Kushekabra Hill Quarry Project

of

Tri-County Inc.

Project Summary

Proposed Quarry Site at

Kushekabra Hill, Linden – Mabura Road, Region 10

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1.0 Executive Summary

- Tri-County Inc. (the company) recognizes the demand for aggregate, the current limitations of supply, and the anticipated increase in demand from the emerging oil and gas sector and the expanding construction sector.
- As such the company seeks to obtain from the Guyana Geology and Mines Commission (GGMC) a Quarry License (QL) to develop a modern, large-scale quarry to meet the existing and projected demand for aggregate.
- There are no historic or active quarries in the vicinity of this proposed new quarry development.
- The proposed Kushekabra Hill Quarry project site is located on the left bank of the Demerara river, ~20 km NE of Mabura, ~75 km from Linden, and ~175 km from Georgetown, all distances measured along the terrestrial routes.
- The potential for hard rock occurrences which may become exploitable quarry material is very good. The region is part of the Trans-Amazonian Craton and the underlying rocks are collectively known as the Barama – Mazaruni Supergroup (BMS) and the QL, more specifically, lies on boundary between the younger intrusions within the Bartica - Gneiss Complex and metabasic super crustals of the BMS. The general area is covered by young alluvium, fluviatile materials as well as saprolitic material. The observed outcropping, float rock and the topography are indications of the underlying the 'hard rock' quarriable material.
- The proposed QL lies on the major dominant regional structural trends of younger intrusions and is perfectly placed to host a significant quarry reserve
- The proposed project site encompasses approximately ~805 acres of land. This covers a large topographic high that is known as the Kushekabra Hills, it is over 250 meters in elevation and occupies most of the aerial extent of the proposed QL. The elevation at the bank of the Demerara River is less than 12 meters.
- This topographic high will be the initial focus for the development of the new quarry, where initial reconnaissance has shown the presence of rock at and close to the surface.
- The main operational center will be closer to the western sector of the license; rocks harvested from the other sectors of the QL will be transported here for processing into aggregate.
- The proposed QL is on the Linden – Lethem roadway and is well placed to support the construction of the Guyana – Brazil highway and associated development.
- The company will be investing and expending approximately Three Million United States Dollars (US$3,000,000) in the development and commissioning of this new quarry operation.

- This investment is being made to meet the demand for aggregate domestically as the economy continues to be boosted by expanding construction and infrastructure works, in particular the construction of the Guyana – Brazil highway and the associated development planned along highway.
- The initial output of this quarry is expected to be at least 4000 tons per week of aggregate (½”, ¾”,⅞”,1 ½” & <3/8”).
- The company is committed to being a responsible corporate partner to the Government of Guyana and is currently assembling a team of experienced and professional persons to manage this project.
- This project developmental plan will be revised at the direction and requirements of the relevant regulatory bodies.

1.1 Fact Sheet of Project

Table 1-1: Summary of Main Parameters of the Quarry Project

Project Developer	Tri-County Inc.
Project Name	Kushekabra Hill Quarry
Project Type	Quarry for Aggregate
Location:	Region 10 (Upper Demerara – Upper Berbice))
Name of River:	Demerara River
Locality	Kushekabra Hill
Size of Project Area	~805 acres
Type of Rock	Gabbro, Diorite & Granite
Reserves	~15,000,000 metric tons (above nominal elevation)
Production (initial)	~200,000 metric tons/year • 200,000 tons aggregate
Product	Aggregate: • Sifting (<3/8) • ½”, 7/8”, 3/4” • 1 ½”, (Crusher Run)
Project Components	Quarry Operating Area Crushing Facility Haul Roads and Service Roads Stockpile Area and Dumps Support Facilities • Admin Office Complex • Mechanical Service Bay • Power Generation • Ore Washing • Quarry Drainage

	• Settling Pond
Power Requirement (Generators)	650 KVA (2)
Primary Crusher	250 tph, Jaw Crusher
Secondary Crusher	120 tph, Cone Crusher
Tertiary Crusher	120 tph Cone Crusher
Overall Utilization	~75%
Life Span of Quarry	>15 years
Employment/Staff	~60
Capital Investment:	~4,000,000 USD
Current Status of Project	Application and Permitting
Nearest Habitation	~6 km SW
Nearest Town	Linden
Nearest Airstrip	Omai, 30km , WSW
Nearest Police Station	Mabura, 20 km South
Nearest Fire Station	Linden, 75 km North
Telecommunications Tower	Mabura, 20 km South
Ecologically Sensitive Zone	None in or around project area

2.0 Introduction

The project is presently in the permitting stage at all relevant state agencies to obtain the permissions necessary to secure the Quarry License for the area identified and the resources thereon. The quarry is being developed by Tri-County Inc., a company duly incorporated and registered in Guyana. The area being applied for is state land and has already been identified for mining activities.

Applicants Details:

Company : Tri-County Inc.

Address: Lot 4292 Richmondville, Providence, E.B.D., Guyana

Tel#: +592-653-0629

2.1 Nature of the Project

This Quarry Project is being designed to produce 200,000 metric tons of aggregate per year in its initial capacity. This will increase when the project recovers capital expenditure and further invests in expanding production capacity. The quarry outputs will be transported by truck to various points along the Linden – Mabura road. The quarry will produce mainly aggregate for the construction industry and road building. The main objective of the project is to carry the business of prospecting, exploring, developing drilling, blasting, and crushing capabilities onsite for the supply of these products to the market in and around location of the QL.

2.2 Project Rationale

Quarrying is linked to many other industries and other sectors in the economy, including transportation, construction, and environmental management. The proposed project site is a good source of dolerite, diorite, gabbro and associated metabasic rocks. This development will create significant positive impacts for the Government and GGMC, both of which will benefit through government taxes, fees, and duties. This project will also play a huge role in the economic growth of the country by generating revenues and promoting employment while supplying the materials needed to support the construction industry. The key beneficiaries will include the local workforce and businesses allied to the quarrying operations.

2.3 Demand – Supply Gap

The potential for quarries in this area is now being developed because of the impending construction of the Linden – Mabura road. The existing quarries have been established in the Mazaruni area, around Bartica, they have supplied most of the quarry products to the local market in and around Georgetown by these riverain routes. However, due to operational constraints and lack of expansion these and other local operations have been unable to meet the increasing local demand for quarry materials. This first phase of the Linden – Mabura roadworks will require at least 3 million tons of aggregate. For 2018, 2019 and 2020 the GGMC has reported an average of 180,000 – 210,000 metric tons of aggregate being imported to supply the demand of the market. The 2021 projections for demand based on the government projects and private development are between 1 – 1.5 million metric tons of quarry product. This is a conservative estimate and demand will be increasing consistently over the next few years as the oil and gas sector expands and drives development.

Over the period 2018 – 2020 the total domestic quarry production has been approximately 600,000 metric tons. Even with the imports, there was still a significant shortfall to satisfy market demand. This has not only delayed work but has driven up prices locally.

Given the projections for demand are in excess of 1.5 million metric tons of quarry product per year there is a definite need for the establishment of new quarry operations. The area selected has a significant resources of quarriable material to support not only the road project but the associated development in the area. The geography of the area prevents any of the riverain quarries from supplying this segment of the market, as this area depends of land based transport.

2.4 Domestic and Export Markets

The company will not pursue or engage in the export of quarry products given the large demand which exists in the local market. 100% of the product from this quarry will be supplied to the local projects here in Guyana.

2.5 Employment

The project is expected to generate approximately 80 jobs during construction and 60 jobs during operation. The following are the possible areas for employment:

<u>Construction</u>

Laborers
Electricians
Engineers
Masons
Carpenters
Surveyors
Security
Drivers
Cleaners
Caterers
Supervisors
Managers
H&S Officer
Logistics
Accountant
Cooks

<u>Operation</u>

Maintenance Personnel
Operators
Engineers
Cleaners
Security
Electrician
Drivers
Linesmen
Drillers
Blasters
Cooks
Managers
H&S Officer
Accountant

The company will hire local persons, including women, based on their experience and skills to support the construction, operational, and closure phases of the project.

3.0 Project Description

This will be designed and set up as a modern open pit stone mining project with a mechanized crushing circuit to produce aggregate. There will be a complex where accommodation, administration, storage, maintenance, and other necessary infrastructure will be established on site.

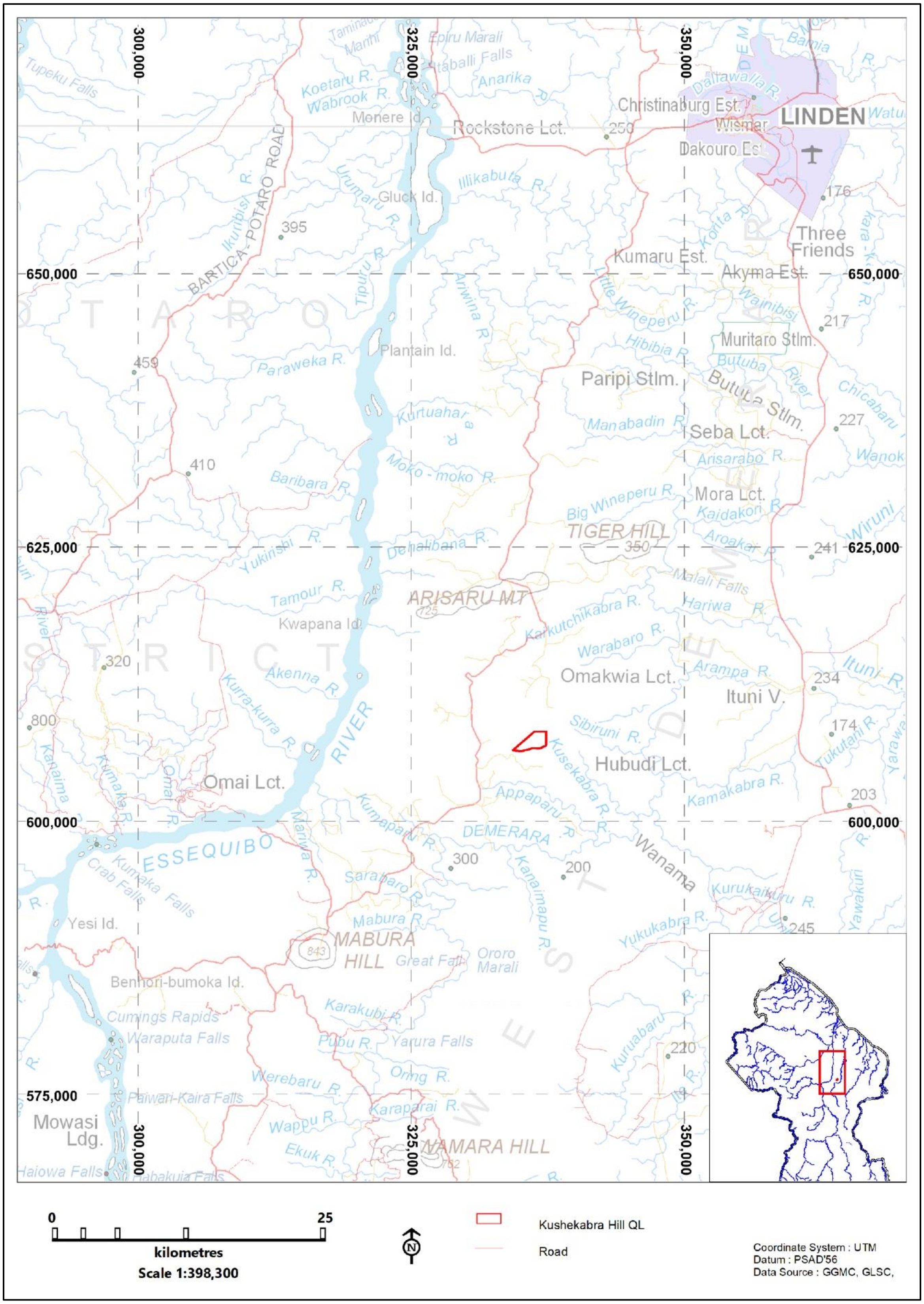
3.1 Location

The project is located in Administrative Region #10: Upper Demerara - Upper Berbice. The Quarry Project area is centered on N 5° 29.50' W 58° 28.60' in the Potaro #2 Mining District, central Guyana (See Map 3.1). The area is on the left bank of the Demerara River, approximately 175 km south-southwest of the capital city of Georgetown and the closest town is Linden some 75 km to the north.

The Project area is located in the Amazon rainforest of Guyana. It is bracketed to the west by the Linden – Mabura road, and to the east by the Warabaru Creek. To the North and South are forested areas. The location of the project site is shown in Map 3.1 below.

3.2 Project Life and Sustainability

The quarry project is being developed with an economic life span of at least 15 years. This life span is based on the extraction of reserves both above and below nominal elevation. The company will be the owner and operator of the Quarry Operations within the License, under the supervision of the Guyana Geology and Mines Commission and other regulatory agencies. It is estimated that the project will have a payback period of 10 years. The quarry material produced by this operation will help to reduce imports, supply the local market demand and reduce the cost being borne by the consumer.



Map 3.1: Location of the Proposed Quarry Project

3.3 Local Geology

The area under and around the proposed QL is dominated by three main features.

The first is a large granitic intrusion which stretches approximately 50km along its axis. This granite is locally metamorphosed to Gneiss and has a NE-SW orientation. The intrusion is expressed at the surface in a series of non-uniform topographic highs. The granite, as described by H. Schielly 1968, is made up of 'uniform and massive, leucocratic muscovite granite which contains a few angular, black xenoliths of biotite hornblende hornfels (less than 1%)'.

This type of granitic material is already being extracted by three quarries in the Mazaruni River and it is an excellent source of quarriable material.

The second feature is the Bartica - Gneiss complex, which is a broad term applied to a large area of metamorphosed rock. The bartica gneiss complex contains younger intrusions of leucocratic muscovite-bitotite granite, younger intrusions of mafic dykes of the Avanavero, Apatoee and PAPA suites, and older rocks such as biotite, biotite hornblende hornfels, biotite hornblende gneiss, granite gneiss, biotite hornblende schists, migmatite etc.

'The foliation and banding of the gneisses at Kereti Quarry are mainly the results of tectonism; concomitant metamorphism within the Amphibolite Facies was succeeded by a two-phase metasomatism involving successive additions of Na and K. These results appear valid throughout the Bartica Assemblage and it is further suggested that the main rock type distribution in the Bartica Assemblage is also controlled by tectonism.' - 1962, R.T. Cannon.[1]

From H. Schielly 1968 observations in this and similar areas found the variation in this setting to be between biotite gneiss /biotite granite/granite gneiss and biotite hornblende gneiss. The material within the project area is described by Schielly as heavily jointed, foliated, hornblende-biotite gneiss with granite and pegmatite dykes and even if fractured moderately still carries good characteristics for the following utilization:

1. It is suitable for first class concrete aggregate.

2. It is suitable for road foundation works and other foundation and fill applications.

[1] R.T. Cannon. 1962. The Gneisses of the Bartica Assemblage, British Guiana, Article in Geological Magazine 99(02) ·

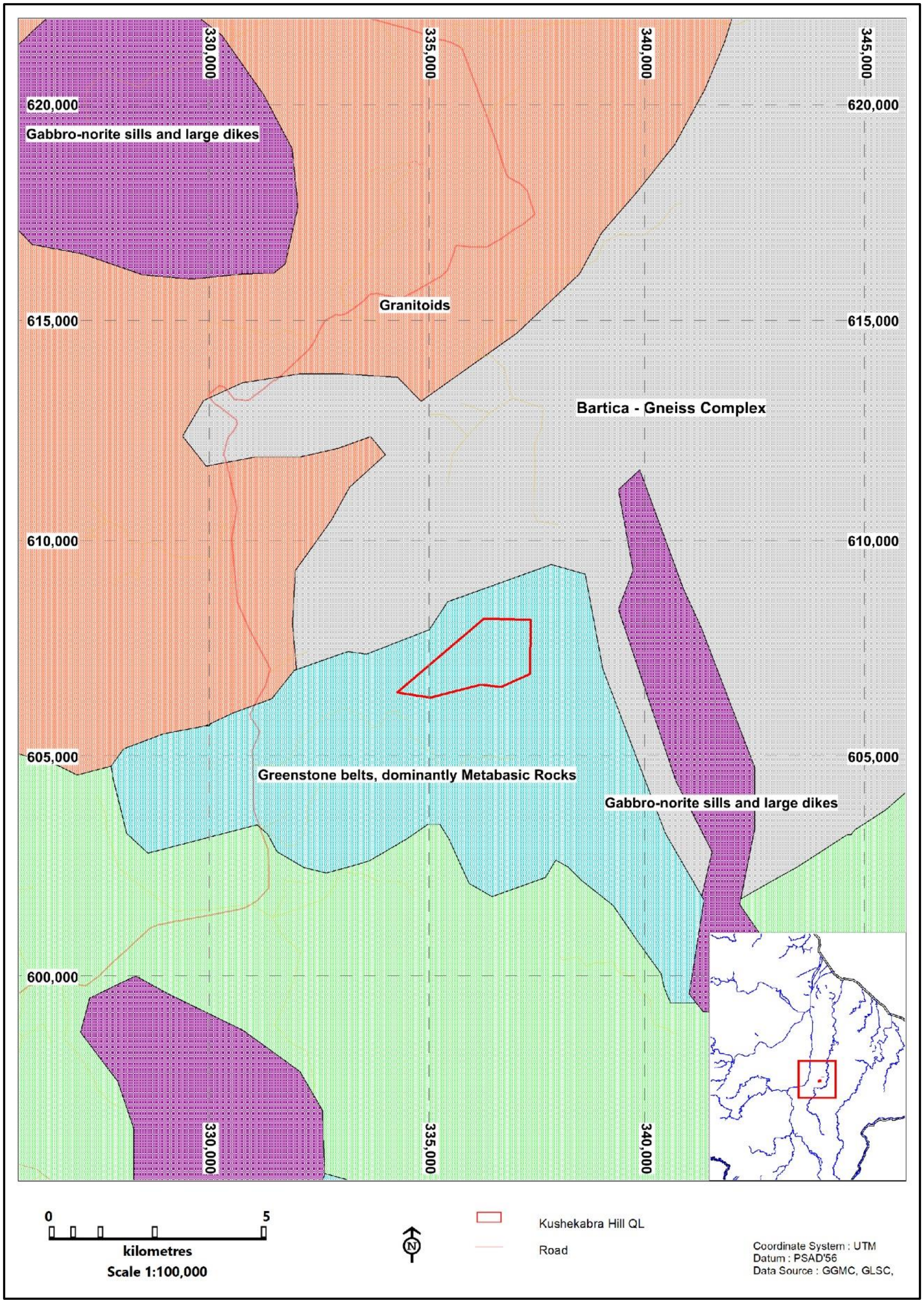
3. Large boulders and armour layer material for use in sea defences

The suitability for utilization of the rocks originating from the Bartica - Gneiss complex will depend on the extent to which it may have been deformed/metamorphosed/foliated and will be determined upon further investigation.

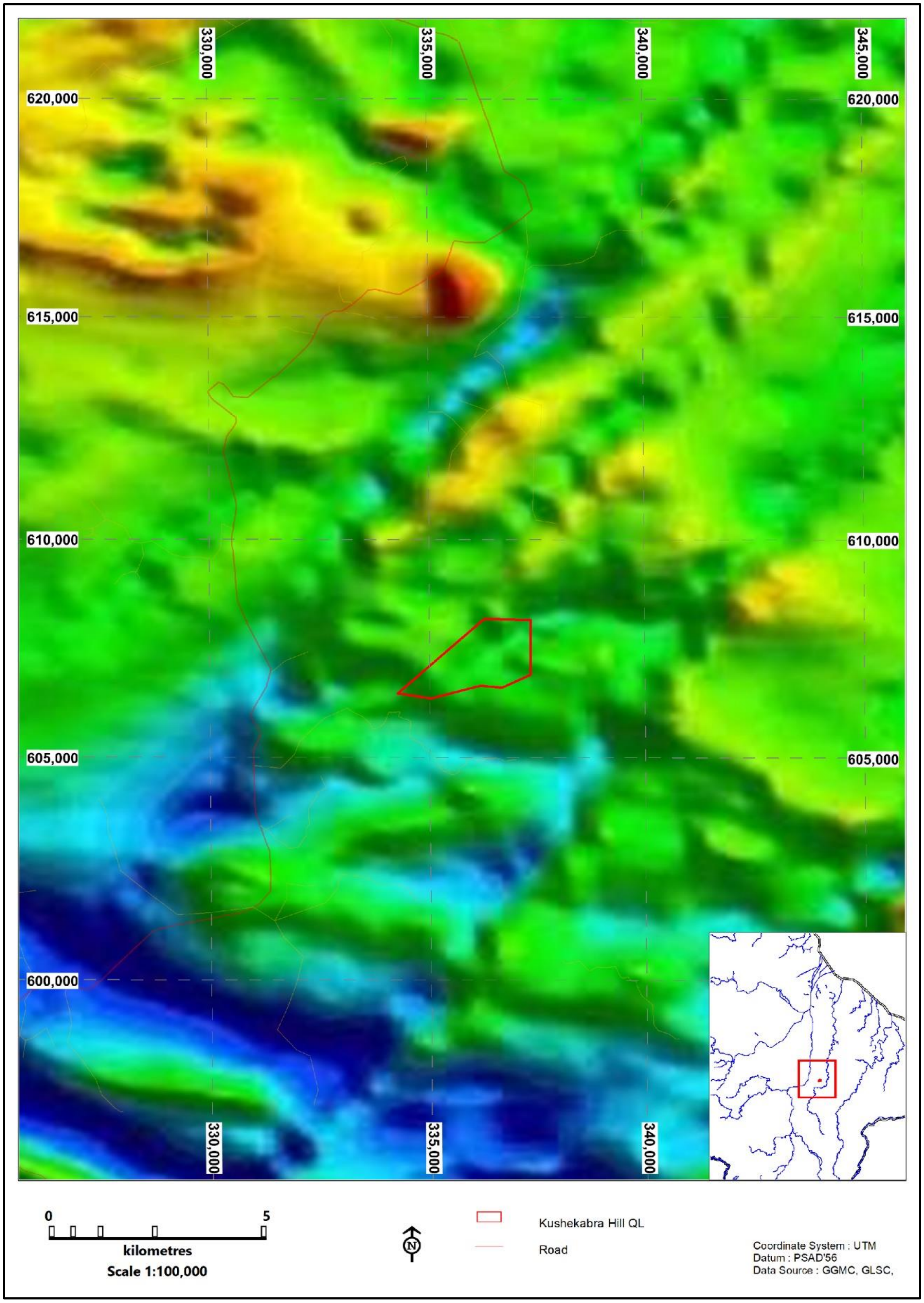
The third feature is metabasic rock from the Barama Mazaruni Supergroup. In this area these are thought to be andesitic lithologies.

To the east of the project site there is a N-S trending dyke of the Avanavero suite. Those dykes are usually between gabbro to diabase in composition.

The aeromagnetic map shows the contacts between the three different lithologies. The lithologies are apparent from the contrasting aeromagnetic signatures. The granite is more felsic, Bartica gneiss complex is more intermediate between felsic and basic and the metabasic are more mafic. The lithological contacts being a zones of weakness allowed the rivers to develop drainage as they eroded faster than the bordering topographic highs that are underlain by the younger and more weather resistant material.



Map 3.2: Geological Map of the Proposed Quarry Project



Map 3.3: Aeromagnetic Map of the Proposed Quarry Project

3.4 Resource

The main type of rock that will be utilized for quarrying in this project will be mafic in nature. Mafics in this region are usually Gabbro and have a density of approximately 2.9 - 3.1 tons per cubic meter. The overburden, based on the presence of outcrops and float is not expected to exceed 10 meters, pending verification by augering. In other quarries in the region this has been found to the case. Based on the general topographic data, presence of float rock and profiles of other nearby quarries, it can be expected that upon the completion of a drilling program a resource in excess of 15 million tons will be proven.

3.5 Process Details

The proposed mining operations will be carried out by open cast semi-mechanized methods. The process flow diagram is given below to depict the expected mining process:

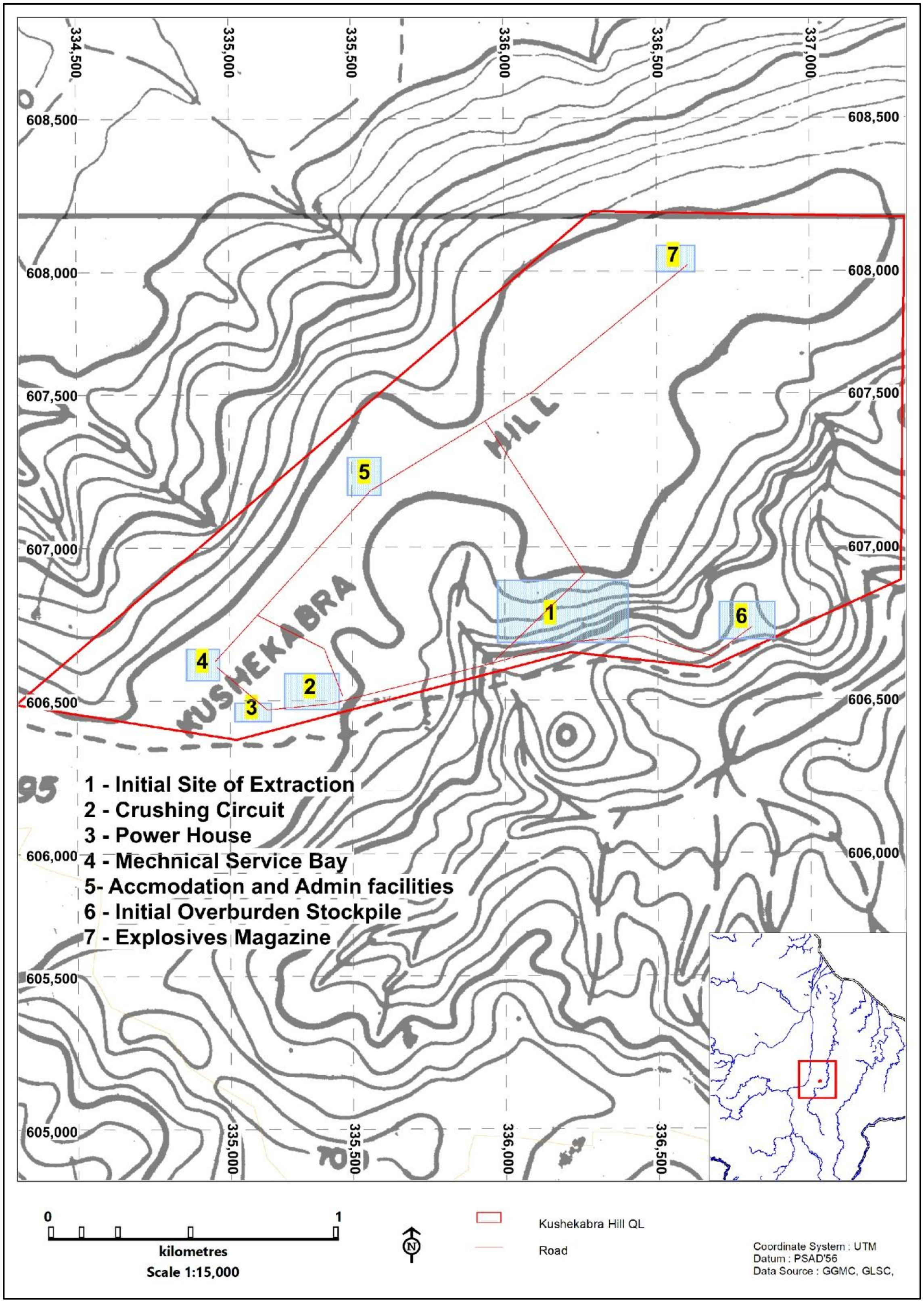
1. Cutting & Clearing of Vegetation
2. Removal of Top Soil and Overburden
3. Excavation by Drilling and Blasting
4. Rock Braking and Transport to Crusher
5. Crushing of Rocks in Crushing Circuit
6. Segregation and Stacking of products
7. Dispatch to End User by Transshipment

3.6 Project Components

The quarry project infrastructure is expected to comprise the following major components:

- An automated crushing plant comprising the following:
    - A 350 metric ton per hour primary crusher.
    - A 250 metric ton per hour secondary crusher
    - A 100 metric ton per hour tertiary crusher
- Ore Washing facilities
- Siltation / Settling Pond
- Haulage Roads and Service Roads
- Stockpiles and Dumps for ore and overburden
- Power Generation Unit of 650 KVA
- A fleet of heavy-duty earthmoving equipment
- Rock drills for establishing blast pattern
- Mechanical support/service bay
- Explosives Magazine and Police Outpost
- Admin and accommodation facilities
- Loading facilities for transshipment to the wharf

Map 3.4, below, shows the proposed layout of the project components at the project site.



Map 3.4: Proposed Layout and Site plan for the quarry development.

3.7 Proposed method of mining

It is proposed to undertake Open Cast Semi-Mechanized Mining which includes blasting, loading, transportation of rubble, and dispatch to the crusher. The surface plan showing the mining steps will be developed in detail after the permit is issued and initial exploration works are carried out to inform the preparation of the finalized mining plan.

Open Pit Mining

In the open cast mining, the bench height and width will be maintained at 5 to 6 m respectively. Excavated material is transported to the crusher unit located near the complex for further processing.

Salient Features of the Mining Method

The salient features of the proposed mining method are given below.

• The height and width of the bench will be maintained at 5 m and 6 m respectively.

• The mining will be done from top to bottom by slicing of 2.5 m thick.

• The exploitation of rock is being done from 250 meter to 100 meter above mean sea level in the conceptual phase.

• Considering the stability of rocks the final slope or say ultimate pit slope is proposed between 30° to 45° from vertical.

• Haul road will be developed up to point of loading.

• Transportation of the mineral from pit-mouth to crusher and then to the destination/market will be by tippers/trucks (25-ton capacity) and barges (2000-ton capacity).

3.8 Equipment to be Utilized

The following list of equipment is proposed to be used in the mining operations:

Category	Equipment	# Units
Mine Transportation	Trucks (45-ton)	4
Material Handling	Excavators (CAT345)	6
	Bulldozers (CAT D8)	2
	Frontend Loaders (CAT 966)	2
	Drills (Atlas Copco 25-SP)	2
Crushing Circuit	Jaw Crusher (250-Ton/Hr)	1
	Cone Crushers (120-Ton/Hr)	2
	Screens	2
	Conveyors	10
Road Transportation	Road Haulage (25 Ton)	10

Table 3.1: Primary Heavy Duty Equipment to be Utilized.

3.9 Description of Project Components

Crushing Plant

The crushing plant is expected to comprise:

- **Primary Crusher:** This will be a jaw crusher. The main purpose is to reduce the material to a small enough size that it can be transported by conveyors to the next crushing stages. As the name suggests, jaw crushers reduce rock and other materials between a fixed and a moving jaw. The moving jaw is mounted on a pitman that has a reciprocating motion, and the fixed jaw stays put. When the material runs between the two jaws, the jaws compress larger boulders into smaller pieces. The primary will accept the run of mine ore from blasting, i.e. boulders of between 1- 2 meters in diameter, and reduce them to approximately 8-10 inches diameter. This allows the rock to be fed to the downstream crushers for further processing.

- **Secondary Crusher:** This will be a cone crusher. Cone crushers have an oscillating shaft, and the material is crushed in a crushing cavity, between an external fixed element (bowl liner) and an internal moving element (mantle) mounted on the oscillating shaft assembly. The secondary will accept the output of the primary and further reduce the particle size from 8-10 inches to either 5/8" or 3/4" as required.

- **Tertiary Crusher:** This will be a cone crusher also, It will accept the output from the secondary crusher and further reduce the particle size from 5/8" or ¾" to < 1/2".

- **Vibrating Screens:** A vibrating screen is formed by a vibrant chassis that supports in its interior one or several surfaces or elements of screening. The screens serve to classify the different particles by size, starting from a bulk product in a continuous process. The inlet material advances from the part where the screen is fed to the opposite end in which the particles come out separately according to their size. Screens will be utilized within the crushing circuit to control the feed and output particle sizes of all crushers.

- **Conveyors:** These are bulk material handling units that will facilitate the automated feed, discharge, and returning of input and output materials within the crushing circuit. They are generally designed to be discrete units of belts on frames with all necessary drive units included so they may be repositioned as necessary. These units will have 30" wide, heavy-duty belting that will travel in a concave manner. Units will be between 60 and 100 feet in length. The discharge capacity is regulated mainly by the speed of travel of the belt and will be automatically regulated by the control facility.

- **Control Room**: This is a fully integrated and automated crushing circuit. There will be cameras and sensors at all points monitoring a range of factors such as speed, weight, temperature, etc. The computer in the control room will regulate the circuit to maintain the set output requirements. The control system is also a safety mechanism that can detect failure or unsafe parameters to alert the operator or automatically shut down the system.

Figure 3-1, below, indicates the locations of the key project components and the plant site. At this stage, these are indicative since the detailed design phase will entail geotechnical and other analyses which will then influence the final location, specifications, design, and layout of project components.

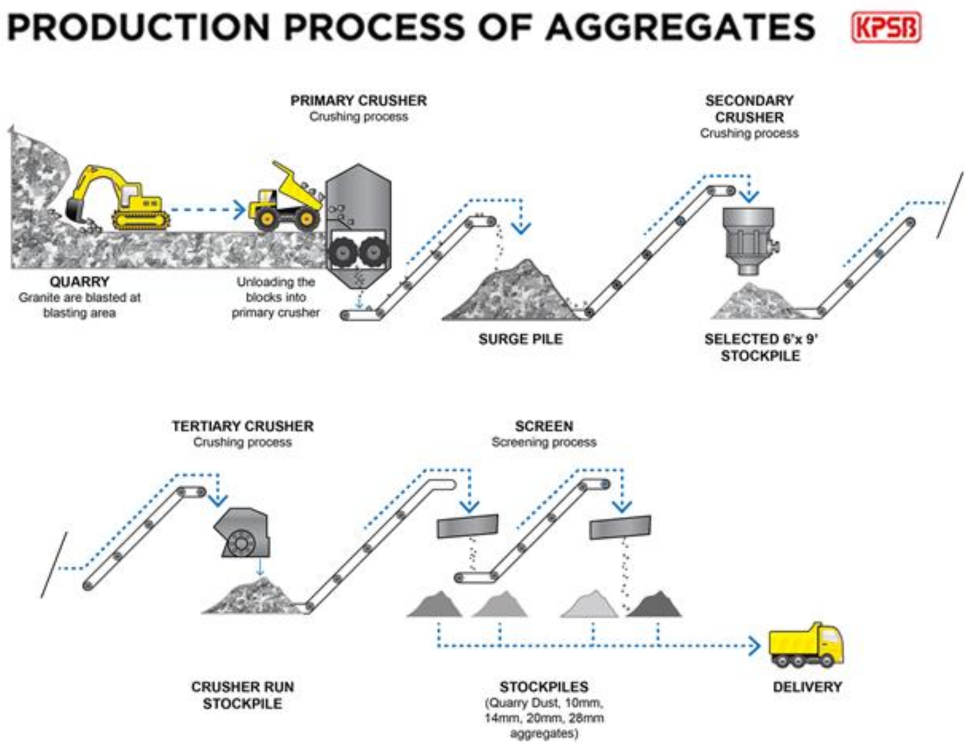


Figure 3-1: Generic Crushing plant process flow

Ore Washing facilities and Settling Ponds

- The rock which will be fragmented from the blasting to feed the crushing circuit must be washed to prevent contaminants, particularly clay particles, from entering the circuit. The presence of clays in the final product is undesirable as it will weaken the resulting concrete if mixed into the cement with the aggregate.
- Washing will be done by having the trucks which are loaded with rocks from the quarry face drive through an overhead wash bay where jets will direct water into the tray of the truck from above. This washing facility will have a concrete floor with drains leading to a settling pond.
- The settling pond will be located to receive flow from the washing facility as well as from the quarry face. This pond will have a capacity to hold approximately 6000 cubic meters and will be cellular in construction. It will operate on an overflow principle where water will fill one cell before overtopping to the next. Settlement of suspended particles will take place as the water is held in these cells before discharge. There will be strict control of the water quality at the discharge point. The released mine effluent will be directed to a suitable naturally wet area which will act as a final settlement area and soakaway.
- The settlement pond will periodically be desilted as necessary, the removed material will be taken to the waste dumps where the overburden is being stored.

Haulage Roads and Service Roads

There will be several roads within the project site to facilitate the movement of vehicles and equipment as they carry out the quarry process and supporting activities. The main haul roads from the quarry face to the ore washing facility and then to the crushing plant will be designed to accommodate the passage of two 25 ton trucks simultaneously in opposite directions. Within the quarry, the haul roads will be circular so that trucks enter from one side to be loaded and then exit from the other side.
Service roads will be designed to accommodate the passage of smaller vehicles and support equipment such as fuel trucks and personnel transport vehicles. Main haul roads will be approximately 35 feet in width, service roads will be approximately 20 feet in width. All roads will have grades not exceeding 15% and will be capped with laterite and/or crusher run to provide an all-weather surface.

Stockpiles and Dumps for ore and overburden

There will be several stockpiles associated with the quarry development and operations. These being stockpiles for top-soil, overburden, feed material for primary crusher, feed for secondary crusher, feed for tertiary crusher, final products from crushing circuit. Topsoil will be dumped and stored separately for use in reclamation activities. Overburden will be dumped in a flat area away from the working face and not in the direction of advancement of the quarry. Overburden will be piled to heights of 20 meters with slopes not exceeding 30 degrees.

Power Generation Units of 650 KVA

The crushing circuit, as well as support facilities, will be run by electricity generated on-site by diesel generators. There will be 2 generators, each rated at 650 KVA, these will be used alternatingly so that one is always on standby in the event that the other develops a fault.

Fleet of heavy-duty equipment

There will be a number of hydraulic excavators, bulldozers, trucks, drill rigs, front-end loaders, fuel trucks, service trucks, and other heavy-duty equipment on-site to carry out the quarrying and other supporting activities. These will all be diesel-powered equipment. As per the list in table 3.1 above.

Rock drills for establishing blast pattern

There will be two drill rigs on-site to carry out drilling to establish the necessary blast patterns to allow blasting for primary fragmentation. These drills which have been identified for use on this project are Atlas Copco T-35. These Drills will work either one or two shifts per day depending on the required blast pattern at the time of execution. Under normal circumstances, it is envisioned that these drills will work alternatingly so that one is always on standby in the event that the other develops any mechanical problem.

Mechanical support/service bay

There will be a fully equipped mechanical service bay on-site to maintain, service, and repair all of the equipment on site. This service bay will be a modern facility with all necessary facilities in place to adequately service the fleet of equipment on site.

Fuel Storage

It is estimated that the project will require approximately 25,000 gallons of fuel per month. As such there will have to be storage facilities on-site to accommodate the holding of roughly 8,000 - 10,000 gallons of fuel to support operations. Permission from the Guyana Energy Agency and other relevant authorities for this fuel storage facility will be sought by the company after the Quarry License is obtained from the GGMC.

Explosives Magazine and Police Outpost

There will be the need to store explosives on-site to facilitate blasting at the quarry face. This activity is controlled by the Guyana Police Force (GPF). The GPF will oversee and approve the siting and construction of a Magazine and Police outpost within the project area to safely store and secure the explosives. The GPF will allow only a registered and authorized blaster to access the magazine and carry out blasting.

Admin and accommodation facilities

There will be the construction of adequate housing, offices, administrative, and support buildings on the project site to allow personnel on-site to have hospitable and safe accommodations. There will also be the construction of storerooms and other necessary facilities. These will all be designed and built in keeping with the relevant codes and regulations. These facilities will all be adequately sited so as to be well away from the quarry face and crushing circuit.

Distribution

The main mode of transportation for the quarry products will be by 25-ton haul trucks along the Linden – Mabura trail. This will be to support the road project as well as to support the associated development which will take place along the road.

3.10 Drilling and Blasting

Drilling

The excavation of loose/soft material is proposed by excavators. Where the material is fractured and easily exploitable by rock breakers and excavators these will be utilized. The hard strata are proposed to be excavated after drilling and blasting them for fragmentation.

Blasting

The controlled blasting is proposed by adopting all the safety measures as per the laws and regulations of Guyana. Multiple blast holes of 3.0 to 10.0 m depth will be drilled with the help of 32 mm drill rod, Jack Hammer, and Air Compressor of 100 cubic feet per minute capacity. It is estimated about 1000g of explosives per hole is required. About 20 holes per blast are proposed. Therefore, the requirement of explosives will be about 20 kg/ blast. This is be confirmed and adjusted as detailed site investigations are undertaken upon the issuance of necessary permits and approvals.

3.11 Mineral Reserves

To be determined quantitively by drilling after the issuance of all permits to the company. A rough estimate based on data from surrounding operations and other available data it can be expected that reserves will exceed fifteen million tons for rock.

3.11 Planned Production

The applicant is proposing to develop a production line that will output approximately 200,000 tons of aggregate per year for the first 5 years of the project's life span. During that time detailed documents about the further expansion will be prepared for submission to the relevant authorities.

3.12 Estimate of Waste to be Generated and treatment

Top Soil

Topsoil will be removed and stored appropriately according to mining regulations and accepted best practices for use in the rehabilitation of the mine. Volumes are to be determined by a detailed mine plan after geotechnical works are carried out on-site when the Quarry License is issued.

Overburden

Overburden will be removed from above the rock strata and sock piled in accordance with mining regulations and best practices. Volumes to be determined upon completion of detailed mine plan.

Solid Waste

Domestic solid waste may be around 200 kg per month. This will be put into compost and layered dumpsite as appropriate in accordance with the appropriate regulations.

Hazardous Waste

Such as used engine oil and old batteries will be appropriately stored until removed by a service provider. Waste oil generation to be approximately 50 gals per month. Batteries have a life span generally of 2 years, the total number expected to be in use is approximately 24 units.

Liquid Waste

Water from the process will be directed to multi-stage settlement ponds before being directed for release to the environment. Process water is expected to be approximately 3000 gals per day.

Sewage

Sewage will be dealt with through the construction of septic tanks in accordance with the regulations of Guyana Water Incorporated. Septic systems will be sized based on 50 person occupancy at a rate of 1.5 liter/person/day or as recommended by the GWI regulations.

4.0 Site Analysis

4.1 Proximity

Particulars	Distance & Direction
Nearest Town	Linden, 75 km, N
Connecting Roads	6m wide, Laterite surface
Nearest Airport	Omai Airstrip, 30 km, SW
Nearest Major Road	Linden – Mabura , 2 km, W
Nearest Major Waterway	Demeara River, 11 km, E
Nearest Settlement	Mabura , 20 km, S

Table 4.1: Proximity to Major Infrastructure

4.2 Land Form and Land Use

Extent

The proposed project site would cover an area of 805 acres. The Mine would be developed incrementally, initial infrastructure and the first open-pit would occupy approximately 20% of the total area.

Land Use

The land is devoid of any development or current active users, presently the lands are forested and are allocated for use by the GGMC for the issuance of mineral properties.

Land Ownership

Presently the land being applied for is designated state lands and is under the control of the Government of Guyana through its statutory bodies, for this project in the mining sector the Guyana Geology and Mines Commission is the relevant authority to whom the application was made to obtain a Quarry License for this area.

Topography

The area in the central sector of the project area is dominated by hills reaching up to 250 meters in elevation. These hills are in elongated ridges oriented to in an NE-SW direction. The elevation at the Demerara river bank is below 40 meters. Relief is therefore approximately 200 meters. The area is drained by a dendritic network of streams that flow into the Kushekabra River, which then flows east into the Demerara River.

Map 4.1, below, shows the topography of the project site.

Sensitive Areas

There are no environmentally, culturally, ecologically, historically, or otherwise sensitive areas within or nearby the project site.

Existing Infrastructure

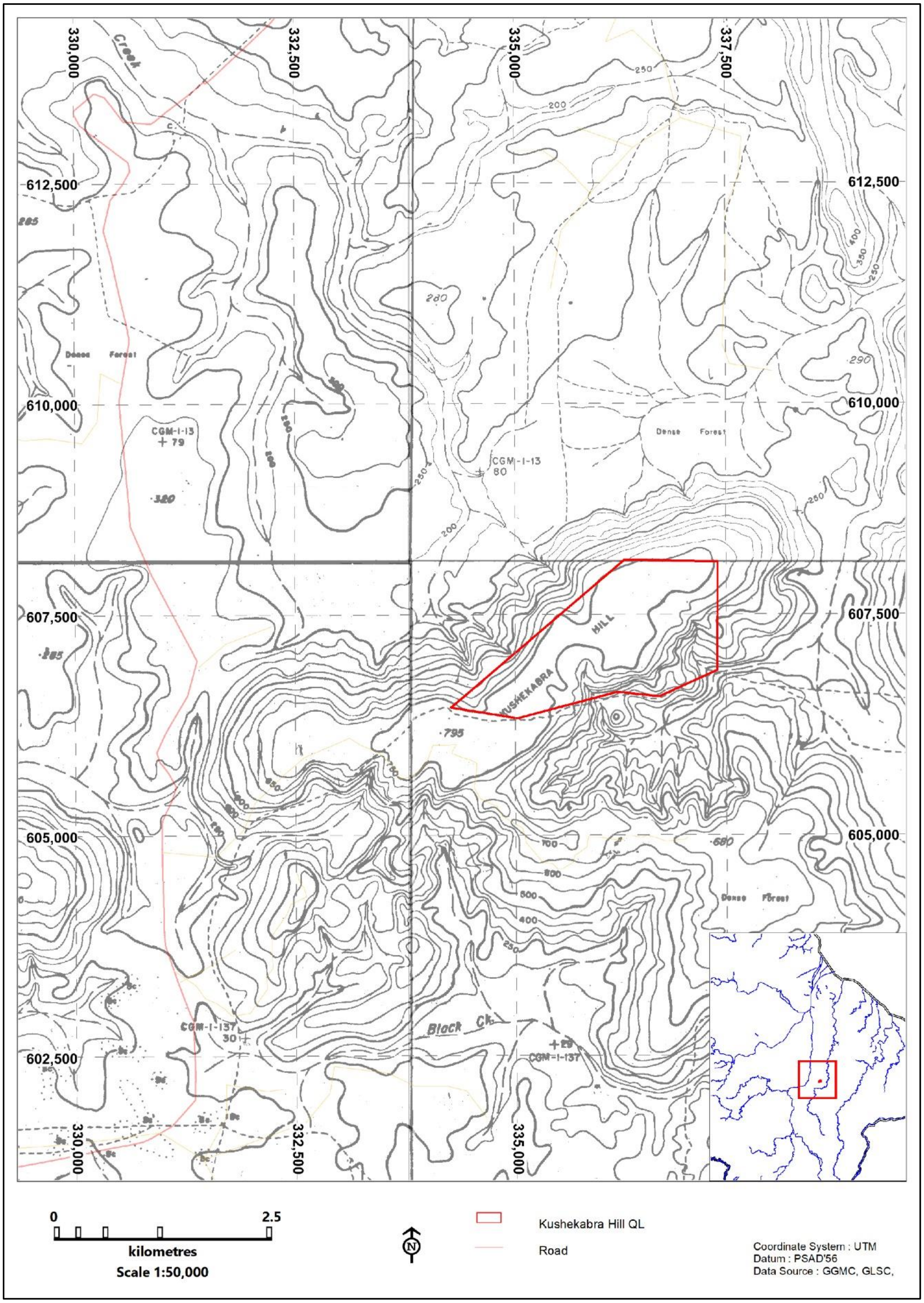
There is no existing infrastructure on the project site, except a section of the Linden – Mabura trail that passes nearby the western boundary.

Soil and Rock Classification

Soils are lateritic and saprolitic with outcrops of mafic rocks visible in many places.

Climatic Conditions

The climate in Guyana is strongly influenced by the Inter-tropical Convergence Zone (ICZ). Due to the movement of the ICZ, most climate variables show bimodality throughout the year. There are generally two rainy seasons and two dry seasons in Guyana. The longer rainy season being from May to June and the shorter is from December to January. The project is located in the tropical rainforests of the Amazon jungle, regular showers are experienced as a normal occurrence. Temperatures range from 26 – 33 degrees Celsius within the project area.



Map 4.1: Topography of the Project Site

5.0 Planning Brief

Operational Method

Surface Mining Methods, particularly, open pit quarrying will be employed for the whole project operation. The quarry operation will be divided into two stages: the quarry development and the production stage. The operation of the quarry will require that stripping of overburden, drilling, and blasting be done in advance of production as to maintain supply to the primary crusher. These will be full-time ongoing activities. The aim being to stockpile 'run of the mine' ore to keep the primary crusher fed for at least two weeks of production. The quarry operations will focus initially on the rock material in the elevations above that of the riverbank. These hills will be quarried using multi bench approach along the operational face. The crushing circuit will operate for 10 hours daily with a 1-hour break for physical inspection and maintenance.

Transshipment Operations

The main demand for the supply of aggregate is to the Linden – Mabura road project which will require quarry products for all aspects of work. This demand will be met by trucking the quarry product from the production site to various points along the road as required during its construction. The QL is connected to the Linden – Mabura Road directly and this be the haulage route for distribution. Supply to other persons or projects which are expected to develop along the route of the road project will be met by utilizing the same haulage route.

Production Costs and Consumer Benefits

Data taken from the quarries operating in the area has placed production costs between 40 – 60 % and is heavily dependent on the rate of production. Presently consumers are paying between G$9,000 – G$12,000 / metric ton of quarry product. Based on the company's business model the expected cost of production should be reduced and the benefit of lower retail prices be passed on to consumers. The majority of consumers for the aggregate would be in Georgetown, greater Georgetown and environs. The government projects for roads and sea defenses across the country will utilize virtually all of the crusher run, gabion, armor, and boulders produced.

Construction Phase

The construction of the crushing plant is expected to cover a period of 4-6 months and employ approximately 80 persons as detailed in section 2.5. Construction materials are readily available from Bartica and surrounding areas where there are existing sandpits, quarry operations, and lumberyards.

This developmental phase is the stage in the quarry where preparation for full blast operation will be carried out and it will involve removal and grubbing of vegetative covers, stripping of overburden, and establishment of production benches, drainage canals, settling ponds, and access roads to the deposit.

The rock will have production benches of five to ten meters high with a 70° bench slope during the development and production stage. Development work will generally start from the uppermost portion of the permit area and progresses downward. A portion of the area will be developed until a production bench with a slope of 70° and a loading area of 30 meters, will be formed enough to sustain the safe movement of quarry equipment. Once a bench is formed, a new working level will be worked out to form another set of benches. Should safety and economy warrant, the cycle of creating a new working level (benches) at lower elevation will continue until the desired target is reached.

Operation Phase

The extraction of the production stage is the actual removal of the deposit from the cleared benches. The major activities in this stage are drilling and simply ripping and dozing on the soft and medium ground while drilling, cutting, and blasting for hard rock area followed by loading and hauling of quarry materials. Materials from the bench will be loaded by either a wheel loader or excavator shovel into 25-ton trucks and will be transported to the crushing facility. The operational phase of the quarry is expected to be approximately 15 years, during the operational phase approximately 60 jobs will be created as detailed in section 2.5.

Once commissioned, the crushing plant is expected to work 10 hours, every day of the year, except national and major religious holidays, unless subject to unscheduled maintenance or other operational constraints. On an annual basis, at least 200,000 tons of aggregates is expected to be produced. Output is expected to be relatively constant throughout the year since the operation is designed to stockpile at least two weeks of feed material for the primary crusher.

Closure Phase

Consistency with the policy and regulations of the Government to assure the availability, sustainability, and equitable distribution of the country's natural resources, the GGMC adopts the policy that mining activities shall be managed in a technically, financially, socially, culturally, and environmentally responsible manner to promote the general welfare of the county. One of the objectives of this policy is the establishment of a functional post-disturbance land use capability.

Moreover, remediation and rehabilitation of abandoned mines shall be accorded top priority to address the negative impacts of mining activities. This is through protection and conservation of the environment by identification of appropriate rehabilitation and mitigating measures per project component to inhibit and/or prevent any possible risks or adverse impacts that could endanger humans and the environment.

During the life of the mine, there will be continuous mine rehabilitation carried out with supervision and input from the GGMC and EPA. The company will work with these agencies and other stakeholders towards the development of an approved mine rehabilitation and closure plan. The closure phase will take approximately 8 months and will require approximately 20 persons.

Support and Supplies

The project will be supported at all stages by the sourcing and supply of all necessary industrial inputs from Georgetown, Linden, and Mabura based on the cost and availability of the required products and services. Other supplies, such as vegetables, will be taken from the surrounding artisanal farmers to support the local economy.

Environmental Benefits

This quarry operation will seek to minimize its carbon footprint by carefully planning and controlling its development while utilizing methods and equipment that are eco-friendly.

Socio-Economic Benefits

The quarry project is expected to have positive socio-economic benefits through the provision of an affordable and reliable supply of quarry products throughout the year to the local market. The quarry will also create employment and allow employees to be trained in various vocations.

As is outlined in Section 5.1 below the cost of aggregate produced by the project will be cheaper than the current cost, and with this quarry in operation the cost can be stabilized. The project is estimated to produce approximately 20-30% of the demand.

Once the project is operational there may be other benefits, such as having a tourism value whereby visitors can visit the project site to access the surrounding eco-tourism attractions.

Advantages of Selected Project

In the consideration of this quarry development several considerations were made, including;

- the projected demand (2020-2035)
- the quantity and quality of the material available
- the logistics and site accessibility
- the projected life span of the project

- the reduced cost of aggregate on the local market
- the high yield of quarry material per surface area cleared

5.1 Economic Analysis

Particular	Details (GUY$)
Quarrying Cost	3000 / ton
Transportation Cost	1500 / ton
Royalty and Other Expenses	1500 / ton
Total Cost of Production	6000 / ton
Selling Price	8500 / ton
Gross Profit	2500 / ton
Current Market Price	~9500 / ton

Table 5.1 Proposed Economic Model of the Project

Present demand as presented by the GGMC and Ministry of Public Works is in excess of 1.5 million tons per year.

5.2 Environmental Considerations

Upon obtaining the Quarry License the company will engage a team of professional consultants, approved by the Environmental Protection Agency, to prepare a detailed Environmental Management Plan for the project site. However, at this stage the company is cognizant of the main/common anticipated environmental impacts associated with stone quarry activities, which are listed as follows:

- Air pollution
- Noise pollution
- Airblast, fly-rocks, and ground vibration
- Water quality
- Erosion and sedimentation
- Slope stability
- Overburden material management
- Waste disposal
- Ecology
- Traffic and transportation
- Social-economic
- Visual impact
- Cultural heritage
- Closure or potential abandonment
- Residual Impacts

Impact : Air Pollution

Air pollution during stone quarry activities is caused by dust nuisance. Dust can be defined as finely divided solid matter and is a concern due to its harmful physiological effects. The dust becomes a nuisance when it is in the form of clouds, reducing visibility, creating an uncomfortable environment (irritation of eyes, ears, nose, throat, and skin). In addition, dust nuisance may also increase equipment maintenance costs due to excessive wear and premature failure of components.

A wide variety of stone quarry activities produce dust. These include:

- Site clearing;
- Drilling;
- Blasting;
- Crushing;
- Excavating;
- Filling;
- Dust from overburden disposal area;
- Transportation of materials; and
- Vehicle movements on unsealed surfaces.

Dust particles are transported by wind. Wind-borne dust can settle on neighboring, or distant, properties, resulting in particle deposition on surfaces, which may affect operations or simply represent a nuisance for others. Dust deposition on vegetation can affect the photosynthesis process, thus impacting the growth of vegetation. In addition, excessive dust emissions may cause site health and safety concerns due to the higher risk of accidents and downtime. High levels of dust concentration in the environment may represent a health hazard to local residents.

Key Mitigation Measures - Air Pollution

The mitigation measures that can be considered for air pollution control include (but are not limited to):

- **Air quality compliance** - Air pollution and dust need to be managed in compliance with the recommended limits for air quality.

- **Location of stockpiles** - At the planning stage, there should be an assessment of prevailing winds, and this should guide the location of stockpiles, spoil mounds, conveyors, and others to minimize dust being blown outside the site boundary.

- **Vegetation barriers** - These consist of dense stands of mature trees, can act as windbreaks to help alleviate dust generation.

• **Dust control for crusher plan**t - Conveyors and transfer points can be major sources of dust generation. Acceptable mitigation measures for these can be any or all the following:

- Enclosures,
- Mist sprays,
- Dust extraction equipment.

• **Minimising distance** - Minimising the distance between the discharge point and the top of the stockpile can reduce dust generation.

• **Cease operations** - During periods of high wind speeds operations may be ceased or curtailed to prevent excessive dust leaving the site.

• **Water spraying –** Grounds of the quarry site and stockpiles including overburden areas and access roads may be regularly sprayed with water to reduce dust generation. The frequency should be determined based on site conditions.

• **Wheel washing facility** - Provide a wheel washing facility at site exit points to avoid dirt being carried out of the project area. Water from the washing facility should be changed regularly to ensure clean water (without silt) at all times. The facilities should be connected to the sedimentation basin to treat dirty water, prior to final discharge.

• **Speed limit** - Speed limits should be applied to unsealed roads to limit dust generation (as well as noise, and maintenance requirements).

• **Material cover** - Dust can also be reduced during the transportation of materials by covering loads on trucks. Less effective, but still useful is to limit the fill height of material in the tray to the level of the top of the tray.

• **Site Entrance** - Quarry entrance can be sealed/ layered with aggregates to minimize dirt carried offsite on vehicle tyres.

Impact :Noise Pollution

Noise can cause annoyance; nuisance; sleep disturbance and can affect wildlife and domesticated animals.

Stone quarries can have many activities that generate noise:

- Earthworks;
- Excavation;
- Drilling and blasting;
- Crushing and screening; and
- Transport of materials.

Noise can affect humans psychologically as well as physically. It can potentially lead to hearing damage and affect the quality and precision of work.

Key Mitigation Measures - Noise Pollution

The mitigation measures that can be considered for noise pollution control include (but are not limited to):

- **Noise quality compliance** - Noise generated from the site needs to be kept within the national standards. This may require restrictions to operating hours.

- **Vehicles/Equipment** - Avoid deployment of poorly maintained, or old transport vehicles and equipment.

- **Physical Barriers** - Noise attenuation may be achieved to some degree by barriers. These may be bund walls installed at the site, zinc hoardings, vegetation barriers, or natural topographic features.

- **Vegetation barriers** - If trees are being considered as effective noise attenuation means, the trees need to be mature, the plantings relatively dense, and the width of the barrier greater than 20 meters. The stand of trees also needs to extend to well above the point source of the noise.

- **Silencers** - Machinery such as compressors, engines, generators, and exhausts may be fitted with silencers to reduce their impact, if necessary.

- **Speed limit** - Truck noise on access roads and haulage roads can be reduced by maintaining low speeds and through regular vehicle maintenance. Proper selection of access roads can also reduce noise impacts.

<u>Impact : Air-blast, Fly-rocks and Ground Vibration</u>

Blasting: Quarry blasting involves drilling of blast holes in the rock, either vertical or inclined or sometimes horizontal, at an appropriate distance between one another. Each hole is then filled with explosive material, primed and detonated. The timing of the detonation of each hole is in a delayed fashion in an effort to utilise the maximum energy for breakage and at the same time lessen air-blast, fly-rocks and ground vibrations.

Air-blast: Air-blast is the airwaves generated by blasting. Air-blast creates over-pressure which means simply that the pressure is over and above the atmospheric pressure. It is unusual for airwaves from blasting operations to reach potentially damaging levels for residences. If they do, the damage is usually in the form of broken windows. Even in operations where there is no damage potential, airwaves are still a matter of considerable concern when they generate sounds that are heard by residents of an area. These waves can generate audible sounds which can be heard if they fall within the frequency range of the listener (about 20 – 20,000 Hertz). Not all blasts are directly audible. If the distance is great, or charges are deeply buried, or the frequencies are too low, the blast may not be heard by persons outside the quarry site. However, small pulses of air-blast may generate audible secondary sounds in houses in the vicinity; i.e. rattling of loose windows and doors or sound like an impact against the walls. Such effects may lead some building occupants to have concerns that strong shaking has taken place and that damage may have occurred. When people are outdoors, they may not hear those sounds and usually pay little attention to the same airwaves.

The sources of air-blast or objectionable blast noise are:

• The use of lay-on or plaster charges often used in secondary blasting;

• Poorly stemmed holes; and

• Blown-out shots resulting from poor design patterns.

Fly-rocks: Fly-rock is the term for undesirable projectiles of blasted material. In particular types of rock there is a compatible relationship between the height of the explosive column in the holes, drilling pattern and charge ratio. When this is compromised, the explosive’s gas energy is vented violently into the atmosphere and propels rocks in front of it. Probable reasons for fly-rock could be:

• Insufficient overburden;
• Inadequate stemming;
• Incorrect spacing;
• Overcharging with explosives;
• Secondary blasting; and
• Out of sequence initiation.

Damage to life, equipment and buildings can be severe if fly-rock occurs. However, with good supervision and blasting design techniques, the chances of fly-rock can be minimised. Ground Vibration: Upon explosive detonation in rocks, the charge is converted instantly to hot gases at intense pressure, which causes rock to fracture or break. This action will produce air-blast into the surrounding air and induce vibration in the ground. The ground vibration caused from blasting is similar to the motion of a floating object placed in water near an energy source. The distance between the wave crests that move the object is the wavelength. The speed at which the waves travel outward from the energy source and move past the object is the propagation velocity.

In blasting, ground particles oscillate in response to a vibration wave. This oscillation is measured in particle velocity. The maximum rate is the Peak Particle Velocity (PPV). In blasting, this is measured in millimeters per second (mm/s). Peak particle velocity is the maximum rate of particle movement. Displacement is the distance the particle moves back and forth or the distance a particle or object moves from its position of rest. The change in displacement over a unit of distance is called strain.

Ground vibration is similar to a seismic event, in that it causes the ground to shake. It does have the capacity to cause damage to structures at very high readings. The concern is commonly raised about the vibration level of single events and the cumulative effects of low-level vibration from multiple events. A person can normally feel vibration levels in excess of 1 mm/sec. Vibrations in quarries can result from:

• Blasting;

• Machinery (rock breakers, and others); and

• Truck traffic.

Vibration Caused by Blasting

Ground vibration is transmitted from the site of a blast through the ground. Its transmission is affected by the geology of the terrain and the distance to the receptor source. Ground vibration will typically move faster and at a higher frequency in rock than in soil. Ground vibration is measured in peak particle velocity (PPV) in mm/s. Blast design can be modified to ensure vibration and air over-pressure levels are within acceptable limits. The principal design criteria that can be employed for this are:

• Number of blast holes;
• Weight of explosive;
• Amount of stemming; and
• Delay timing.

Vibration Caused by Machinery

Typically, stone quarry activities involve the use of hydraulic rock breakers which generally has ground vibration effects. There are a number of strategies for reducing the effect of vibration from machinery:

i. Distance. The vibration value decreases rapidly with distance from the source. The actual rate of reduction is dependent on the geology of the site and on the surrounding terrain.

ii. Machinery supports. Machines can be mounted on footings that use rubber bearing pads or springs to isolate the vibrations from the ground.

iii. Machinery enhancement. Inertia blocks can be used to add system mass and therefore reduces vibration

Vibration Caused by Road Traffic

The most severe vibrations associated with road traffic result from heavy vehicles with stiff suspension moving rapidly along roads with irregular surfaces.

Key Mitigation Measures - Air-blast, Fly-rocks and Ground Vibration

The mitigation measures that can be considered for air-blast, fly-rocks and ground vibration include (but are not limited to):

• **Blasting design** - Drilling and blasting are common activities at stone quarry operations. Drilling depths, spacing, and blast patterns are subject to specialist design and need to be closely managed by the quarry operator. If these are not adequately managed it can result in uncontrolled fly-rock, high levels of ground vibration, and air-blast noise, and unsafe bench faces or quarry floors. Drilling and blasting designs vary with a number of factors - type and hardness of the rock, moisture content, degree of existing fracture, size of material that is sought, type of explosive used, and others. It is the responsibility of the quarry operator to ensure that the operational impacts described above, as well as the safety issues, are managed through appropriate drilling and blasting design and operational procedures. The preliminary blasting design by a licensed blaster should be made available to the relevant agencies for approval.

• **Safe Distances** - For any sites subject to blasting there should be a minimum buffer of as prescribed in the appropriate regulations within which there should be no structure or activity.

• **Permit requirements** - There are regulations and permits for any blasting activities. Noise and vibrations associated with blasting activities must fall within standards specified in the permit and regulations. Higher noise levels may be allowed for blasting, given the very short period of the noise event.

Impact : Deterioration of Water Quality

Stone quarry activities will change the topography of the site, with consequent changes in drainage pattern. Vegetation removal also increases the rate of rainfall runoff. It is often necessary to manage surface drainage with the provision of drainage interception bunds (e.g. at the top of the excavation) to redirect flows, and with the installation of drainage channels to cater for concentration of flow. Where the stone quarry excavation intercepts the groundwater table, it may necessitate separate measures to drain the quarry pit, often involving pumping. The interception of groundwater and its diversion to surface drainage may also result in an interruption of groundwater flows, a lowering of the water table in the local area, and potentially dewatering of adjacent watercourses.

Any runoff from cleared surfaces, or discharges from the quarry pit or floor, is likely to have elevated levels of sediment (both suspended and dissolved). In addition there may be other contaminants depending on the nature of the soils and/ or rocks that are exposed in the quarrying process, and any leakages from machinery at the stone quarry. The quality of the water discharged from the site can have impacts on downstream ecological communities and water users.

Key Mitigation Measures - Deterioration of Water Quality

The key objective of the mitigation measures is to protect existing waterways and groundwater resources from impacts from the stone quarry activities. The mitigation measures that can be considered for water quality deterioration include (but are not limited to):

• **Drainage flow** - As far as possible, drainage should follow existing drainage lines with vegetation along the drainage lines retained.

• **Cut-off drainage** - Cut-off drains or diversion banks can prevent surface flows from entering the quarry works areas. These should discharge into vegetated natural drainage lines, or as distributed flow across an area stabilised against erosion.

• **Sedimentation ponds** - Run-off from work areas should be routed towards sedimentation ponds. These trap sediment and reduce suspended sediment loads before runoff is discharged from the stone quarry site. Sedimentation ponds should be designed based on runoff, retention times, and soil characteristics. There may be a need to provide a series of sedimentation ponds to achieve the desired outcome.

• **Flow barriers** - Additional methods for trapping sediments include using barriers to flow such as silt fences, crushed rock filters, hay bales, logs, or sandbags.

• **Vegetation buffer** - A vegetated buffer strip around the perimeter of the site where surface water flow passes through can be effective, and should be provided along any significant waterways passing through the site.

• **Groundwater** - Where groundwater may be impacted (i.e. excavations below the water table) a detailed study may be required to determine potential impacts and appropriate mitigation.

Impact : Soil Erosion and Sedimentation

Soil erosion and excessive sedimentation problems arising out of stone quarry development activities can pose a threat to the environment if not systematically controlled. Soil erosion can also lead to the cumulative effects of siltation and sedimentation in streams and rivers downstream as well as reduced depth of riverbeds and watercourses, which inhibits navigation and leads to flash floods in low-lying areas. Any disturbance of the in-situ soil will elevate the potential for increased soil erosion and run-off - in particular steep rock faces that are typical of quarry operations and are very prone to erosion. Eroded material is carried downstream to areas of flatter terrain where it is deposited as sediment.

Stone quarry activities at a site will result in some, or all, of the following occurring:

• Removal of protective vegetation cover;

• Exposure of underlying soil horizons that may be less pervious, or more erodible than the surface layers;

• Reduced capacity of soils to absorb rainfall;

• Shortened time of concentration of surface runoff due to altered steepness, distance and/ or surface roughness characteristics (including removing vegetation and top-soil);

• Increased energy in storm-water runoff due to concentration and velocity;

• Alteration of ground-water regime, with potential impacts on drainage and slope stability; and

• Exposure of subsurface materials which are unsuitable for vegetation establishment. The potential for erosion relates to the characteristics of the soil, the vegetative cover, exposure of the site to storm-water runoff, steepness of the site, slope length, and concentration of storm-water flows.

Key Mitigation Measures - Soil Erosion and Sedimentation

The mitigation measures that can be considered for soil erosion and sedimentation include (but are not limited to):

• Sedimentation ponds - Provision of sedimentation ponds based on the finalized mine plan to capture material eroded at the site before discharge.

• Ground cover - Design of surface ground cover to minimise soil exposure to intense rainstorm. Adequate soil compaction works should be conducted at the end of each working day to reduce soil erosion.

• Retain vegetation - Retain existing or re-plant the vegetation at the site wherever possible.

• Run-off diversion - Minimise or divert high velocity runoff away from sensitive/ easily prone to erosion areas through provision of proper drainage systems.

• Drainage - Construction of high volume drainage systems conforming to site conditions to handle concentrated or increased runoff from intense rainstorms.

• Monitoring and maintenance - Regular monitoring and maintenance of erosion control systems so that they perform as specified.

Impact : Slope Stability

Landforms are the products of the local balance between weathering, erosion and deposition, and are continuously evolving. Slopes that are too steep for weathered material to remain stable are subject to periodic failure. Instability may be associated with moderate to steeply sloping terrain or with land which has been disturbed by man. Natural slopes that have been stable for years may fail during the quarry activities, which may bring about (a) changes in the slope topography; (b) changes in groundwater conditions; (c) stress changes in the soil underlying the slope and (d); acceleration of the rate of weathering of rock. Blasting activities during quarry operation change the slope topography and release residual horizontal stresses allowing expansion of the slope. Joints or weak zones may be exposed along which sliding may occur. Over steepening of the slope gradient to create a platform can also induce instability. The change in groundwater flow patterns may cause detrimental changes to the stability of the newly constructed slope or the existing in-situ slopes that were stable prior to quarry operation

Key Mitigation Measures - Slope Stability

Applying appropriate slope design and protection can prevent slope failure, thus minimize soil erosion as well as improving safety. The mitigation measures that can be considered for slope stability include (but are not limited to):

• **Benching** - Provision for slope benching system at the quarry face.

• **Turfing** - Turfing should be carried out to establish vegetation on the slope making it more stable.

• **Weather condition** - Blasting activities and related earthworks should not be carried out during wet and rainy weather conditions.

• **Retain vegetation** - Existing vegetation on hill slopes especially on undeveloped areas are to be retained as much as possible to act as natural buffers.

• **Checking slope areas** - Regular checking of the slope surface and surrounding areas for signs of possible slope failure and soil erosion should be carried out.

Impact : Overburden Management

Overburden or top soil is removed prior to rock extraction. Methods of overburden disposal vary for each quarry operation. Overburden removal from the rock face and disposal within or outside the quarry area can be a major source of erosion and sediment discharges, particularly if the disposal site is not properly located and managed.

Key Mitigation Measures - Overburden Management

The mitigation measures that can be considered for overburden management include (but are not limited to):

• **Sediment barriers** - Overburden which mainly consists of topsoil should be protected from stormwater runoff using temporary perimeter sediment barriers such as gravel bag berm, silt fence, sand bay, sedimentation pond or rock filter. Suitable slope gradients should be provided together with proper perimeter drainage system to ensure proper runoff flow.

• **Compaction** - Proper earth compaction to an appropriate density should be conducted immediately to stabilize the soil materials, thus reducing the amount of surface runoff.

• **Turfing** - Close turfing should be conducted on the ground of the overburden disposal site if it is not immediately used for other uses.

• **Drainage maintenance** - Regular maintenance on the drainage system around the overburden disposal sites.

• **Overburden management** - Overburden materials can also be sold to sites nearby and the environmental consultants need to take into consideration the environmental impacts caused during the transportation from the overburden disposal site to the destination site as well as its suitability for disposal. Else, the overburden materials can also be utilised to construct earth bunds for internal roads.

Impact - Waste Management

Wastes generated by stone quarry activities include:

• Sludge (usually clay/ silt) materials collected in sedimentation ponds;

• Waste oils or chemicals from vehicle, machinery, or other uses;

• Domestic wastes (sewage, drainage) from on-site sanitary or kitchen facilities;

• Vegetative waste from site clearing activities; and

• General waste. If these wastes are not properly managed they can result in pollution of surface or groundwater, soil contamination, health impacts, and visual unsightliness.

Key Mitigation Measures - Waste Management

The mitigation measures that can be considered for waste management include (but are not limited to).

• **Minimise waste** - All efforts must be made to minimise the amount of waste generated through recycling and prudent procurement and operation. Where feasible, waste should be removed to public waste disposal sites. Where this is not feasible, pits may be dug at safe distances from water bodies and to a depth that does not pose any instability to slopes or offer opportunities to wildlife or pests to dig it up. It is imperative that groundwater is not impacted by the disposal of wastes in these pits.

• **Zero burning** - Biomass waste from site clearing may not be burned but can be left for natural decomposition. The environmental consultant should emphasise options for better utilisation of smaller dimensions of woody biomass (such as small trees and branches) from site clearing.

• **Provision of waste bins** - Provision for sufficient waste bins for collection of solid waste generated onsite. These bins should be emptied on a regular basis and the waste collected should be disposed off at the local authority's approved disposal sites.

• **Housekeeping** - Good housekeeping practice onsite (wastes should be properly disposed off at designated containers/ areas).

• **Location of facilities –** The location of workshops and fuel/ lubricant storage facilities (if any) should be at least 50 metre distance from the nearest natural waterway and installed with proper oil traps and spill containment.

• **Oily/ scheduled waste** - Collect used oil and oily wastes from machinery and transportation vehicles and store and label in proper containers for disposal. A temporary storage facility should be constructed within the project site, and should be fenced, covered, bunded, sign posted, have impervious flooring, and be provided with spill containment, proper drainage and oil trap. The facility should be sited more than 50 m away from any river, stream or sensitive area.

Impact - Ecology

Stone quarry establishment will necessitate the removal of vegetation. Depending on the area affected, this may represent impacts on native flora species, or removal of important habitat for native fauna. Particular focus should be placed on the assessment of potential impacts on unique or rare plants, or species of major conservation or scientific interest.

Key Mitigation Measures - Ecology

The mitigation measures that can be considered for ecological impacts include (but are not limited to):

• **Protection** - Identify and protect sites deemed as valuable habitats or containing threatened species.

• **Relocation** - Where important habitats or species cannot be protected at the site the following should be considered:

- Relocation of fauna species, nesting sites and others to a suitable nearby location.

- Multiple replanting, or conservation activities at an alternative site, as an offset strategy for mature vegetation that has to be removed.

• **Buffers** - Provide vegetative buffers to protected areas.

• **Vegetation linkages** - Retain vegetation linkages to intact ecological communities on the boundary of the site as far as possible.

• **Wetlands** - Incorporate wetlands into sedimentation pond designs to provide additional or alternative habitat for wetland flora and fauna species.

Impact : Traffic and Transportation

Transportation of finished products - i.e. aggregates to potential buyers - can cause dust and noise nuisance as well as affecting the traffic volume, flow and density in the surrounding area. In some circumstances, this increased traffic volume may impact other road users, as well as the public amenities associated with residential users and nearby sensitive areas. Increased truck traffic may leading to increased road maintenance costs.

Key Mitigation Measures - Traffic and Transportation

The mitigation measures that can be considered for traffic and transportation impacts include (but are not limited to):

• Road upgrading - Upgrading and/ or widening of local roads used to access the site.

• Planned routes - Using specified routes to and from the site that avoid sensitive areas such as residential or settlements.

Impact - Socio- Economic

Stone quarry activities generally provide significant economic and social benefits such as: long term economic and employment benefits; enhancement of surrounding infrastructure; stimulation of secondary industry and services, as well as enhancement of technical skills and educational levels. However, if they are conducted without proper planning and operation, stone quarry activities also have the potential for significant impact on the environment, including disruption to the ground surface and ecosystem and changes to the existing social patterns/ community livelihood

Key Mitigation Measures - Socio-Economic

Consideration should be given to the affected local population by protecting sources of local water supply, fishing and recreation areas. In addition, effective public relations exercise is important in ensuring social acceptability of the project. The mitigation measures that can be considered for socioeconomic impacts include (but are not limited to):

a) Employment

• **Employment and Business Opportunities** - Preference for employment and business should be given to local population. This will provide some opportunities to the local people to participate in the operation of the project, as well as providing them with an opportunity to earn extra income. In addition, their employment and business participation will prevent social resentment and conflicts, increase their positive feelings towards the project, and create a sense of pride towards the development of their area.

b) Consultation

• **Public Relations** - Conduct a proper public relations exercise involving the local authorities. Two-way communications through dialogue helps both parties to understand each other, sets a forum for understanding, and establishes rapport. Information about the numerous benefits of the project and environmental impacts should be made readily available to the public.

• **Dialogue** - Hold regular meetings/ dialogues with the surrounding population and their community leaders, both prior to, and during the operation of the project. The Project Proponent should explain to the villagers the nature of the project, the extent to which it will affect their villages, and the mitigation measures undertaken to eliminate or minimize environmental, social and economic problems.

Impact : Visual Impact

Stone quarries can cause visual impact through:

• Removal of existing landscape features such as hills; and

• Introduction of intrusive features such as quarry faces or overburden mounds. The features of a quarry that can visually affect the landscape depend very much on the specific location and surrounding environment of the quarry. These include:

• Size, form and colour of plant and machinery;

• Exposure of the ground surface or quarry face;

• Location, size, and shape of bund walls, stockpiles, waste disposal areas, fences; and

• Location of access roads.

Key Mitigation Measures - Visual Impact

The visual impact of the quarry needs to be considered at the planning stage. Careful location decisions regarding angle of approach to the quarry face, location of access roads, plant, machinery and stockpiles, retention of vegetation and others can make a big difference to the visual impact.

The mitigation measures that can be considered for visual impacts include (but are not limited to):

• Retain vegetation - Retain existing vegetation where effective for screening of the site.

• Vegetation screens - Provide screens in the form of grass, bushes, vegetated or earthen bunds.

• Plant vegetation - Plant additional vegetation in areas facing the surrounding settlements to minimise visual intrusion.

• Site layout - Where practical, working faces and plant locations should be oriented away from vantage points.

• Rehabilitation - Where feasible, uppermost benches should be worked out and rehabilitated as soon as possible.

• Painting - Machinery, plant, fences, and exterior faces of buildings can be painted to blend in with, rather than contrast with, the surrounding environment

Impact - Cultural Heritage

The establishment of a quarry may impinge on existing archaeological assets, whether known prior, or discovered during the course of the project. The company needs to check on ground and consult with the relevant government agencies to verify whether there is any known cultural significance at the proposed project area.

Key Mitigation Measures - Cultural Heritage

The discovery of any cultural or archeological sites must be immediately preserved and reported to the relevant government agencies.

Impact - Site Closure/ Abandonment

When the rock source within the site boundary has been exhausted, the project site will be closed down. The closure will be in accordance with a conceptual project closure plan that has been established prior to closure in collaboration with the relevant stakeholders and state agencies. The manner in which the quarry is managed for the post-operation phase will define its long-term environmental implications. Globally, there are examples of quarry areas being reestablished for productive use including housing and commercial development and recreational facilities.

Key Mitigation Measures - Abandonment/ Closure

In the event that the stone quarry operations are abandoned, every attempt should be made to reinstate the condition of the site to that which existed prior to commencing quarry activities. Whilst this will not be feasible where large scale excavation works have taken place, as a minimum, the cleared area should be re-vegetated. This will involve breaking up compacted ground, covering with topsoil, and planting/ seeding with selected local tree species and/ or cover crops.

Where a structure is partly erected, this should be demolished and removed from the site. All drainage provisions, including sedimentation ponds should be retained. All equipment, machinery and waste materials should be removed from the site.

Impact - Residual Impacts

It is unavoidable that there will be some adverse impacts from the earthwork activities even if these are carried out with every intention of avoiding or minimising such impacts.

There will be a loss of ecological features, in terms of natural wildlife habitat together with surface runoff which pollutes the waterway as a result of land clearing. For such impacts, the risk and the magnitude should be assessed as part of the assessment procedure.

Key Mitigation Measures - Residual Impacts

Residual impacts are already minimised through the choice of technologies or methodologies. Mitigation is therefore only possible through compensation or substitution. Compensatory measures in terms of replacement of habitat loss, re-vegetation, alternative access to livelihoods and others are among the available options for mitigation of residual impacts.

Monitoring

Environmental monitoring provides feedback on the actual environmental impacts of a project. Monitoring results will assist in the judgement of whether the environmental mitigation measures proposed are successful in reducing or eliminating negative environmental impacts. An environmental monitoring programme is also used to ensure compliance to the recommended mitigation measures and environmental standards stipulated by the EPA and other relevant agencies.

Generally, an environmental monitoring programme will involve collecting data for one or more of the following purposes:

i. To establish a baseline, that is, gathering information on the basic site characteristics prior to development or to establish current conditions;
ii. To establish long term trends in natural undisturbed systems to establish natural baselines;
iii. To estimate inherent variation within the environment, which can be compared with the variation observed in another specific area;
iv. To make comparison between different situations (for example, predevelopment and post development; upstream and downstream) to detect changes; and
v. To make comparisons against a standard or target level.

Without a monitoring system, there is no mechanism for ensuring that the specified mitigation measures are being implemented and for evaluating the success of the mitigation measures undertaken. The environmental monitoring programme will generally comprise compliance and impacts monitoring. Compliance monitoring aims to ensure compliance to the recommended mitigation measures and environmental standards stipulated by the EPA, and other relevant agencies whereas impacts monitoring provides feedback on the actual environmental impacts of a project in order to confirm that a project is meeting the agreed level of impact and that the predictions of impacts made during the environmental assessment have been accurate.

An appropriate mentoring system will be set out in the Environmental Management Plan which will be conducted upon the issuance of the Quarry License.