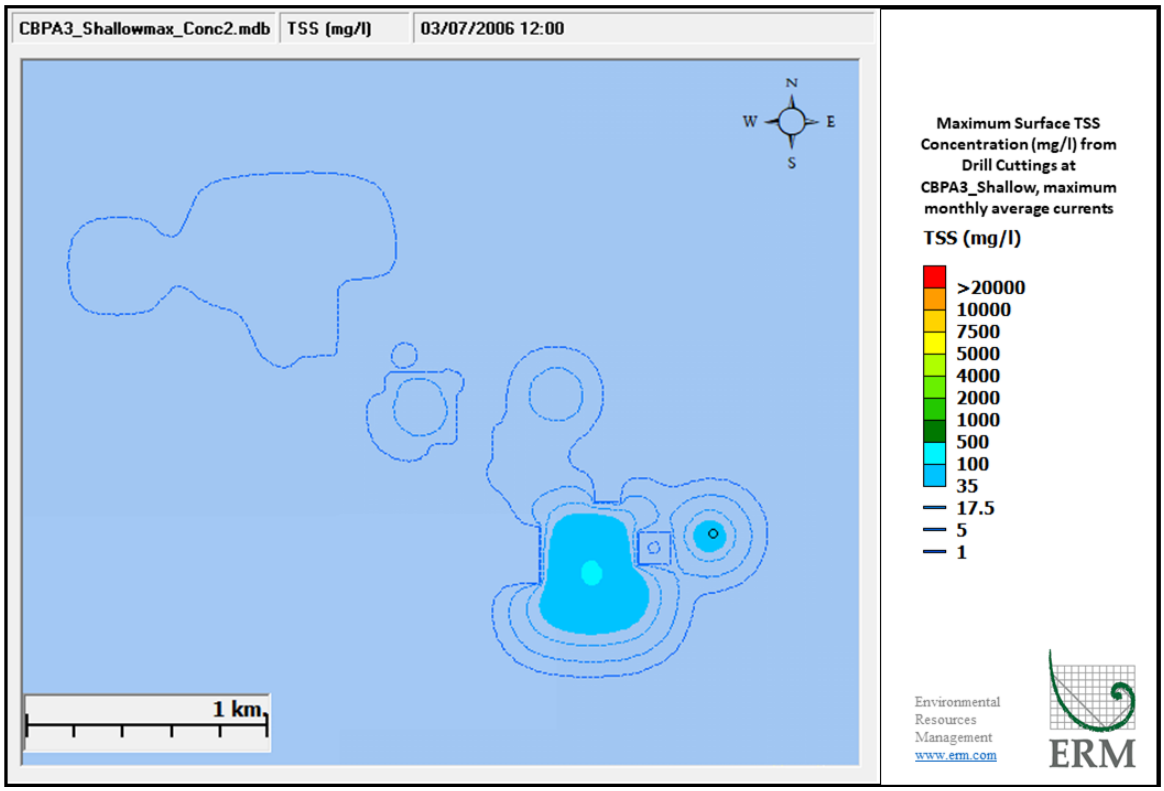


Figure 6-7: Maximum TSS Concentrations at Surface at the Shallow Well Under Maximum Currents

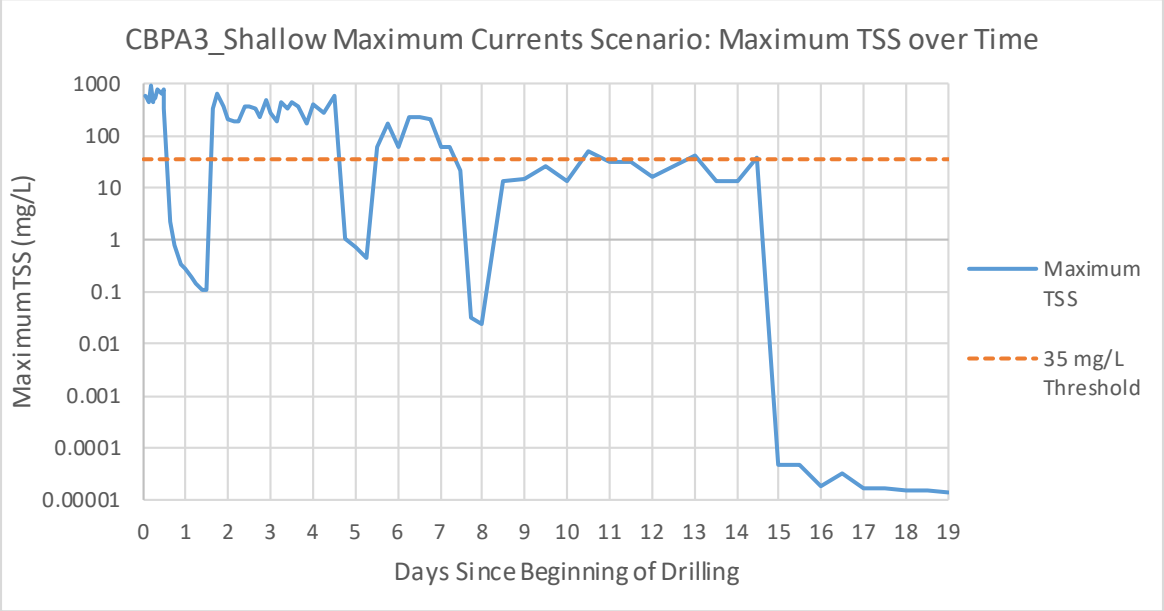


Figure 6-8: Maximum TSS Concentration Peak at Shallow Well Within the Water Column with Time Under Minimum Currents

6.2.1.2 Representative Middle Well (CBPA1_Middle)

Minimum Currents

The minimum currents scenario for the middle depth well had a maximum TSS concentration of approximately 4,517 mg/L, which occurred near the sea bottom shown in Figure 6-9. Figure 6-10 shows maximum TSS concentrations near the surface. The area exceeding 35 mg/L is larger at the sea bottom and covers 0.14 km². As noted for the shallow well, the TSS concentration peaks are temporary in nature as shown in Figure 6-11, which shows maximum TSS concentrations within the water column over time.

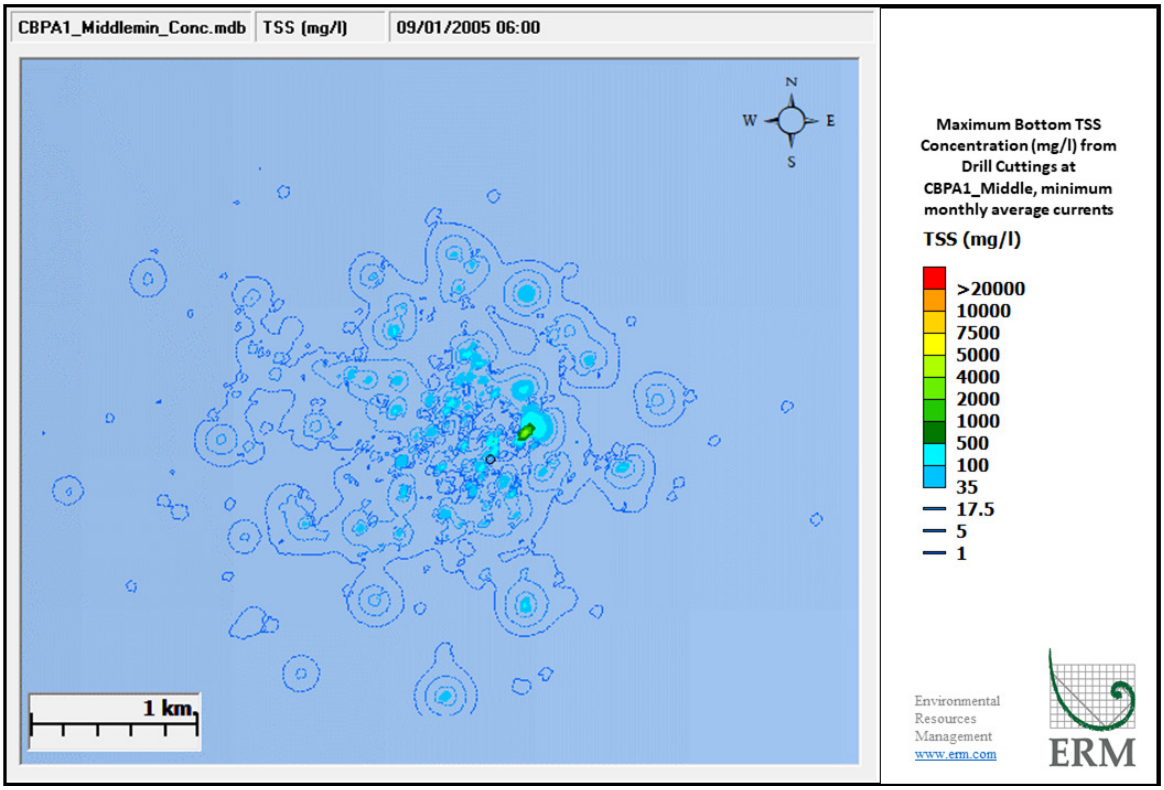


Figure 6-9: Maximum TSS Concentrations at Sea Bottom at the Middle Depth Well Under Minimum Currents

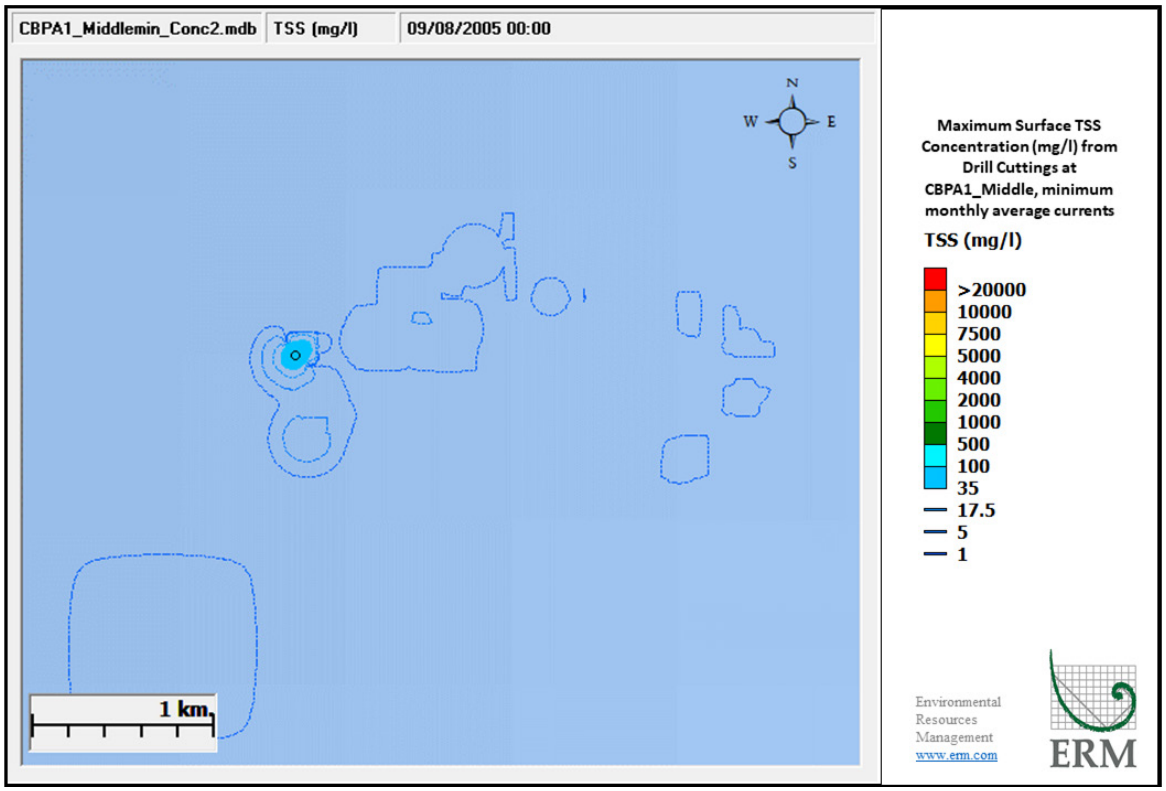


Figure 6-10: Maximum TSS Concentrations at Surface at the Middle Depth Well Under Minimum Currents

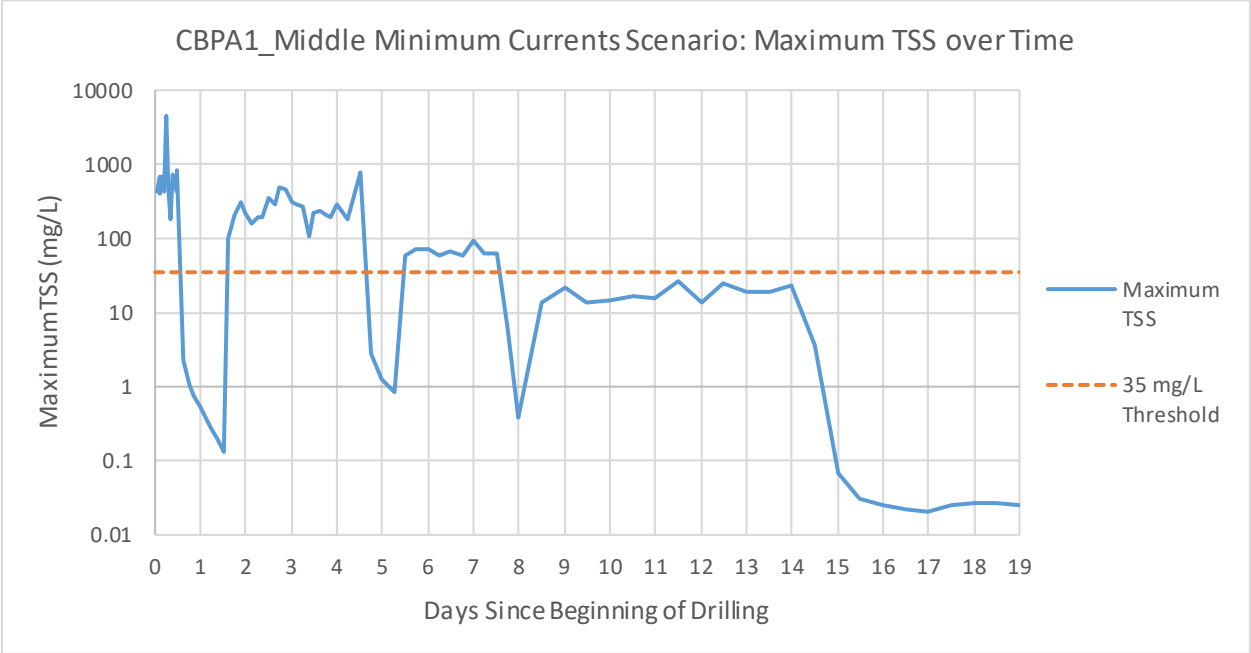


Figure 6-11: Maximum TSS Concentration Peak at Middle Depth Well Within the Water Column with Time Under Minimum Currents

Maximum Currents

The maximum currents scenario for the middle depth well had a maximum TSS concentration of approximately 2,248 mg/L, which occurs near the sea bottom as shown in Figure 6-12. Figure 6-13 shows maximum TSS concentrations near the surface. The area exceeding 35 mg/L is larger at the sea bottom and covers 0.15 km². As noted for the other scenarios, the TSS concentration peaks are temporary in nature as shown in Figure 6-14, which shows maximum TSS concentrations within the water column.

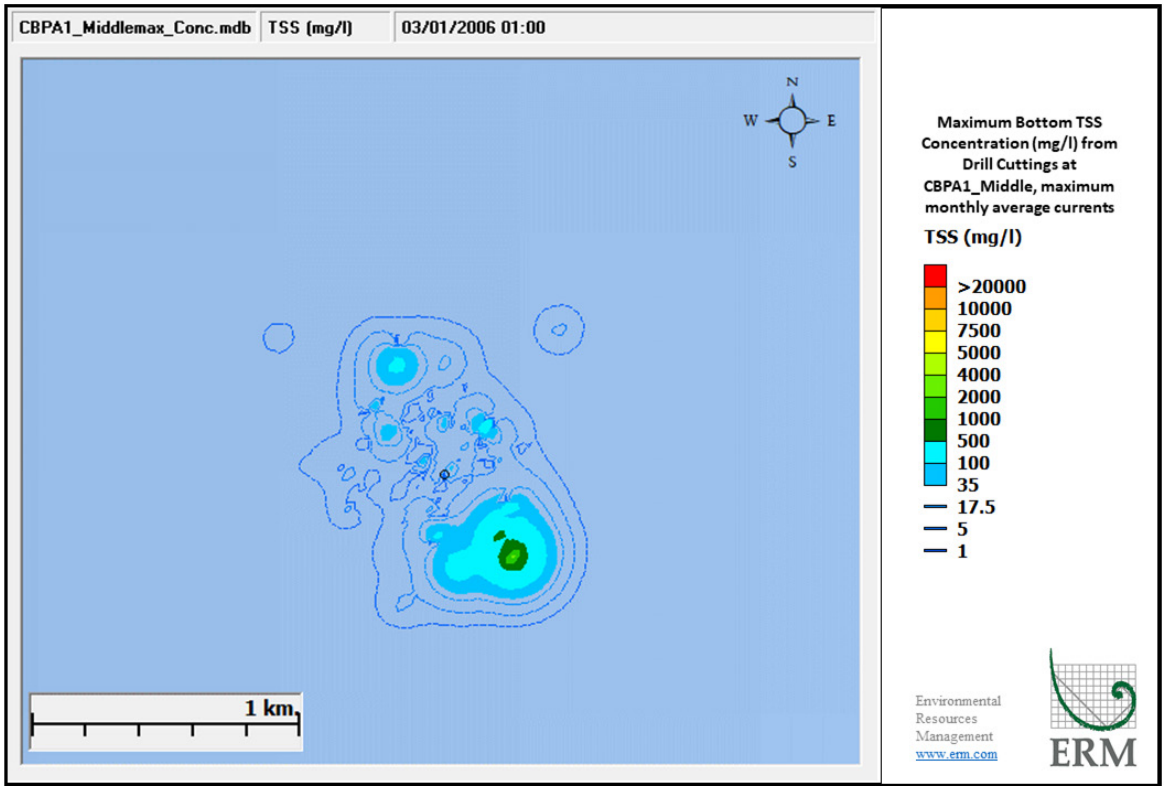


Figure 6-12: Maximum TSS Concentrations at Sea Bottom at the Middle Depth Well Under Maximum Currents

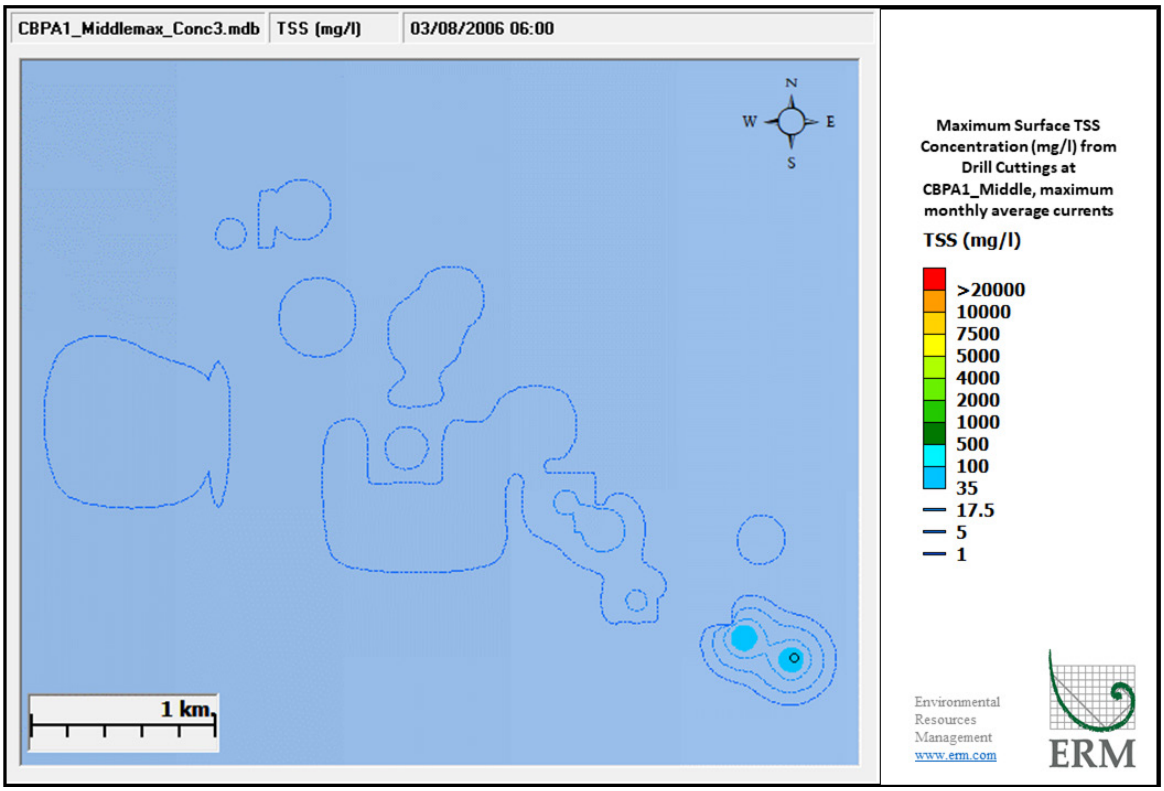


Figure 6-13: Maximum TSS Concentrations at Surface at the Middle Depth Well Under Maximum Currents

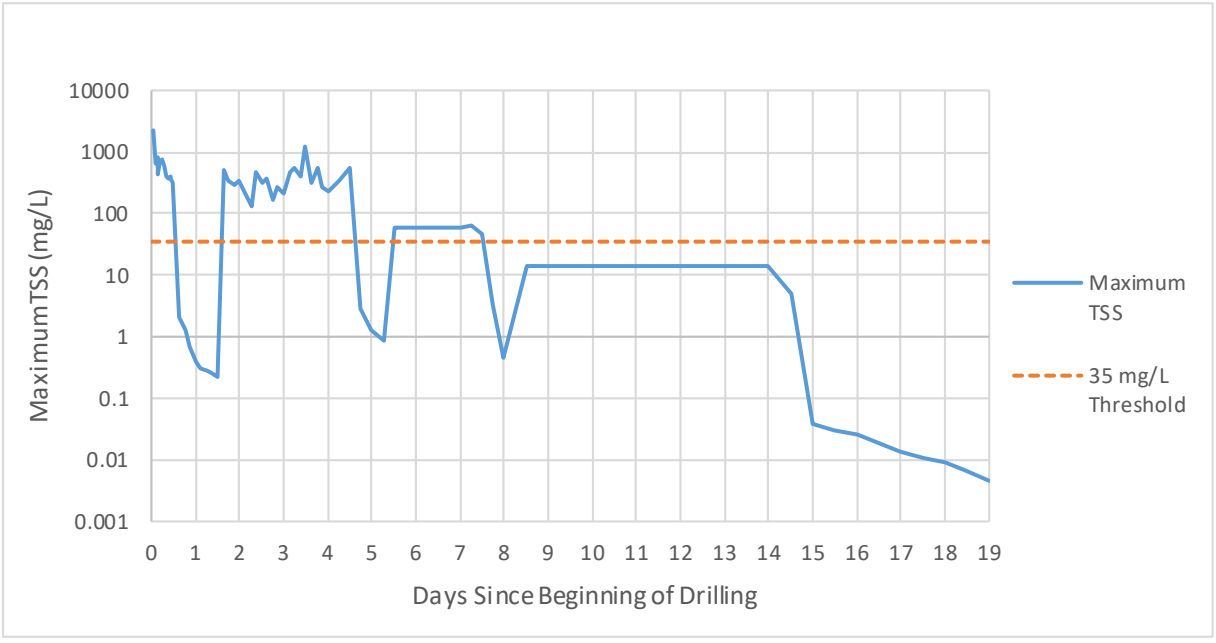


Figure 6-14: Maximum TSS Concentration Peak at the Middle Depth Within the Water Column with Time Under Maximum Currents

6.2.1.3 Representative Deep Well (CBPA1_Deep)

Minimum Currents

The minimum currents scenario for the deep well had a maximum TSS concentration of approximately 1,471 mg/L, which occurred near the sea bottom shown in Figure 6-15. Figure 6-16 shows maximum TSS concentrations near the surface. The area exceeding 35 mg/L is larger at the sea bottom and covers 0.17 km². As noted for the shallow and middle depth well, the TSS concentration peaks are temporary in nature, as shown in Figure 6-17, which shows maximum TSS concentrations within the water column over time.

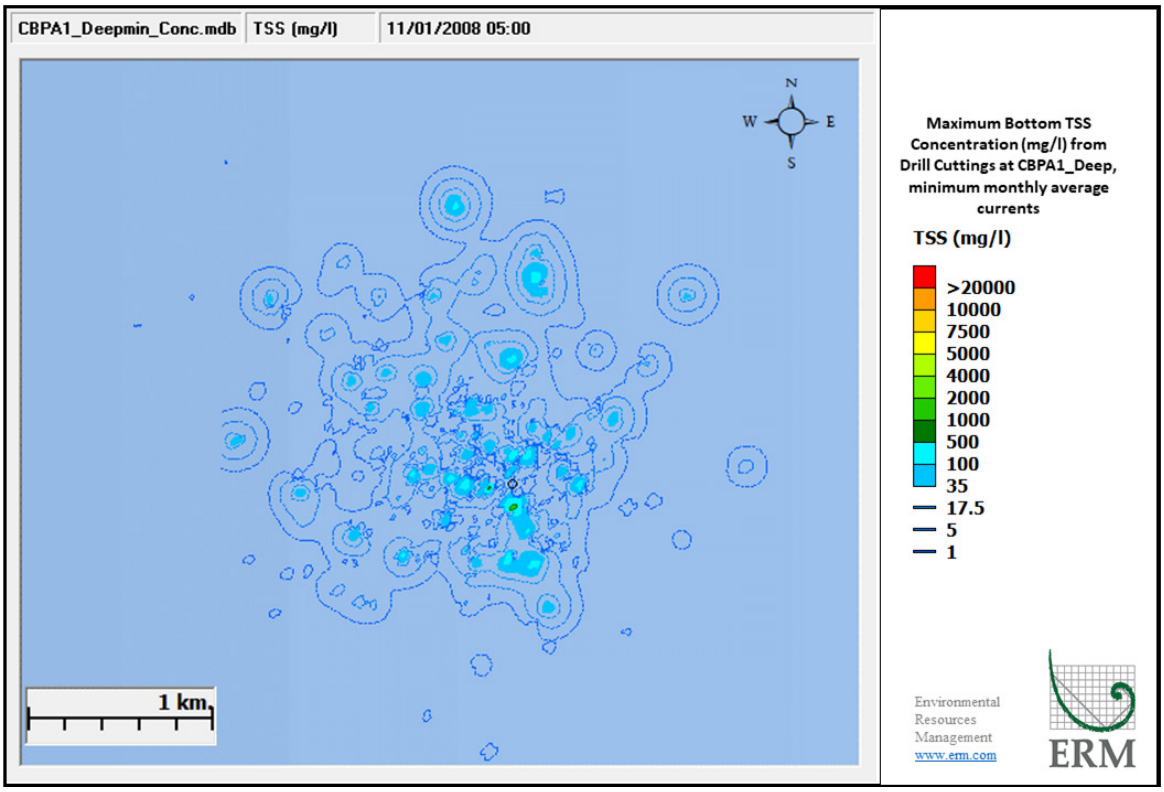


Figure 6-15: Maximum TSS Concentrations at Sea Bottom at the Deep Well Under Minimum Currents

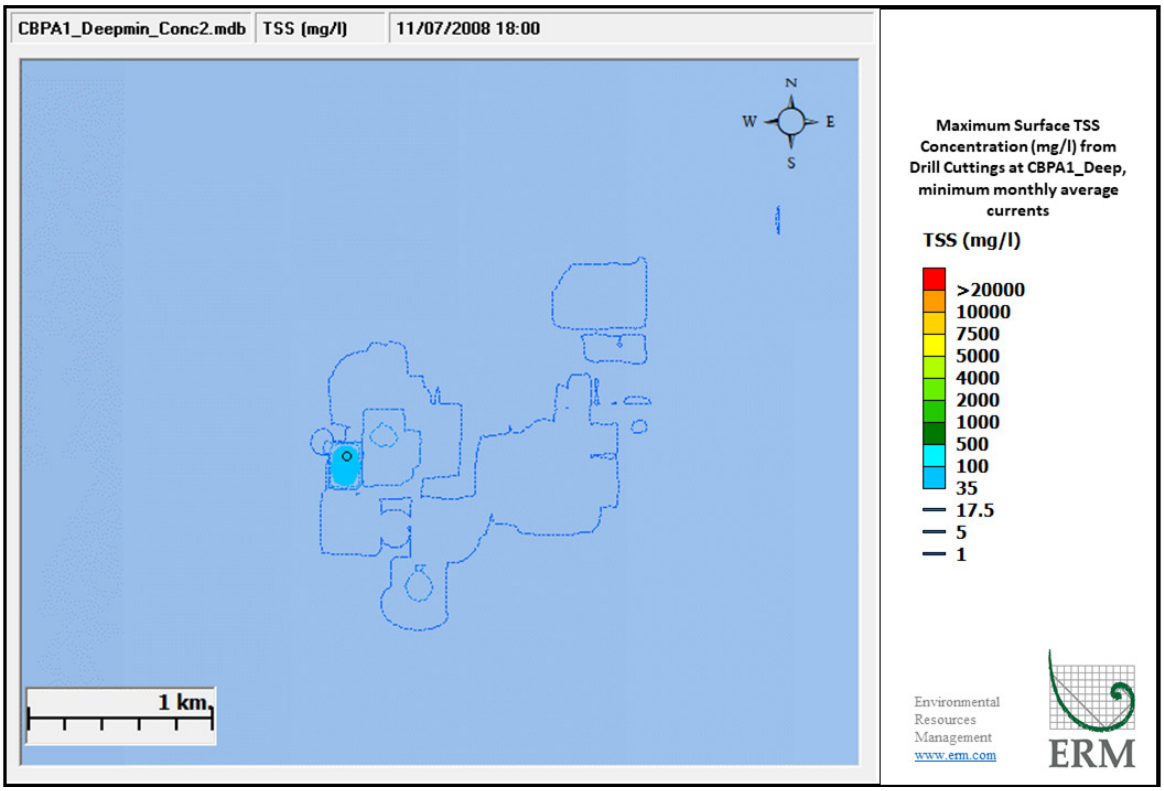


Figure 6-16: Maximum TSS Concentrations at Surface at the Deep Well Under Minimum Currents

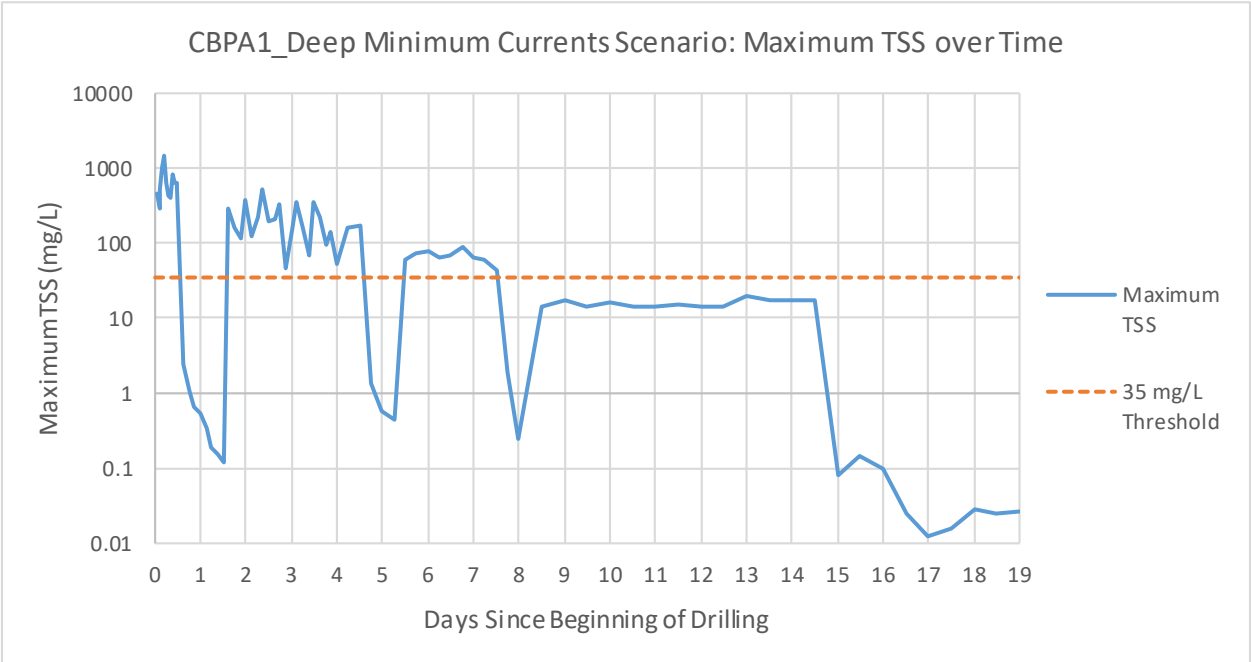


Figure 6-17: Maximum TSS Concentration Peak at Deep Well Within the Water Column with Time Under Minimum Currents

Maximum Currents

The maximum currents scenario for the deep well had a maximum TSS concentration of approximately 1,074 mg/L, which occurs near the sea bottom as shown in Figure 6-18. Figure 6-19 shows maximum TSS concentrations near the surface. The area exceeding 35 mg/L is larger at the sea bottom and covers 0.008 km². As noted for the other scenarios, the TSS concentration peaks are temporary in nature as shown in Figure 6-20, which shows maximum TSS concentrations within the water column over time.

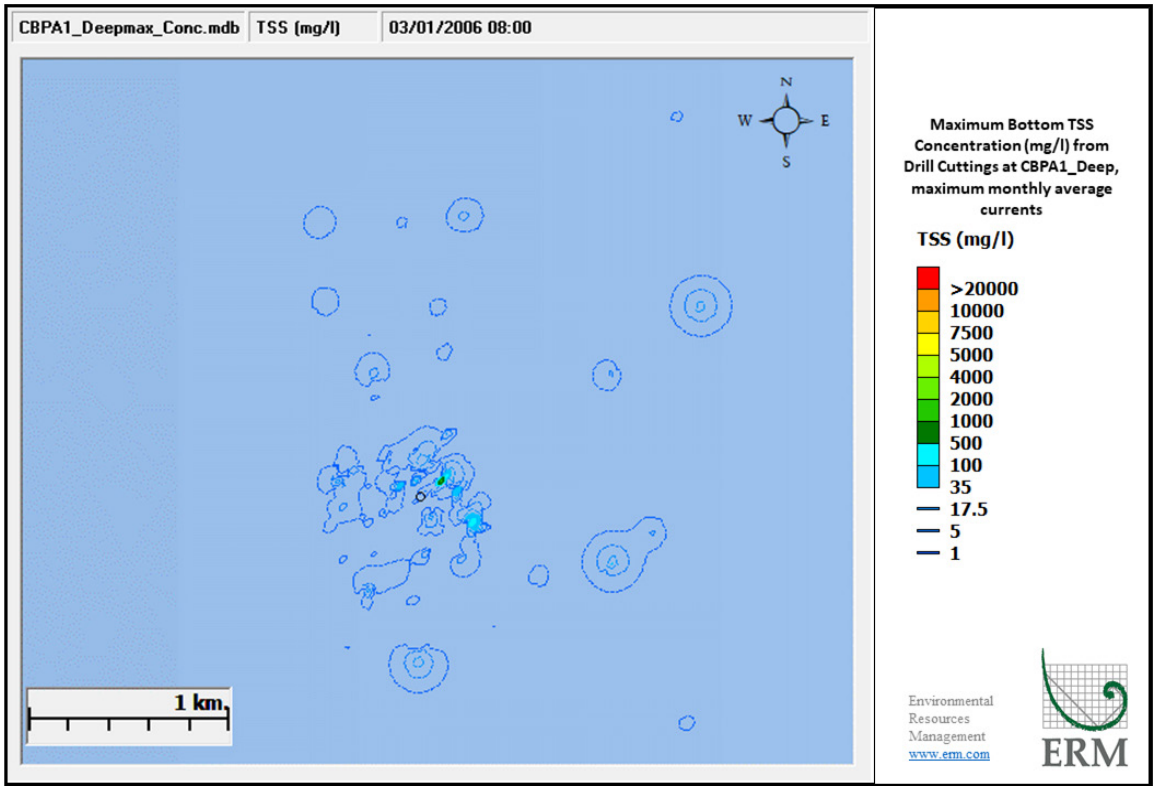


Figure 6-18: Maximum TSS Concentrations at Sea Bottom at the Deep Well Under Maximum Currents

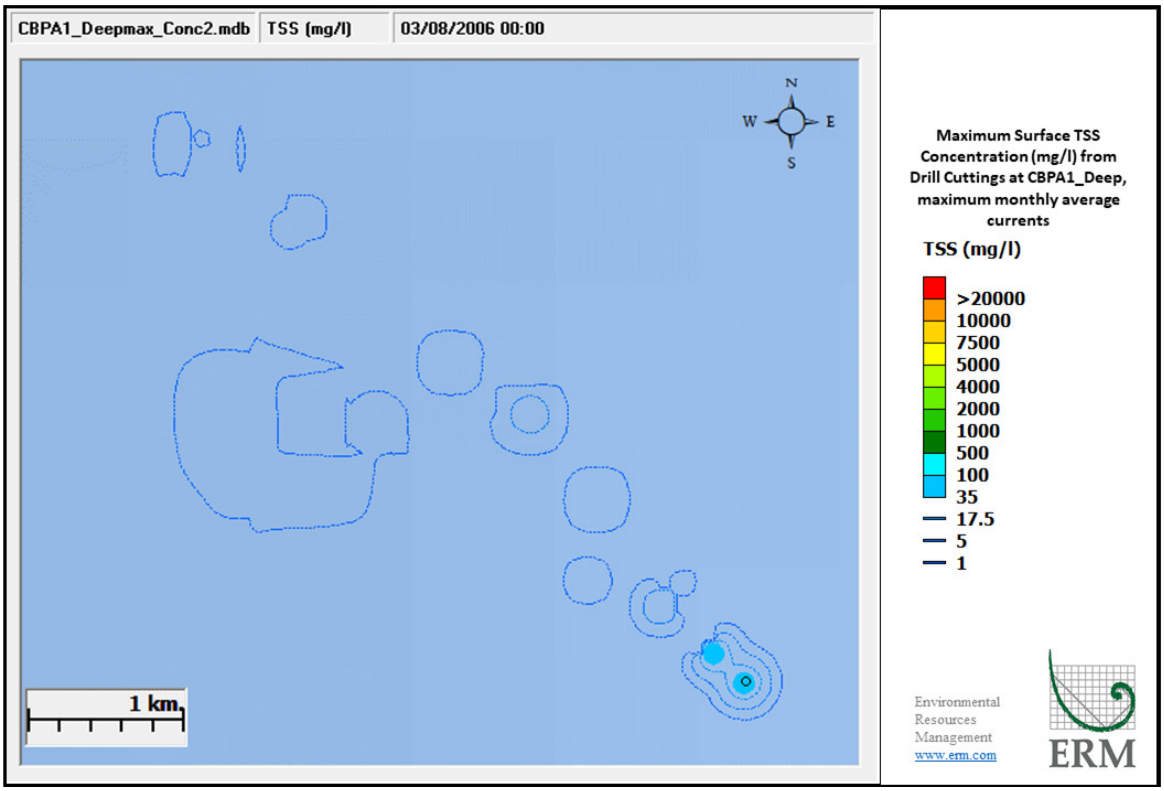


Figure 6-19: Maximum TSS Concentrations at Surface at the Deep Well Under Maximum Currents

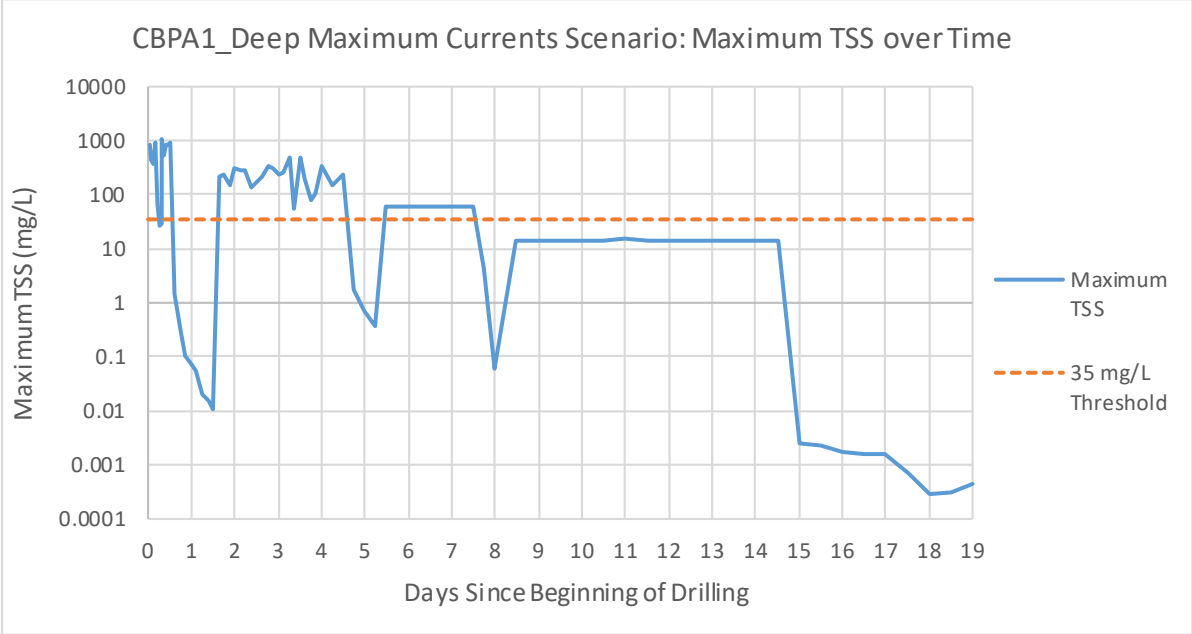


Figure 6-20: Maximum TSS Concentration Peak at Deep Well Within the Water Column with Time Under Maximum Currents

6.2.1.4 Summary

Table 6-2 summarizes the results found in the TSS analysis for the three well locations under minimum and maximum currents scenarios.

Table 6-2: Summary of Results for Deep, Middle Depth, and Shallow Wells under Different Currents at Time of Maximum TSS Occurrence

	Section 1 and 2 - Bottom Release		Sections 3 and 4 - Surface Release	
Scenario	**Maximum Bottom TSS (mg/L)**	**Area (km^2) with TSS > 35 mg/L threshold**	**Maximum Surface TSS (mg/L)**	**Area (km^2) with TSS > 35 mg/L threshold**
CBPA1_Deepmin	1,471	0.1680	89.5	0.0241
CBPA1_Deepmax	1,074	0.0078	60.5	0.0246
CBPA1_Middlemin	4,517	0.1390	96.03	0.0186
CBPA1_Middlemax	2,248	0.1542	61.99	0.0254
CBPA3_Shallow min	1,135	0.1038	102.19	0.0205
CBPA3_Shallow max	913	0.1265	231.98	0.1762

6.2.2 Drill Cuttings Depositional Thickness

A threshold of 5 centimeters per month is suggested by MarLIN (2011) for smothering of benthic species.

6.2.2.1 Representative Shallow Well (CBPA3_Shallow)

Minimum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 5-centimeter threshold was 0.0046 km^2 as shown in Figure 6-21. The maximum length of this mound in any direction was 100 meters (328.1 feet).

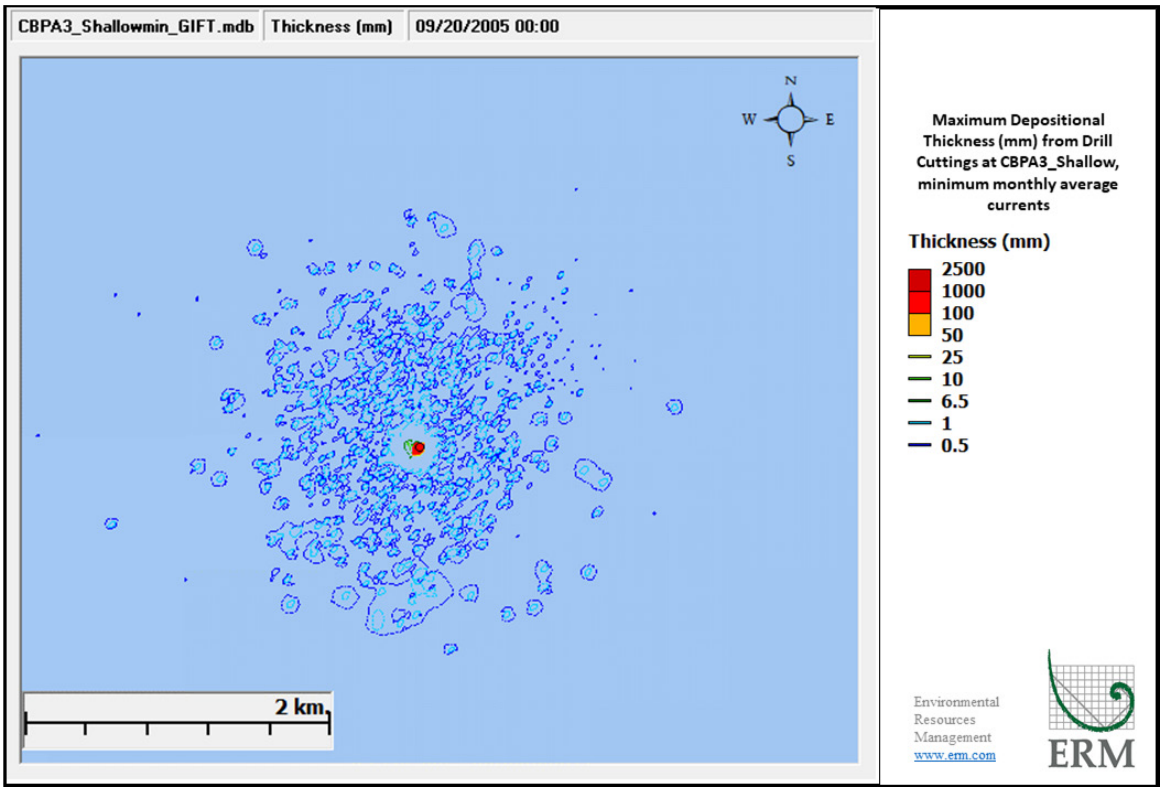


Figure 6-21: Maximum Cuttings Deposition Thickness for Shallow Well Under Minimum Currents

Maximum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 5-centimeter threshold was 0.0045 km^2 as shown in Figure 6-22. The maximum length of this mound in any direction was 100 meters (328.1 feet).

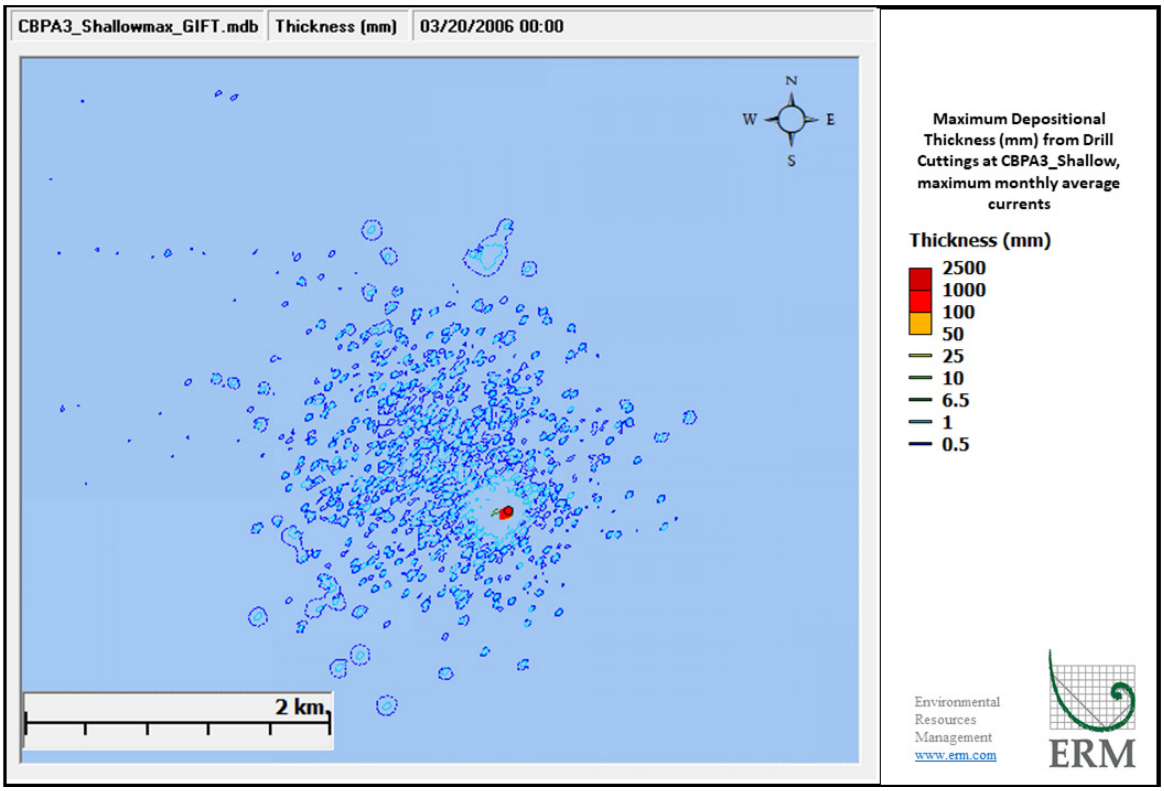


Figure 6-22: Maximum Cuttings Deposition Thickness for Shallow Well Under Maximum Currents

6.2.2.2 Representative Middle Depth Well (CBPA1_Middle)

Minimum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 5-centimeter threshold was 0.0046 km^2 as shown in Figure 6-23. The maximum length of this mound in any direction was 100 meters (328.1 feet).

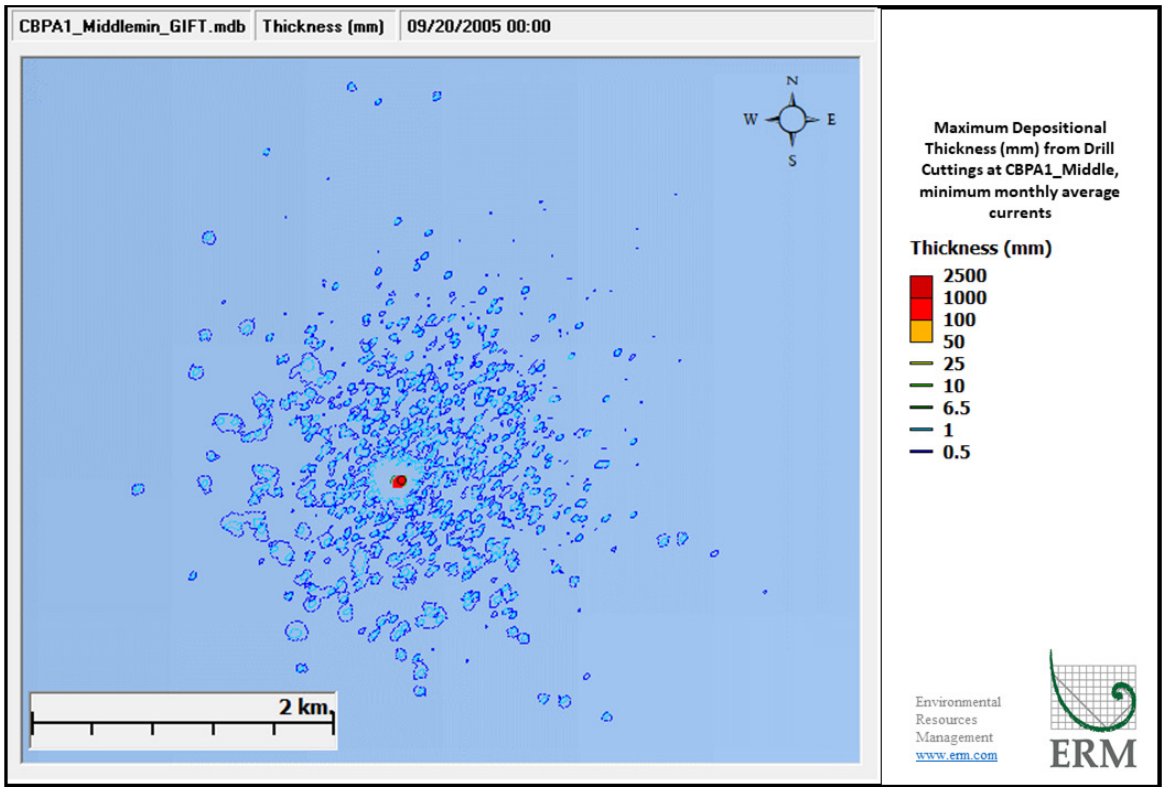


Figure 6-23: Maximum Cuttings Deposition Thickness for Middle Depth Well Under Minimum Currents

Maximum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 5-centimeter threshold was 0.0046 km^2 as shown in Figure 6-24. The maximum length of this mound in any direction was 102 meters (334.6 feet).

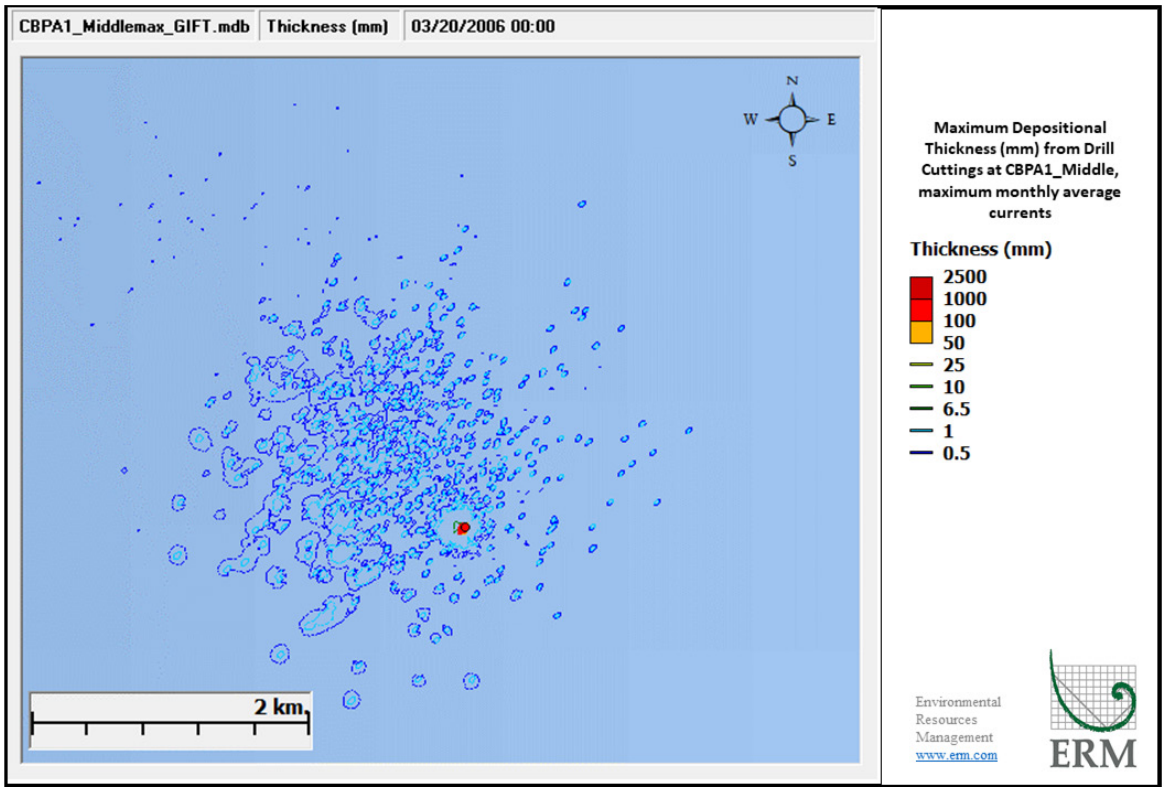


Figure 6-24: Maximum Cuttings Deposition Thickness for Middle Depth Well Under Maximum Currents

6.2.2.3 Representative Deep Well (CBPA1_Deep)

Minimum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 5-centimeter threshold was 0.0047 km^2 as shown in Figure 6-25. The maximum length of this mound in any direction was 104 meters (341.2 feet).

Maximum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 5-centimeter threshold was 0.0047 km^2 as shown in Figure 6-26. The maximum length of this mound in any direction was 103 meters (337.9 feet).

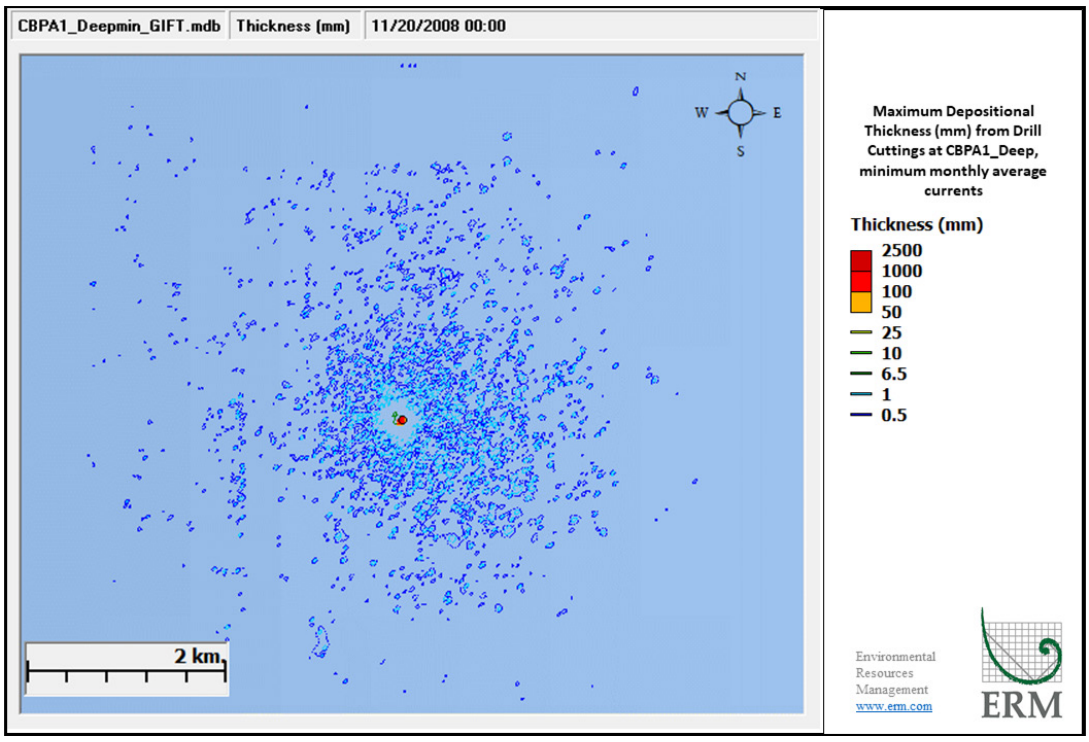


Figure 6-25: Maximum Cuttings Deposition Thickness for Deep Well Under Minimum Currents

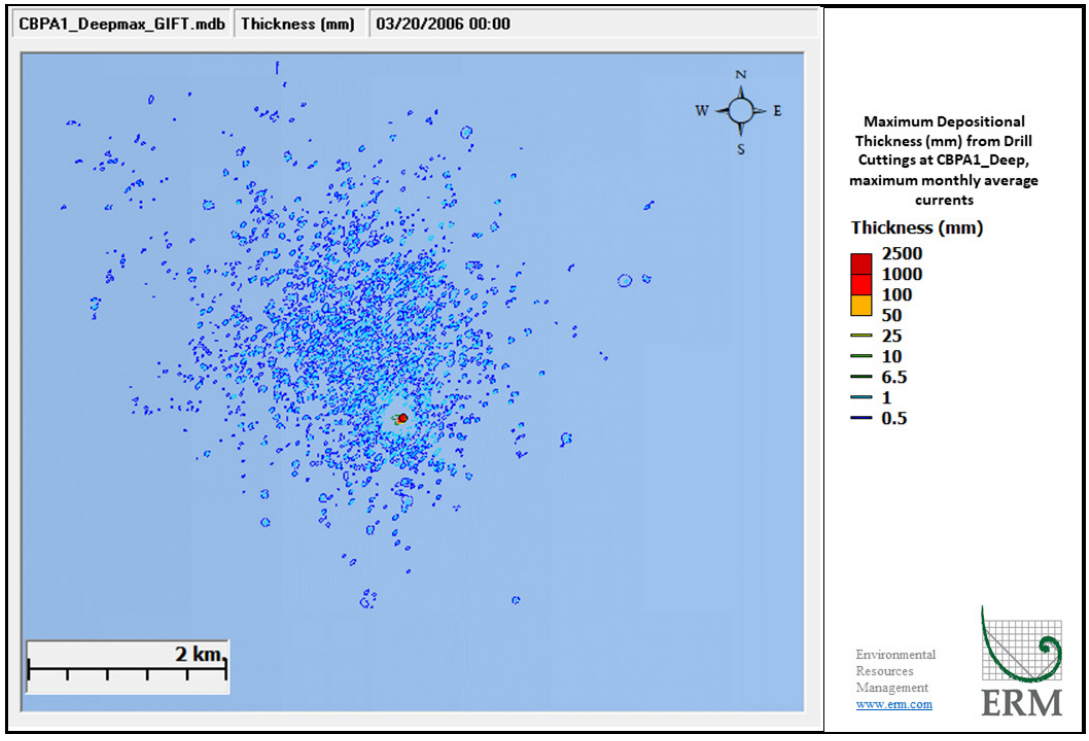


Figure 6-26: Maximum Cuttings Deposition Thickness for Deep Well Under Maximum Currents

6.2.2.4 Summary

Table 6-3 shows the cuttings accumulation (depositional thickness) analysis for the three well locations under minimum and maximum currents scenarios. Note that the table presents the area and length of the depositional mound exceeding the depositional threshold (5 centimeters).

Table 6-3: Summary of Cuttings Deposition Results for Deep, Middle Depth, and Shallow Wells under Different Currents

Scenario	Area (km^2) with Thickness > 5 cm threshold	Maximum Length of Mound(s) of Exceedance (meters)
CBPA1_Deepmin	0.0047	104
CBPA1_Deepmax	0.0047	103
CBPA1_Middlemin	0.0046	100
CBPA1_Middlemax	0.0046	102
CBPA3_Shallow min	0.0046	100
CBPA3_Shallow max	0.0045	100

6.3 Cumulative Impact Assessment Results

6.3.1 Assessment of Cumulative Impacts within the Project

Cumulative impacts from multiple wells could occur if the TSS plumes or cuttings deposits overlap. The depositional mound persists for a longer duration relative to the TSS plume, which is short-lived. The TSS plumes, as modeled and discussed in earlier sections, dissipate to less than the 35 mg/L threshold within 3 days or less. For the exploration wells to cause any cumulative impact with other wells in the region, the distance to half of the various thresholds (17.5 mg/L for TSS concentrations and 2.5 centimeters for depositional thickness) would have to exceed the separation distance between different wells (i.e., such that an overlap would result in a combined exceedance of the threshold). The distances between the various wells, as currently planned, are much larger than the extents of these plumes, as discussed further below. Based on the modeled results, the spatial extent of TSS concentrations at half the impact threshold is shown in Table 6-4. Similarly, the spatial extent of cuttings deposition at half of the impact threshold is shown in Table 6-5.

Table 6-4: Summary of Cuttings TSS Results for Deep, Middle Depth, and Shallow Wells under Different Currents with Respect to Half of Impact Threshold

	Sections 1 and 2 (Bottom Release)				Sections 3 and 4 (Surface Release)			
Scenario	Maximum Bottom TSS (mg/L)	Area (km^2) with TSS > 17.5 mg/L (50% of threshold)	Farthest Distance (meters) from Well with 17.5 mg/L Exceedance	Approximate Width (meters) of Plume at Farthest Extent of 17.5 mg/L Exceedance	Maximum Bottom TSS (mg/L)	Area (km^2) with TSS > 17.5 mg/L (50% of threshold)	Farthest Distance (meters) from Well with 17.5 mg/L Exceedance	Approximate Width (meters) of Plume at Farthest Extent of 17.5 mg/L Exceedance
CBPA1_Deepmin	1,471	0.4205	1,560	85	89.5	0.0451	271	141
CBPA1_Deepmax	1,074	0.0220	1,640	50	60.5	0.0669	350	214
CBPA1_Middlemin	4,517	0.3967	1,570	65	96	0.0363	140	251
CBPA1_Middlemax	2,248	0.2256	550	500	62	0.0719	361	222
CBPA3_Shallow min	1,135	0.2863	2,700	60	102.2	0.0343	177	270
CBPA3_Shallow max	913	0.2922	1,725	125	232	0.2627	820	560

Table 6-5: Summary of Cuttings Deposition Results for Deep, Middle Depth, and Shallow Wells under Different Currents with Respect to Half of Impact Threshold

Scenario	Area (km^2) with Thickness > 2.5 cm (50% of Threshold)	Length of Mound of Exceedance of 50% Threshold (meters)
CBPA1_Deepmin	0.0049	105
CBPA1_Deepmax	0.0049	105
CBPA1_Middlemin	0.0048	105
CBPA1_Middlemax	0.0048	104
CBPA3_Shallow min	0.0048	104
CBPA3_Shallow max	0.0049	104

6.3.1.1 Total Suspended Solids

As discussed before, due to the short-lived nature of the TSS plume, cumulative impacts from TSS concentrations are highly unlikely, as TSS plumes will not persist very long beyond the time of drilling, as shown previously in Figure 6-5, Figure 6-8, Figure 6-11, Figure 6-14, Figure 6-17, and Figure 6-20. Furthermore, from the spatial perspective, the maximum distance from a well location of a TSS plume exceeding 17.5 mg/L was 2.7 kilometers. Even in the event that the two closest proposed exploration wells are drilled simultaneously, their separation distance is 5.8 kilometers, which is more than twice the distance to the maximum 17.5 mg/L TSS concentration extent.

6.3.1.2 Cuttings Depositional Thickness

Cumulative impacts from seabed accumulation of cuttings are also unlikely. The maximum length of a sediment deposition mound exceeding 2.5 centimeters is 105 meters (344.5 feet), roughly centered on the well. This distance is significantly smaller than the smallest distance between the two closest wells (at 5.8 kilometers). In Figure 6-27 and Figure 6-28, the model results of the cuttings depositional thickness were applied to each possible well location for the minimum and maximum currents scenarios based on water depth classification. As seen in these figures, there will be no potential overlap and therefore no resulting cumulative impact from the proposed exploration wells.

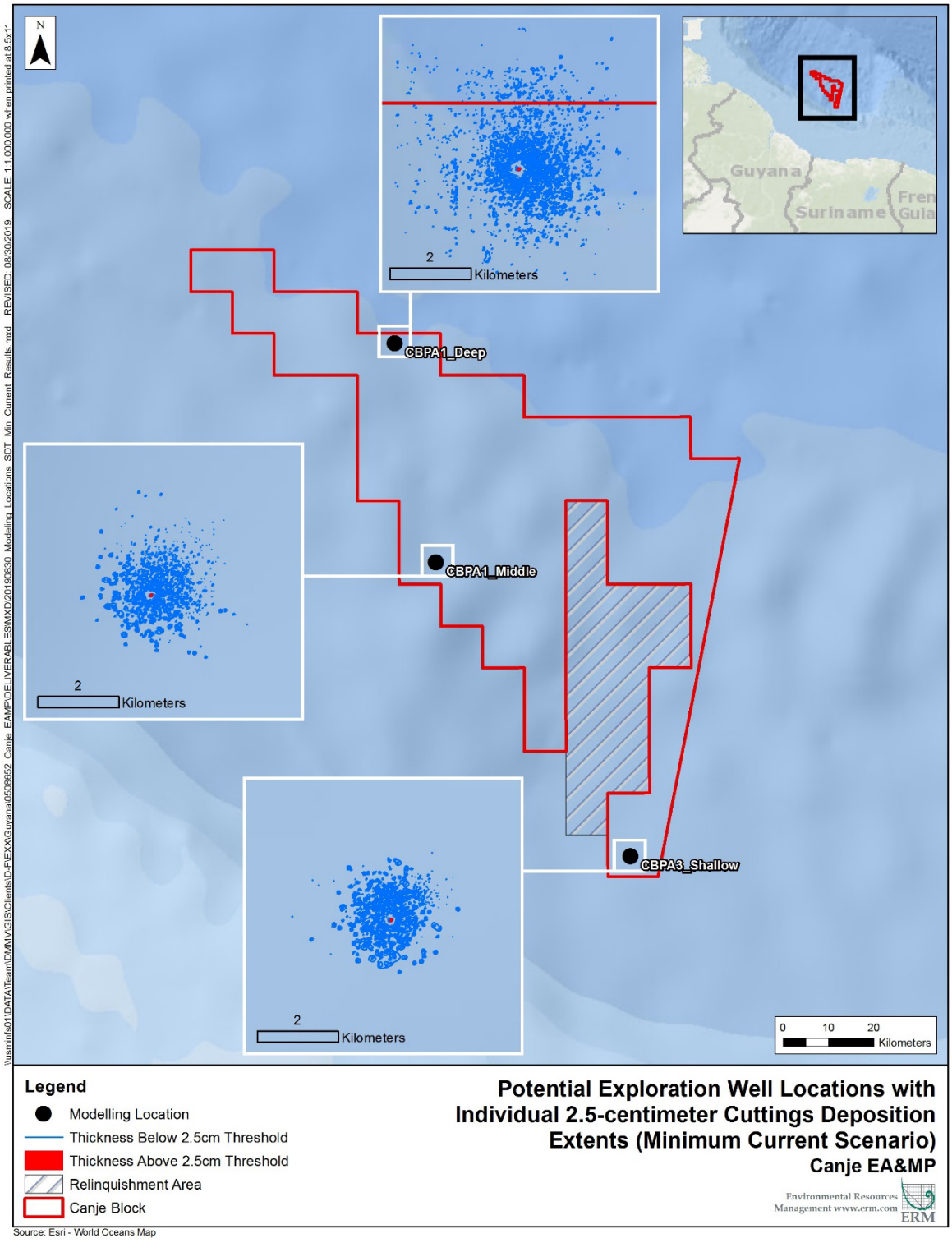


Figure 6-27: Potential Exploration Well Locations with Individual 2.5-centimeter Cuttings Deposition Extents (Minimum Currents) Overlaid to Demonstrate Lack of Overlap and Resulting Lack of Cumulative Impacts from Sediment Deposition

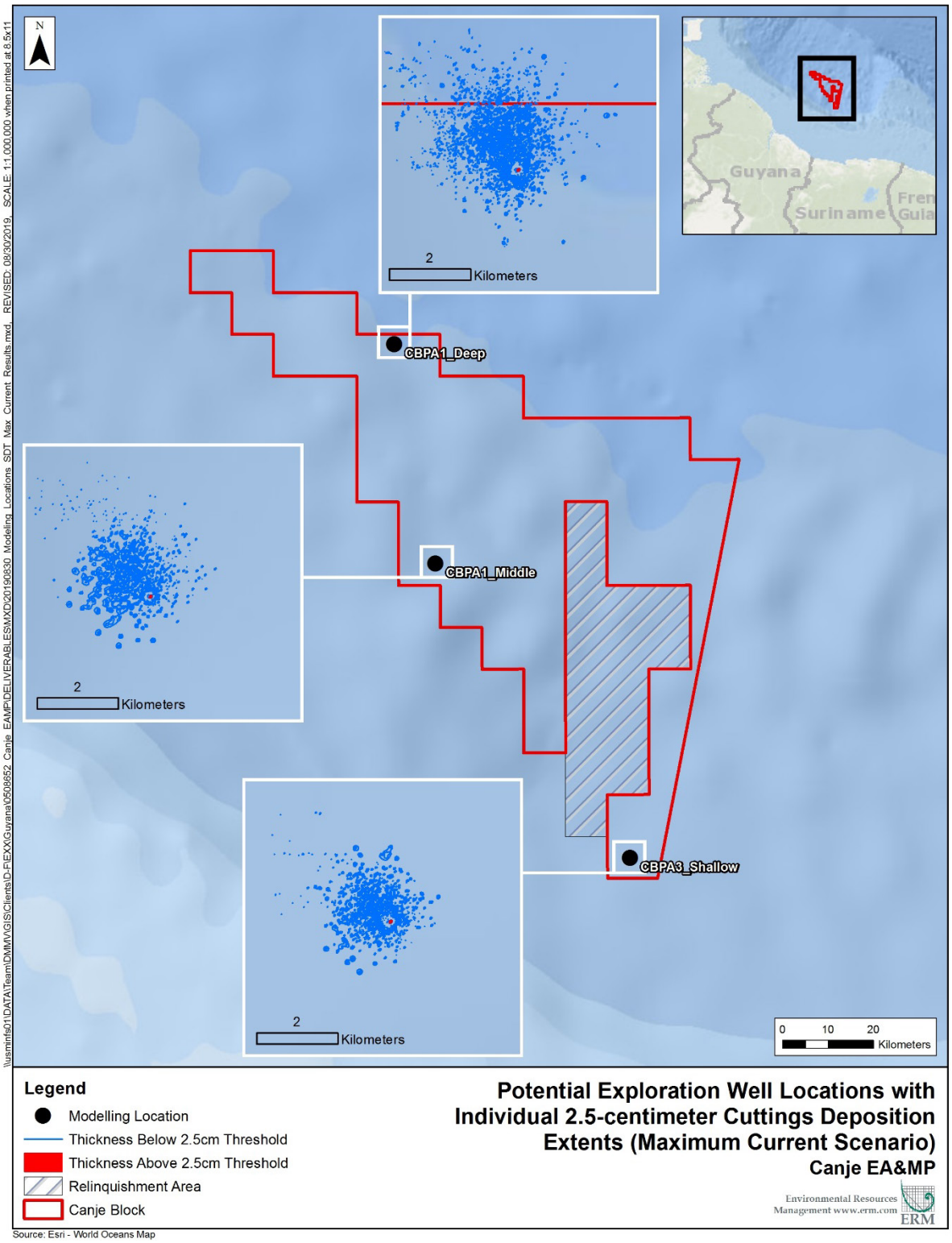


Figure 6-28: Potential Exploration Well Locations with Individual 2.5-centimeter Cuttings Deposition Extents (Maximum Currents) Overlaid to Demonstrate Lack of Overlap and Resulting Lack of Cumulative Impacts from Sediment

6.3.2 Assessment of Cumulative Impacts with Other Projects

In addition to assessing the potential for cumulative impacts from wells within the Project, the potential for cumulative impacts from Project wells and development wells for the Liza Phase 1, Liza Phase 2, and Payara Development Projects was evaluated. Prospect Area 1 is the area where a possible exploration well location is closest to a Liza Phase 1, Liza Phase 2, or Payara Development well location, as shown in Figure 6-29. Prospect Area 1 is 32.5 kilometers from the closest Liza Phase 2 well (DC3-P1) and 31.4 kilometers from the closest Liza Phase 1 well (LIZ_1P1). Prospect Area 1 is closest to planned Payara Drill Center (PY3-I), at 23.6 kilometers away. Prospect Area 3 is closest to a Stabroek Block exploration well (Location “A”) at 6.8 kilometers. For the same reasons discussed above, it is therefore unlikely that any cumulative impacts would occur from the combined activities of the Canje drilling program, other EEPGL exploration drilling, and EEPGL development well drilling.

6.3.2.1 Total Suspended Solids

Cumulative impacts from TSS plumes are also unlikely. From a spatial perspective, the maximum distance from a Canje well location for a TSS plume exceeding 17.5 mg/L is 2.7 kilometers. Considering that the smallest distance between any two well locations (considering proposed Stabroek exploration wells, Liza Phase 1, Liza Phase 2, and Payara) is 6.8 kilometers, there is no potential for overlap and therefore no resulting cumulative TSS impact.

6.3.2.2 Cuttings Depositional Thickness

Cumulative impacts due to cuttings accumulation overlap (considering proposed Stabroek exploration wells, Liza Phase 1, Liza Phase 2, and Payara) are also unlikely. The maximum length of a cuttings deposition mound exceeding 2.5 centimeters is 105 meters (344.5 feet), roughly centered on the well. This distance is much smaller than the smallest distance between a Canje well and any other EEPGL exploration or development well location (6.8 kilometers).

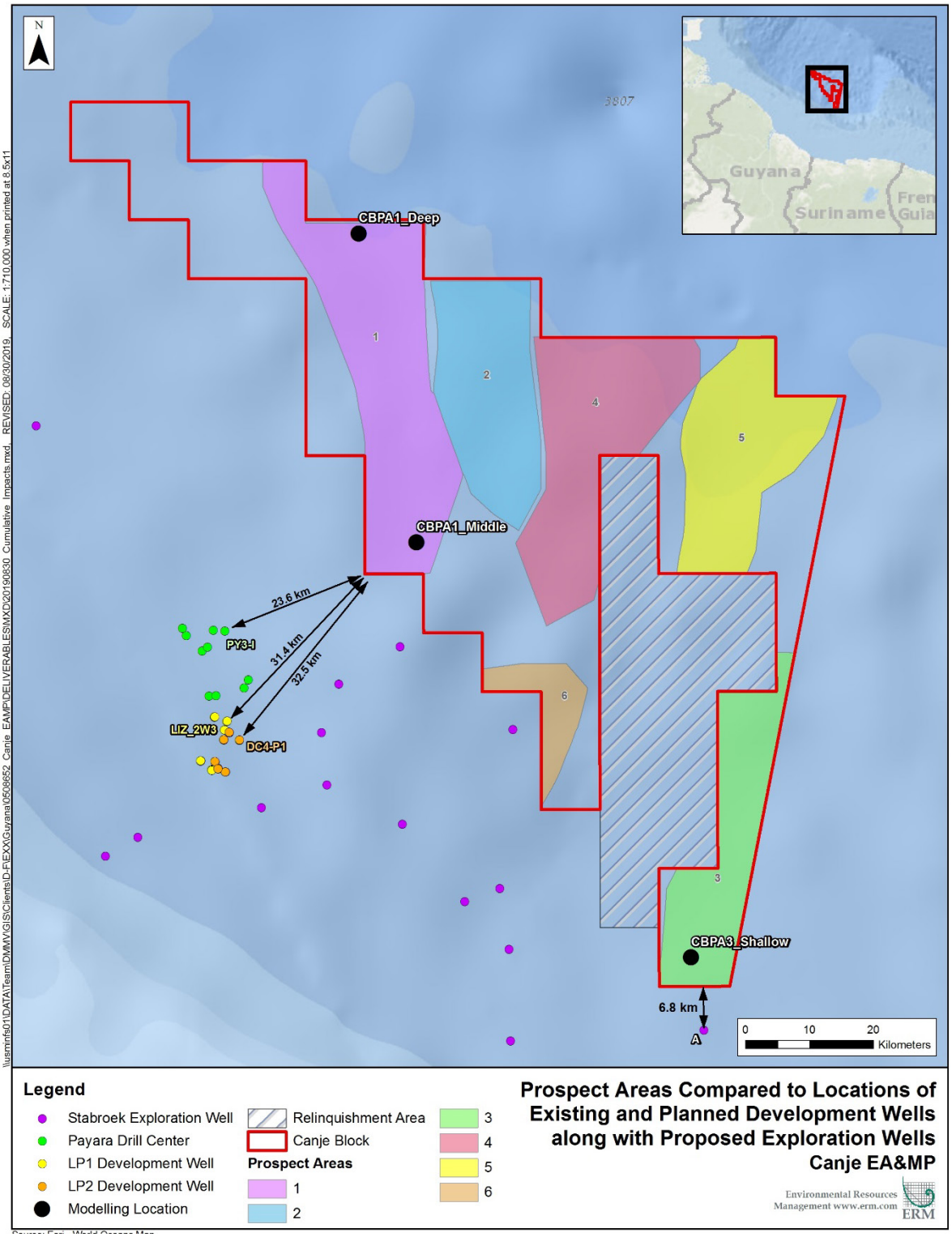


Figure 6-29: Locations of Project Prospect Areas Compared to Locations of Existing and Planned Development Wells Along with Proposed Exploration Wells (Liza Phase 1, Liza Phase 2, Payara, and Stabroek 12-well Exploration)

7. KAIETEUR 1-WELL EXPLORATION CAMPAIGN (EA&MP)

7.1 Introduction

7.1.1 Approach

In this report, potential impacts to water quality and sediment from the planned discharge of drill cuttings is evaluated. The evaluation is for individual and cumulative impacts during the planned drilling of an exploration well as part of a proposed 1-well exploration drilling campaign in the Kaieteur Block (hereafter, “the Project”). The exact location for the well has not been determined, but existing information indicates it will be within an area referred to herein as Prospect Area 1, located within the southwestern portion of the Kaieteur Block and shown on Figure 7-1.

It is assumed that there will be a direct discharge (i.e., near the seabed) of cuttings with water-based drilling fluids during drilling of the initial riserless open-hole section and the second section. For the remaining two (deeper) well sections, it is assumed that cuttings, after treatment on the drill ship, will be discharged from the drill ship, with a small fraction of adhered non-aqueous drilling fluid from material removed in the lower well sections.

Modeling was performed to predict the following as a result of these cuttings and fluids discharges:

- Total suspended solids (TSS) concentrations in the water column; and
- Accumulation (thickness) of the adhered muds and drill cuttings on the seafloor.

To evaluate cumulative impacts, locations of previously completed exploration wells, the potential Project well location, potential well locations for other approved exploration programs, and previously completed and or proposed development wells were considered. The proximities of these other completed or proposed wells to the potential Project well location were reviewed to understand the potential cumulative effects. A mapping exercise was then performed to evaluate the potential for overlap from these individual discharges.

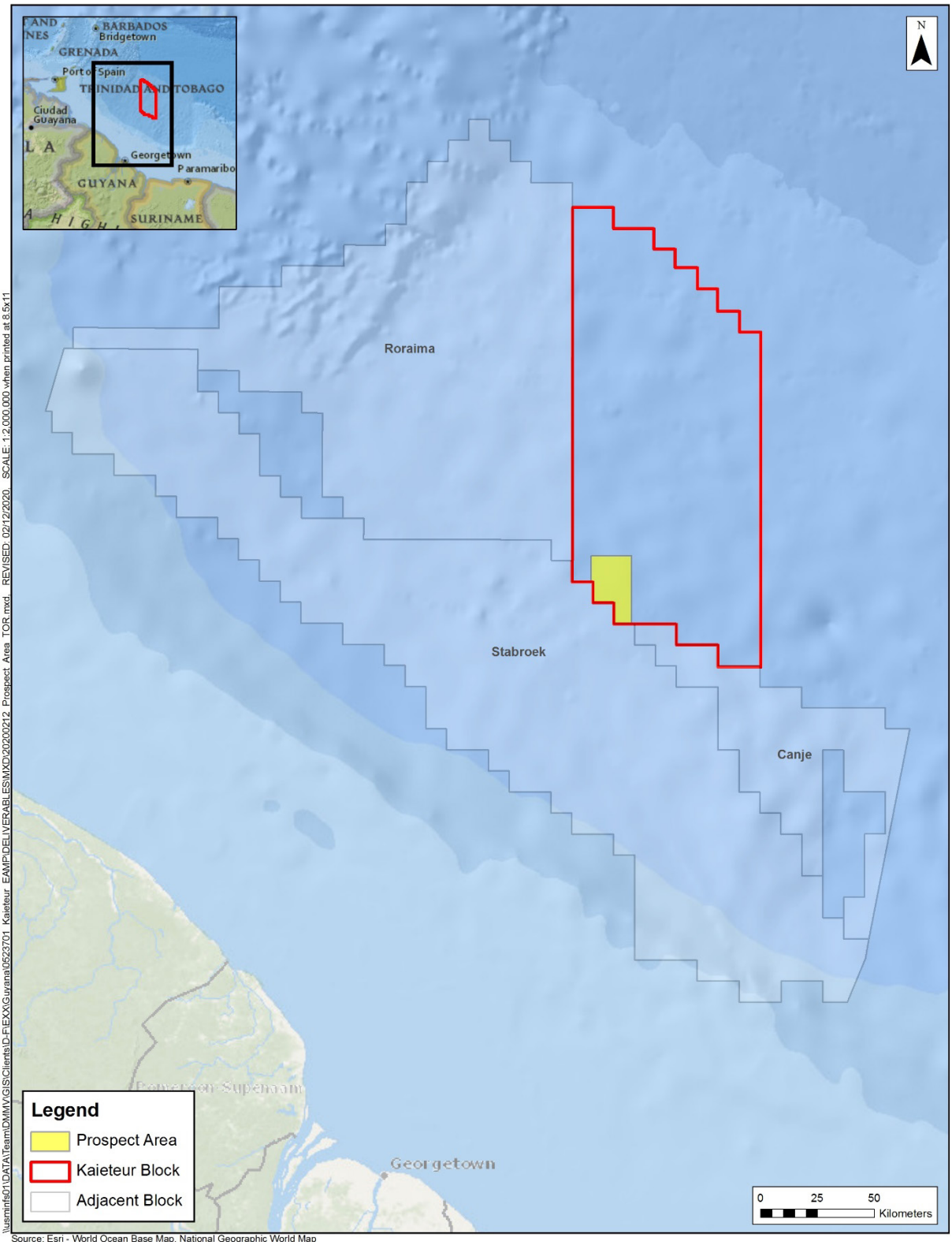


Figure 7-1: Location of the Prospect Area Within the Kaieteur Block

7.1.2 Simulation Design

Released material will pass vertically through the water column because cuttings and muds are denser than the receiving water. Released material will also migrate horizontally due to advection by local and regional currents. The dispersion of cuttings and muds is fundamentally a three-dimensional phenomenon requiring three-dimensional hydrodynamic fate and transport modeling.

The released material migrates downwards; therefore, the depth that these cuttings and muds have to travel determines the time they are in suspension, and eventually how far they spread laterally. A shallow location would result in quicker settling and a consequently smaller lateral spread. At a deeper location, cuttings and muds will take longer to settle, facilitating a larger lateral spread. However, the relative differences in currents' magnitude at different locations may significantly influence this expected outcome for the lateral spread. The representative well location is tentatively named "K_Shallow" due to the Prospect Area being in the shallower part of the block (see Figure 7-2 and Table 7-1). It is worth noting that K_Shallow has a water depth greater than 2,800 meters, indicating the deep nature of the Kaieteur Block. The minimum and maximum monthly averaged, depth-averaged currents scenarios were modeled to represent a range of impacts in seabed cuttings accumulation and TSS concentrations.

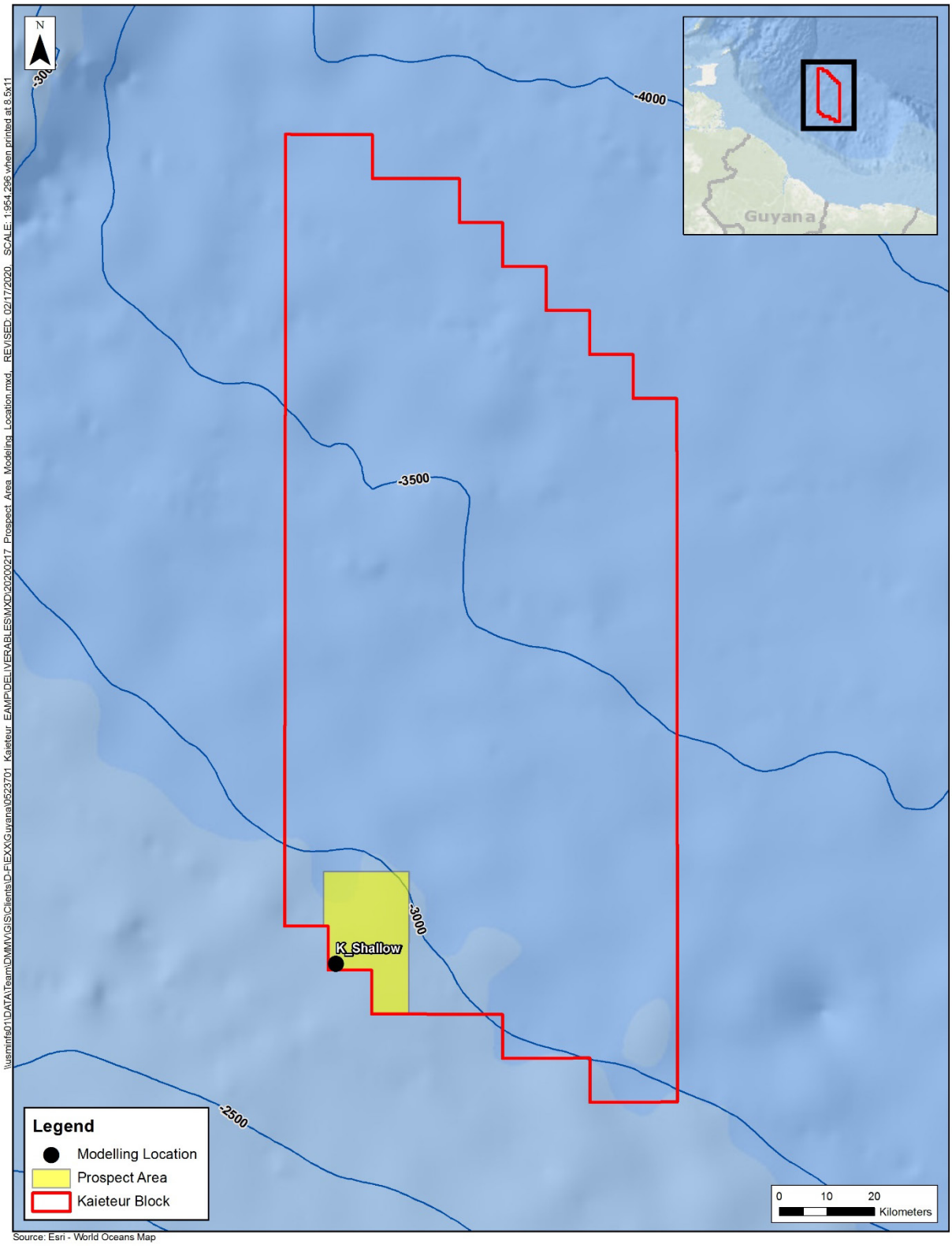


Figure 7-2: Modeling Locations Within the Kaieteur Block

Table 7-1: Selected Modeling Location of Project Exploration Well and Approximate Water Depth

Name	X	Y	Latitude	Longitude	Approximate Water Depth (meters)
K_Shallow	465041	1005390	9.095177	-57.31814	-2,874

7.2 Assessment Criteria

7.2.1 Total Suspended Solids

Increases in the concentration of TSS will occur due to discharges of drill cuttings and adhered mud. The highest concentration increases will exist at the point of discharge from the drillship during drilling of bottom well sections or at the seafloor during drilling of the riserless sections; these will decrease over time and distance as the suspended solids plume dissipates and settles. Larger particles will settle out more quickly than fine particles, such that a TSS plume of tiny particles may linger and travel farther than plumes of larger grain sizes. As such, elevated TSS concentrations may form in regions where tiny suspended particles linger in a cloud and mix with subsequent discharges. Impacts on biological resources related to elevated TSS may occur if light penetration is impeded significantly for long periods such that it reduces the ability of plants and phytoplankton to photosynthesize. Increases in TSS concentrations may also decrease water clarity and clog fish gills. The guidance value for TSS provided by the International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 is 35 milligrams per liter (mg/L) for effluent discharges (IMO 2006).

7.2.2 Depositional Thickness

Drill cuttings and adhered mud discharges will create a footprint on the seabed. The deposition of cuttings and adhered muds may result in physical damage and habitat loss or disruption over a defined area of the seabed through physical smothering.

Burial by drill cuttings and adhered mud may cause physical impacts on benthic communities. The specific burial thickness that may cause an impact varies depending on the benthic species and the amount of oxygen depletion that may occur; the deposition could cause anoxic conditions beneath the depositional layer.

The severity of burial impacts also depends on the sensitivity of the benthic organism, the thickness of deposition, the amount of oxygen-depleting material, and the duration of the burial. Thickness thresholds vary by species and sediment permeability. A suggested threshold deposition rate of 5 centimeters (50 millimeters) per month is recommended for considering impacts on benthic communities based on publications by Ellis and Heim (1985) and MarLIN (2011), and this threshold is used for this evaluation. While the threshold value represents a rate of deposition rather than a total deposition, it was assumed for the purpose of individual well analyses that all deposition from the well drilling occurs within a 30-day period, and the deposition rate was therefore used for comparison to total deposition predictions generated by the modeling.

7.3 Individual Well Results

7.3.1 Total Suspended Solids (TSS)

7.3.1.1 Representative Well (K_Shallow)

Minimum Currents

The minimum currents scenario for the representative well had a maximum TSS concentration of approximately 3,565 mg/L, which occurred near the surface. Figure 7-3 shows maximum TSS concentrations near the sea bottom while Figure 7-4 shows maximum TSS concentrations near the surface. The area exceeding 35 mg/L is larger near the surface and covers an area of 0.165 square kilometer (km²). The maximum TSS concentration is sustained for a very short time period, as ambient currents tend to spread suspended solids, and settling tends to remove particles from the water column. The TSS peaks (within the water column) with time is shown in Figure 7-5. The longest duration over which TSS concentrations stay above 35 mg/L is less than 3 days.

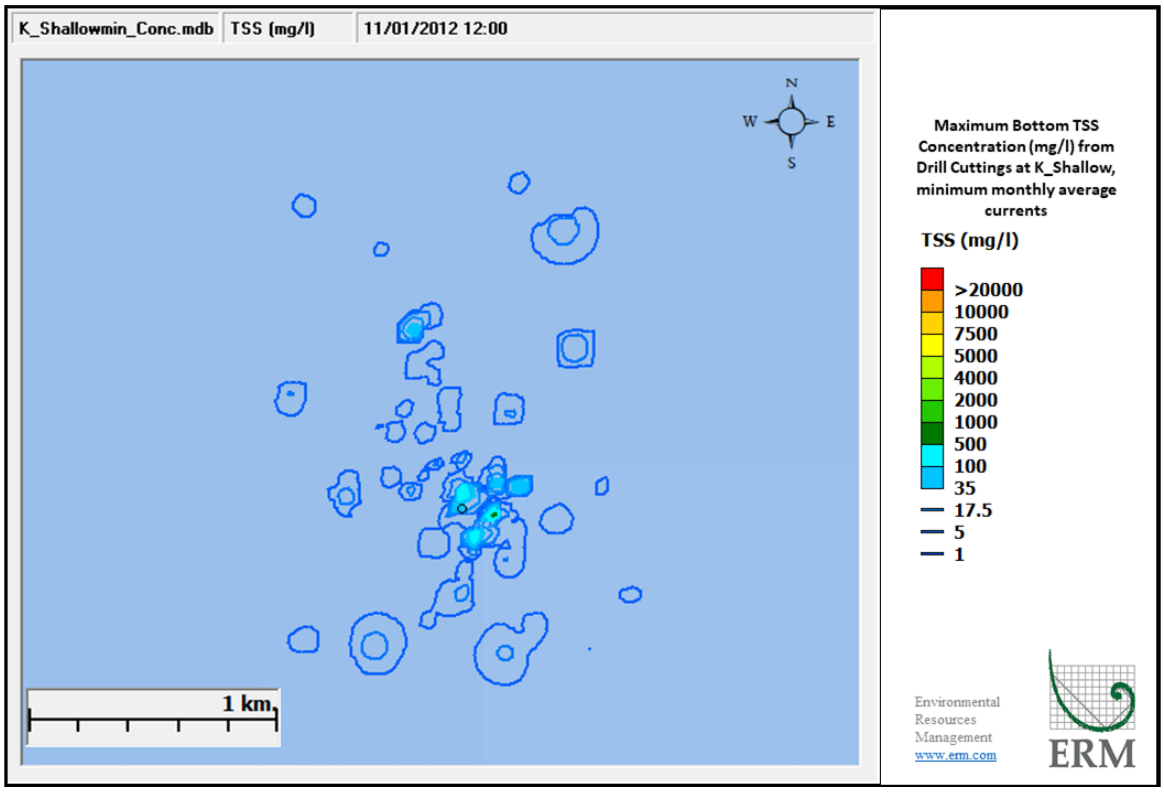


Figure 7-3: Maximum TSS Concentrations at Sea Bottom at the Representative Well Under Minimum Currents

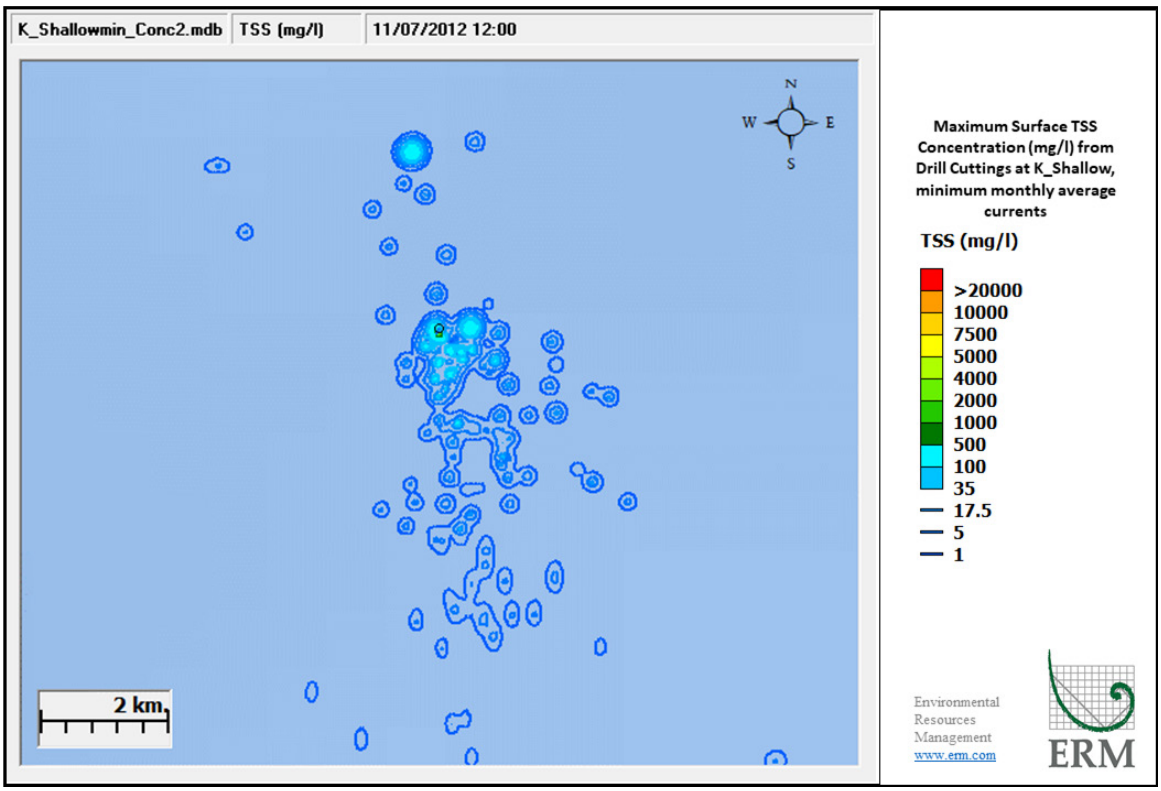


Figure 7-4: Maximum TSS Concentrations at Surface at the Representative Well Under Minimum Currents

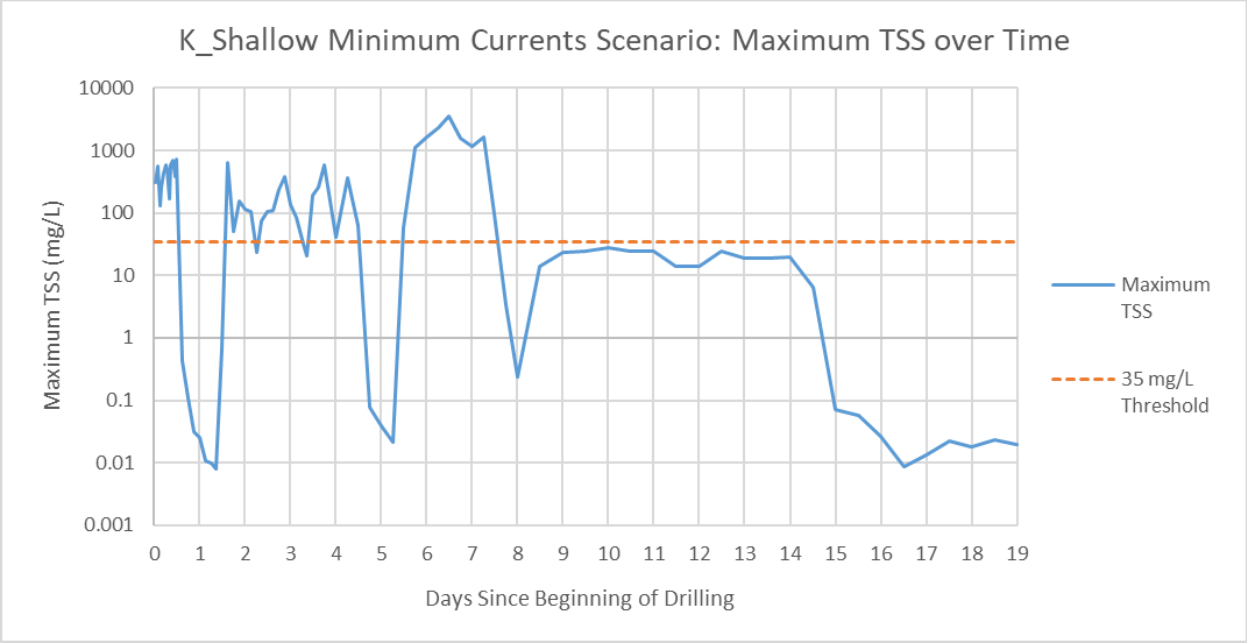


Figure 7-5: Maximum TSS Concentration Peak at Representative Well Within the Water Column with Time Under Minimum Currents

Maximum Currents

The maximum currents scenario for the representative well had a maximum TSS concentration of approximately 6,751 mg/L, which occurred near the surface. Figure 7-6 shows maximum TSS concentrations near the sea bottom while Figure 7-7 shows maximum TSS concentration near the surface. The area exceeding 35 mg/L is larger at the sea surface and covers 0.18 km^2. Temporally, the TSS peaks exist only for a short duration of time as shown in Figure 7-8. The peak TSS levels (within the water column) stay above the impact threshold (35 mg/L) only for a few days (< 3 days).

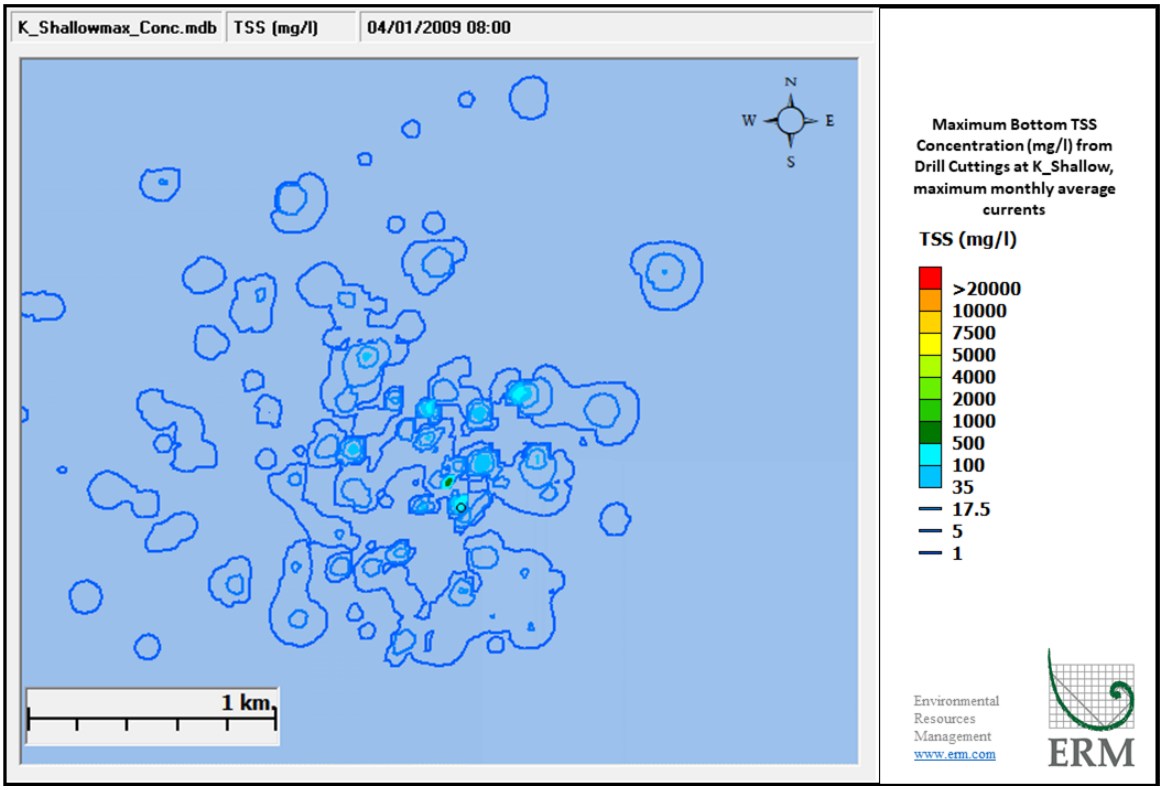


Figure 7-6: Maximum TSS Concentrations at Sea Bottom at the Representative Well Under Maximum Currents

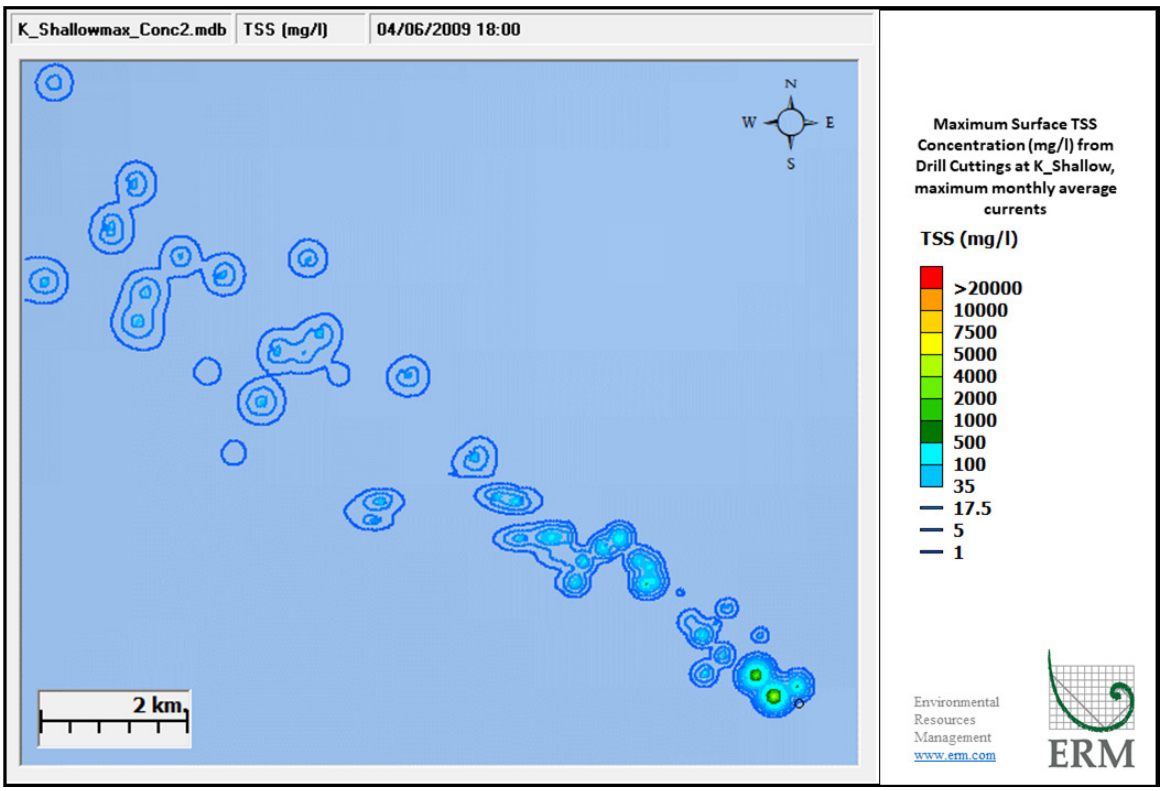


Figure 7-7: Maximum TSS Concentrations at Surface at the Representative Well Under Maximum Currents

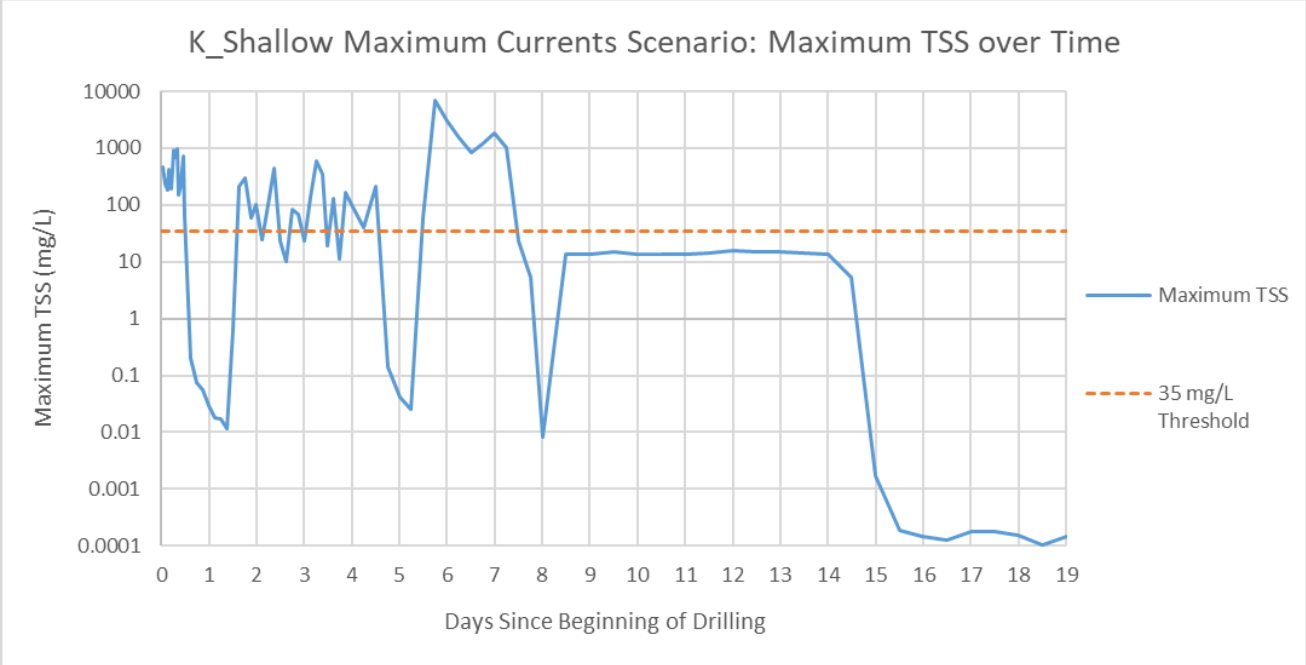


Figure 7-8: Maximum TSS Concentration Peak at Representative Well Within the Water Column with Time Under Minimum Currents

7.3.1.2 Summary

Table 7-2 summarizes the results found in the TSS analysis for the representative well location under minimum and maximum currents scenarios.

Table 7-2: Summary of Results for Representative Well under Different Currents at Time of Maximum TSS Occurrence

Scenario	Section 1 and 2 (Seabed Release)		Sections 3 and 4 (Surface Release)	
	Maximum Bottom TSS (mg/L)	Area (km^2) with TSS > 35 mg/L Threshold	Maximum Surface TSS (mg/L)	Area (km^2) with TSS > 35 mg/L Threshold
K_Shallow min	739	0.0076	3,565	0.1651
K_Shallow max	980	0.0076	6,751	0.1803

7.3.2 Drill Cuttings Depositional Thickness

7.3.2.1 Representative Well (K_Shallow)

Minimum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 5 centimeters threshold was 0.0064 km^2 as shown in Figure 7-9. The maximum length of this mound in any direction was 103 meters.

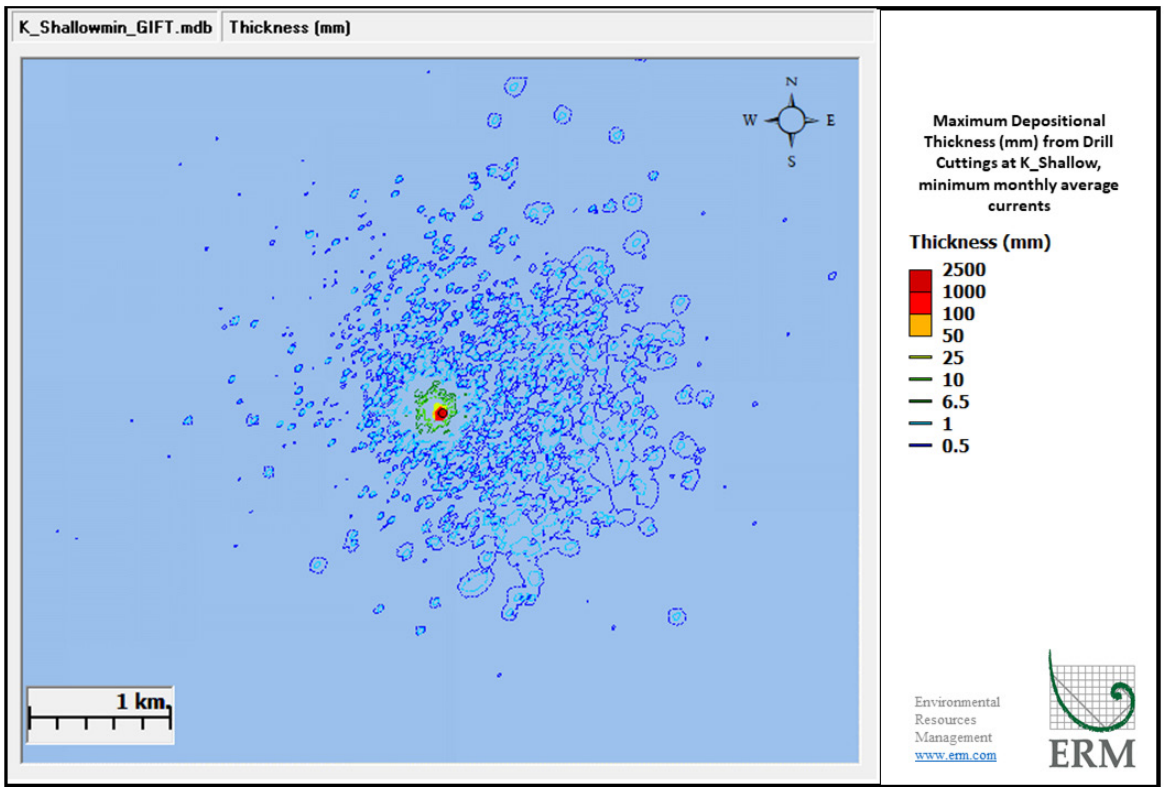


Figure 7-9: Maximum Cuttings Deposition Thickness for Representative Well Under Minimum Currents

Maximum Currents

The predicted seabed accumulation of the adhered muds and drill cuttings exceeding the 5 centimeters threshold was 0.0059 km^2 as shown in Figure 7-10. The maximum length of this mound in any direction was 107 meters.

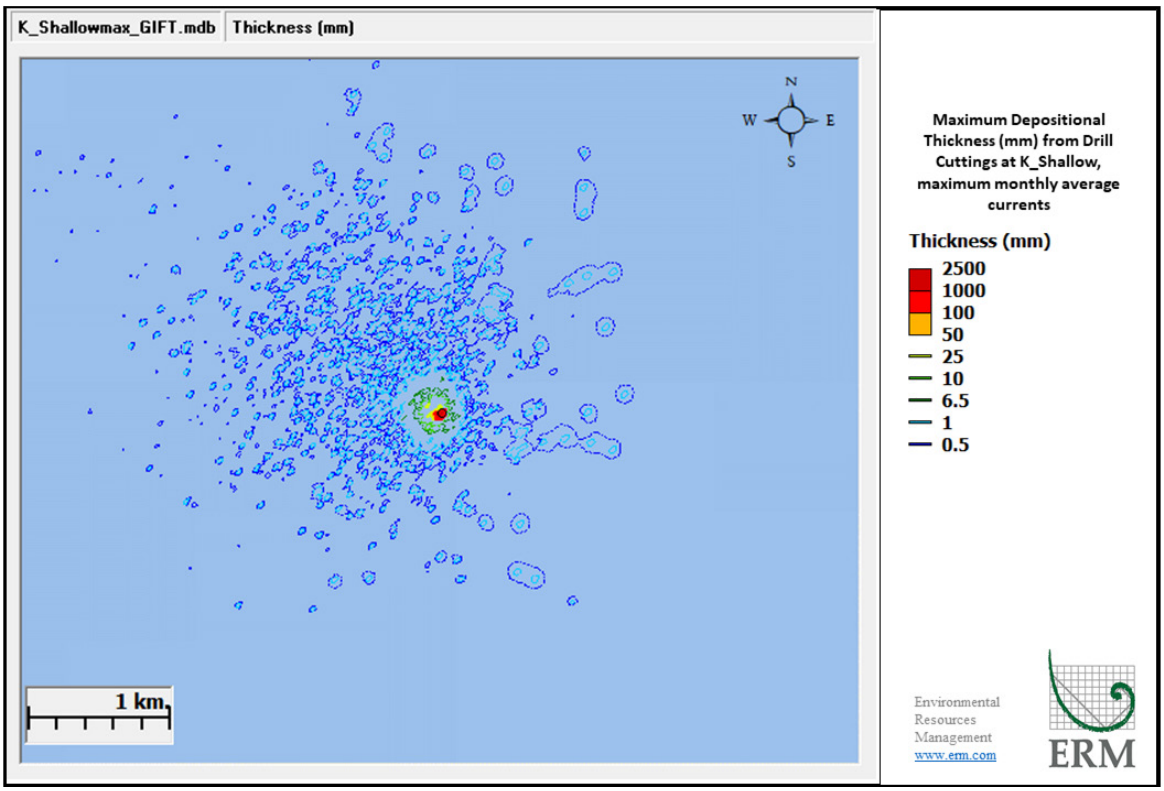


Figure 7-10: Maximum Cuttings Deposition Thickness for Representative Well Under Maximum Currents

7.3.2.2 Summary

Table 7-3 shows the cuttings accumulation (depositional thickness) analysis for the representative well location under minimum and maximum currents scenarios. Note that the table presents the area and length of the depositional mound for the depositional threshold (5 centimeters).

Table 7-3: Summary of Cuttings Deposition Results for Representative Well under Different Currents

Scenario	Area (km^2) with Thickness > 5 cm Threshold	Maximum Length of Mound(s) with Threshold Exceedance (meters)
K_Shallow min	0.0064	103
K_Shallow max	0.0059	107

7.4 Cumulative Impact Assessment Results

7.4.1 Assessment of Cumulative Impacts within the Project

Cumulative impacts could occur if the TSS plumes or cuttings deposition mounds overlap from multiple wells. The depositional mound persists for a longer duration compared to the TSS plume, which is very short-lived. The TSS plume, as modeled and discussed in earlier sections, dissipates to less than the 35 mg/L threshold within 3 days after drilling. For the Project well to result in cumulative impacts with other wells in the region, the distance from the well to half of the respective thresholds (17.5 mg/L for TSS and 2.5 centimeters for depositional thickness) would need to exceed the separation distance between it and

any other well. Additionally, this scenario would have to occur at the same time, as the impacts are only relevant in a specific timeframe. The maximum extents of the "one-half threshold" TSS plumes for the various scenarios are shown in Table 7-4, and the maximum extents of the "one-half threshold" cuttings deposition mounds for the various scenarios are shown in Table 7-5.

Table 7-4: Summary of Cuttings TSS Results for Representative Well under Different Currents with Respect to "One-Half Threshold"

	Sections 1 and 2 (Seabed Release)				Sections 3 and 4 (Surface Release)			
Scenario	Maximum Bottom TSS Concentration (mg/L)	Area (km^2) with TSS > 17.5 mg/L[a]	Farthest Distance (meters) from Well to Edge of 17.5 mg/L Plume	Approximate Width (meters) of Plume at Edge of 17.5 mg/L Plume	Maximum Surface TSS Concentration (mg/L)	Area (km^2) with TSS > 17.5 mg/L	Farthest Distance (meters) from Well to Edge of 17.5 mg/L Plume	Approximate Width (meters) of Plume at Edge of 17.5 mg/L Plume
K_Shallowmin	739	0.0129	760	60	3,565	0.297	3,000	30
K_Shallowmax	980	0.0201	725	40	6,751	0.3249	11,200	70

m = meters

[a] One-half of the threshold of 35 mg/L

Table 7-5: Summary of Cuttings Deposition Results for Representative Well under Different Currents with Respect to "One-Half Threshold"

Scenario	Area (km^2) with Thickness > 2.5 cm [a]	Maximum Length (meters) of Mound Exceeding 2.5 cm
K_Shallow min	0.0085	116
K_Shallow max	0.0085	121

[a] One-half of the threshold of 5 centimeters

7.4.1.1 Total Suspended Solids

The potential for cumulative impacts from the Project well, other exploration wells, and development wells for the Liza Phase 1, Liza Phase 2, or Payara Development Projects was evaluated. As discussed before, due to the short-lived nature of the TSS plumes, cumulative impacts from TSS are highly unlikely because TSS plumes will not persist beyond about 3 days after the drill cuttings discharges end, as shown previously in Figure 7-5 and Figure 7-8. From a spatial perspective, the maximum distance from the potential Project well location to the edge of a 17.5 mg/L TSS plume was modeled at 11.2 kilometers. As shown in Figure 7-11, the Prospect Area is located in close proximity to the Stabroek Block's Ranger-2 exploration well (10.7 kilometers). This indicates that there is theoretically potential for TSS plumes from the Project well and another well to overlap and result in areas with a combined TSS concentration exceeding 35 mg/L, but only in situations where the currents are similar to the maximum monthly averaged, depth-averaged currents scenario and only in situations where the two wells were being drilled at the same time.

While this scenario is theoretically possible, it is unlikely. Beyond the first few kilometers from a well, the TSS plume is extremely spotty and fragmented. For any overlap to occur spatially, the individual patches of higher TSS would need to occur at the same exact location, and at the same time, which is also unlikely. Note also that at any given time, the currents will move the TSS plume in the same direction for all wells (if drilled at the same time). For instance, an easterly current will move the patches of high TSS concentrations to the east, in the same manner for both wells, not in opposite directions (which would be

necessary to facilitate overlapping of the plumes). This means that the separation distance between the plumes will, to a large extent, be maintained at the separation distances of the wells themselves, further reducing the potential for overlap. Furthermore, as discussed above, the short-term existence of the elevated TSS plumes further reduces the possibility of overlap occurring, as the individual spots of high TSS would need to occur within the same timeframe (i.e., within the same few days as seen from temporal plots). Beyond these limited timeframes, suspended solids would continue to disperse and settle, thus reducing the potential for a cumulative impact.

7.4.1.2 Cuttings Depositional Thickness

The cumulative impacts from seabed accumulation of cuttings are also unlikely. The longest sediment deposition mound exceeding 2.5 centimeters is 121 meters, roughly centered on the well. It is highly unlikely that another exploratory well is drilled closer than 121 meters to result in any cumulative impact from the proposed exploration wells. Considering only one well is being proposed for the Project, cumulative impact is not a concern within the Project.

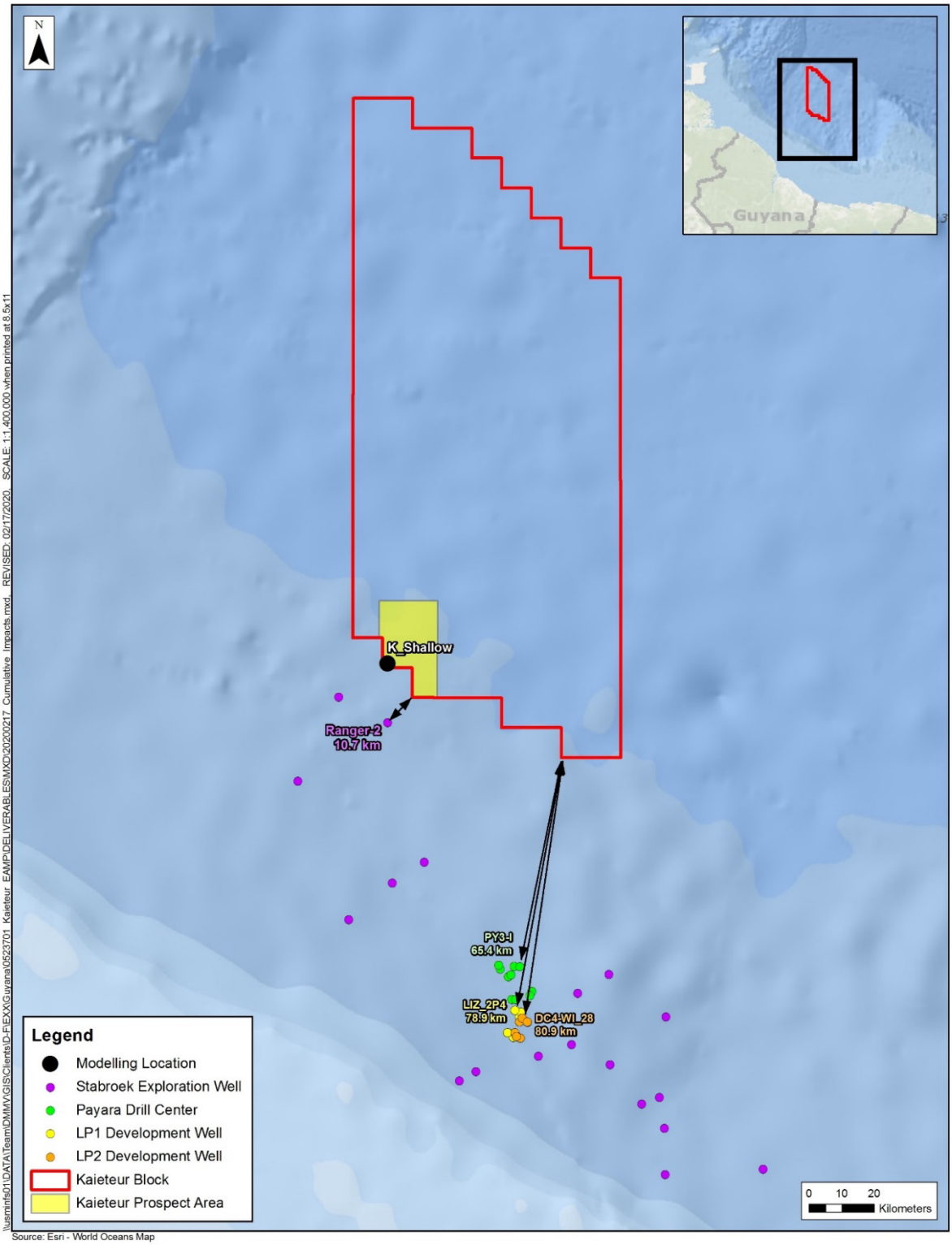


Figure 7-11: Location of the Project's Prospect Area Compared to the Nearby Existing and Planned Development Wells (Liza Phase 1, Liza Phase 2, Payara, and Stabroek 12-well Exploration Wells)

7.4.2 Assessment of Cumulative Impacts with Other Projects

Cumulative impacts due to cuttings accumulation overlap (considering proposed Stabroek exploration wells, and development wells for Liza Phase 1, Liza Phase 2, and Payara) are also unlikely. The maximum distance across a cuttings deposition mound exceeding 2.5 centimeters is 121 meters, roughly centered on the well (see Figure 7-11). This distance is much smaller than the smallest distance between any two well locations (10.7 kilometers).

7.4.2.1 Total Suspended Solids

Cumulative impacts from TSS are unlikely. From a spatial perspective, the maximum distance from a well location of a TSS plume exceeding 17.5 mg/L was 11.2 kilometers. However, it is important to note that the width of this plume is only 60m and this dissipates to below to the threshold after drilling. When considering the time-varying and depth-varying nature of TSS plumes along with directionality of the currents at a given time, the potential for overlap is extremely low even though the smallest distance between any two well locations (considering proposed Stabroek exploration wells, Liza Phase 1, Liza Phase 2, and Payara) is 10.7 kilometers. For this same reason, the newly-proposed Stabroek exploration wells and Canje explorations wells are unlikely to have cumulative impacts as well.

7.4.2.2 Cuttings Depositional Thickness

Cumulative impacts due to cuttings accumulation overlap (considering proposed Stabroek exploration wells, Liza Phase 1, Liza Phase 2, and Payara) are also unlikely. The longest cuttings deposition mound exceeding 2.5 centimeters is 121 meters, roughly centered on the well. This distance is much smaller than the smallest distance between any two well locations (10.7 kilometers). The newly-proposed Stabroek exploration wells and Canje explorations wells are unlikely to have cumulative impacts since the exploration wells are unlikely to be less than 121 meters apart.

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Appendix D
IUCN-Listed Coastal and Marine Species Known From Guyana

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Table 1: 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	Detected in EEPGL-Commissioned Studies
Birds				
Agamia agami	Agami Heron	VU	Coastal lowland forest and marsh	
Buteogallus aequinoctialis	Rufous Crab Hawk	NT	Coastal mangrove	X
Calidris canutus	Red Knot	NT	Coastal mudflat and beach; marine during migration	X
Calidris pusilla	Semipalmated Sandpiper	NT	Coastal mudflat and beach; marine during migration	X
Conirostrum bicolor	Bicolored Conebill	NT	Coastal mangrove	X
Harpia harpyja	Harpy Eagle	NT	Coastal mangrove	X
Oceanodroma leucorhoa	Leach's Storm Petrel	VU	Marine	X
Patagioenas subvinacea	Ruddy Pigeon	VU	Coastal and inland forest	X
Picumnus spilogaster	White-bellied Piculet	VU	Coastal mangrove	X
Pterodroma hasitata	Black-capped Petrel	EN	Marine	X
Ramphastos tucanus	White-throated Toucan	VU	Coastal and riverine forest	X
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	X
Trichechus manatus	West Indian Manatee	VU	Coastal and riverine	X
Marine and Terrestrial Turtles				
Chelonia mydas	Green Turtle	EN	Marine and coastal	X
Dermochelys coriacea	Leatherback Turtle	VU	Marine and coastal	X
Eretmochelys imbricata	Hawksbill Turtle	CR	Marine and coastal	X
Geochelone denticulata	Yellow-footed Tortoise	VU	Riverine and interior forest	X
Lepidochelys olivacea	Olive Ridley Turtle	VU	Marine and coastal	
Fishes				
Aetobatus narinari	Spotted Eagle Ray	NT	Offshore and coastal pelagic	

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana	Detected in EEPGL-Commissioned Studies
Albula vulpes	Bonefish	NT	Coastal demersal	X
Alopias vulpinus	Common Thresher Shark	VU	Offshore and coastal pelagic	
Balistes capriscus	Gray Triggerfish	VU	Coastal demersal	X
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	
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	X
Galeocerdo cuvier	Tiger Shark	NT	Offshore and coastal pelagic	X
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	

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana	Detected in EEPGL-Commissioned Studies
Lopholatilus chamaeleonticeps	Golden Tilefish	EN	Offshore and coastal demersal	
Lutjanus analis	Mutton Snapper	NT	Coastal demersal	X
Lutjanus cyanopterus	Cubera Snapper	VU	Coastal demersal	
Lutjanus synagris	Lane Snapper	NT	Coastal demersal	X
Makaira nigricans[a]	Blue marlin	VU	Offshore pelagic	X
Manta birostris	Giant Manta Ray	VU	Offshore and coastal pelagic	
Megalops atlanticus	Tarpon	VU	Coastal pelagic	
Mola mola	Ocean Sunfish	VU	Offshore pelagic	X
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	X
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	X
Sciades parkeri	Gillbacker Sea Catfish	VU	Coastal demersal	X
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	X
Thunnus obesus	Bigeye Tuna	VU	Offshore pelagic	
Thunnus thynnus	Atlantic Bluefin Tuna	EN	Offshore pelagic	

Table 2: IUCN-Listed Coastal and Marine Species Known From Guyana with Red List Status Classified as Data Deficient

Scientific Name	Common Name
Mammals	
Globicephala macrorhynchus	Short-finned Pilot Whale
Kogia breviceps	Pygmy Sperm Whale
Kogia sima	Dwarf Sperm Whale
Mesoplodon densirostris	Blainville's Beaked Whale
Balaenoptera brydei	Bryde's Whale
Sotalia guianensis	Guiana Dolphin
Pseudorca crassidens	False Killer Whale
Orcinus orca	Killer Whale
Feresa attenuata	Pygmy Killer Whale
Delphinus capensis	Long-beaked Common Dolphin
Fishes	
Ancylopsetta kumperae	Four-eyed Flounder
Breviraja nigriventralis	Blackbelly Skate
Carcharhinus porosus	Smalltail Shark
Dasyatis americana	Southern Stingray
Dactylobatus clarkii	Hookskate
Elops smithi	Malacho
Echeneis naucrates	Live Sharksucker
Fenestraja plutonia	Pluto Skate
Genyatremus luteus	Torroto grunt
Ginglymostoma cirratum	Nurse Shark
Gymnura micrura	Smooth Butterfly Ray
Hexanchus nakamurai	Bigeyed Sixgill Shark
Himantura schmardae	Chupare Stingray
Holothuria arenicola	Sea cucumber
Hypanus guttatus	Longnose Stingray
Lonchurus elegans	Blackfin Croaker
Mugil liza	Lebranche mullet
Myliobatis freminvillii	Bullnose Ray
Myliobatis goodei	Southern Eagle Ray
Panulirus argus	Caribbean Spiny Lobster
Panulirus laevicauda	Smoothtail Spiny Lobster
Rhizoprionodon lalandii	Brazilian Sharpnose Shark
Sciades passany	Passany Sea Catfish
Sphyrna media	Scoophead Shark
Scyllarides delfosi	Three-spot Slipper Lobster
Tetrapturus georgii	Roundscale Spearfish
Torpedo nobiliana	Great Torpedo Ray

Source: International Union for Conservation of Nature. 2018. 2017 Red List of Threatened Species Version 2017.3. Accessed: May 2018. Retrieved from: http://www.iucnredlist.org/

Appendix E
Air Quality Modeling Report

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Esso Exploration and Production Guyana Limited

Air Quality Modeling Report

Stabroek Block 25-Well Exploration Drilling Campaign

March 2020

Project No.: 536199

The business of sustainability

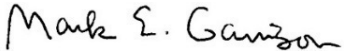
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March 2020

Air Quality Modeling Report

Stabroek Block 25-Well Exploration Drilling Campaign



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Acronyms and Abbreviations

Name	Description
$\mu g/m^3$	micrograms per cubic meter
am^3/hr	actual cubic meters per hour
Btu/scf	British thermal units per standard cubic foot
cal/sec	calories per second
CALPUFF	California PUFF model
CO	carbon monoxide
FPSO	Floating Production, Storage, and Offloading (Vessel)
E+	Scientific notation—10 to the E+ power. Example 1.0E+2 = 100.0
E-	Scientific notation—10 to the E- power. Example 1.0E-2 = 0.01
EA&MP	Environmental Assessment & Management Plan
EEPGL	Esso Exploration and Production Guyana Limited
ERM	Environmental Resources Management
H_2S	hydrogen sulfide
HHV	higher heating value
HP	high pressure
HU&C	Hook-Up and Commissioning
K	degrees Kelvin
LP	low pressure
LSBC	land-sea breeze circulation
m/s	meters per second
MMBtu/hr	million British thermal units per hour
MMscf/hr	million standard cubic feet per hour
NA	not applicable
NO_2	nitrogen dioxide
NOx	nitrogen oxides
PM	particulate matter
PM_{10}	particulate matter (aerodynamic diameter less than 10 microns)
$PM_{2.5}$	particulate matter (aerodynamic diameter less than 2.5 microns)
Project	Proposed Stabroek Block 25-Well Exploration Drilling Campaign
Q	Quarter
SO_2	sulfur dioxide
SURF	Subsea, Umbilicals, Risers, and Flowlines
WHO	World Health Organization
WRF	Weather Research and Forecasting (meteorological model)

1. INTRODUCTION

In support of the proposed Stabroek Block 25-Well Exploration Drilling Campaign (Project) Environmental Assessment & Management Plan (EA&MP), Esso Exploration and Production Guyana Limited (EEPGL) commissioned Environmental Resources Management (ERM) to model air emissions from planned Project activities. The modeling included an evaluation of direct Project-related emissions as well as an evaluation of cumulative air quality impacts from other offshore activities coinciding temporally with the Project.

The purpose of the modeling analysis was to estimate maximum Project-generated ground-level air quality concentrations at onshore locations where community receptors could potentially be exposed to them. Additionally, in support of the cumulative impact analysis for the Project, combined emissions from the Project and other reasonably foreseeable EEPGL offshore activities were also modeled. A number of possible Prospect Areas have been identified in the Stabroek Block (locations are illustrated on Figure 1-1), and the 25 exploration/appraisal wells comprising the Project are expected to be drilled within these Prospect Areas. Figure 1-2 shows the modeling domain including the potential Project well locations that were assumed for the purpose of modeling, the locations of other possible exploration wells that may be drilled during the timeframe of the Project, and the locations of offshore EEPGL Development Project activities that were modeled as part of the cumulative analysis. The other activities include production activities planned during the timeframe of the Project. The Project is anticipated to commence in 2021 and conclude in 2022.

This report provides a description of the modeling methodology—including source characteristics and emissions, receptor locations, model selection, and meteorological data development—and a summary of modeling results.

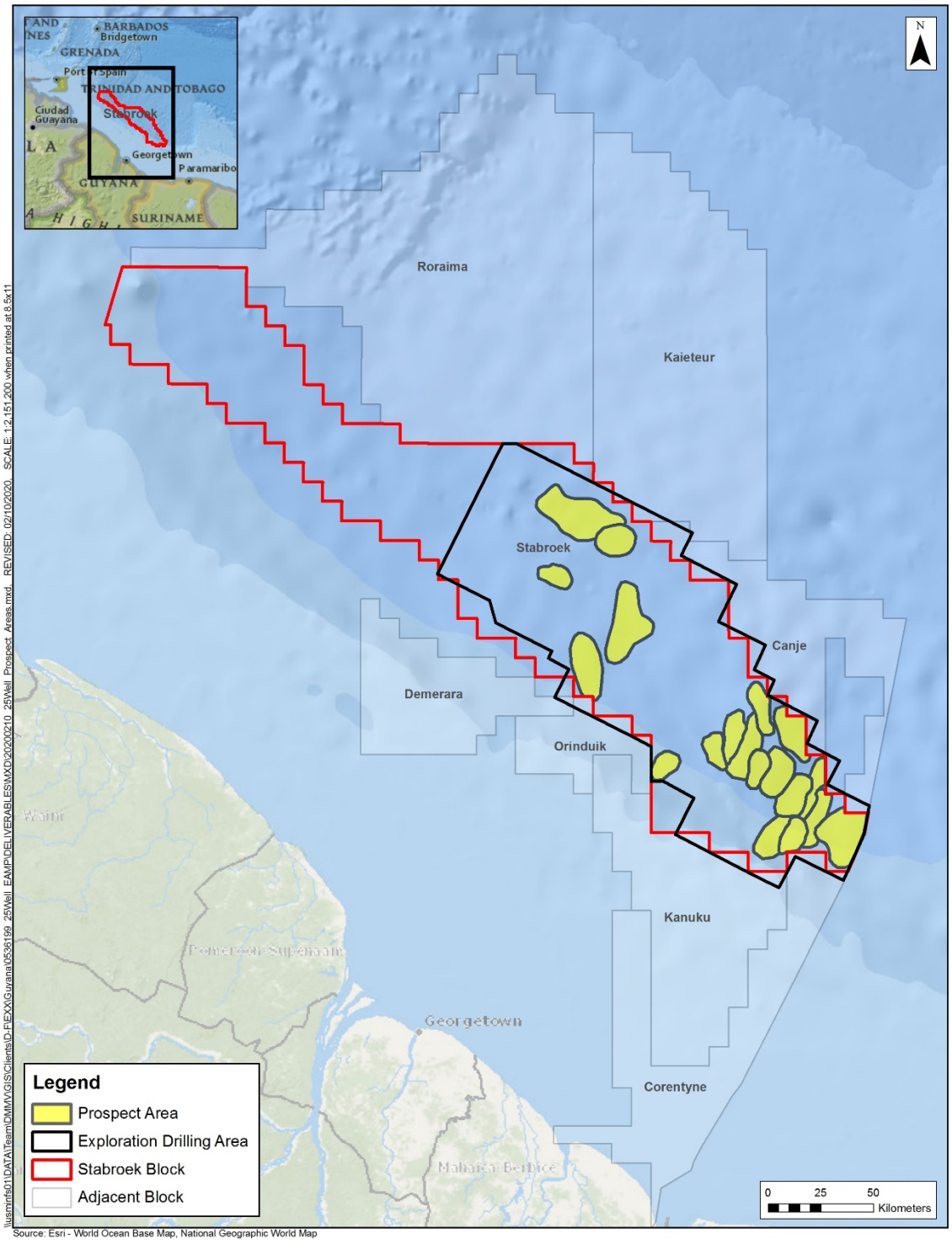


Figure 1-1: Project Prospect Areas within the Stabroek Block

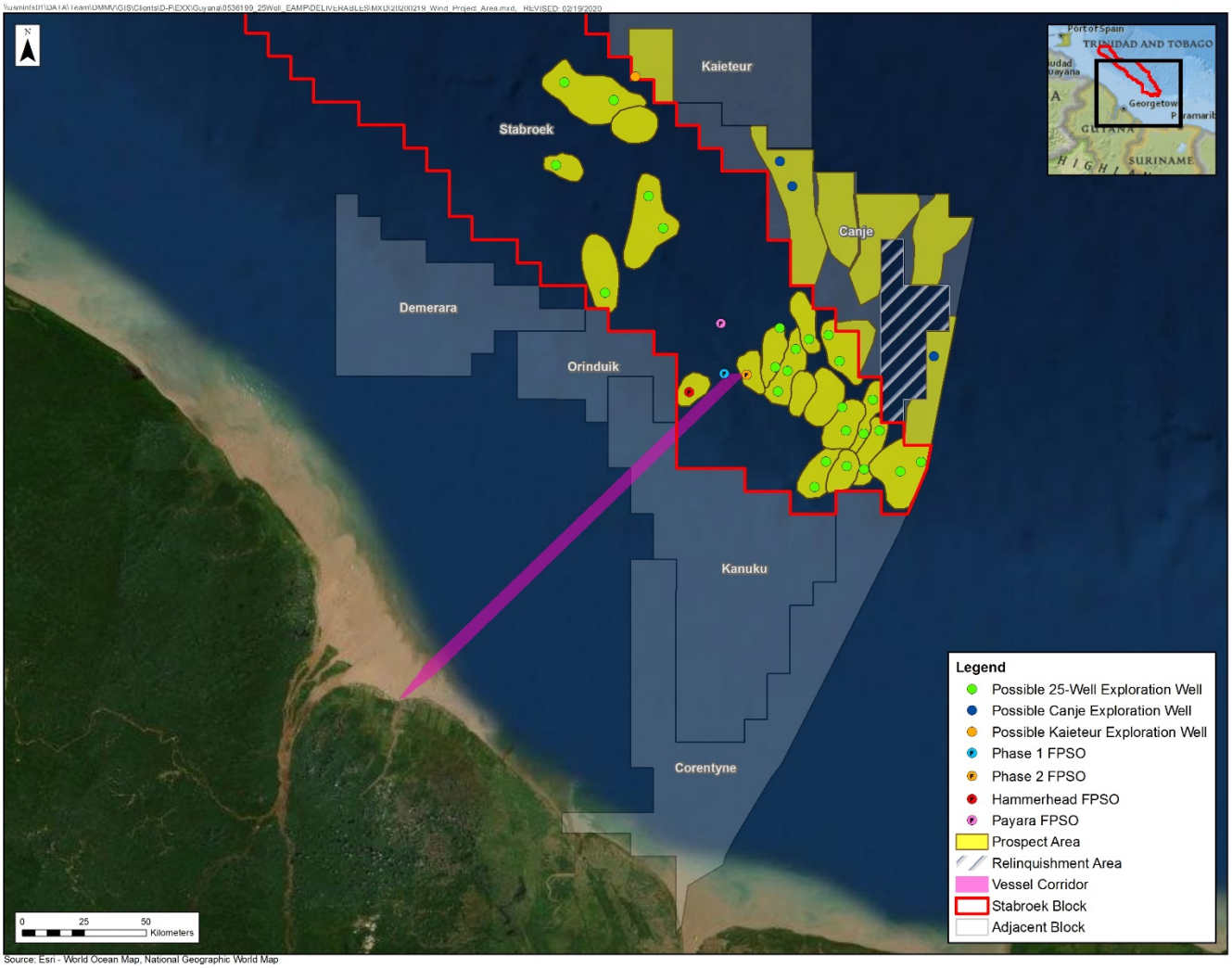


Figure 1-2: Air Quality Modeling Domain

2. AIR QUALITY MODELING METHODOLOGY

2.1 Modeled Activities

Emissions generated by the Project will generally emanate from two source categories: (1) specific point sources (i.e., the diesel engines and flares on drill ships), and (2) general area sources such as support vessels and helicopters. Since it is not known precisely at this time where drilling will occur and for how long, a conservative approach was used. Drill ships were assumed to be operating continuously at the location (out of the 25 locations modeled) that would have the maximum impact at any shore-based receptor. Figure 1-2 shows the location of the Hammerhead Development Project Floating Production, Storage, and Offloading Vessel (FPSO). Preliminary plans call for the initiation of development drilling for this project in 2022. In consideration of this, drilling at the Hammerhead FPSO location was also modeled and included in the assessment of maximum impact at shore-based receptors. The maximum modeled concentrations of pollutants were recorded and used to determine the maximum potential Project-related impact on shore-based receptors. This approach is conservative, and ensures that irrespective of where exploration drilling occurs, the actual modeled concentration impacts will be no more than the values reported herein.

For the cumulative impact assessment, the following additional EEPGL offshore activities were modeled:

- Exploration drilling in 2021 and 2022, including exploration drilling in the Stabroek, Canje, and Kaieteur blocks;
- Liza Phase 1 Development Project (2021 and 2022: FPSO operation);
- Liza Phase 2 Development Project (2021: Subsea, Umbilicals, Risers, and Flowlines (SURF) installation and development well drilling; 2022: development well drilling and FPSO operation);
- Payara Development Project (2021 and 2022: SURF installation and development well drilling); and
- Hammerhead Development Project (2022: development well drilling).

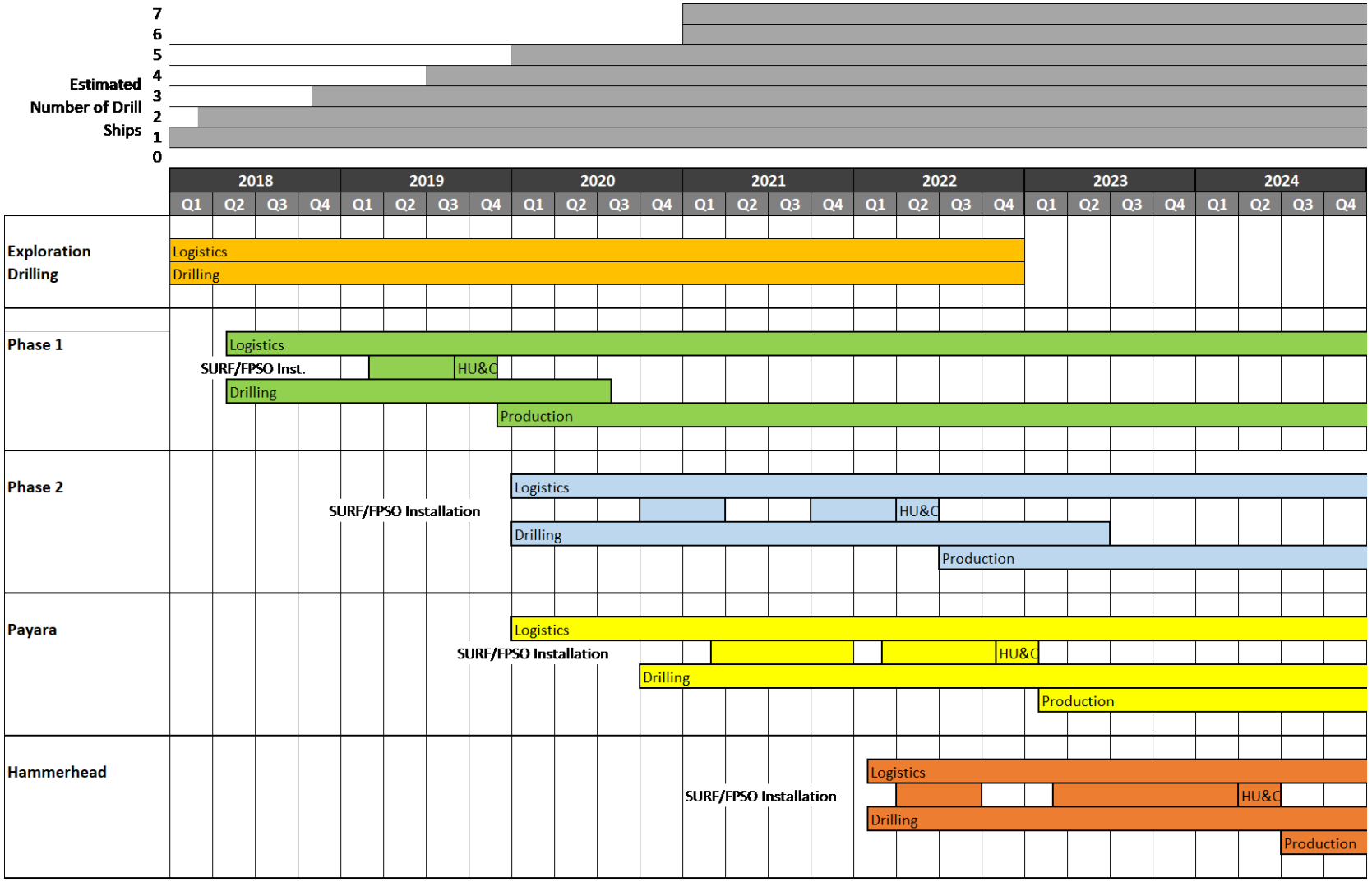
The specific source emissions modeled for these other EEPGL offshore activities were selected based on their currently forecasted timing (and location, in the case of exploration drilling) relative to that of the Project. Figure 2-1 presents the cumulative impact assessment schedule used for this purpose. This figure identifies a timeline for development activities other than in 2020–2021; however, these activities will occur outside of the period of Project exploration drilling which was assumed for the purpose of modeling and are therefore not included in the cumulative assessment. A total of seven drill ships involved with development and exploration drilling were modeled for each of the 2021 and 2022 calendar years. This consideration led to the assumption of three drill ships supporting the Project in 2021 and four drill ships supporting the Project in 2022. Emissions from support vessels and helicopters were adjusted to support the total number of drill ships in operation. It is possible that some drill ships could be dedicated to both development and exploration in the same calendar year. The methodology used to estimate combined (cumulative) impacts has been designed to be conservative (i.e., to identify maximum impacts irrespective of the exact location and purpose of the drill ships).

2.2 Model Inputs: Source Characteristics and Emissions

Modeling stack sources involves first calculating plume rise (i.e., how high the plume rises due to momentum and buoyancy of the exhaust). Plume rise is added to the physical stack height to determine final plume height, and the plume is tracked as it is transported downwind and dispersed by atmospheric turbulence. Stack parameters needed for model input include the physical stack height, internal diameter, exhaust velocity, elevation of the base of the stack, and exhaust temperature.

Table 2-1 displays the values for the emission source parameters used in modeling all EEPGL offshore activities considered in the assessment, including Project sources and other sources included in the cumulative impact analysis. For the cumulative analysis, each operating source during specific time periods is modeled with appropriate location, parameter, and emissions information. For the Project modeling, the parameters for drill ship and flare sources presented in Table 2-1 were used to estimate Project impacts with the location and emissions information discussed below. Support vessel and helicopter emissions associated with the Project were modeled using the area source parameters noted in this table. Due to the distance between Project sources and potential onshore receptors, modeled concentrations are not very sensitive to changes in stack parameters.

Flares associated with the Project were modeled as point sources, with adjustments made to account for and maintain buoyancy of the hot plume. Table 2-2 displays the inputs and results of the calculations that were conducted to estimate an effective diameter and an effective stack height that accomplishes this goal. These parameters were used for all modeling that was conducted for flare impacts, adjusted for emissions as appropriate.



HU&C = Hook-Up and Commissioning; Q = Quarter

Figure 2-1: Cumulative Impact Assessment Basis for EEPGL Offshore Activities

Table 2-1: Stack Parameters for Model Input—EEPGL Offshore Emissions Sources

Name	Base Elevation	Height	Exhaust Flow	Exhaust Temperature	Diameter	Exhaust Velocity
	meters	meters	am^3/hr	K	meters	m/s
Combustion Turbines	30	28.00	638,716	803.15	3.100	23.507
Flare—HP Normal Flaring [a]	30	136.36	NA	1,273.0	0.257	20.0
Flare—LP Normal Flaring [a]	30	147.84	NA	1,273.0	2.691	20.0
Flare—HP Full Flaring [a]	30	169.12	NA	1,273.0	7.476	20.0
Flare—LP Full Flaring [a]	30	153.75	NA	1,273.0	3.997	20.0
Auxiliary Boiler (Heaters)	30	24.40	98,457	681.15	1.150	26.330
Essential Services Generators	30	15.50	14,791	578.15	0.305	56.234
Emergency Generators	30	3.20	15,229	719.15	0.300	59.845
Deck Cranes	30	28.90	7,360	795.55	0.522	9.539
Export Tanker	30	24.40	98,457	681.15	1.150	26.330
Drill Center	0	22.00	73,470	682.60	0.800	40.601
Support Vessels within Project Area	0	20.00	NA	NA	NA	NA
Support Vessels between Shore and Project Area	0	10.00	NA	NA	NA	NA
Helicopters between Shore and Project Area	0	300.00	NA	NA	NA	NA
General Project Area (Installation)	0	10.00	NA	NA	NA	NA

am^3/hr = actual cubic meters per hour; HP = high pressure; K = degrees Kelvin; LP = low pressure; m/s = meters per second; NA = not applicable
[a] Effective height/diameter calculated based on heat release to maintain buoyancy flux

Table 2-2: Flare Calculations

Description	Gas Usage	Gas HHV	Total Heat Release	Total Heat Release	Sensible Heat Release	Effective Stack Diameter [a]	Physical Stack Height	Effective Stack Height [a]
	MMscf/hr	Btu/scf	MMBtu/hr	cal/sec	cal/sec	meters	meters	meters
Purge and Pilot Gas								
HP	1.67E-03	1,284.6	2.1	1.50E+05	6.76E+04	0.257	135	136.36
LP	1.38E-01	1,707.4	235.5	1.65E+07	7.42E+06	2.691	135	147.84
Max Flaring (Commissioning, Non-Routine)								
HP	1.41	1,284.6	1,817.5	1.27E+08	5.73E+07	7.476	135	169.12
LP	0.30	1,707.4	519.6	3.64E+07	1.64E+07	3.997	135	153.75

Btu/scf = British thermal units per standard cubic foot; cal/sec = calories per second; HHV = higher heating value; HP = high pressure; K = degrees Kelvin; LP = low pressure; MMBtu/hr = million British thermal units per hour; MMscf/hr = million standard cubic feet per hour; m/s = meters per second
[a] Effective diameter and effective stack height calculated based on U.S. Environmental Protection Agency guidance, using 20 m/s exit velocity and 1,273 K exhaust temperature.
Note: E+ and E- are scientific notations. E+ = 10 to the E+ power, i.e., 1.0E+2 = 100.0; E- = 10 to the E- power, i.e., 1.0E-2 = 0.01.

Emissions to air 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 U.S. Environmental Protection Agency in *AP-42: Compilation of Air Pollutant Emission Factors* (USEPA 2018). As described in this publication, 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 [NO_x] 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.

Table 2-3 summarizes expected emissions from planned Project activities. These emissions were used as source inputs to the model. Table 2-4 presents the total emissions (over all other sources, excluding those of the Project) for the other EEPGL offshore activities that were modeled as part of the cumulative impact assessment. For the purpose of the cumulative impact assessment, the total number of drill ships operating (across all EEPGL activities) was assumed to be seven for both 2021 and 2022. The number of drill ships operating in the 25-Well campaign was assumed to be three for 2021 and four for 2022.

Table 2-3: Air Emissions Summary—Stabroek 25-Well Exploration Campaign (Project)

Emissions Source	NO_x	SO_2	PM	CO	H_2S
Emissions in tonnes / month					
Drill Ships [a]	321	11	23	67	<0.01
Flaring	32	50	<0.5	171	0.6
Support Vessels	16	<0.5	<0.5	3	<0.01
Helicopter Flights	1	<0.1	<0.1	<0.5	<0.01
Incineration	<0.1	<0.01	<0.01	<0.01	<0.01
Total Monthly Emissions	370	62	25	242	0.6
Emissions in tonnes/year					
Drill Ships [a]	3,856	129	271	803	<0.1
Flaring	378	605	11	2,056	7
Support Vessels	193	6	14	40	<0.1
Helicopter Flights	8	1	1	2	<0.1
Incineration	1	<0.1	<0.1	<0.1	<0.1
Total Annual Emissions	4,436	742	296	2,902	7

CO = carbon monoxide; H_2S = hydrogen sulfide; PM = particulate matter; SO_2 = sulfur dioxide
[a] Based on 5,044 kilogallons of diesel per year per drill ship / 12 months per year = 420 kilogallons/month
Notes:

1. The annual estimated totals generally reflect the current preliminary Project schedule and remain subject to adjustment. The totals shown here reflect ***four*** drill ships conducting Project exploration drilling activities (the number of ships modeled for 2022).
2. PM emissions represent total PM; for the purpose of the assessment, the results from modeling of total PM values were used for comparison to both PM_{10} (particulate matter with an aerodynamic diameter less than 10 microns) standards and $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5 microns) standards (a conservative assumption).

Table 2-4: Air Emissions Summary—Other EEPGL Offshore Activities (Excluding Stabroek 25-Well Exploration Campaign)

Pollutant	Source Category	Annual Emissions (tonnes)	
		2021	2022
Nitrogen Oxides (NOx)	All Sources	9,973	12,769
Sulfur Dioxide (SO_2)	All Sources	614	675
Particulate Matter (PM)	All Sources	615	654
Carbon Monoxide (CO)	All Sources	3,585	6,781
Hydrogen Sulfide (H_2S)	All Sources	2	<1

Notes:

1. The annual estimated totals reflect the current preliminary schedules of other EEPGL offshore activities and remain subject to adjustment.
2. PM emissions represent total PM; for the purpose of the assessment, the results from modeling of total PM values were used for comparison to both PM_{10} (particulate matter with an aerodynamic diameter less than 10 microns) standards and $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5 microns) standards (a conservative assumption).
3. 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 (for example, deck cranes), 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.

The Project is anticipated to emit approximately 172 kilotonnes of carbon dioxide-equivalents per year of greenhouse gas emissions and approximately 85 tonnes per year of volatile organic compounds. As there are no ambient guidelines or standards for greenhouse gas emissions or volatile organic compounds, these emissions were not included in the modeling.

2.3 Receptors

A grid of potential receptor points was established for onshore areas, with a denser grid used in coastal areas (closer to the 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 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 will be not significant. For this reason, specific locations of sensitive receptors were not identified at the onset of modeling. Figure 2-2 illustrates the potential receptor location grid used. At each potential receptor grid node, terrain elevations were specified and used by the California PUFF model (CALPUFF) to model plume interaction with onshore terrain.

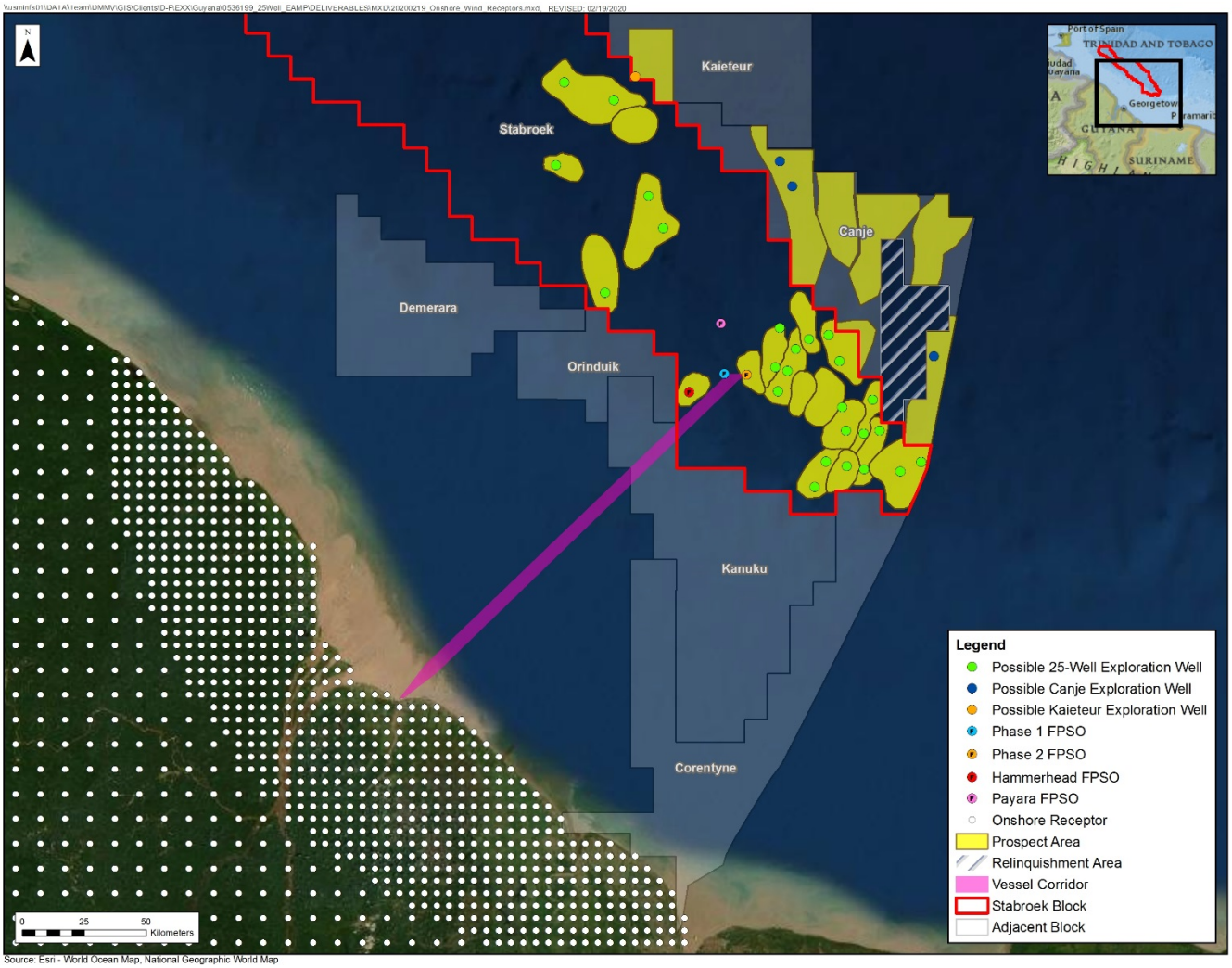


Figure 2-2: Potential Receptor Grid Used for Air Quality Modeling

2.4 Model Selection

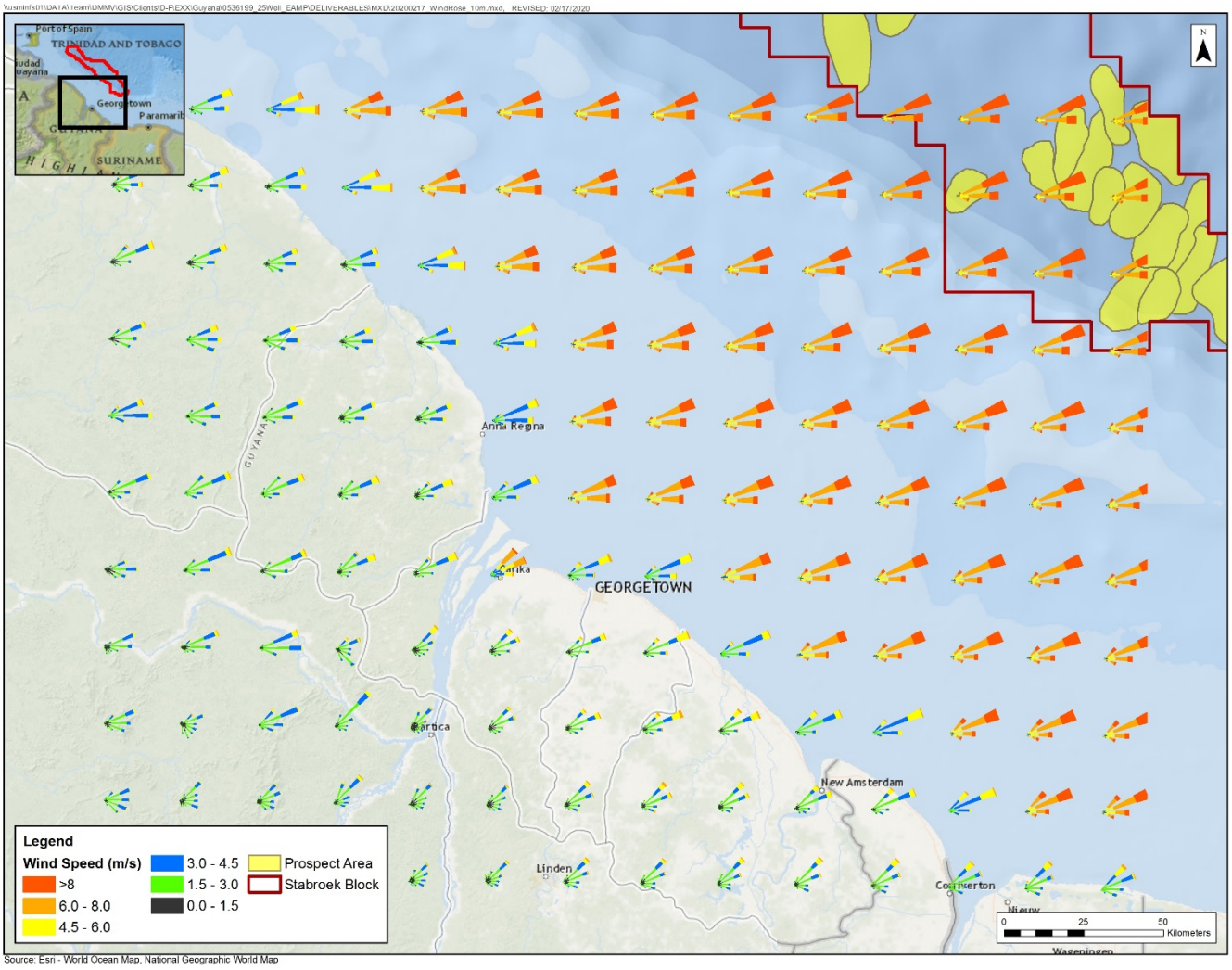
The CALPUFF model (Version 7.2.1, level 150618) used in the assessment is a non-steady-state model used in the United States and around the globe for long-range transport and complex wind modeling. CALPUFF is a Lagrangian "puff" model that treats a plume as a series of puffs that it tracks as the wind carries it toward potential receptor locations. The selection of CALPUFF was based on the relatively large distance between the well locations and the potential onshore receptors. The smallest distance from any potential Project well location to the closest shoreline is on the order of approximately 160 kilometers (100 miles). At this distance, emission plumes released from the point sources modeled will travel for approximately 8 to 9 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. Additionally, due to the vast differences in surface characteristics between open water and land, coastal areas frequently experience a classic meteorological phenomenon known as the land-sea breeze circulation (LSBC). This phenomenon is due to the diurnal surface temperature differences that develop between the land and the open water. LSBC effects can play an important role in the dispersion modeling analysis of emission sources as plumes interact with onshore receptors. CALPUFF, combined with gridded meteorological

data, is capable of accounting for the LSBC phenomenon. CALPUFF was run for each well location individually and post-processing was used to calculate pollutant-specific totals for applicable averaging periods.

2.5 Meteorological Data

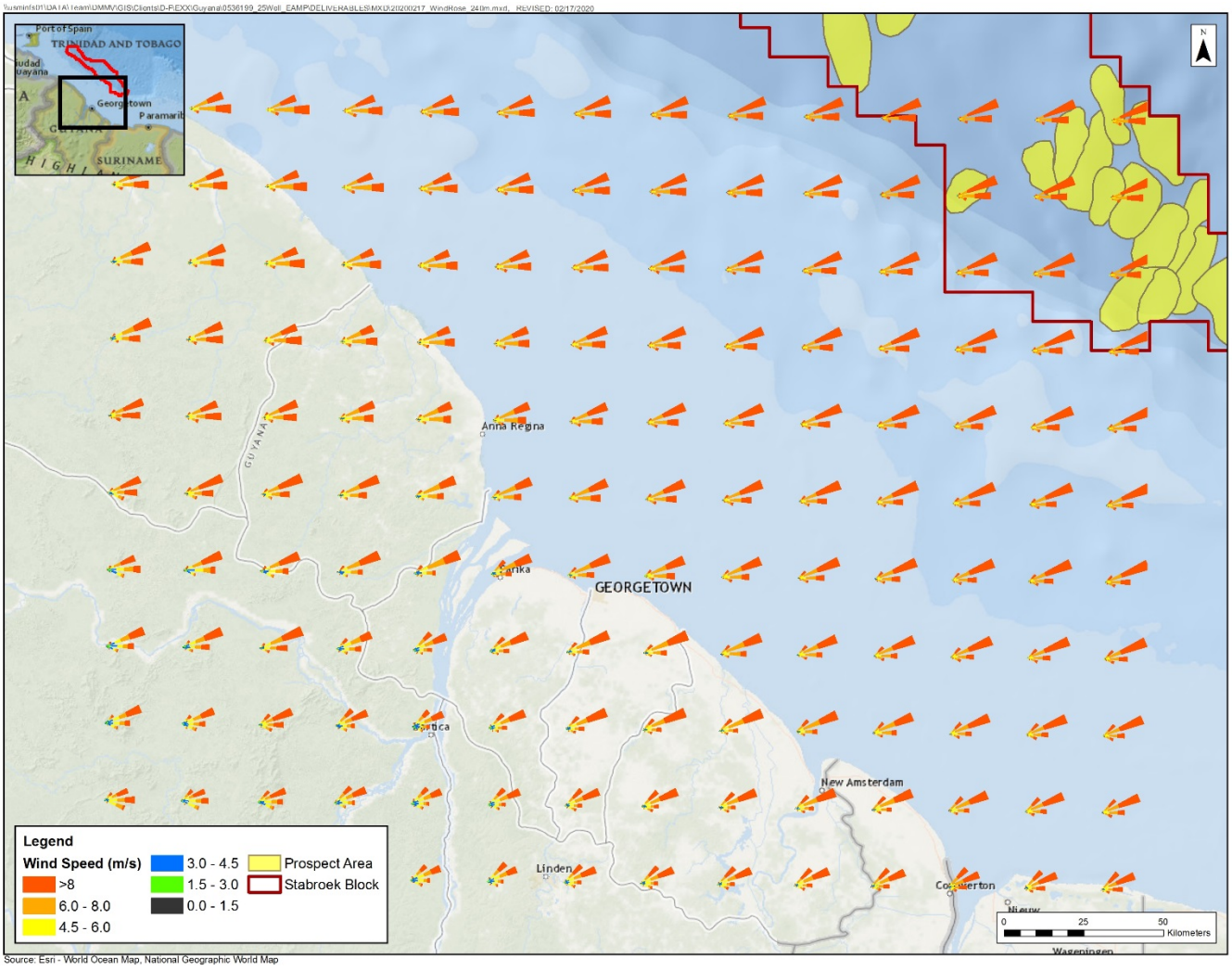
The Weather Research and Forecasting (WRF) model was used to develop hourly meteorology inputs for CALPUFF for 3 years—calendar years 2014, 2015, and 2016. WRF is a prognostic meteorological model that creates profiles of winds and temperature at grid points across a domain. The grid spacing chosen for 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 domain shown in Figure 2-2. The profiles were used by CALPUFF to simulate the transport and dispersion of emission plumes from modeled sources, allowing the model to calculate ambient constituent concentrations at potential receptor locations, accounting for changes in meteorology as the plumes travel downwind.

Illustrations of how the WRF model accounts for the effects on meteorological variables from height above the surface and underlying land use characteristics (i.e., overland and overwater) are provided in Figures 2-3 and 2-4. These figures display the locations of the 12-kilometer (7.5-mile) grid points (the WRF model was used to create profiles of wind and temperature for each of these locations). At every other grid point, wind roses were created to illustrate wind direction and speed frequencies at that location. Wind roses shown in Figure 2-3 were created from the profile of wind conditions 10 meters (33 feet) above the surface for the year 2014; wind roses shown in Figure 2-4 were created from the profile of wind conditions 240 meters (787 feet) above the surface for the year 2014 (240 meters [787 feet] is representative of typical plume heights for the larger Project sources). At a height of 240 meters (787 feet), the effects of the land surface on winds are considerably less pronounced than the effects at a height of 10 meters (33 feet). Figure 2-3 (10-meter level [33-foot]) shows a pronounced effect on wind speed over land, where surface friction acts to slow down the wind.



m/s = meters per second

Figure 2-3: Wind Roses—10-Meter (33-Foot) Level (2014)



m/s = meters per second

Figure 2-4: Wind Roses—240-Meter (787-Foot) Level (2014)

3. RESULTS

3.1 Ambient Air Quality Guidelines

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 vulnerable individuals 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 the World Health Organization (WHO). The WHO guidelines are summarized in Table 3-1. 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 the carbon monoxide (CO) and hydrogen sulfide (H_2S) guidelines, which were published in WHO's *Air Quality Guidelines for Europe, 2nd edition* (WHO 2000).

Table 3-1: 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

Sources: WHO 2000; WHO 2005

µg/m^3 = micrograms per cubic meter; NO_2 = nitrogen dioxide; $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); SO_2 = sulfur dioxide

3.2 Predicted Concentrations and Comparison to Guidelines

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 3-1). Additionally, the cumulative impact analysis modeling scenario combined the results from the Project with modeled emissions from the other EEPGL offshore activities identified above.

All results are summarized in Table 3-2 (Project only) and Table 3-3 (Cumulative). For the Project only modeling scenario, the maximum predicted concentrations at any potential onshore receptor location for all pollutants and averaging periods was for one-hour average nitrogen dioxide (NO_2) concentrations, was consistent over both years, and was equal to 1.1 percent of the applicable WHO guideline. For the cumulative modeling scenario, the maximum predicted concentration at any potential onshore receptor location was also for one-hour average NO_2 concentrations, and was equal to 3.6 percent of the applicable WHO guideline. These results are consistent with the expectation that onshore air quality impacts from the Project will be relatively small in magnitude, based on the distance of Project emissions sources from the nearest potential onshore receptors. These results are also consistent with similar modeling analyses for prior exploration activities and development projects.

Table 3-2: Summary of Modeling Results—Maximum Predicted Concentrations at Potential Onshore Receptor Locations (Project Only)

Pollutant	Averaging Period	WHO Guideline Concentration (µg/m^3)	Predicted Onshore Concentration (µg/m^3) Maximum of 2021, 2022	Percent of WHO Guideline
NO_2	1-hour	200	2.21	1.1%
	Annual	40	0.16	0.4%
SO_2	10 Minute	500	0.57	0.11%
	24 hour	20	0.174	0.9%
PM_{10}	24 hour	50	0.073	0.15%
	Annual	20	0.014	0.07%
$PM_{2.5}$	24 hour	25	0.073	0.29%
	Annual	10	0.014	0.14%
CO	1-hour	30,000	1.62	0.005%
	8-hour	10,000	1.06	0.011%
H_2S	30 minutes	7	0.00619	0.088%

Sources: WHO 2000; WHO 2005

µg/m^3 = micrograms per cubic meter; $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); SO_2 = sulfur dioxide

Table 3-3: Summary of Modeling Results—Maximum Predicted Concentrations at Potential Onshore Receptor Locations (Cumulative Scenario)

Pollutant	Averaging Period	WHO Guideline Concentration (µg/m^3)	Predicted Onshore Concentration (µg/m^3) Maximum of 2021, 2022	Percent of WHO Guideline
NO_2	1-hour	200	7.26	3.6%
	Annual	40	0.56	1.4%
SO_2	10 Minute	500	1.67	0.33%
	24 hour	20	0.497	2.5%
PM_{10}	24 hour	50	0.207	0.4%
	Annual	20	0.041	0.20%
$PM_{2.5}$	24 hour	25	0.207	0.8%
	Annual	10	0.041	0.4%
CO	1-hour	30,000	4.48	0.015%
	8-hour	10,000	2.73	0.027%
H_2S	30 minutes	7	0.00626	0.089%

Sources: WHO 2000; WHO 2005

µg/m^3 = micrograms per cubic meter; $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); SO_2 = sulfur dioxide

Monitoring of current onshore air quality was undertaken at three sites in Guyana, as described in Section 5.1.2.2 of the EA&MP. Results of the monitoring study showed that concentrations of all of the modeled pollutants were lower than respective air quality guidelines, with the exception of particulate matter with aerodynamic diameter less than 10 microns (PM_{10}) and particulate matter with aerodynamic diameter less than 2.5 microns ($PM_{2.5}$). The sums of the modeled cumulative scenario concentrations and the measured ambient concentrations for all pollutants (other than PM_{10} and $PM_{2.5}$) also do not exceed any guideline values. For PM_{10} and $PM_{2.5}$, cumulative modeled impacts are less than 1 percent of the WHO guidelines and can therefore be considered negligible even though current air quality shows some exceedances.

3.3 Contributions from Non-EEPGL Activities

Additional potential exploration well drilling activities by Tullow, Repsol, and CGX, for which further exploration and development plans have not been publicly announced were not modeled explicitly, as there is no indication of the nature of these activities or the degree of temporal overlap with the activities of the Project. However, the relatively low impact of the Project (and of the cumulative EEPGL activities considered for the assessment) suggests that EEPGL's activities would not contribute significantly to a cumulative impact with activities of other oil and gas operators.

4. REFERENCES

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