ENVIRONMENTAL IMPACT STATEMENT

Proposed Quarrying and Mineral Processing at Halberstadt Quarry, St. Andrew, Jamaica

Report Version: **Final**

Date: **October 2013**

Prepared by: **CL ENVIRONMENTAL CO. LTD.**

Submitted to: **CARIBBEAN CEMENT COMPANY**

ENVIRONMENTAL IMPACT STATEMENT FOR THE PROPOSED QUARRYING AND MINERAL PROCESSING AT HALBERSTADT QUARRY, ST. ANDREW, JAMAICA

Submitted to:
CARIBBEAN CEMENT COMPANY LIMITED
Rockfort
Kingston 2

Prepared by:
CL ENVIRONMENTAL CO. LTD.
22 Fort George Heights
Kingston 9

OCTOBER2013

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ACRONYMS

A	AADT	Annual average daily traffic
	ACGIH	American Conference of Industrial Hygienists
	AMC	Antecedent moisture conditions
	amsl	Above mean sea level
B	BA	Basal area
C	C	Celsius
	CBD	Convention on Biological Diversity
	CCCL	Caribbean Cement Company Limited
	CDMP	Caribbean Disaster Mitigation Project
	CN	Curve number
	CO	Carbon Monoxide
	CO2	Carbon Dioxide
D	DAFOR	Dominant, Abundant, Frequent, Occasional, Rare
	dBA	A-weighted sound level (decibel)
	DBH	Diameter at breast height
	DEM	Digital elevation model
	DO	Dissolved oxygen
E	E	East/ Easting
	EIA	Environmental Impact Assessment
	EMP	Environmental Monitoring Programme
	ESRI	Environmental Systems Research Institute
	FHA	Federal Highway Administration
	FOG	Fats Oil and Grease
F	ft	Feet
G	g/l	Grams per litre
	GIS	Geographic information system
	GOJ	Government of Jamaica
	GPS	Global Positioning System
H	HA	Hectares
	hr	Hour
	Hz	Hertz
I	IPCC	Intergovernmental Panel on Climate Change
	IUCN	International Union for Conservation of Nature
J	JAD 2001	Jamaica Grid 2001
	JGQ	Jamaica Gypsum and Quarries Limited
	JNHT	Jamaica National Heritage Trust
K	km	Kilometre
L	LDUC	Land Development and Utilization Commission
	Leq	Time-average sound level
	Lj	jth sound level

M	m	Metre
	m/s	Metres per second
	m3/sec	Cubic metres per second
	mg/l	Milligrams per litre
	mg/m^3	Milligrams per cubic metre
	min	Minute (s)
	mm	Millimetre
	mm/24 hr	Millimetres per 24 hour period
	mS/cm	milli Siemens per cm
	MSDS	Material Safety Data Sheets
N	N	North/ Northing
	NAAQS	National Ambient Air Quality Standards
	NEPA	National Environment and Planning Agency
	NMIA	Norman Manley International Airport
	NO2	Nitrogen Dioxide, Nitrite
	NO3	Nitrate
	NOx	Nitrogen Oxides
	NRCA	Natural Resources Conservation Act
	NSWMA	National Solid Waste Management Authority
	NTU	Nephelometric turbidity units
	NWA	National Works Agency
	NWC	National Water Commission
O	ODPEM	Office of Disaster Preparedness and Emergency Management
	OSHA	Occupational Safety and Health Administration
P	PCQ	Point-Centred Quarter
	PEL	Hearing Conservation and Permissible Exposure Limit
	PIF	Project Information Form
	PM10	Particulate matter smaller than 10 microns in diameter, respirable particulate matter
	PM2.5	Particulate matter smaller than 2.5 microns in diameter, fine particulate matter
	ppm	parts per million
	ppt	parts per thousand
Q	QSP II	Quest suite Professional II
S	s	Second
	SCS	US Soil Conservation Service
	SIA	Social Impact Area
	SO2	Sulfur Dioxide, sulfite
	SO4	Sulfate
	SOx	Sulfur Oxides
	STATIN	Statistical Institute of Jamaica
T	TCP Act	Town and Country Planning Act
	TDS	Total dissolved solids

	TSS	Total Suspended Solids
	TCL	Trinidad Cement Limited
U	USEPA	United States Environmental Protection Agency
W	WHO	World Health Organization
	WRA	Water Resources Authority
Y	yr	Year

1.0 EXECUTIVE SUMMARY

PROJECT DESCRIPTION

Project Concept

Caribbean Cement Company Limited (CCCL), through its subsidiary Jamaica Gypsum and Quarries Limited (JGQ), operates a gypsum quarry in the Bito District, Bull Bay, St. Andrew. The Bito Gypsum Quarry is now depleted of mineable ore and reclamation activities will begin in 2014. As a result, CCCL is desirous of reopening the Halberstadt Quarry, approximately 2 km northeast of the Bito Quarry. Though dormant for 40 years, this quarry is the only economical reserve of gypsum remaining and it is intended for this quarry to supply the cement plant with the gypsum required in the manufacturing of Ordinary Portland and Blended Cements.

The size of the property within which the quarry will be located is approximately 0.67 km2 or 166 acres; the Environmental Impact Statement (EIS) for the proposed mining at Halberstadt Quarry however is with regards to an initial one hectare (0.01 km2) allowance.

An exploration drilling programme was conducted by NHL Engineering and based on the laboratory results, the average content of the gypsum is approximately 52% and therefore the volumetric reserve estimate of gypsum is 1,350,804 m^3. Applying the in-situ densities of gypsum and anhydrite (2.33 t/m^3 and 2.9 t/m^3 respectively), gives a reserve estimate of 3,147,373 tonnes of gypsum and 3,586,418 tonnes of anhydrite. A total gypsum/anhydrite reserve of 6.7 million tonnes is estimated to be present in the Halberstadt deposit to the depth that was drilled.

Project Design

Slope
All slopes will be vertical to facilitate blasting. Bench heights average 8 m (26 ft) with a bench width of 20 m (66ft) and length not exceeding 100m (328 ft).

Access
The current access road to Halberstadt is not adequately designed to accommodate haulage; various roadways will require immediate repairs and modification prior to commencement of mining. In addition, the Salt

Spring Parochial road will be reopened to facilitate the transporting of material from the quarry to storage. Over the life of the mine, the quarry profile will undergo numerous changes and so the road will have to be redesigned to meet the requirements of proper mining practices.

Pit Cross-section

Pit resembles a step like profile with each step having one bench with a height of 8 m (26 ft.). The width of the bench will be a minimum of twice the height to allow for safe operating of loading equipment and haul trucks.

Bench Elevations

Cut off elevation will be at 460 m above sea level based on the depth of gypsum/anhydrite reserves as shown in the boreholes.

Site Facilities

A site office will be erected at Halberstadt and will house quarters for the mining engineer, production supervisor, changing rooms, bathrooms, lunch room/waiting area and JGQ's field Laboratory.

Wastewater Solution

A septic tank and tile field for 12 persons is being designed by CEAC Solutions.

Project Operations and Maintenance

Development Stage

The Halberstadt quarry has been dormant for many years and the project will require the removal of vegetation and topsoil. Stripping and development in 2013 will be concentrated in the lower section of the deposit to facilitate the production of 100 k tonnes of Gypsum for the TCL Group. Test holes will be drilled at a spacing of 30 m around BH 103 and BH 105, following stripping to determine the grade distribution of the gypsum on those benches. This information will then be used to determine where to mine first, based on the gypsum demand for the Trinidad Cement Ltd. (TCL) group.

Mining Schedule

The mine schedule will be for the benches containing BH 103 and BH 105 to be mined in 2013, down to a depth of 12 m each.

Mining Method

The mining method to be employed is open-pit mining, by benching. Material will be extracted by drilling and blasting and subsequent to this an excavator will be used to load the material into a mobile crusher which reduces the particle size distribution of the gypsum to minus 2”. This 2” product will then be stockpiled at designated areas until it is ready to be sent to the CCCL plant and JGQ’s Export Facility.

Mode of Operation

All mining and haulage activities at Halberstadt Quarry will be outsourced to qualified contractors with JGQ maintaining oversight and management of the mining. It is anticipated that the mining activities will see the employment of a total of thirty-eight staff, including permanent, casual and contractual employees.

The quarry will operate five days per week (Monday to Friday), eight hours per day (8am to 4pm) to achieve a 40 hour work week.

Quality Process and Tracking

The quality and tracking process will be much the same as with current operations; the only difference is that the lab will have to be relocated.

Proposed Environmental Management System

The company is examining the possibility of implementing an Environmental Management System (EMS) that will enable the organisation to address the impacts of its products, services and processes on the environment. These issues include air pollution, noise pollution, ground vibration, water pollution, impact on vegetation, visual intrusion and landslide risk. Several mitigation measures will be implemented prior to commencement of mining operations at Halberstadt.

Rehabilitation Plan

Rehabilitation will be carried out on a progressive agenda, in that as the mine face progresses, mined out sections will be rehabilitated simultaneously. A rehabilitation plan has been developed for the proposed quarry.

DESCRIPTION OF THE EXISTING ENVIRONMENT

Physical

Meteorology and Climate

June 26-30, 2013:

- Average temperature was 24.7 ^{o}C and ranged from a low of 21.2 ^{o}C to a high of 31.1 ^{o}C.
- Average relative humidity was 80% and ranged from a low of 59% to a high of 94%.

- Average wind speed was 0.7 m/s and ranged from a low of 0 m/s to a high of 8.5 m/s.
- Dominant wind direction was from the southeast.
- Measurable precipitation during the assessment was 0.31 inches (7.87 mm) over a total of 2 rain days.
- Mean barometric pressure was 962.79 millibar and ranged from a low of 960.8 millibar to a high of 964.5 millibar.

July 1-28, 2013:

- Average temperature was 25.3 ^{o}C and ranged from a low of 19.8 ^{o}C to a high of 32.9 ^{o}C.
- Average relative humidity was 74.89% and ranged from a low of 49% to a high of 98%.
- Average wind speed was 0.7 m/s and ranged from a low of 0 m/s to a high of 13 m/s.
- Dominant wind direction was from the east southeast.
- Measurable precipitation during the assessment was 3.65 inches (92.71 mm) over a total of 5 rain days.
- Mean barometric pressure was 963.97 millibar and ranged from a low of 960.7 millibar to a high of 966.7 millibar.

Geology and Geomorphology

The area is located in the south-eastern section of the fault bounded Wagwater Belt. The rocks in the Wagwater Belt are result of the depositional processes in a fan delta and proximal submarine fan complex. Deposits in such in environment are characterized by significant lateral and vertical variation in lithology. In the Wagwater Belt these deposits include plutonic, volcanic and volcaniclastic rocks to alluvial submarine-deltaic sediments, limestones and evaporites such as gypsum and anhydrite.

Newport Volcanics is the dominant formation found in the immediate vicinity of the Halberstadt Quarry. The existing access road runs almost over its entire length through the Newcastle volcanics.

The Brooks Gypsums are the evaporate deposit which occur as relatively thin layers and lenses in the south eastern section of the Wagwater belt south of Gordon Town. They are Sulphate deposit consisting of both gypsum and anhydrite. The rocks are well bedded and often deformed. The anhydrite tends forms the core of the deposits. The gypsum is found near the outer, more exposed surfaces. The Boundary of Gypsum/Anhydride is the extent of the deposits that is expected to be extract economically based on the current mining techniques. The primary permeability of gypsum/anhydride deposits is low but the secondary permeability can be moderately high. While no groundwater was encountered, it should be noted that water seepage was noticed along the internal mining road #1 at the foot of the bench, due south of the proposed overburden storage area. In addition there appears to be evidence of piping in the gypsum deposits near the intersection with the internal quarry road # 2 indicating significant groundwater movement under certain circumstances.

The Halberstadt Volcanic do not occur in the foot print or immediate adjacent to the quarry but is present south and west of the Newcastle Volcanic which surround the Halberstadt quarry. Halberstadt Limestone are generally interbedded with the top section of the Halberstadt Volcanics but as is the case here in the small outcrop south east of the Halberstadt quarry they can also be interbedded with Newcastle volcanics. These are sound and competent rock which do not pose major stability problems.

The Wagwater Formation is intercalated with volcanic flows of the Newcastle Volcanics, the evaporites of the Brooks Gypsum. As stated in the section on the Newcastle Volcanics. Although competent and well-cemented bed are not uncommon, the Wagwater formation if often highly fractured and are susceptible to frequent landslide especially in fault zones. It should be noted that although the Wagwater Formation shown in the Geological Sheet 18 to located west of the Brooks Gypsum, the Wagwater Formation has not been remapped in the recent geological and geotechnical assessments.

Although the Halberstadt quarry is located deeper in the mountains, at a higher elevation, the topography of the quarry area itself is not significantly steeper and extremer than of the other quarries. While the Halberstadt Quarry site has a higher average slope than Bito Quarry, it has the same average slope as the Upper and Cave quarry and considerable lower average slope than the Brooks Quarry, the oldest all the gypsum quarries. The natural drainage on the terrace level i.e. in the quarry is neither perpendicular nor parallel to the Halberstadt Quarry Gully. The natural drainage in the quarry flows generally in a W-E direction. All existing surface drainage from the proposed quarry site merges however with the Halberstadt Quarry Gully which exits in the main channel of the Bull Bay River.

The topographic map in the mining plan shows the proposed overburden storage area as a closed depression. This was verified in the field and was found to be incorrect. The area identified for the storage of the overburden is a mined out section of old Halberstadt quarry which can be accessed by the internal mining road #1. The topography of that area is characterized by an old quarry bench, which was abandoned without any form of rehabilitation. The near vertical bench wall is about 20m high and the near flat bench floor is about 20m wide. The total length of the semi-circular bench is about 140m. This is about 50% longer than the length of proposed overburden storage area. Neither the bench wall nor the bench floor have been affected by significant landslide activity or show signs of instability. Secondary vegetation is fully re-established throughout the quarry area except on the steepest section of the bench wall. Gullying and minor landslide activity near the intersection with the main Quarry road have made the internal mining road #1 inaccessible for vehicular traffic.

There a two (2) drainage issues that currently affect the proposed overburden area and may need to be addressed to prevent unwanted mobilisation of the stored material:

1) A small drainage channel of about 1m wide, which conveys the runoff from the slopes above the internal quarry road #2, passes through middle of the proposed overburden storage area.
2) Seepage of water was observed near the southern edge of the proposed overburden storage area at the foot of the bench wall on internal mining road #1. This feature appears to line up with the piping feature near the intersection with the internal road #2. These features should be looked at together as it is not impossible that they may be connected.

Topography, Hydrology and Drainage

The contour data obtained revealed that the overall project area is mountainous and is sloping in a general North-west to South-east direction. The elevations across the project area vary from a low of 480 metres above Mean Sea Level (msl) to a high of 620m; Most of the project areas are found predominantly in the mid to high ranges.

The topography of the project area comprises of mountainous lands within the northern segments of the catchment (elevation = 620m above MSL) and steep sloping areas in the south with sharp increases/decreases in elevations.

The landslide susceptibility map demonstrates that there is a group of highly vulnerable areas within the catchment which are prone to landslides. To be more specific, the southern 80% of the Halberstadt proposed deposit boundary is located within areas determined to have high susceptibility while the remaining regions are moderate. In addition, 50% of the over burden storage site is located with highly vulnerable zones.

The estimated peak runoffs were generated for the Halberstadt site catchment using the SCS method as described above. The peak runoffs ranged from 2.19 cubic metres per second to just below nine (8.82) cubic metres per second for the 2 year to 100 year return periods under existing conditions. The post development condition showed a cumulative increase across the site catchment that is predicted to occur as a result of the clearing of vegetation and mining of the land surface; as the mining surface increases so does the surface runoff. The increases in peak runoffs that are estimated to occur are in the range of 0.18% to 0.68% for the 2 year to 100 year return periods under existing conditions. The corresponding 50 year return period peak runoffs are 7.63 cubic metres per second and 9.25 cubic metres per second under both existing and post development conditions respectively.

Three (3) scenarios were also simulated during the evaluation of the overall catchment: pre-development (existing), post development without climate change and post development with climate change. The runoff generated for the bull park river catchment, under existing conditions, was determined to be 1,058 cubic metres per second for a 100-yr return period event. This value is based on an overall catchment with an approximate area of 2,197 hectares and a slope of 14.89%. Future development within the catchment was then applied to the model without considering the effects of climate change. The expected runoff determined within the catchment is approximately 1,064 cubic metres per second considering further development within the catchment. Climate change was then applied to the design rainfall to reflect future hydrological conditions with post development. The runoff that is predicted to be generated within the bull park river catchment is approximately 1,116 cubic metres per second considering climate change with further development.

The land use for the catchment was determined from inspection of the Forestry Department land use map as well as satellite imagery of the catchments. The following was noted:

1. The western 15% of the catchment is comprised primarily of disturbed broad leaf forests.

2. The remaining 85% of the catchment consists solely of disturbed broad leaf forests and fields.

Air Dispersion Modelling

An air dispersion modelling exercise involving the AERMOD air dispersion model was conducted to predict the impact of the emissions on ambient air quality from the proposed quarry facility at Halberstadt in St. Andrew, Jamaica. According to the Natural Resources Conservation Authority (NRCA) Guideline Document (2006), air pollutant sources within 10 km of the proposed facility were considered as part of the air dispersion modelling analyses. The facilities of concern were Caribbean Cement Company (CCC) and Jamaica Gypsum & Quarries (JGQ) Port Facility.

It was determined that the emissions of concern from the quarrying operations were total suspended particulates (TSP) and particulate matter less than ten microns (PM10), and consequently these pollutants were considered also for other nearby facilities. The emissions for the proposed quarry operations and the JGQ Port facility were calculated based on the use of published emission factors from the United States Environmental Protection Agency AP-42 Documentation, as well as project information supplied by facility personnel. Emissions for the CCC facility were obtained from the Air Dispersion Modelling Report for Jamaica Ethanol Processing Limited that was conducted in 2009.

Five years (2007-2011) MM5 meteorological data (both surface and upper air data) at an elevation of 162m that were available for the Norman Manley International Airport were pre-processed using the AERMET software programme to generate meteorological input files that were used for the modelling analyses for the proposed facility.

A receptor grid system was included as part of the modelling analyses using a multi-tier grid system that included a 100-meter grid spacing within 3 km from the centre of all proposed quarry sources, a 250-meter grid spacing between 3 and 5 km from the centre of proposed quarry sources, and a 500-meter grid spacing between 5 and 10 km from the centre of proposed quarry sources. Special receptors inclusive of schools, health centres, churches, police stations, postal offices, and hospitality attractions were included as part of the receptor network.

With all the input files established, the air dispersion model was executed. The model was run using the rural option based on the Auer (1978) Land Use categories.

It was determined that the predicted maximum concentrations as a result of the operation of the proposed quarry were in compliance with the respective JNAAQS. It was also highlighted that these predicted maximum concentrations were obtained based on the implementation of a mitigation measure to spray water on the unpaved haul roads during the operation of the quarry facility. And it was also recommended that monitoring for PM10 occur at the highest predicted concentrations in order to track the effectiveness of the watering control mitigation measure.

Ambient Particulates

All locations sampled for PM10 particulates had values compliant with the USEPA 24hr standard of 150µg/m^3 and all locations sampled for PM2.5 particulates had values compliant with the USEPA standard of 35µg/m^3.

Ambient Noise

Three stations (N5, N7 and N8) were non-compliant with the NEPA noise guidelines during the daytime (7am – 10 pm). During the night time two stations were non-compliant with the NEPA guidelines. These stations were N7 and N8.

Vibration

The results indicate that vibration levels at Locations 2 and 3 are barely perceptible in residential environments and have no effect on building structures. At Location 1 however, between the hours of 11:09am – 00:00am, vibrations were at a level considered unacceptable for most persons exposed to it continuously, and will result in complaint.

Biological

Terrestrial Flora

The vegetation within the Halberstadt Quarry area showed signs of notable anthropogenic disturbance. Evidence of vegetation clearing was observed with the occurrence of fire-damaged trees and the presence of unpaved access roads/routes. These were cut and graded into the slopes.

The flora consisted mainly of early successional species with several of the constituents appearing to have escaped from cultivation in the lowlands. Their occurrence was likely aided by continued anthropogenic incursions into the area. As a result, the site may be described as being species-rich with a total of 122 species encountered. Four endemic species were noted.

From the surveys conducted and the data garnered, it was concluded that the vegetation on the quarry site was typical in structure and composition to those described by Asprey & Robbins (1953): that is (disturbed) vegetation occurring on lower shale hills.

Several direct and indirect impacts were determined and are listed here. Recommendations were also provided to help mitigate these impacts.

- Habitat destruction
- Habitat fragmentation
- Accidental/intentional removal of important plant species
- Increased topsoil erosion
- Increased effects of dust
- Effects from the storage of overburden and other waste.
- Increased human and invasive species access.

Fauna

Twenty two bird species were observed during the bird assessment. Of the 22 species 3 are migrants, 13 residents and 5 endemics. The forest type in the area is dry limestone forest and bird species typical of a dry limestone forest in Jamaica such as Columbids (Common Ground Dove, Caribbean Dove and White-crowned Pigeon); Olive throated Parakeet and Jamaica Oriole was identified in the assessment. Only 5 of the 29 endemic birds on the island were observed on the property. No migrant warblers were observed during the assessment as a result of the time of year the assessment was carried out. Migrant warblers are known to arrive on the island as early as September. Hence, the bird species diversity will increase in the forested areas as a result of the arrival of the migrant warblers. It is also possible that a few nocturnal bird species such as owls could be present in the area. No nocturnal bird survey was carried out in the area.

Thirty-three species of Arthropods were recorded. This included twelve species of butterflies and ten species of plant bugs. The number of individuals in each species was generally low. This was not unexpected as the area is quite harsh with low rainfall and limestone substrate. Young leaves, flowers and herbs which for the food and larval hosts for most insect was therefore not in abundance, but rather rare.

Socioeconomic Environment

Demography and Housing

The total population within the Social Impact Area (SIA) in 2011 was approximately 990 persons (STATIN 2011 Population Census). Examination of the 2001 population data showed that there were approximately 1,144 persons within the 2 km radius of the proposed plant location in 2001. From this population, and that calculated for the year 2011 (990 persons), it was estimated that the actual growth within the SIA between 2001 and 2011 was approximately -1.44% per annum.

The 15-64 years age category accounted for 68% of the 2011 population for the SIA, with the age 0-14 years (26%) and the age 65 and over category accounting for 7%. The segment of a population that is considered more vulnerable are the young (children less than five years old) and the elderly (65 years and over). In this population, approximately 7% were in the young category and this is similar to the 7% within the 65 years and older category as mentioned previously.

The child dependency ratio for the SIA in 2011 was 379 per 1000 persons of labour force age; old age dependency ratio stood at 101 per 1000 persons of labour force age; and societal dependency ratio of 480 per 1000 persons of labour force. This indicates that the youth (child dependency) is more dependent on the labour force for support when compared with the elderly.

The land area within the SIA was calculated to be approximately 14,597,712.6 m^2 (14.6 km^2). With a population of 990 persons, the overall population density was calculated to be 68 persons/km^2. This population density is considerably lower than the regional level for the parishes of St. Andrew, which is approximately 1,321 persons/km^2 and St. Thomas, 127 persons/km^2, as well as the national figure of 246 persons/ km^2).

Most persons within the SIA attained a secondary school education (68.0%) followed by those attaining a primary education (20.7%). Secondary educational attainment is higher in the SIA than the parishes of St. Andrew and St. Thomas and the island; however, there were noticeably lower percentages of those attaining a university, other tertiary or other educational level. Statistics for pre-primary and no education are similar amongst all extents examined. The relatively high proportion of the population in proximity to the quarry location attaining a secondary education suggests that the labour pool is relatively educated, and as such, there should be no problem in obtaining non-technical workers from the community.

The SDC 2009 Community Profile data revealed that 45% of the Bito community households were headed by unemployed persons. In contrast, only 6% of households were headed by unemployed persons in the community of Bloxborough.

There were 272 housing units, 291 dwellings and 293 households within the SIA in 2001. The average number of dwellings in each housing unit was 1.1 and the average household to each dwelling was 1.0. The average household size in the SIA was 3.9 persons/ household (Table 6.40). Comparisons of the SIA with national and regional ratios indicate that they were generally similar except for the higher SIA average household size.

In 2001, 35.9% of the households in the SIA owned the land on which they lived. Approximately 6.6% leased the land on which they were, 16.1% rented, 24.5% lived rent free, 9.7% "squatted" and 0.1% had other arrangements. Compared to higher percentages of no reports for the national (21.9%) and St. Andrew (35.2%) extents, the SIA had a very low percentage (7.1%) of persons not reporting the type of ownership arrangements they had. The relatively higher percentage of households in the SIA living rent free and squatting indicates that there were a higher percentage of households in the SIA compared to the national and regional setting with temporary living arrangements.

Sixty-three percent (62.7%) of the households within the SIA received their domestic water supply from the National Water Commission (NWC). It was reported by SDC that over 95% of the residents in the communities of Bito and Bloxborough utilise cellular services for communication in 2009. In the community of Bito, 64.5% of residents used electricity for lighting whilst in Bloxborough, 66% used this source of lighting (SDC 2009 socioeconomic survey). These figures are comparable with those estimated for the SIA (61.9%).

It is estimated that approximately 174,609.9 litres/day (~46,127.1 gals/day) of wastewater is generated within the study area (for 2013) and is expected to decrease to 121,554.6 litres/day (~32,111.3 gals/day) over the next twenty five years based on calculated growth rates. It is estimated that households in the study area generated approximately 1,204.2 kg (~1.2 tonnes) of solid waste in 2001. Based on the population growth, it has been estimated that at the time of this study (20123), approximately 1,171.4 kg (~1.17 tonnes) of solid waste was being generated and it is expected that within the next twenty five years, if the annual population growth rate remains the same (-1.44%), the amount will be 813.8 kg (~0.8 tonnes).

Community Perception

Approximately 91.7 % of all respondents had heard of the Jamaica Gypsum and Quarries Limited while 8.3 % of respondents indicated they had never heard of the company. Based on interviewees' comments and responses, it was thought that some respondents were aware of the gypsum company but could not categorically confirm the name of the company. 100 % of respondents indicated awareness of the Caribbean Cement Company.

As it related to respondents awareness of the proposal to reopen the Halberstadt Quarry to mine gypsum for the manufacture of cement, 50 % of respondents were aware of the proposal and 50 % of respondents were not aware.

On the issue of concerns and comments related to the project, there were a series of mixed opinions. 58.3 % of respondents indicated that they did not have any concerns regarding the reopening of the quarry while 41.7 % of respondents expressed concerns. In general, concerns highlighted, related to the increase in noise and dust, employment opportunities for individuals in communities nearby the quarry, the possible need for relocation , the increase in siltation of gullies and flooding, the need for Jamaica Gypsum to be more involved in the community, the need for improvement of the existing roads and the increased chance of damage to homes as a result of anticipated blasting associated with quarrying activities.

46.7 % of respondents indicated that they thought the reopening of the quarry would affect their lives while 53.3 % of respondents indicated that they did not expect their lives to be affected. Of the 46.7 % of interviewees indicating an expectation of the quarry reopening to affect their lives, 44.4 % of respondents anticipated a negative impact while 55.6 % of respondents anticipated a positive effect. Positive impact was anticipated in the areas of income generation and work and business opportunities.

It was realized during the administering of questionnaires that the survey area has an issue with potable water supply. Respondents indicated that their water source was "Tank Weld Water". Respondents clearly indicated that this water was not treated water and in times of heavy rainfall the water is high in turbidity and cannot be used. Interviewees indicated that there was a connection to the "Tank Weld Water", however the legitimacy of the connection could not be verified. It was also implied that potable water used to be in the Bito area, but the mains were destroyed during quarrying activities and were never repaired. Again this could not be verified as the Bito community is small.

On the issue of electricity, respondents indicated electricity for lighting, however many irregular connections were observed and some respondents indicated that their electricity supply was not legitimate as the utility company has not installed power poles to facilitate legal connections.

Both water closets and pit latrines are present in the survey area, but it was noticed that pit latrines were used in the areas where there was no water, including no connection to “Tank Weld Water”.

Cultural and Heritage

Halberstadt is named after a town in Germany. The Tainos were the first occupants of the area evidenced by the find of a cave containing the skeletal remains of at least 34 individuals and other artefacts in 1895. The Halberstadt property has seen various land uses over the past centuries. In 1763 sugar was the main produce but by 1811 the estate was producing 6,588 bushels of coffee. In 1824 the estate possessed 156 enslaved persons. The estate has passed through several owners such as Jakob Kellerman, John Mais, John Weiss and Beresford Gossett. The location of the quarry was once the provision grounds, Guinea grass and ruinate. As in the historical period the site is found to be in ruinate and Guinea grass piece. This clearly accounts for the absence of archaeological features and artefact assemblages.

Aesthetics

Due to the topography of the area, the proposed Halberstadt deposit is situated behind a hill, away from view of the coastal main road. Therefore, the proposed quarry is not expected to have a negative visual impact being viewed from the Bull Bay area.

IDENTIFICATION AND IMPACTS AND RECOMMENDED MITIGATION

Site Clearance/Preparation and Construction

Impact	**Mitigation**
Vegetation/Habitat Disturbance	• Limit the development of roadways to the existing road network. • The removal of endemic species, especially in the areas surrounding the site, should be avoided. • If removal is necessary, a nursery or buffer should be established for the maintenance and propagation of the endemic species and other naturally occurring plants. These plants may later be reintroduced into the area based on a rehabilitation plan. • If possible, trees with trunks of DBH 20 cm and greater should be left intact. • Remove trees only as necessary. • A site preparation plan should be developed prior to project initiation. • Leaving or planting strips of vegetation on steep slopes may help to prevent erosion. • Vegetation and soil should be removed together (mixed) so that the plant matter helps to hold the soil. Alternatively, vegetation can be stripped and stockpiled and then spread over the newly made stockpiles of soil. • In terms of aesthetics, natural vegetation surrounding the quarry should be retained (such as in a buffer area) so as to help minimise dust emissions.
Noise Pollution	• Use equipment with low noise emissions as stated by manufacturer, and fitted with noise reduction devices such as mufflers • Operate noise-generating equipment during regular working hours (e.g. 7am – 7pm) to reduce potential of creating noise nuisance at night • Construction workers operating noise-generating equipment should be equipped with noise protection (ear muffs, ear plugs)
Air Quality	• Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance, and on hotter days this frequency should be increased • Minimize cleared areas to those that are needed to be used • Cover or wet construction materials such as marl • Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators
Solid Waste Generation	• Skips and bins should be strategically placed within the campsite area. • The skips and bins at the campsite should be adequately designed and covered to prevent access by vermin and minimise odour.

Impact	Mitigation
	• The skips and bins at both the campsite and construction site should be emptied regularly to prevent overfilling. • Disposal of the contents of the skips and bins should be done at an approved disposal site.
Wastewater Generation/Disposal	• Provide portable sanitary conveniences for the construction workers for control of sewage waste. A ratio of approximately 25 workers per chemical toilet should be used
Transportation and Traffic	• Construction traffic entering of leaving the site will be scheduled for off peak hours to minimize additional congestion at the intersection and or disruptions in the regular traffic flow. • Erection of signs ahead of the works warning motorists of the heavy/construction units entering the Bull Bay Main Road right of way. • Appropriate traffic warning signs, informing road users of a construction site entrance ahead and instructing them to reduce speed, should be placed along the main road in the vicinity of the intersection of the Bull Bay main Road and the PC road for the duration of the construction and operational period. • Flagmen should be utilized to minimize the likelihood of accidents when heavy units are entering the roadway.

Operation

Impact	Mitigation
Rock Blasting	• Directional controlled blasts • Constructing rockfall protection mesh systems, for example catch fences, rockfall drapery or rockfall netting, which are made from high-tensile steel wire.
Soil Loss and Erosion	• Implementation of check dams which are small dams, temporary or permanent, constructed across a channel or drainage ditch. They are constructed not only to capture the runoff sediment directly, but also to decrease the volume and discharge runoff sediment (sediment control). • The introduction of reinforcement elements such as metal soil nails or anchors to increase the shear strength of the rock and to reduce the stress release created subsequent to soil cutting. Gravity walls or concrete walls with counterforts may also be introduced. • Re-profiling the slope with the purpose of improving stability by either reducing the slope angle or cutting benches into the face of the soil. There are three options: Balanced cut and fill, full bench cut or through cut.

Impact	Mitigation
	• Erecting gabion walls from the foot of the slope along its faces which act as a type of low gravity retaining structure. These are generally wire frames filled with aggregates. • Constructing rockfall protection mesh systems, for example catch fences, rockfall drapery or rockfall netting, which are made from high-tensile steel wire. • The implementation of soil erosion preventative measures, for instance, geomats, geogrids or brushwood mats, as water near the surface of the hillside may cause the erosion of surface material.
Surface and Subsurface Water Pollution	• Only clean uncontaminated water should be discharged, under the approved licence, to surface waters including clean dewatering from the quarry floor to minimise surface water run-off into the quarry workings • The developer/proprietor should construct and commission proposed detention ponds/silt ponds prior to the commencement of extraction operations • All the run-off from roads and paved areas should pass through adequately sized and located oil/petrol interceptors before discharge to surface water drainage. Refuelling should only take place on such paved areas with oil/petrol interceptors • All above ground chemical (petroleum/oil) storage tanks should be adequately bunded to protect against oil spillage. Bunding should be impermeable and capable of retaining a volume equal to 110% of the capacity of the largest tank. Drainage from bunded areas should be collected and disposed of in a safe manner and to the satisfaction of the planning authority • The developer should maintain on site an adequate supply of containment booms and suitable absorbent materials to contain and absorb any spillage; • Washing ponds (used to separate the suspended solids during the aggregate washing process) should be carefully designed and operated to ensure that where practicable water is recycled and not discharged to watercourses. • No surface water should be allowed to flow from the site onto the public road during the construction or operational phases of the development. • The haul road is to be properly graded and drained to prevent run-off from cutting into banks of the road, avoiding erosion. • If excavating below the water table, a hydro-geological study should be conducted to determine the likely effect on groundwater flows in the area, particularly in relation to wells. Replacement wells or water supplies may have to be provided in the event of de-watering. Stream augmentation should be considered where there exists the possibility for reduction of base flow in streams. • Sufficient sewage and storm water treatment should be provided on site; strict control of

Impact	Mitigation
	run-off from pits, quarries, spoil heaps, embankments and all other parts of sites, including access roads and wheel-wash facilities is required; • Groundwater can be adversely affected by residues from explosives used in rock quarries. It is important that blast operatives ensure that all material is ignited; Use of explosive slurries in karst terrain should be avoided.
Drainage and Flooding	• The surface runoff traversing the site from the north-west to south-east will be channelled through proposed earth swales with implemented check dams where possible. In addition, the drains located on the eastern boundary of the site will be bounded with compacted berms designed to be 0.3m above the estimated water level. • With the proposed boundary storm drains along the site roads, several culvert crossings were identified which would be required in order to efficiently convey stormwater flows across the roads. The capacities of the culverts were analysed using the peak flows generated from a 50 year rainfall event. The box culverts are proposed to be constructed of concrete varying in two (2) main sizes: 2.2m wide by 1.5m high and 1.5m wide by 1.5m high • The flows generated from the site catchment will, where possible, pass through a detention basin prior to final discharge through the proposed culvert. There is a natural depression within the topography of the site where the space required to construct detention ponds is available. It was envisaged that the proposed pond should be capable of reducing up to the 25yr peak future flows without any significant construction.
Vegetation/Habitat Disturbance	• A phased approach to mining activities is recommended. • Establish a site rehabilitation plan for the site. • A buffer zone of minimal to no activity should be established surrounding the proposed area. The vegetation in this area may then become a natural seed-source to the mined-out lands after closure. If considered, seedlings may also be actively transplanted from this area as well. • The staged and sequential clearing of vegetation over the life of the quarry should be contemplated. • Consider the development of a conveyor-belt system for the transport of aggregate which would minimise the need for the construction of additional roads and minimise the impact of vegetation removal. It would also lead to a decrease in traffic through the area. • Conveyor belts, if used, should be covered so as to minimise the spread of particulates over the plant community. • Vegetation should only be cleared where it is absolutely necessary for operation. • As the quarry expands, the time between clearing and quarrying should not be protracted. • When trucking material it should be covered for the duration of the trip and when idle.

Impact	Mitigation
Noise Pollution	• Use equipment with low noise emissions as stated by manufacturer, and fitted with noise reduction devices such as mufflers • Operate during regular working hours (e.g. 7am – 7pm) to reduce potential of creating noise nuisance at night • Conduct annual noise assessment to determine if the noise from quarry operations is having negative impact on the environment.
Air Dispersion and Quality	• It should be noted that the calculation of the dust emissions from the unpaved haul roads assumed that the roads would be sprayed with water, and therefore the spraying of the unpaved haul roads with water is a recommended mitigation measure.
Vibration	• All blasts must be so designed to minimize ground vibration. Prior warning and explanation should been given to residents in the area before blasting occurs.
Storage of Quarry Material	A set of management guidelines should be implemented in order to curtail the impact of stored quarried material, identify formalized storage sites and for the appropriate management using quarried material. The storage and use of stored material is required to be managed to: • Efficiently utilize material previously quarried; • Minimise the spread of environmental pathogens (infectious); • Ensure legal requirements are met for storing quarried material.
Transportation and Traffic	• Erection of signs ahead of the works warning motorists of the heavy units entering the Bull Bay Main Road right of way. • Flagmen should be utilized to minimize the likelihood of accidents when heavy units are entering the roadway. • The weight of the heavy vehicles traversing the roads to access and leave the site would be a contributor to the destruction of the roads, especially during the operational phase. It is therefore recommended that a scale be placed onsite to ensure the trucks leaving the site are within the appropriate weight limits as prescribed by the NWA. The National Works Agency of Jamaica (NWA) has a standard for loads per axel that all trucks exert on roads. • It is further recommended that a maintenance plan be put in place to address the issue of the PC road degradation over the operational life of the quarry. This is needed because it is anticipated that even though the trucks may be within the weight limits, the PC roads in the unpaved areas especially will deteriorate with continued used by trucks from the quarry.
Rehabilitation Plan Considerations - Ground Control Management Plan	It is recommended that the implemented and planned rehabilitation activities (as outlined in section 5.4.7) be included in a Ground Control Management Plan (GCMP), which will be made available (submitted) to the regulators. Through the life of the quarry the GCMP will define

Impact	Mitigation
	and report on, including but not limited to: • excavation geometry • ground reinforcement and support • excavation methods • ongoing data collection procedures and monitoring strategies • monitoring of ground movements • mapping of geological structure • groundwater monitoring • recording general ground performance • emergency action procedures • production • rehabilitation The GCMP should be reviewed annually, or at any time changes in the quarry design are to be implemented to address safety or performance issues.

2.0 INTRODUCTION

2.1 Project Background

Caribbean Cement Company Limited (CCCL), through its subsidiary Jamaica Gypsum and Quarries Limited (JGQ), operates a gypsum quarry in the Bito District, Bull Bay, St. Andrew. The Bito Gypsum Quarry is now depleted of mineable ore and reclamation activities will begin in 2014. The only economical reserve of gypsum remaining is contained in the Halberstadt Deposit. Owing to this, CCCL is desirous of reopening the Halberstadt Quarry, approximately 2 km northeast of the Bito Quarry in the parish of St. Andrew.

The Halberstadt quarry, now revegetated, has been dormant for 40 years, however a recent exploration drilling programme conducted by NHL Engineering indicated that there are reserves of approximately 5 million tonnes of gypsum/anhydrite in the quarry. This quarry will supply the cement plant with the gypsum required in the manufacturing of Ordinary Portland and Blended Cements. It will also supply export markets in the Caribbean Community (CARICOM) and South America.

At Trinidad Cement Limited (TCL) Group’s current consumption rate (approx. 100k tonnes), mine life at Halberstadt will be 50 years. With existing quarries nearing the end of mine life, it is incumbent on JGQ, in order for its survival, to develop the Halberstadt deposit for production.

2.2 Project Objectives and Execution

Caribbean Cement Company Limited (CCCL) requires a permit for the mining of gypsum/ anhydrite at the Halberstadt Quarry, and following an application submitted to the National Environment and Planning Agency (NEPA), it was determined that an Environmental Impact Assessment (EIA) is required for the clearance and mining of the proposed Halberstadt Quarry site involving an initial area of 13.7 hectares and an ultimate area of 67 hectares of land. However, considering the urgency of the proposed mining project, NEPA agreed to allow the mining and clearance of one (1) hectare of land subject to the completion of an Environmental Impact Statement (EIS) prior to the commencement of quarrying activities.

This report summaries the approach and results of the EIS tasks that have been undertaken in fulfilment of the Terms of Reference provided by NEPA (Appendix 1). A multidisciplinary team undertook the required tasks and the project team may be viewed in Appendix 2.

3.0 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

3.1 Background

An Environmental Impact Assessment (EIA) is "a structured approach for obtaining and evaluating environmental information prior to its use in decision-making in the development process. This information consists, basically, of predictions of how the environment is expected to change if certain alternative actions are implemented and advice on how best to manage environmental changes if one alternative is selected and implemented" (Bisset, 1996).

The basis and rationale of an EIA has been summarised as follows[1]:

- Beyond preparation of technical reports, EIA is a means to a larger end - the protection and improvement of the environmental quality of life.
- It is a procedure to discover and evaluate the effects of activities on the environment - natural and social. It is not a single specific analytical method or technique, but uses many approaches as appropriate to the problem.
- It is not a science but uses many sciences in an integrated inter-disciplinary manner, evaluating relationships as they occur in the real world.
- It should not be treated as an appendage, or add-on, to a project, but regarded as an integral part of project planning. Its costs should be calculated as a part of adequate planning and not regarded as something extra.
- EIA does not 'make' decisions, but its findings should be considered in policy - and decision-making and should be reflected in final choices. Thus, it should be part of decision-making processes.
- The findings of EIA should focus on the important or critical issues, explaining why they are important and estimating probabilities in language that affords a basis for policy decisions.

EIAs are not only recommended in project design, but also required by Jamaican legislation. The following section includes a discussion of

---

[1] Wood, C., "Environmental Impact Assessment: A Comparative Review" p. 2. (from Caldwell, 1989, p.9)

relevant national legislation, regulations/standards, and policies thought to be relevant to the proposed project. The following main areas are covered:

- Development Control: construction (including building codes and site management controls) and subsidiary inputs (quarry material, etc.), public safety and vulnerability to natural disasters
- Environmental Conservation: forestry, wildlife and biodiversity, protected areas and species, water resources, heritage and cultural resources.
- Public Health & Waste Management: air quality, noise levels, public health, solid waste, storm water, etc.

In all cases, the roles of agencies with responsibility for implementing legal mechanisms are described. Where Jamaican standards or policy are insufficient, international standards and policies are outlined.

3.2 National Legislative Framework

3.2.1 Development Control

Town and Country Planning Act (TCP Act), 1957 (Amended 1987)

This act provides the statutory requirements for the orderly development of land (planning) as well guidelines for the preparation of Development Orders, stipulations for Advertisement Control Regulations, Petrol Filling Stations and Tree Preservation Orders. It establishes the Town and Country Planning Authority, which in conjunction with the Local Planning Authorities, (Parish Councils), are responsible for land use zoning and planning regulations as described in their local Development Orders. The Town and Country Planning Act is administered by the National Environment and Planning Agency.

Local Improvement Act, 1944

The Local Improvements Act is the primary statue that controls the subdivision of land.

Parish Council Act

Under the Parish Council Act each Local Planning Authority may revoke or alter regulations concerning the construction and restrictions as to the elevation, size and design of buildings built with the approval of the relevant Minister. It may also make regulations concerning the installation of sewers on premises.

Land Acquisition Act (1947)

The Land Acquisition Act was passed in 1947. As stipulated under Section 3 of this Act, any officer authorized by the Minister may enter and survey land in any locality that may be needed for any public purpose. This may also involve:

- Digging or boring into the sub-soil;
- Cutting down and clearing away any standing crop, fence, bush or woodland;
- Carrying out other acts necessary to ascertain that the land is suitable for the required purpose.

The Minister is authorized to make a public declaration under his signature if land is required for a public purpose, provided that the compensation to be awarded for the land is to be paid out of the Consolidated Fund or loan funds of the Government and funds of any Parish Council, the Kingston and St. Andrew Corporation or the National Water Commission.

Once the Commissioner enters into possession of any land under the provisions of this Act, the land is vested in the Commissioner of Lands and is held in trust for the Government of Jamaica in keeping with the details stated in Section 16. The Commissioner shall provide the Registrar of Titles with a copy of every notice published, as well as a plan of the land. The Commissioner will also make an application to the Registrar of Titles in order to bring the title of the land under the operation of the Registration of Titles Act.

Land Development and Utilization Act (1966)

This act specifies conditions pertaining to the development and utilization of land, dispossession of owners or occupiers and the Land Development and Utilization Commission as it pertains to agricultural and unused land. The Land Development and Utilisation Act is administered by the National Environment and Planning Agency.

Registration of Titles Act (1989)

The Registration of Titles Act was passed in 1989 and speaks to the legalities associated with land registration in Jamaica.

Jamaica National Heritage Trust Act (1985)

The Jamaica National Heritage Trust Act has been in operation since 1985 with the main goal of preserving and protecting the country's national heritage. This Act established the Jamaica National Heritage Trust (JNHT) whose functions are outlined in Section 4 of the Act as follows:

a) to promote the preservation of national monuments and anything designated as protected national heritage for the benefit of the Island;
b) to conduct such research as it thinks necessary or desirable for the purposes of the performance of its functions under this Act;
c) to carry out such development as it considers necessary for the preservation of any national monument or anything designated as protected national heritage;
d) To record any precious objects or works of art to be preserved and to identify and record any species of botanical or animal life to be protected.

The Act also states the following offences are liable to a fine and/or imprisonment:

- wilfully defacing, damaging or destroying any national monument or protected national heritage;
- wilfully defacing, destroying, concealing or removing any mark affixed or connected to a national monument or protected national heritage;
- altering any national monument or marking without the written permission of the Trust
- Removing any national monument or protected national heritage to a place outside of Jamaica.

Quarries Control Act (1983)

The Quarries Control Act is administered by the Mines and Geology Division It regulates the extraction of material such as sand, marl, gypsum, and limestone for construction purposes. Quarry zones and licenses, quarry tax, enforcement, safety, Quarry Advisory Committee, fines for illicit quarrying and bonds for restoration are addressed in this act.

Under this act, the Quarries Advisory Committee, which advises the Minister on general policy relating to quarries as well as on applications for licenses, was established. On the recommendation of the Quarries Advisory Committee, the Minister may declare an area in which quarry zones are to be established and establish quarry zones within any such specified area. A license is required for establishing or operating a quarry, unless the Minister decides to waive this requirement based on the volume of material to be extracted (if the mineral to be extracted is less than 100 cubic metres, a license may not be required).

Factories Act, 1968

The Factories Act (1968) authorizes the Minister of Labour to register factories, inspect and regulate their operations. The regulations updated in 1968 provide for the following:

- The safe means of approach or access to, and exit from, any factory, or machinery.
- The fencing and covering of all dangerous places or machines;
- Life-saving and first aid appliances.
- Securing safety in connection with all operations carried on in a factory.
- Securing safety in connection with the use of cranes, winches, pulley-blocks and of all engines, machinery, mechanical gear and contrivances generally whatsoever.
- The periodic inspection, testing and classification, according to age, type or condition, of boilers.
- The duties and responsibilities assignable to any person generally, and in particular to employers, owners, and managers in charge of factories, in connection with any one or more of such regulations.
- The proper ventilation of any factory, having regard to the nature of the process carried on therein.
- The sanitation, including the provision of lavatory accommodation (having regard to the number of workers employed) at any factory.

Petroleum and Oil Fuel (Landing & Storage) Act (1925)

This extends to the storage of petroleum in quantities greater than one hundred and twenty imperial gallons in a building specially appointed for this purpose by the Minister.

The Office of Disaster Preparedness and Emergency Management Act (1998)

This Act was established by the Office of Disaster Preparedness and Emergency Management (ODPEM) to develop and implement policy and programmes to achieve and maintain an appropriate state of national and sectoral preparedness for coping with emergency situations. Caribbean Cement Company should have its own disaster and emergency response plan specific to its operations, to minimise loss of life, injury and damage to structures.

3.2.2 Environmental Conservation

Natural Resources Conservation Authority (NRCA) Act (1991)

The Natural Resources Conservation Act (NRCA) may be considered Jamaica's umbrella environmental law. The purpose of the Act is to provide for the management, conservation and protection of the natural resources of Jamaica. This Act was passed in the Jamaican Parliament in 1991 and subsequent to this; the Natural Resources Conservation Authority (NRCA) was established with the function of taking necessary steps to ensure the sustainable development of Jamaica through the protection and management of Jamaica's physical environment. The NRCA Act, under Sections 9 and 10 specifies that an Environmental Impact Assessment (EIA) is required from an applicant for a permit for undertaking any new construction, enterprise or development.

Under the Act, the NRCA has a number of powers including:

- issuing of permits to persons responsible for undertaking any construction, enterprise or development of a prescribed category in a prescribed area, including power generation facilities;
- requesting an Environmental Impact Assessment (EIA) from an applicant for a permit or the person responsible for undertaking any construction, enterprise or development; and
- Revocation or suspension of permits.

The Act also gave power of enforcement of a number of environmental laws to the NRCA, namely the Beach Control Act, Watershed Act and the Wild Life Protection Act.

The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order (1996)

Section 9 of the NRCA Act declare the entire island and the territorial sea as 'prescribed area', in which specified activities require a permit, and for which activities an environmental impact assessment may be required. The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order (1996) and the Permits & Licensing Regulations was passed as a result of section 9 of the NRCA Act.

Wild Life Protection Act (1945)

The Wild Life Protection Act of 1945 is mainly concerned with the protection of specified faunal species. Under this Act, the removal, sale or possession of protected animals; use of dynamite, poisons or other noxious material to kill or injure fish; and the discharge of trade effluent or industrial waste into harbours, lagoons, estuaries and streams are prohibited. In addition, this Act protects several rare and endangered faunal species including six species of sea turtle, one land mammal, one butterfly, three reptiles and a number of game birds. The establishment of Game Sanctuaries and Reserves is authorized under this Act.

The Endangered Species Act (2000)

The Endangered Species (Protection, Conservation and Regulation of Trade) Act was created in 2000 in order to ensure the codification of Jamaica's obligations under the Convention for the International Trade in Endangered Species of Wild Fauna and Flora. This Act governs international and domestic trade in endangered species in and from Jamaica. Under this act, the functions of NEPA include the grant of permits and certificates for the purpose of international trade, the determination of national quotas and the monitoring of the trade in endangered species. Sea turtles, in addition, to yellow snakes and parrots are often traded illegal internationally and are endangered.

Water Resources Act (1995)

The Water Resources Act (1995) was promulgated in the Jamaican Parliament in September 1995 and ratified in April 1996. This Act established the Water Resources Authority (WRA), which is authorized to regulate, allocate, conserve and manage the water resources of the island. The WRA is also responsible for water quality control; as stipulated under Section 4 of the Act the WRA is responsible for providing any department or agency of Government, technical assistance for any projects, programmes or activities relating to development, conservation and the use of water resources.

Section 25 advises that a proposed user will have to obtain planning permission, if this is a requirement, under the Town and Country Planning Act. In addition, under Section 21 it states that if the water to be used will result in the discharge of effluents, an application for a license to discharge effluents will have to be made to the Natural Resources Conservation Authority or any other relevant body as indicated by the Minister.

Forest Act (1996)

The 1996 Forest Act repealed the 1937 legislation and was the legal basis for the organization and functioning of the Forestry Department. The Forestry Department is an independent entity established in 1942, subsequent to the Forest Division of the Department of Agriculture (1938) and the Forest Branch of the Lands Department (1937). In 1938, the Forest Branch gazetted some 78,800 hectares of Crown Lands as forest reserves, this making up more than 75% of the present day forest reserves. Following this, these reserve areas were added to by purchase, lease and other arrangements.

The Forestry Department is the lead agency responsible for the management and conservation of the forest resources in Jamaica. The management of forests on a sustainable basis in an aim to maintain and increase the environmental services and economic benefits is the Forestry Department's main function.

The following are some offences under this act:

- Cut a tree in forest reserve without valid permit
- Fell, cut, girdle, mark, lop, tap, uproot, burn, damage, debark, strip/remove leaves of a tree
- Kindle, keep, carry lit material
- Clear or break up land
- Establish or carry on forest industry
- Remove soil, gravel or sand
- Unlawfully/illegally affix forest officer mark to any tree/timber
- Alter, deface/obliterate mark placed by forest officer on tree/timber
- Pasture/allow cattle trespass

There are also a set of Forest Regulations (2001) which are administered by the Forestry Department as well.

The Flood Water Control Act (1958)

The Flood Water Control Act of 1958 is administered by the National Works Agency and designates specific personnel with the responsibility of and the required power to ensure compliance with the legislation.

Any Government department/agency or any statutory body or authority appointed by the Minister may enter land in flood-water control area to:

- Survey, measure, alter or regulate watercourses, maintain or build tools required to undertake works
- Clean watercourse or banks of such and deposit where required
- Construct, improve, repair or maintain floodwater control works

Wilfully or maliciously blocking, obstructing, encroaching on or damaging any watercourse, pipes or appliances used to execute works under the Act is an offence.

3.2.3 Public Health & Waste Management

The Natural Resources Conservation Authority (Air Quality) Regulations, 2002

Under section 38 of the NRCA Act, regulations pertaining to air quality in Jamaica are stipulated. The National standards, known as the National Ambient Air Quality Standards (NAAQS), are categorized into two groups. In one group, there are the primary standards, designed to protect human health and in the other, there are the secondary standards designed to protect the environment and limit property damage.

Part I of the NRCA Air Quality Regulations (2002) instructs on license requirements and indicates that every owner of a major or significant facility shall apply for an air pollutant discharge license. Part II makes reference to the stack emission targets, standards and guidelines.

Water Quality Standards

The NRCA has primary responsibility for control of water pollution in Jamaica. National Standards for industrial and sewage discharge into rivers and streams, in addition to standards for ambient freshwater exist. For drinking water, WHO Standards are utilized and these are regulated by the National Water Commission (NWC).

Noise Abatement Act (1997)

The Noise Abatement Act of 1997 was created in order to regulate noise caused by amplified sound and other specified equipment. This act has been said to address “some concerns but is too narrow in scope and relies on a subjective criterion” (McTavish2). Given this, McTavish conducted a study to recommend wider and more objective criteria in accordance with international trends and standards, but tailored to Jamaica’s conditions and culture. To date, apart from the Noise Abetment Act (1997), Jamaica has no other National legislation for noise.

The National Solid Waste Management Authority Act (2001)

The National Solid Waste Management Authority Act of 2001 is “an act to provide for the regulation and management of solid waste; to establish a body to be called the National Solid Waste Management Authority and for matters connected therewith or incidental thereto”. The National Solid Waste Management Authority (NSWMA) was established in April 2002 as a result of this Act to effectively manage and regulate the collection and disposal of solid waste in Jamaica. As such, the NSWMA aims to safeguard public health and the environment by ensuring that domestic waste is collected, sorted, transported, recycled, reused or disposed of in an environmentally sound manner. In addition, public awareness and education is a part of their responsibilities.

Public Health Act (1985)

The Public Health Act is administered by the Ministry of Health through Local Boards, namely the Kingston and St. Andrew Council and the parish councils for the other parishes.

The Public Health (Nuisance) Regulations (1995) aims to control, reduce or prevent air, soil and water pollution in all forms. Under the regulations:

- No individual or organization is allowed to emit, deposit, issue or discharge into the environment from any source;
- Whoever is responsible for the accidental presence in the environment of any contaminant must advise the Environmental Control Division of the Ministry of Health and Environmental Control, without delay;
- Any person or organization that conducts activities which release air contaminants such as dust and other particulates is required to institute measures to reduce or eliminate the presence of such contaminants; and
- No industrial waste should be discharged into any water body, which will result in the deterioration of the quality of the water.

The Clean Air Act

The Clean Air Act (1964) refers to premises on which there are industrial works, the operation of which is, in the opinion of an inspector, likely to result in the discharge of smoke, fumes, gases or dust in the air. An inspector may enter any affected premise to examine, make enquiries, conduct tests and take samples of any substance, smoke, fumes, gas or dust that may be considered necessary or proper for the performance of his/her duties.

Trade Effluent Standards

Since 1996, Jamaica has had draft regulations governing the quality of the effluent discharged from facilities to public sewers and surface water systems. These draft guidelines require the facility to meet certain basic water quality standards for trade effluent including sewage.

Country Fires Act (1942)

The Country Fires Act of 1942 details legislation associated with setting fire to crop, trash diseased plants, charcoal kilns; fires during night or unattended, prohibited; power of Minister to prohibit setting fire to trash; application for permit; setting fire contrary to order or permit; proof of fire evidence against occupier; occupier to extinguish fire; negligent use of fire and power to enter land and extinguish fire.

The Country Fires Act is administered by the Ministry of Agriculture. The Act designates specific personnel who are given the responsibility of and the required power to ensure compliance with the legislation.

Some offences stipulated in this Act are as follows:

- Setting fire to trash between the hours of 6.00 p.m. and 6.00 a.m.
- Leaving a fire unattended in the open air before it is thoroughly extinguished.
- Carrying in or upon any plantation, torch, or other matter in a state of ignition, not sufficiently guarded so as to prevent danger from fire
- By the negligent use or management of fire in any place; or by smoking any pipe, cigar, or cigarette, in any plantation, save and except within a dwelling- house on such plantation, endangers any buildings, fences, lands, cultivated plants, or other property.

The Pesticides (Amendment) Act (1996)

The Pesticides Act is administered by the Pesticides Control Authority who has the responsibility to control the importation, manufacture, packaging, sale, use and disposal of pesticides. Offences include:

- Not registering imported or manufactured pesticide.
- Selling a restricted pesticide.
- Engaging in, performing or offering pest extermination services without a pest control operator licence.

3.2.4 Other Applicable National Policies

It is understood that policies concerning mining and quarrying activities have been developed for the Draft Kingston and Saint Andrew Development Order 2013.

The Mines and Geology Division has delineated a quarry zone in the Ferry area, located on the boundary of St Andrew and St Catherine, and in the Bito area in St Andrew, while the Cane River area in St Andrew, has been identified as a proposed quarry zone. Quarrying will be permitted in these areas after the necessary licenses have been obtained. Notwithstanding, sites outside of these zones may be quarried once the required licences are obtained under the Quarries and Mining Acts.

- POLICY SP M5 The planning authority will not normally support quarry operations in locations outside of Quarry Zones as identified and approved by the Commissioner of Mines, except in extenuating circumstances.

On completion of quarry operations it is expected that restoration of the quarried areas will take place in the shortest possible time and to the satisfaction of the planning and other relevant authorities.

- POLICY SP M6 Mining and quarrying plans for all phases of extraction should be submitted to the Commissioner of Mines and all permissions obtained before any such activity commences.
- POLICY SP M7 Rehabilitation plans for each phase of extraction should be prepared and approved by the Commissioner of Mines and all relevant authorities.
- POLICY SP M8 All mined out and quarried lands are to be restored in accordance with conditions of approval and to a vegetative state approved by the relevant authorities, or to a state which is satisfactory to the local planning authority and related authorities.
- POLICY SP M9 In determining the proposed land use for rehabilitated lands, the highest and best use of the lands should be considered and the use must be compatible with the zoning and or surrounding land uses.

3.3 International Legislative and Regulatory Considerations

3.3.1 Cartagena Convention (Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region) (1983)

Adopted in March 1983 in Cartagena, Colombia, the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, more commonly referred to as the Cartagena Convention, is the sole legally binding environmental treaty for the Wider Caribbean. The Convention came into force in October 1996 as a legal instrument for the implementation of the Caribbean Action Plan and represents a commitment by the participating countries to protect, develop and manage their common waters individually and jointly. The Convention was ratified by twenty (20) countries and acts as a framework agreement that sets out the political and legal foundations for actions to be developed.

The operational Protocols, which direct these actions, are designed to address special issues and to initiate concrete actions. The Convention is currently supported by three Protocols as follows:

- The Protocol Concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region (The Oil Spills Protocol), which was adopted and entered into force at the same time as the Cartagena Convention;
- The Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean Region (The SPAW Protocol), which was adopted in two stages, the text in January 1990 and its Annexes in June 1991. The Protocol entered into force in 2000;
- The Protocol Concerning Pollution from Land-based Sources and Activities in the Wider Caribbean Region (LBS Protocol), which was adopted in October, 1999.

3.3.2 The Convention on Biological Diversity

Signed by 150 government leaders at the 1992 Rio Earth Summit, the Convention on Biological Diversity (CBD) is committed to promoting sustainable development. The CBD is regarded as a means of translating the principles of Agenda 21 into reality and recognizes that “biological diversity is about more than plants, animals and microorganisms and their ecosystems – it is about people and our need for food security, medicines, fresh air and water, shelter, and a clean and healthy environment in which to live”.

The CBD may be considered the first global, comprehensive agreement which focuses on all aspects of biodiversity, to include genetic resources, species and ecosystems. In order to achieve its main goal of sustainable development, signatories are required to:

- Develop plans for protecting habitat and species.
- Provide funds and technology to help developing countries provide protection.
- Ensure commercial access to biological resources for development.
- Share revenues fairly among source countries and developers.

- Establish safe regulations and liability for risks associated with biotechnology development.

Jamaica's Green Paper Number 3/01, 'Towards a National Strategy and Action Plan on Biological Diversity in Jamaica', is evidence of Jamaica's continuing commitment to its obligations as a signatory to the Convention.

3.4 EIA Process

3.4.1 National Environment and Planning Agency

The National Environment and Planning Agency (NEPA) is the government executive agency and represent a merger of the Natural Resources Conservation Authority (NRCA), the Town Planning Department (TPD) and the Land Development and Utilization Commission (LDUC). Among the reasons for this merger was the streamlining of the planning application process in Jamaica. The Agency is moving towards one application to NEPA for new developments and new modifications that will review and approve environmental aspects as well as planning, building control and zoning considerations. It is this agency that will review the Environmental Impact Assessment.

The National Environment and Planning Agency (NEPA) has been given responsibility for environmental management in Jamaica under the NRCA Act of 1991. Since the promulgation of the Act, the NRCA has been developing local standards. The Act was strengthened by supporting regulations, which became effective in January 1997. The underlying principles, which have been used in the development of the Act, are:

- The Polluter pays Principle
- The Cradle to Grave approach to waste management

3.4.2 Permits and Licenses

The Environmental Permit and License System (P&L) is administered by NEPA through the Applications Section. It was introduced in 1997 to ensure that all developments meet required standards and negative environmental impacts are minimized. Under the NRCA Act of 1991, the NRCA has the authority to issue, suspend and revoke environmental permits and licenses. An applicant for a Permit or License must complete a Permit Application Form (PAF) as well as a Project Information Form (PIF) for submission to the NRCA/NEPA.

3.4.3 NRCA/NEPA Process

The EIA Process is described below:

- The NRCA permit procedure is initiated by the submission of the Project Information Form (PIF) to the Authority. The PIF screening form is reviewed to determine whether an EIA is required and to begin determining areas of environmental significance, especially in waste discharge.
- Based on the review of the PIF, the NRCA advised Carib Cement Co. Ltd. that an EIA would be required for their development. Carib Cement Co. Ltd. then liaises with the NRCA to determine the scope of the EIA through proposed Terms of Reference (TORs). The TORs are proposed by Carib Cement Co. Ltd. using NRCA guidelines and are approved by the NRCA. Appendix 1 gives the approved TORs for the proposed project.
- The NRCA requires that the EIA include the following:
    - A description of the present environment, i.e. physical, biological and social environment. This includes, for example, consideration of economic situations, cultural heritage and ecological preservation;
    - A description of the significant impacts the environmental professionals expect the development to have on the environment, compared to the environment that would remain if there were no development. This will include indirect and cumulative impacts;
    - An analysis of alternatives that were considered in order to consider means of minimising or eliminating the impacts identified above; and
    - An Environmental Management Plan, which includes a Monitoring & Hazard Management Plan and an Auditing schedule.
- The NRCA guidance on EIAs states that this process “should involve some level of stakeholder consultation in either focus groups or using structured questionnaires.” A draft EIA is submitted to the developer to solicit the proponents’ input into the description of the project (to check for accuracy of statements, and to enter into realistic discussions on the analysis of alternatives, as well as to inform the proponents of any other relevant legislation with which they must comply).
- Eleven copies of the finalised draft are then submitted to NRCA, two to the client, and the consultant keeps one (14 in all are

produced). The NRCA distributes these to various other public sector institutions who sit on the Technical Committee (e.g. Water Resources Authority (WRA), Environmental Control Division in the Ministry of Health (ECD), Jamaica National Heritage Trust (JNHT)) for their comments. Typically this depends on the nature of the project.

- As deemed necessary by the NRCA, Public Meetings are then held, following the deposition of the Draft EIA at Parish Libraries (by the NRCA). A verbatim report of the public meetings is required, as well as a summary report of the main stakeholder responses which emerged.
- The comments of the NRCA, the other GOJ interests and the public are compiled and submitted in writing to the consultant not only for finalisation of the report, but for incorporation into the development's design.
- The NRCA then reviews this report again, and if further clarifications are needed, these are again requested. Once the NRCA is satisfied, the EIA is submitted to the Technical Committee of the NRCA Board for final approval. If the EIA is not approved, the proponents may appeal to the Office of the Prime Minister.

3.4.4 Public Participation in EIAs

There are usually two forms of public involvement in the EIA process. The first is direct involvement of the affected public or community in public consultations during the EIA study. These consultations allow the developer to provide information to the public about the project and to determine what issues the public wishes to see addressed. The extent and results of these consultations are included in the documented EIA report.

The second level of involvement is at the discretion of the NRCA and takes place after the EIA report and addendum, if any, has been prepared and after the applicant has provided the information needed for adequate review by NRCA and the public.

Community interaction and transparency is a critical area of focus for the success of this development and the second level of involvement described above is possible. Please see Appendix 3 for the NRCA reference document entitled "Guidelines for Public Participation" in EIAs.

4.0 PUBLIC PARTICIPATION AND CONSULTATION

In order to facilitate consultation with the public, assistance in coordinating the review of the EIS by constantly communicating with NEPA and in distribution of the report to relevant government agencies and stakeholders, will be provided as required by NEPA.

One (1) Public Presentation will be scheduled and this will be conducted in the manner as outlined in NEPA's "Guidelines for Conducting Public Presentations" (Appendix 3). This meeting will be held after the submission of the Draft EIS Report to NEPA. The Public has thirty (30) days to provide comments on the report, after the Public Consultation Meeting. All findings form the meeting will be presented in the Final EIS report.

Regular contact with the Client and the National Environmental Planning Agency (NEPA), and other involved regulatory agencies will be maintained so as to ensure that all problems are rectified as quickly as possible in an environmentally sound manner. Additionally, CL Environmental will represent the Client at meetings with NEPA and other relevant Government bodies as necessary.

5.0 PROJECT DESCRIPTION

5.1 The Proponent

Caribbean Cement Company Limited (CCCL), a member of the Trinidad Cement Limited (TCL) Group is located in Rockfort, Kingston and has been producing a consistently high quality of Portland cement for approximately 60 years. One of CCCL's subsidiary companies, namely Jamaica Gypsum and Quarries Limited (JGQ), supplies the Company with the gypsum used in the manufacture of its cement.

The JGQ is engaged in the mining of pozzolan, gypsum and anhydrite and its quarrying operation is located 15 km east of Kingston, Jamaica. The Company exports its surplus gypsum to countries such as Colombia, Venezuela, Trinidad and Barbados, whilst a smaller amount is used locally by CCCL in the final stage of cement processing.

CCCL is a major contributor to the Jamaican economy and employs over 300 persons. Over 90% of structures present in Jamaica today were built using Carib Cement, as it is commonly known.

5.2 Project Concept and Description

JGQ operates a gypsum quarry, namely Bito Gypsum Quarry, in the Bito District, Bull Bay, St. Andrew which is now depleted of mineable ore and at which reclamation activities will commence in 2014. As a result, CCCL is desirous of reopening the Halberstadt Quarry, approximately 2 km northeast of the Bito Quarry. Though dormant for 40 years, this quarry is the only economical reserve of gypsum remaining and it is intended for this quarry to supply the cement plant with the gypsum required in the manufacturing of Ordinary Portland and Blended Cements.

The budgeted production from Halberstadt for 2013 is approximately 100k tonnes. Based on the reserves, it is proposed that an annual extraction of 100-150k tonnes be targeted to extend the life of the quarry and the supply to the parent company CCCL. This will allow for supplying CCCL annual demand as well as approximately 50-100k tonnes of sales to other group companies and/or third parties. At these levels of production and based on the "proven" reserves, the life of the quarry will be 33-50 years.

5.2.1 Project Location and Siting

The Halberstadt Quarry is located towards the eastern boundary of the parish of St. Andrew, less than 1 km west of the parish of St. Thomas. It is situated approximately 1.5 km north of Salt Spring, St. Andrew and 1.2 km northeast of Bito, St. Andrew on faulted mountains at a height of between 500 and 600 metres amsl overlooking the valley of Bull Park River (Figure 5.1).

The Halberstadt Quarry is one of a group of five gypsum quarries located north of Bull Bay in the Bito – Ramble quarry zone. The 4 other quarries are the Brooks Quarry, the Upper Quarry, Bito Quarry and Cave Quarry, all located south of the project location (Figure 5.2). Gypsum has been mined in this area since 1949; however mining operations have ceased in the Brooks, Upper and Cave quarries and as mentioned previously, Bito Quarry is now deplete of mineable ore.

The size of the property within which the quarry will be located is approximately 0.67 km^2 or 166 acres (Volume# 1035, Folio# 376), with the centre of the deposit being located at 646950 N, 786800 E (JAD 2001 coordinates). The EIS for the proposed mining at Halberstadt Quarry however is with regards to an initial one hectare (0.01 km^2) allowance as depicted in Figure 5.1.

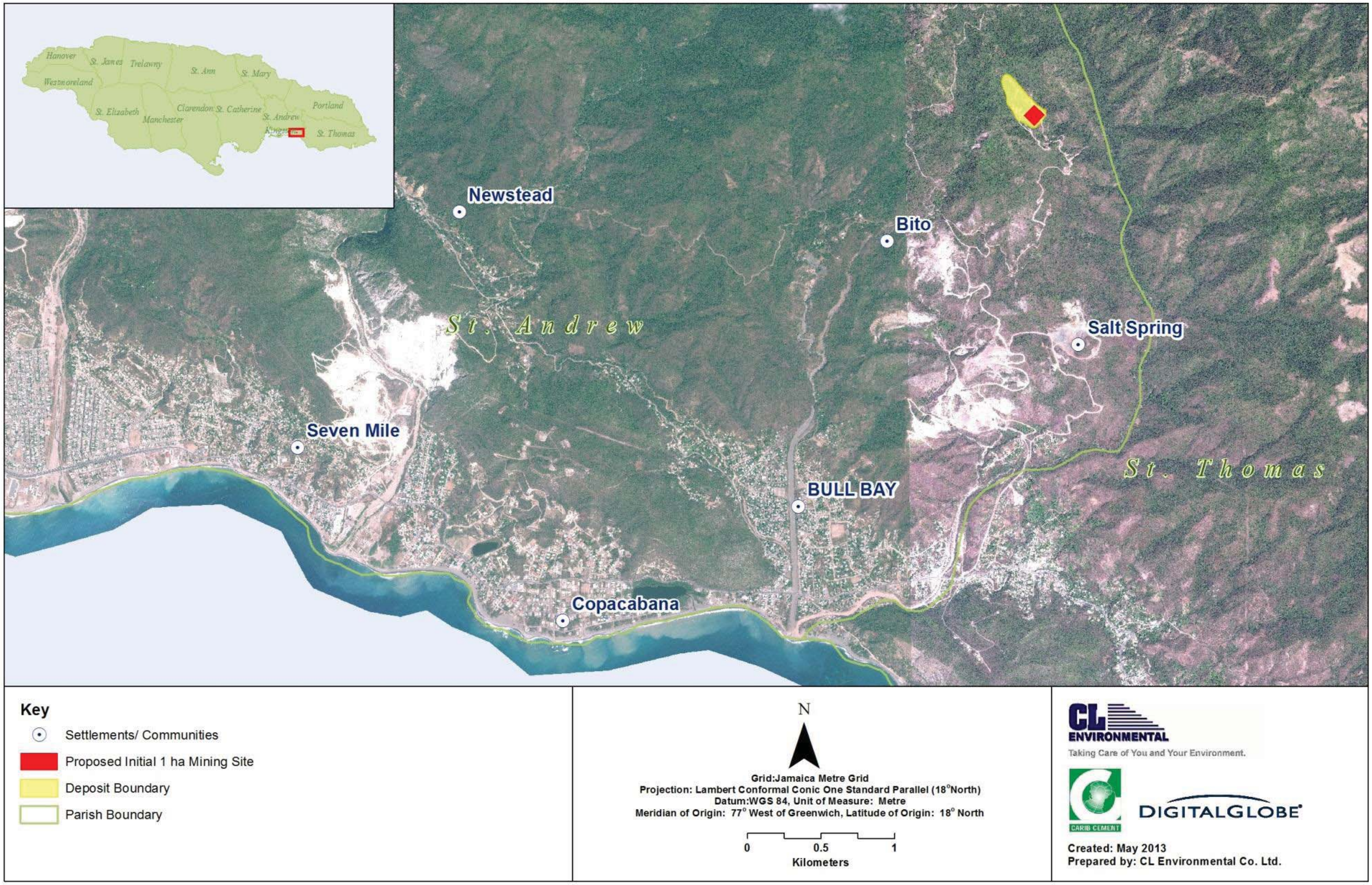


Figure 5.1 *Map showing the location of the proposed mining site at Halberstadt Quarry*

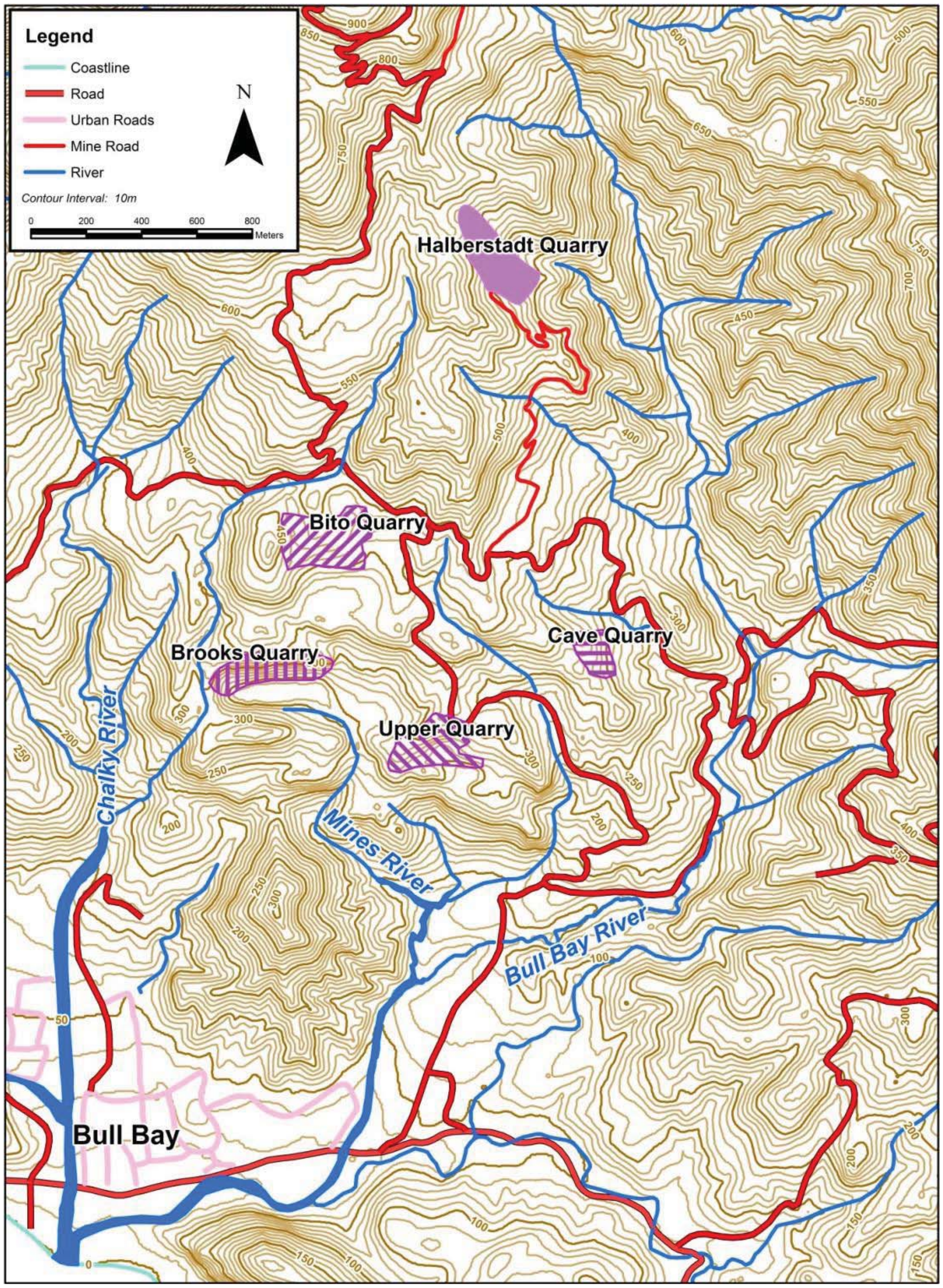


Figure 5.2 Location of gypsum quarries in vicinity of Halberstadt quarry

5.2.2 Quarry Reserves

5.2.2.1 Definition of Terms

Gypsum, CaSO4.H2O (hydrous calcium sulphate) is a soft mineral that can be scratched by the finger nail and has a density of 2.2. Gypsum is used primarily in the manufacturing of building materials such as sheet rock, laths, and tiles. It is also used in the paper and paint industry as filler, in cement manufacture, and as a fertilizer in agriculture. **Anhydrite**, CaSO4 is the anhydrous form of calcium sulphate and is harder and denser with density of 2.7. It is an important industrial raw material in cement, sulphuric acid and fertilizers.

It should be noted that reserves may be calculated as **proven** reserves and **inferred** reserves:

- **Proven-** Gypsum/anhydrite that extends from the surface to any depth reached by bore holes and area of influence based on polygons drawn around the drill hole(s) 7.3 m. Calculations also based on quarry face, are also referred to as proven. All benches are closely sampled and measured, and geology is well known by its size, shape and mineral content. The quality of each bench is monitored in the JGQ lab.
- **Inferred**- Gypsum/Anhydrite material with geological evidence (faults, folds, lithology). Based on the continuity of gypsum/anhydrite, there is no reason to question the validity of such assumption.

5.2.2.2 Exploration Drilling Programme Results

An exploration drilling programme was conducted by NHL Engineering and indicated the existence of approximately 5 million tonnes of gypsum/anhydrite proven reserves at Halberstadt quarry.

During the exploratory survey exploration drilling programme conducted, the following soil types were also identified:

1. The Clays, Sands and Gravels (Depth Range: Variable, typical 0-15m)
2. The Clayey Shales, Sandstones (Depth Range: Variable)
3. The Gypsum/Anhydrite Formation (Depth Range: Variable, typically 15-60m)

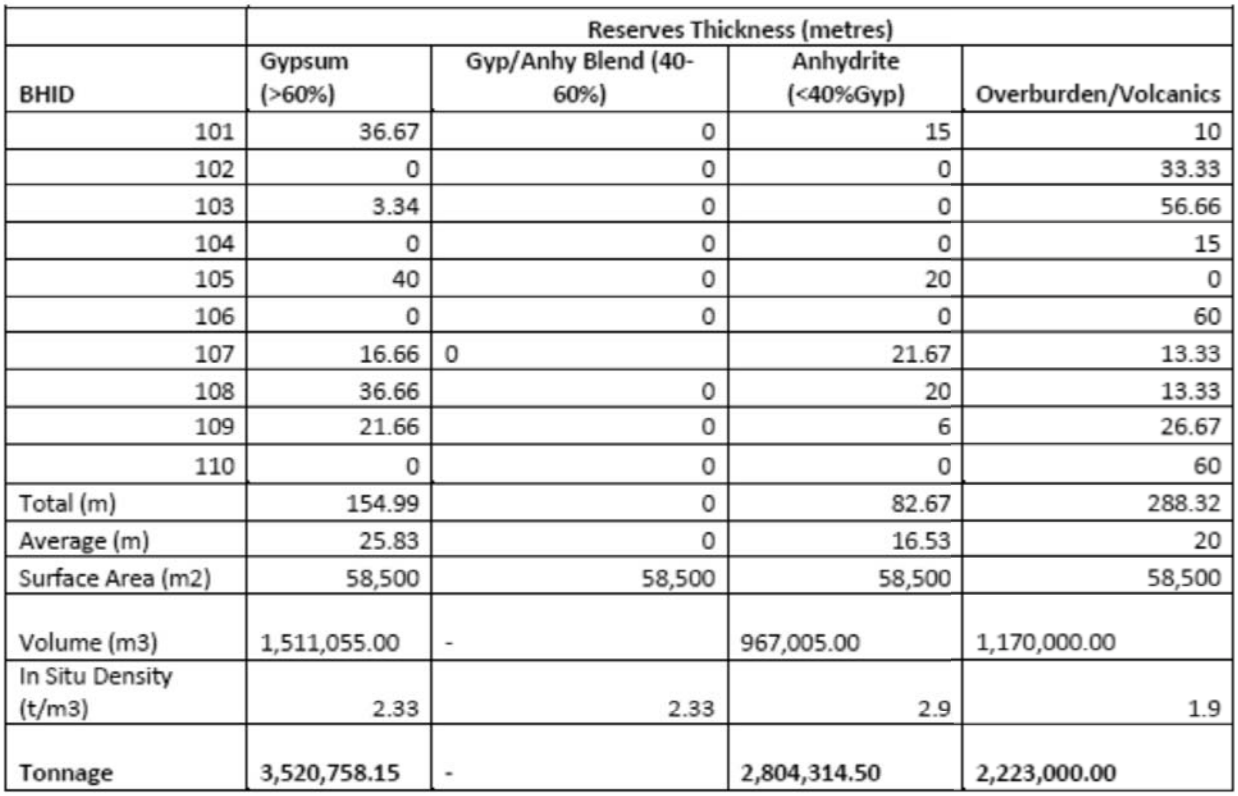
Test results of the core samples taken indicated that the average percentage of gypsum was approximately 50%, with a high of 90%. In general, minimal gypsum was identified in four boreholes (102, 104, 106 and 110) and at other locations, gypsum was encountered between depths of 10.7 to 45 m with the significant concentration (peak depth range) between 13.7 and 37 m depth range. Two boreholes (103 and 105) had gypsum at approximately 1.5 m depth. Figure 5.3 illustrates the location of boreholes taken and Appendix 6 shows the full borehole record.

The reserve was obtained by a simplified representative cross sectional area of the deposit, which varies between 5,625 and 6,300 m^2 (Figure 5.4). The presumptive profile indicates an effective depth of length of the deposit of about 460 m (including slope and dip of strata). A conservative volumetric estimate of the deposit given was 2,587,500 m^3.

Based on the laboratory results, the average content of the gypsum is approximately 52% and therefore the volumetric reserve estimate of gypsum is 1,350,804 m^3. Applying the in-situ densities of gypsum and anhydrite (2.33 t/m^3 and 2.9 t/m^3 respectively), gives a reserve estimate of 3,147,373 tonnes of gypsum and 3,586,418 tonnes of anhydrite.

A total gypsum/anhydrite reserve of 6.7 million tonnes is estimated to be present in the Halberstadt deposit to the depth that was drilled.

Table 5.1 Estimated gypsum and anhydrite reserves in Halberstadt Deposit



	Reserves Thickness (metres)			
BHID	Gypsum (>60%)	Gyp/Anhy Blend (40-60%)	Anhydrite (<40%Gyp)	Overburden/Volcanics
101	36.67	0	15	10
102	0	0	0	33.33
103	3.34	0	0	56.66
104	0	0	0	15
105	40	0	20	0
106	0	0	0	60
107	16.66	0	21.67	13.33
108	36.66	0	20	13.33
109	21.66	0	6	26.67
110	0	0	0	60
Total (m)	154.99	0	82.67	288.32
Average (m)	25.83	0	16.53	20
Surface Area (m2)	58,500	58,500	58,500	58,500
Volume (m3)	1,511,055.00	-	967,005.00	1,170,000.00
In Situ Density (t/m3)	2.33	2.33	2.9	1.9
Tonnage	3,520,758.15	-	2,804,314.50	2,223,000.00

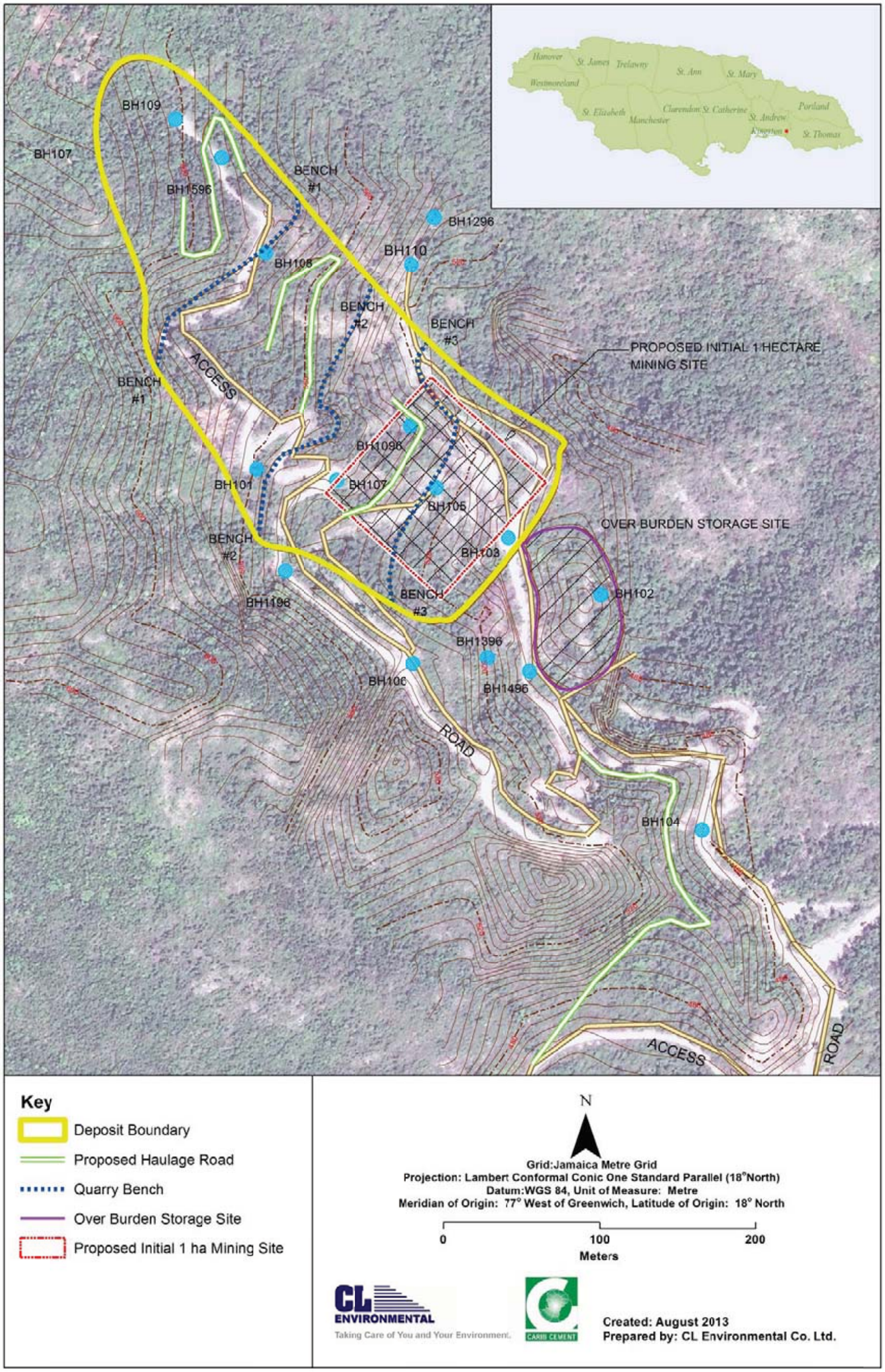


Figure 5.3 *Proposed Halberstadt site layout, along with locations of boreholes*

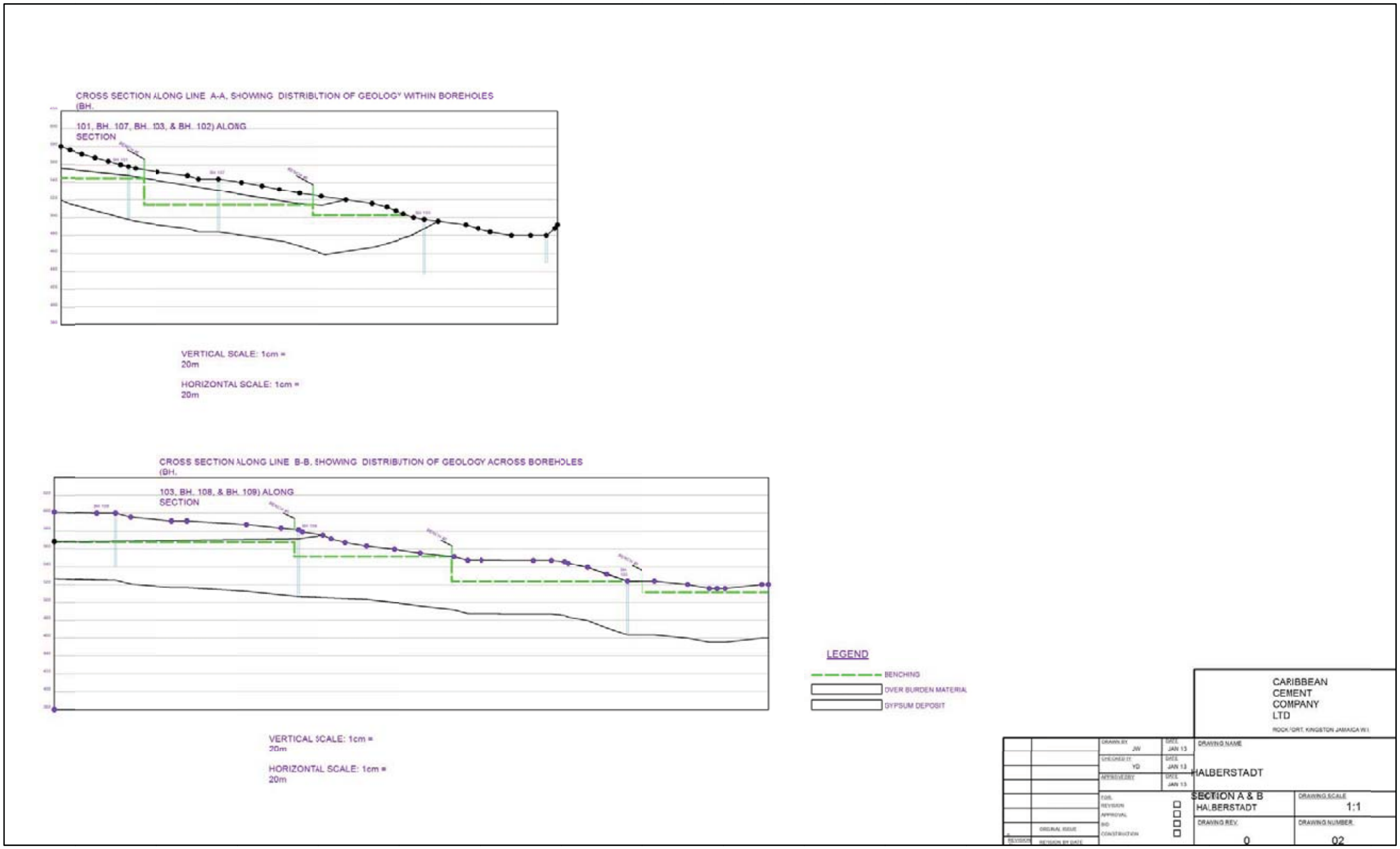


Figure 5.4 *Representative cross-sectional area of deposit at Halberstadt quarry*

5.3 Project Design and Infrastructure

5.3.1 Slope

All slopes will be vertical to facilitate blasting. Bench heights average 8 m (26 ft) with a bench width of 20 m (66ft) and length not exceeding 100m (328 ft).

5.3.2 Access

The current access road to Halberstadt was constructed to facilitate exploration drilling and as such is not adequately designed to accommodate haulage (Figure 5.3). Table 5.2 shows the various roadways that require immediate repairs and modification prior to commencement of mining at Halberstadt. In addition, the Salt Spring Parochial road will be reopened to facilitate the transport of material from the quarry to storage, as the current route through the Bito deposit is not feasible.

Table 5.2 Road networks connecting Halberstadt to surrounding communities

Roadways	**Type**	**Length**	**Required Work**
Salts Spring	Access to Mine	Approx. 2km	Complete restoration including retaining walls and culverts.
From Benoa to Halberstadt	Access to Mine	Approx. 2km	Needs to be widened to accommodate the passage of 2 trucks side by side. A section is to be re-aligned as a result of a major landslide recently.
In Pit Roads	Haul Roads	Approx. 3.5km	To be developed.

Roads will be minimum 15 m wide with maximum slope of 1:7. The minimum width of the road is designed to be at least three times the width of the widest vehicle use in the quarry. Daily wetting of roads to suppress dust and periodic grading is done to provide safe and good quality roads.

Only authorized personnel are allowed to use the road.

Over the life of the mine, the quarry profile will undergo numerous changes and so the road will have to be redesigned to meet the requirements of proper mining practices. All efforts to maintain visibility in the quarry will be taken; hence, bends will be made horizontal or super-elevated.

5.3.3 Pit Cross-section

Pit resembles a step like profile in section (Figure 5.4). Each step is one bench and the height of each bench will be 8 m (26 ft.). The width of the bench will be a minimum of twice the height to allow for safe operating of loading equipment and haul trucks. The borehole survey indicated that the higher elevations of the mine also have significant overburden while in the lower elevations the gypsum/anhydrite rises to the surface.

5.3.4 Bench Elevations

Cut off elevation will be at 460 m above sea level based on the depth of gypsum/anhydrite reserves as shown in the boreholes. This allows for the creation of four benches. Reserves to this elevation are proven in the Halberstadt deposit. Below this elevation, geological composition is unknown. Benches will be defined from top elevation.

5.3.5 Site Facilities

A site office will be erected at Halberstadt. This office will house quarters for the mining engineer, production supervisor, changing rooms, bathrooms, lunch room/waiting area and JGQ’s field Laboratory.

5.3.6 Wastewater Solution

NWC wastewater system does not exist in the area. A septic tank and tile field for 12 persons is being designed by CEAC Solutions.

5.4 Project Operations and Maintenance

5.4.1 Development Stage

5.4.1.1 Site Clearance

The Halberstadt quarry has been dormant for many years and the project will require the removal of vegetation and topsoil for the creation of access and haul roads in the development stage. Topsoil removed will be stored in designated locations and used in the rehabilitation process following mining.

5.4.1.2 Stripping and Development

Due to financial constraints, stripping and development in 2013 will be concentrated in the lower section of the deposit to facilitate the production of 100 k tonnes of Gypsum for the TCL Group.

5.4.1.3 Test Hole Drilling

Test holes will be drilled at a spacing of 30 m around BH 103 and BH 105 (Figure 5.3), following stripping to determine the grade distribution of the gypsum on those benches. This information will then be used to determine where to mine first, based on the gypsum demand for the Trinidad Cement Ltd. (TCL) group.

5.4.2 Mining Schedule

The mine schedule will be for the benches containing BH 103 and BH 105 to be mined in 2013, down to a depth of 12 m each. This is due to the current state of access to these boreholes (Figure 5.3). This will be sufficient to supply the TCL Group gypsum demand for 2013.

Table 5.3 and Table 5.4 show the extraction quantities for 2013 and five (5) year production projection from the proposed Halberstadt quarry.

Table 5.3 Projected production from Halberstadt in 2013 (tonnes)

November (tonnes)	December (tonnes)	Total (tonnes)
10,000	10,000	**20,000**

Table 5.4 Halberstadt Quarry 5 year production projection (tonnes)

2013 (tonnes)	2014 (tonnes)	2015 (tonnes)	2016 (tonnes)	2017 (tonnes)	Total (tonnes)
20,000	113,872	125,259	137,785	151,564	**548,480**

5.4.3 Mining Method

The mining method to be employed is open-pit mining, by benching. Material will be extracted by the process of drilling and blasting and subsequent to this an excavator will be used to load the material into a mobile crusher which reduces the particle size distribution of the gypsum to minus 2”. This 2” product will then be stockpiled at designated areas until it is ready to be sent to the CCCL plant and JGQ’s Export Facility. Equipment required for these operations are summarised in Table 5.5.

Table 5.5 Mining equipment requirement

Equipment	Quantity	Capacity (M/T)
365BL II Excavator	1	10
980H	2	12 each
D11 Dozer	1	-
140H Grader	1	-
Mobile Crusher	1	500-800TPH
Dumper Trucks	15	25-35

5.4.3.1 Drilling and Blasting

Drilling (Plate 5.1) and blasting will be the primary method of extracting the gypsum/anhydrite ore, as is the case with the present operating quarries. Depending on the demand for product, blasting will be done at a maximum of 2 times weekly (Mon – Fri) between 8am to 4pm. Blasting will not be undertaken outside these time periods.

Plate 5.1 Production holes being drilled for blasting using the Ingersoll Rand drill

During mining, blasting will be employed resulting in ground vibration and elevated noise level. Ground vibrations will also be generated by earth moving equipment (dozers, loaders, trucks, etc.) during mining. All efforts will be made to implement policies and practices that minimize the negative impacts on the environment, resulting from mining activities in the area. Caribbean Cement Company Limited has a robust Environmental Management System (EMS) which will be extended to include the operations at the Halberstadt Quarry.

5.4.3.2 Crushing and Screening

Crushing and screening will be done using a mobile crusher and screen at the bench face. A track mounted, fully mobile crusher and screen is the preferred units of choice for the mine site crushing. That model chosen for use is the new generation mobile primary jaw plant Metso Lokotrack LT

101 [2] (Plate 5.2), which has low operating noise levels with modular design; less quarry traffic, less dust and noise and exhaust emissions; 380-650 mtph capacity and a low emission stage 2 diesel engines.

Plate 5.2 Metso Lokotrack LT 101 crusher

The unit components of the Metso Lokotrack LT 101 are as follows:

- **Crusher**
    - Nordberg NP 1110M impact crusher
    - Feed opening of 1040X800 mm (41 x 31")
- **Feeder**
    - Feed Hopper:
        - $5m^3$: Width 2600mm (8'6")
        - $8m^3$: Width 3400mm (11'2")
    - Nordberg TK9-42-2V Vibrating Feeder:
        - Length: 4200mm (13'8")
        - Width: 930mm (3'1")
    - Hydraulic folding of Hopper Walls as standard
- **Engine**
    - CAT C9/C9.3
    - Power 242KW (325 hp)
    - Dimensions
        - Length: 14,850mm (49')
        - Width: 2500mm (8'2")
        - Height: 3400mm (11'2")
        - Weight: 32,000kg (70,500lbs)

---

[2] http://www.metso.com/miningandconstruction/MaTobox7.nsf/DocsByID/82C3864218F149E8C2257BA3004C6861/$File/Lokotrack_eng.pdf

5.4.3.3 Stockpiling and Haulage

The stockpiling area will be approximately 5 acres. It is anticipated that most of the material being stockpiled will be topsoil removed during development. This will be kept for progressive restorative work as mining progresses. We will maintain a small stockpile of approximately 5,000 tonnes of gypsum/anhydrite in close proximity to the crusher.

Stockpiling and loading of crushed product will be done by a 980 front end loader. Dumpers (20-35t) will collect finished product from the quarry and transport for storage and use to JGQ Port and CCCL plant respectively.

5.4.4 Mode of Operation

All mining and haulage activities at Halberstadt Quarry will be outsourced to qualified contractors with JGQ maintaining oversight and management of the mining. The proposed manning structure for the quarry is shown in Table 5.6; it is anticipated that the mining activities will see the employment of a total of thirty-eight staff, including permanent, casual and contractual employees.

Table 5.6 Proposed staff complements

Position	Permanent	Casual	Contractor
Manager (Shared resource)	1		
Senior Professional (shared resource)	1		
Senior staff	2		
Administration	2		
Sampler		1	
Scale Operator		1	
Excavator operator			2
Dozer operator			1
Drillers/blasters			8
Truck drivers			15
Water truck			1
Screen/crusher operators			3
Total	**6**	**2**	**30**

The quarry will operate five days per week (Monday to Friday), eight hours per day (8am to 4pm) to achieve a 40 hour work week.

5.4.5 Quality Process and Tracking

The quality process will be much the same as with current operations. The only difference is that the lab will have to be relocated closer to the mine site to ensure timely collection and analysis of samples. Tracking will be the same as the present modus operandi.

5.4.6 Proposed Environmental Management System

In 2002, JGQ embarked on a new initiative to produce a more comprehensive solution to the environmental issues that quarrying introduces to the existing environment. These issues include air quality noise, vibration, water quality, impact on vegetation, aesthetics and landslide risk. Bearing this in mind, the company is examining the possibility of implementing an Environmental Management System (EMS) that will enable the organisation to address the impacts of its products, services and processes on the environment.

Several mitigation measures will be implemented prior to commencement of mining operations at Halberstadt. Mitigation measures refer to those measures that may be applied in an effort to reduce, minimize or eliminate potential negative impacts on the environment or public health.

The following subsections outline the EMS guidelines as proposed by CCCL, which will be used in addition to the specific mitigative measures outlined in this EIS in section 9.0.

5.4.6.1 Air Quality

Dust emanating from the quarry is a potential hazard and can be detrimental to community and the workers as a whole.

Air pollution results from the dust emanating from the quarries and the crusher. The dust can cause damage to property (equipment and buildings) and can result in respiratory ailments and other related illnesses.

Dust Mitigation

The water truck is used to sprinkle the quarry haul roads and material at the stockpile. A sprinkling water system (mist of water blown by air) is affixed to the main crusher to cut down on dust, created by the crushing operation. A dust monitoring system is to be set up to check the concentration of dust in the atmosphere. A tree planting exercise to re-vegetate the fines dump and surrounding areas is also planned.

5.4.6.2 Noise Pollution

Most quarrying activity will generate noise. Noise in the quarry emanate from many different operations, such as blasting, ripping and pushing operations, as well as from equipment such as drill rigs, compressors, loaders and trucks.

Noise Mitigation

Planting of trees will help to reduce the noise. All employees are given the appropriate personal protective equipment (PPE). The company will engage in buying equipment that generates less noise. Also haul roads will be appropriately designed so as to reduce noise; measures include reducing the gradient of all haul roads to avoid the use of low gear, which results in high, excessive and unnecessary revving of engine.

5.4.6.3 Ground Vibration

Ground vibration is common in this quarry operation given that we are mining relative hard-rock deposits and blasting will be our primary extraction method. The large earth moving equipment and haul trucks will also add to the level of ground vibration emanating from this quarry.

Mitigation

All blast is so designed to minimize ground vibration. Also the cycle time does not allow any truck to be racing another.

5.4.6.4 Water Pollution

Run-off from the quarry is a problem and as a result has adverse impacts on the communities on the flood plain of the Bull Park River.

Mitigation

The haul road is to be properly graded and drained to prevent run-off from cutting into banks of the road, avoiding erosion. The company will be constructing silt traps, to trap silt material from the fines dump (waste dump). A 6ft diameter culvert will be installed to drain water away from the fines dump.

5.4.6.5 Impact on Vegetation

The Halberstadt quarry has been dormant for some time and this has allowed for the natural re-vegetation of the area. The impact on the vegetation will be limited to within the quarry boundary and the access roads.

An area specific vegetation survey (area to be quarried) will be conducted prior to the clearing of vegetation at each site to be quarried. This study will identify the type of vegetation present at the site. This information will be important in the rehabilitation process and will act as a guide as to the type of vegetation best suited for area.

5.4.6.6 Visual Intrusion

At present the Gypsum quarries can be seen from the 11 miles Bull Bay area. Revegetation and building of dirt berms are to be carried out to reduce the impact. The Halberstadt deposit however is situated behind the hill, away from the road so there will be no visual intrusion from the Bull Bay area.

5.4.6.7 Landslide & Flooding Risk

The eastern flank of the deposit is drained by the Bull Park River so extreme care will be given to the prevention of silt accumulating in the channel. The steep sided slopes mean that in times of heavy rainfall, the possibility of landslides is high. All areas influenced by the mining operation will be either benched or geotechnically engineered to prevent downslope movement of material.

5.4.6.8 Impact on Human Settlement

There is a small community known as Benoa of approximately 20 residents located approximately 1km from the deposit. This community however, is right beside the access road and will be affected by the noise from the blasting and from trucks transporting the product from the quarry. They will also be affecting from ground vibrations emanating from earth moving equipment and blasting.

5.4.7 Progressive Rehabilitation Plan

Jamaica Gypsum will implement a progressive rehabilitation plan for the Halberstadt quarry. The rehabilitation will start with the restoration of the mined out bench at the end of mining road #1, which was abandoned by the previous operator. The bench will be backfilled with the overburden that will be removed from the new benches once approval for the re-opening of the quarry has been obtained. The final slope angle of the backfill will be determined based on the geotechnical characteristic of the overburden. Based on experience with the overburden material in other sections of the quarry a slope angle of at least of 50% (26°) should be safe. A narrow service strip can be maintained along the outer edge of bench area for easy maintenance and a safety margin.

The toe of the backfilled slope will be protected as needed where an appropriate geotechnical solution such as boulders, stepped gabions, etc. may be employed. Fast growing vegetation as outlined in Table 5.7 will be planted in front of the toe of the backfilled slope to help to stabilize the toe area. These plants will be obtained from a pre-established nursery within which the species necessary for post-mining rehabilitation will be housed (outlined further, below).

Table 5.7 Fast growing plants currently growing within the Halberstadt area

Herbs	
Alternanthera ficoidea	Crab Withe
Catharanthus roseus	Periwinkle
Leonotis nepetifolia	Christmas Candlestick
Panicum maximum	Guinea Grass
Pluchea carolinensis	Wild Tobacco
Shrubs	
Chromolaena odorata	Christmas Bush
Ricinus communis	Castor Oil Plant
Trees	
Acacia farnesiana	Cassie Flower
Guazuma ulmifolia	Bastard Cedar
Leucaena leucocephala	Lead Tree
Piscidia piscipula	Dogwood

French drains or other suitable internal drainage solution will be constructed in areas where water is seeping or suspected from seeping out the bench wall during wet season. Where surface drainage traverses the backfilled slope, an appropriate stabilized surface drain will be installed and maintained. As the backfill of the slope is completed the surface will be stabilized according to an active planting program. The establishment of a ground cover would be of priority and would include planting the herbs listed in Table 5.7 as well as endemic species such as *Agave* sp., *Croton humilis* var. *adenophyllus, Notoptera hirsute and Piper amalago*. Their progress will be assisted with the deployment of erosion control blankets and appropriate mulch as necessary. Fast growing shrubs and trees will be planted after the ground cover is established (again as outlined in Table 5.7). In the final phase hardwood trees, such as *Bursera simaruba* (Red Birch), *Simarouba glauca* (Bitter Damson), and *Trichilia hirta* (Wild Mahogany) can/will be planted

A plant nursery will be setup to ensure that sufficient, suitable plant material is available to allow a timely re-vegetation of the site. The nursery will primarily facilitate the care of commonly occurring, native, and endemic plants currently found in the area. This rehabilitation process will be repeated for each bench area that has been mined out.

A rehabilitation plan for Halberstadt quarry has been developed and is submitted as a separate document (Appendix 7).

6.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

6.1 Physical Environment

6.1.1 Climate and Meteorology

6.1.1.1 Climate within the Study Area

Methodology

Temperature, relative humidity, wind speed and direction, rainfall and barometric pressure were recorded at one (1) location at the boundary of the proposed quarry site (at noise station N3 / particulate station P3) from Wednesday June 26th – Sunday July 28th, 2013 by using a Davis Instruments wireless Vantage Pro2 weather system with a data logger and a complete system shelter erected on a tripod (Plate 6.1). Data were collected every fifteen minutes and stored on the data logger. This information was downloaded using the WeatherLink 5.9.2 software.

Plate 6.1 Photo showing weather station setup at proposed quarry site

Results

June 26 – 30, 2013

- Average temperature was 24.7 ^{o}C and ranged from a low of 21.2 ^{o}C to a high of 31.1 ^{o}C.
- Average relative humidity was 80% and ranged from a low of 59% to a high of 94%.
- Average wind speed was 0.7 m/s and ranged from a low of 0 m/s to a high of 8.5 m/s.
- Dominant wind direction was from the southeast.
- Measurable precipitation during the assessment was 0.31 inches (7.87 mm) over a total of 2 rain days.
- Mean barometric pressure was 962.79 millibar and ranged from a low of 960.8 millibar to a high of 964.5 millibar.

Table 6.1 shows summarized weather data for June 26-30, 2013.

Table 6.1 Summarized weather data for June 26-30, 2013

JUNE 2013	**TEMPERATURE (^{o}C)**					**RAIN (in)**	**WIND SPEED (m/s)**			**DOMINANT WIND DIR**
DAY	**MEAN**	**HIGH**	**TIME**	**LOW**	**TIME**		**AVG.**	**HIGH**	**TIME**	
26	24.9	30.3	3:15p	21.9	12:00m	0	0.1	4.9	3:30p	ESE
27	25.1	31.1	10:00a	21.2	3:15a	0	0.4	7.2	1:30p	SE
28	24.4	29	12:00p	22.3	8:30p	0.17	0.9	7.2	4:00a	SE
29	24.1	27.3	12:00p	21.7	7:00a	0.14	0.9	8	8:15a	ESE
30	25.1	28.8	2:00p	22.9	4:30a	0	1	8.5	4:15a	SE
	24.7	**31.1**		**21.2**		**0.31**	**0.7**	**8.5**		**SE**

July 1 – 28, 2013

- Average temperature was 25.3 ^{o}C and ranged from a low of 19.8 ^{o}C to a high of 32.9 ^{o}C.
- Average relative humidity was 74.89% and ranged from a low of 49% to a high of 98%.
- Average wind speed was 0.7 m/s and ranged from a low of 0 m/s to a high of 13 m/s.
- Dominant wind direction was from the east southeast.
- Measurable precipitation during the assessment was 3.65 inches (92.71 mm) over a total of 5 rain days.
- Mean barometric pressure was 963.97 millibar and ranged from a low of 960.7 millibar to a high of 966.7 millibar.

Table 6.2 shows summarized weather data for July 1-28, 2013.

Table 6.2 Summarized weather data for July 1-28, 2013

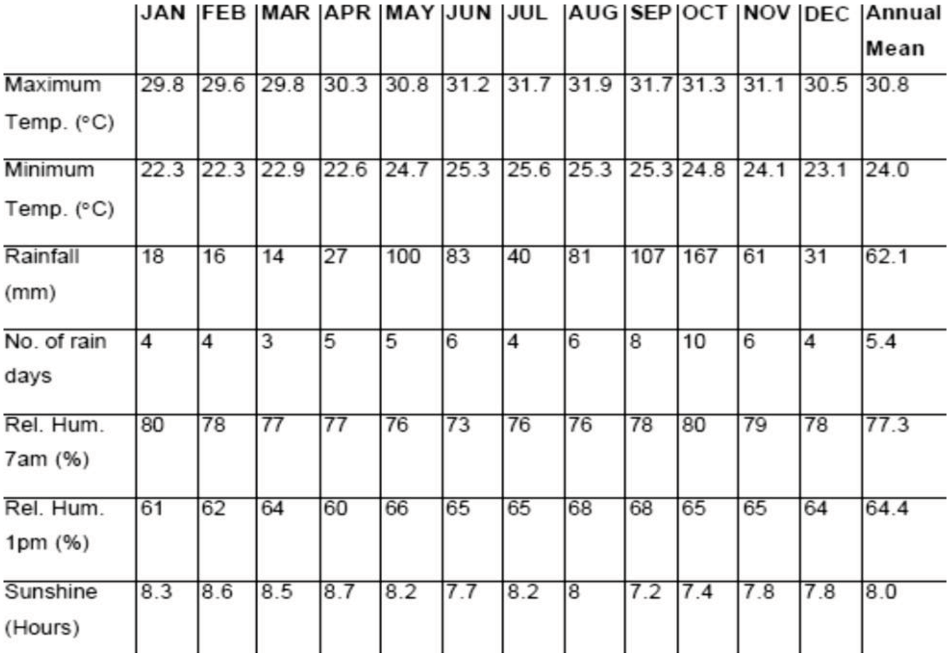
JULY 2013	TEMPERATURE (ºC)					RAIN (in)	WIND SPEED (m/s)			DOMINANT WIND DIR
DAY	MEAN	HIGH	TIME	LOW	TIME		AVG.	HIGH	TIME	
1	23.7	26.8	12:15p	20.8	10:15p	0.94	1.2	9.4	1:45p	SE
2	24.1	27.3	12:15p	21.7	1:00a	0.23	1.3	10.3	8:00a	SE
3	24.4	28.4	2:00p	20.8	4:30a	0	0.8	10.3	7:00p	ESE
4	24.7	27.1	9:45a	21.9	5:45a	0	0.9	8.9	6:30p	ESE
5	25.2	29.8	1:30p	21.9	12:00m	0	0.7	8.5	7:15a	ESE
6	24.7	30.2	9:45a	20.4	5:15a	0	0.3	6.3	3:00p	ESE
7	25.3	30	10:15a	20.9	4:30a	0	0.3	7.2	8:15p	ESE
8	26.1	30.8	12:15p	22.5	12:45a	0	0.7	8.5	11:00p	ESE
9	26	30.4	11:45a	23.1	4:30a	0	0.9	10.3	6:00p	ESE
10	26.7	32.6	12:00p	22.1	6:00a	0.02	0.3	5.4	11:00a	SE
11	23	24	2:15p	20.8	9:15a	2.44	1	8.9	1:45a	ESE
12	24.8	28.4	11:30a	23.1	2:00a	0	1.3	13	6:30a	SE
13	24.4	28.4	11:15a	21.6	10:45p	0	0.2	5.8	12:30a	SE
14	24.1	28.8	2:45p	20.3	5:45a	0	0.2	6.3	3:30p	ESE
15	24.2	29.6	12:30p	19.8	3:15a	0	0.6	8.9	2:15p	ESE
16	24.8	27.8	12:15p	22.8	1:15a	0	1.1	8.5	1:00a	ESE
17	26.1	29.7	11:45a	23.6	12:15a	0	1	9.8	2:30p	ESE
18	27.1	31.9	11:45a	23.5	2:15a	0	0.6	7.2	2:30p	ESE
19	25.3	28.8	11:30a	23.7	5:15p	0.02	1	9.8	8:45a	ESE
20	26.1	30.3	11:15a	22.6	10:30p	0	1	12.5	4:00a	WNW
21	26.6	31.5	2:15p	23.5	2:30a	0	0.7	8.9	7:30a	ESE
22	26.4	31	2:15p	22.2	5:30a	0	0.8	10.7	9:15a	ESE
23	26.4	32.2	11:45a	21.7	2:00a	0	0.5	7.2	11:45a	ESE
24	26.6	32.9	12:15p	22	11:45p	0	0.6	9.4	2:45p	SE
25	25.9	31.3	11:30a	21.2	2:30a	0	0.4	6.7	11:30a	SE
26	25.7	31	10:30a	21.6	6:15a	0	0.2	5.8	5:45p	ESE
27	25.6	30.6	12:45p	22.1	3:00a	0	0.7	6.7	5:15a	ESE
28	24.8	29.9	10:00a	22.7	2:00a	0	0.4	6.3	8:30a	ESE
	25.3	**32.9**		**19.8**		**3.65**	**0.7**	**13**		**ESE**

6.1.1.2 Historical Climate Data

The nearest meteorological station to the site is at the Norman Manley International Airport (NMIA). Table 6.3 shows the meteorological data from NMIA between 1951 and 1980. The temperature values show a minimum temperature range of 22.3-23.1 °C and a maximum temperature range of 29.8-30.5 °C. The data also shows the warmest months of the year being July, August and September. A mean annual rainfall of 62.1 mm was recorded, with the October being the month with the highest rainfall and the most days of rain (167 mm and 10 days respectively).

The main regional scale weather features that affect the island are upper level pressure troughs (an elongated area of low atmospheric pressure at high altitude), tropical waves and incipient storms and cold fronts. Upper level troughs occur year round but are more frequent in the winter when there are more frequent temperate latitude low-pressure systems and fronts.

Table 6.3 Monthly mean and annual mean values for selected meteorological parameters at Norman Manley International Airport 1951-1980



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual Mean
Maximum Temp. (°C)	29.8	29.6	29.8	30.3	30.8	31.2	31.7	31.9	31.7	31.3	31.1	30.5	30.8
Minimum Temp. (°C)	22.3	22.3	22.9	22.6	24.7	25.3	25.6	25.3	25.3	24.8	24.1	23.1	24.0
Rainfall (mm)	18	16	14	27	100	83	40	81	107	167	61	31	62.1
No. of rain days	4	4	3	5	5	6	4	6	8	10	6	4	5.4
Rel. Hum. 7am (%)	80	78	77	77	76	73	76	76	78	80	79	78	77.3
Rel. Hum. 1pm (%)	61	62	64	60	66	65	65	68	68	65	65	64	64.4
Sunshine (Hours)	8.3	8.6	8.5	8.7	8.2	7.7	8.2	8	7.2	7.4	7.8	7.8	8.0

Source: Environmental Solutions Limited, 2005 - Environmental Impact Assessment, Caribbean Cement Company Expansion and Modernisation Programme

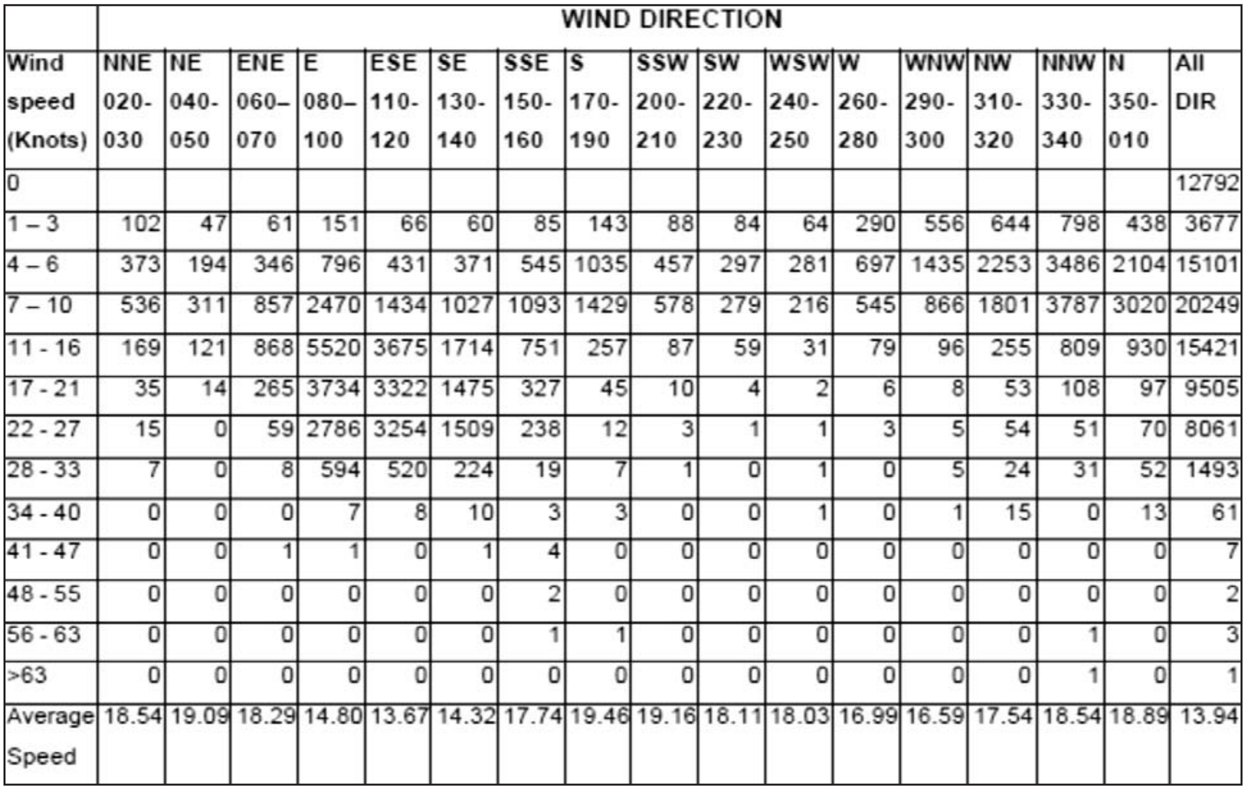
During the winter months, cold fronts associated with low-pressure systems that form over the south central United States can reach Jamaica although the still warm water in the Gulf of Mexico and the Caribbean moderates them. These fronts can be stationary and produce much rainfall over the northern areas of Jamaica.

The summer troughs are fewer but can be more persistent. The troughs sometimes interact with the easterly waves (a wavelike disturbance in the tropical easterly winds that usually moves from east to west) and tropical storms to produce intense rainfall. Tropical waves and incipient storms occur in the summer and move from east to west and are good rainfall producers. A tropical wave is a kink or bend in the normally straight flow of surface air in the tropics that form a low-pressure trough, or pressure boundary, and showers and thunderstorms. It can develop into a tropical cyclone. The dominant winds over Jamaica are the northeast trade winds whose strength is governed by the strength and location of the Azores-Bermuda sub tropic high-pressure cell. During the summer months the high-pressure cell is weaker and farther north (than in summer) and consequently the trade winds are broad, persistent and extend further south. In the winter months, the central pressure of the cell is higher and further south and the winter trade winds are weaker and have a more northerly component.

The wind data for the period 1981 to 1990 (taken from the Caribbean Cement Company Expansion EIA - Environmental Solutions Limited, 2005) shows that the most predominant wind directions are from the east and east-southeast (Table 6.4, Figure 6.1). These are the prevailing sea-breeze directions and reflect the effects of the mountains that lie along an east west axis. The mountains deflect the dominant north-easterly trade winds and provide the easterly component to the winds. The mean wind speed over the period was 10.3 knots (19.1 km/h). Winds from the south had the highest wind speeds (19.5 knots (kt)) followed by the south southwest. Winds from the ESE had the lowest average wind speeds. Calm winds were reported 14.7% of the time and wind speeds of 1 to 3 kt were reported 4.2% of the time.

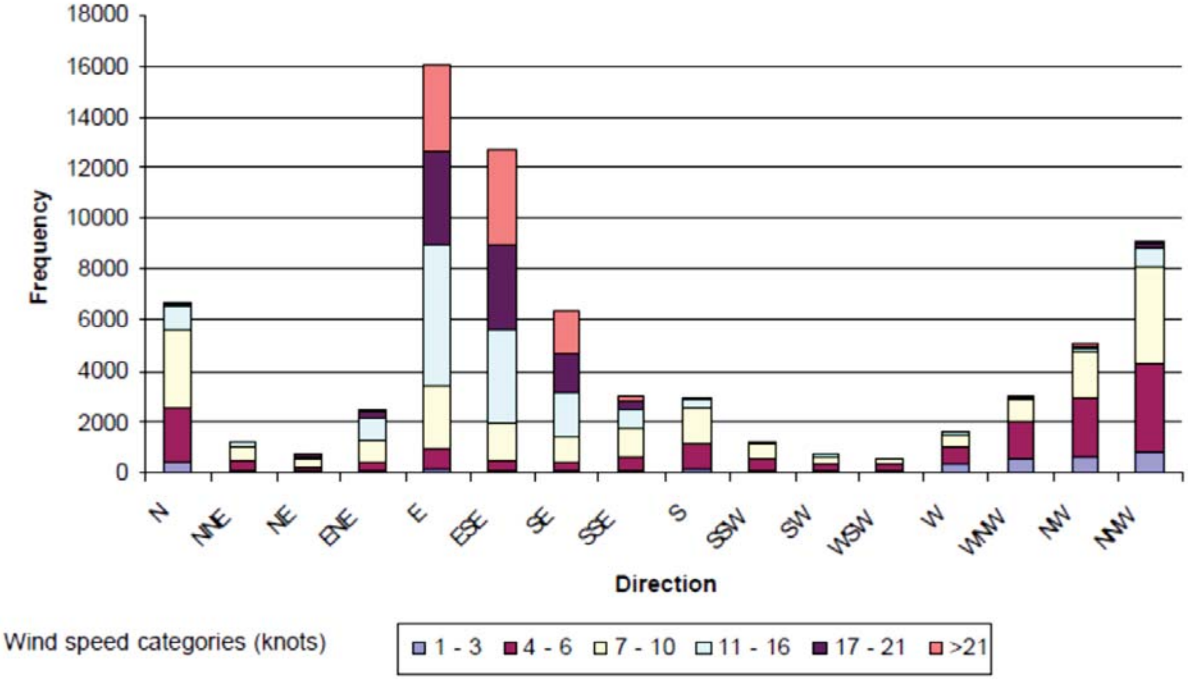
The NMIA wind data recorded in 2002 shows the predominant wind direction was from the southeast, followed by the south-south-easterly winds (Figure 6.2). This is consistent with the historic patterns as reported.

Table 6.4 Wind speed and direction data from Norman Manley International Airport 1981-1990



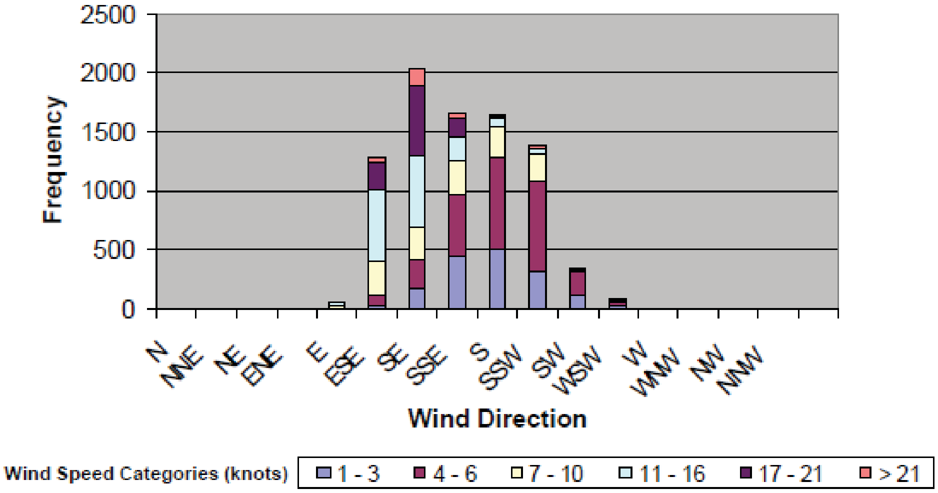
	WIND DIRECTION																
Wind speed (Knots)	NNE 020-030	NE 040-050	ENE 060–070	E 080–100	ESE 110-120	SE 130-140	SSE 150-160	S 170-190	SSW 200-210	SW 220-230	WSW 240-250	W 260-280	WNW 290-300	NW 310-320	NNW 330-340	N 350-010	All DIR
0																	12792
1 – 3	102	47	61	151	66	60	85	143	88	84	64	290	556	644	798	438	3677
4 – 6	373	194	346	796	431	371	545	1035	457	297	281	697	1435	2253	3486	2104	15101
7 – 10	536	311	857	2470	1434	1027	1093	1429	578	279	216	545	866	1801	3787	3020	20249
11 - 16	169	121	868	5520	3675	1714	751	257	87	59	31	79	96	255	809	930	15421
17 - 21	35	14	265	3734	3322	1475	327	45	10	4	2	6	8	53	108	97	9505
22 - 27	15	0	59	2786	3254	1509	238	12	3	1	1	3	5	54	51	70	8061
28 - 33	7	0	8	594	520	224	19	7	1	0	1	0	5	24	31	52	1493
34 - 40	0	0	0	7	8	10	3	3	0	0	1	0	1	15	0	13	61
41 - 47	0	0	1	1	0	1	4	0	0	0	0	0	0	0	0	0	7
48 - 55	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
56 - 63	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	3
>63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Average Speed	18.54	19.09	18.29	14.80	13.67	14.32	17.74	19.46	19.16	18.11	18.03	16.99	16.59	17.54	18.54	18.89	13.94

Source: Environmental Solutions Limited, 2005 - Environmental Impact Assessment, Caribbean Cement Company Expansion and Modernisation Programme



Source: Environmental Solutions Limited, 2005 - Environmental Impact Assessment, Caribbean Cement Company Expansion and Modernisation Programme

Figure 6.1 Wind speed and wind direction frequencies at Norman Manley International Airport, 1981-1990



Source: Environmental Solutions Limited, 2005 - Environmental Impact Assessment, Caribbean Cement Company Expansion and Modernisation Programme

Figure 6.2 Wind speed and wind direction frequencies at Norman Manley International Airport, 2002

6.1.2 Geology and Geomorphology

6.1.2.1 Regional Geology

The area is located in the south-eastern section of the fault bounded Wagwater Belt. The rocks in the Wagwater Belt are result of the depositional processes in a fan delta and proximal submarine fan complex. Deposits in such in environment are characterized by significant lateral and vertical variation in lithology. In the Wagwater Belt these deposits include plutonic, volcanic and volcaniclastic rocks to alluvial submarine-deltaic sediments, limestones and evaporites such as gypsum and anhydrite.

Figure 6.3, an excerpt of the Geological sheet 18 of the Mines and Geology Division, gives an overview of the main rock formations occurring in the vicinity of the quarry.

Newport Volcanics

Newport Volcanics is the dominant formation found in the immediate vicinity of the Halberstadt Quarry. The existing access road runs almost over its entire length through the Newcastle volcanics. The Newcastle volcanics consists mainly of massive lava flows with little or no visible bedding plains. The rocks however are highly jointed and brecciated. In the road cut along the internal mining road # 4, North of the intersection of the internal mining road #3 the Newcastle Volcanics has slickensided surfaces indicating fault activity. The colour is function of the weathering. Fresh rocks that are not weathered are light to dark grey, heavily weathered rocks are dark brown to purplish brown. The weathering of Newcastle Volcanics produces deep soils covers of sandy clays.

The Newcastle Volcanics includes to a lesser extend also volcaniclastic and epiclastic rocks. Volcaniclastic rocks consist of material with particle sizes varying from fine grained tuffs to coarse grained agglomerates typical of grey-green colour. The epiclastic rocks include reworked volcanic and volcaniclastic material with similar colouration as the lava flows but includes also reddish reworked Wagwater Conglomerates, shales and sandstones. Because the Wagwater formation is in fact intercalated with lava flows, the boundary between the Newcastle Volcanics and the Wagwater formation can be hard to distinguish. This may explains why Wagwater Formation shown in the Geological Sheet 18 west of the Brooks Gypsum is not really visible in field and has not been delineated in the recent geological and geotechnical assessments.

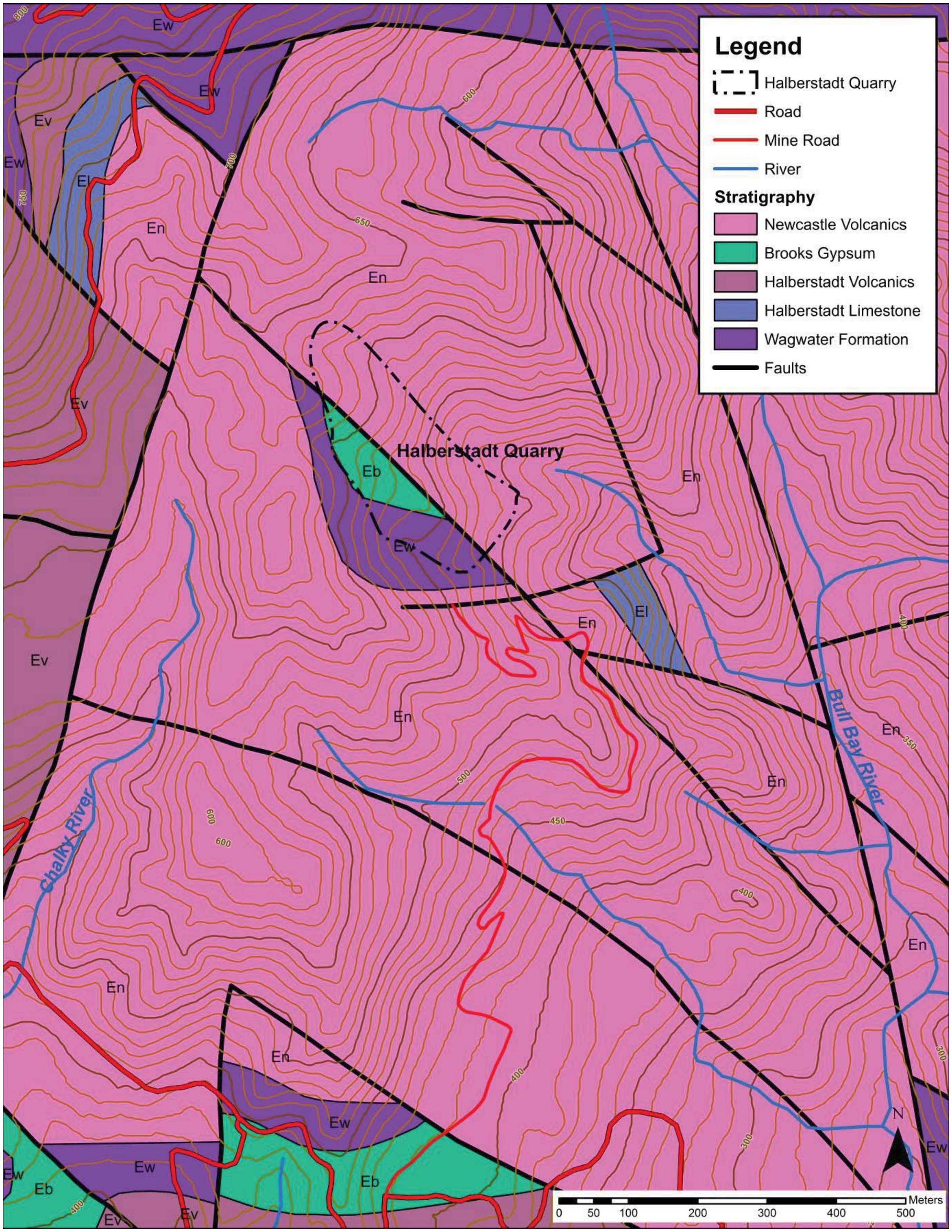


Figure 6.3 *Regional geology based on Sheet 18 of 1:50,000 Geological Map Series*

Where the Newcastle Volcanic is weathered and highly fractured, the slope stability of the Newcastle Volcanic is generally poor and is subject to repeated landslide activity. When no other data is available, the Geotechnical Classification of Jamaican Rocks recommends to design the slopes in the Newcastle Volcanic not to exceed 33% or 18°.

Brooks Gypsum

The Brooks Gypsums are the evaporate deposit which occur as relatively thin layers and lenses in the south eastern section of the Wagwater belt south of Gordon Town. They are Sulphate deposit consisting of both gypsum and anhydrite. The rocks are well bedded and often deformed. They range from transparent/translucent (selenite) to white, brown, red, light grey and dark grey (alabaster) and are typically interbedded with dark bands containing organic matter. The anhydrite tends forms the core of the deposits. The gypsum is found near the outer, more exposed surfaces. Figure 6.4 shows the delineation of the Gypsum/Anhydride reserve carried out by NHL Engineering Ltd using geochemical analysis of borehole to a depth of 60 m. The Boundary of Gypsum/Anhydride is the extent of the deposits that is expected to be extract economically based on the current mining techniques. The High Grade Deposit boundary indicates the area in which good quality deposits with little or no overburden are present.

Gypsum and anhydride are soft incompetent rocks with low shear strength which may serve as lubrication zones for rock slides in associated deposits. It should also be noted that Anhydrite deposits are susceptible to swelling on contact with water. The Brook Gypsum exposed in the old mining benches along the internal quarry road #1 is well bedded and appears to have a general dip of 20° to 30° into the slope. The bench appears to be stable since it has been cut. Gypsum reserve estimation carried out by NHL Engineering Limited reported RQD[3] values that are with few exceptions less than 20%. This would classify these deposits on the high end of very poor rocks. Passed experience with the same drilling technique in the adjacent Gypsum quarries yielded similar low RQD values and the gypsum deposits were too hard to be extracted with ripping (pers. comm. Yhon Downie). It is therefore reasonable to surmise that the gypsum deposits in the Halberstadt quarry are harder than RQD value may suggest and should be able to allow similar cut slopes as in the neighbouring quarries.

---

[3] Rock Quality Designation (RQD) is measure of the strength of the rock. It is the length of the core pieces >0.1m divided by length of the core run multiplied by 100.

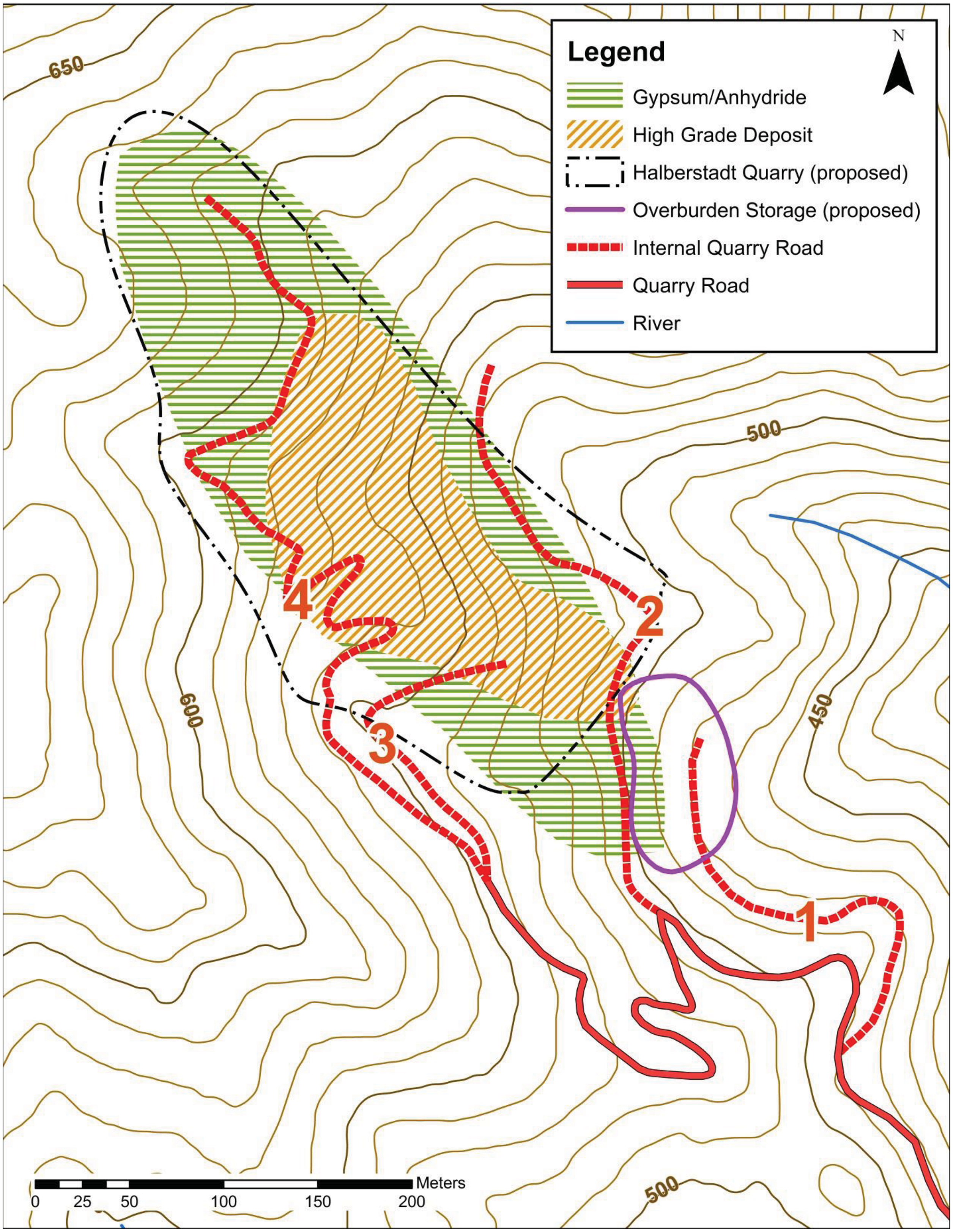


Figure 6.4 Extend of the gypsum / anhydride deposit

The primary permeability of gypsum/anhydride deposits is low but the secondary permeability can be moderately high. While no groundwater was encountered, it should be noted that water seepage was noticed along the internal mining road #1 at the foot of the bench, due south of the proposed overburden storage area. In addition there appears to be evidence of piping in the gypsum deposits near the intersection with the internal quarry road # 2 (Plate 6.2) indicating significant groundwater movement under certain circumstances.

Plate 6.2 Piping in the gypsum deposits near the intersection with the internal quarry road # 2

Halberstadt Volcanics

The Halberstadt Volcanic do not occur in the foot print or immediate adjacent to the quarry but is present south and west of the Newcastle Volcanic which surround the Halberstadt quarry. Halberstadt Volcanics consist of splitized basalt lavas with vesicules and pillow structures and are associated with volcanic breccias and volcaniclastics. The Halberstadt Volcanics are highly fractured, jointed, and calcite veins are common throughout. It generally weathers to a deep brown granular sandy clay soil.

Halberstadt Limestone

The Halberstadt limestone consist of thick lenses of relative small limestones bodies. They are extensively recrystallized, light grey to black impure, sometimes micritic limestones. They contain shallow water fauna such as oysters and small corals and algae. Halberstadt Limestone are generally interbedded with the top section of the Halberstadt Volcanics but as is the case here in the small outcrop south east of the Halberstadt quarry they can also be interbedded with Newcastle volcanics. These are sound and competent rock which do not pose major stability problems.

Wagwater Formation

The Wagwater formation consists of distinct purple – red conglomerates and to a lesser extent breccias and sandstones, siltstones and shales. The conglomerates have mud matrix which is compacted but often poorly cemented. The Wagwater Formation is intercalated with volcanic flows of the Newcastle Volcanics, the evaporites of the Brooks Gypsum. As stated in the section on the Newcastle Volcanics. Although competent and well-cemented bed are not uncommon, the Wagwater formation if often highly fractured and are susceptible to frequent landslide especially in fault zones. In the Geotechnical Classification for Jamaica it is recommended to design slopes in the Wagwater Formation to 50% or 26° unless other data is available. It should be noted that although the Wagwater Formation shown in the Geological Sheet 18 to located west of the Brooks Gypsum, the Wagwater Formation has not been remapped in the recent geological and geotechnical assessments.

6.1.2.2 Geomorphology

Halberstadt quarry is located in a NNW-SSE trending valley flanked by two parallel ridges. These two parallel ridge extend from the ENE-WSW main ridge on which the parochial road between Halberstadt and Bito is situated. The slopes enclosing the valley in which the Halberstadt Quarry is located are quite steep with gradients between 58% (30°) to 100% (45°). Although the Halberstadt quarry is located deeper in the mountains, at a higher elevation, the topography of the quarry area itself is not significantly steeper and extremer than of the other quarries. Table 6.5 compiles the average slope for the 5 Gypsum quarries calculated from the slope map. It shows that while the Halberstadt Quarry site has a higher average slope than Bito Quarry, it has the same average slope as the Upper and Cave quarry and considerable lower average slope than the Brooks Quarry, the oldest all the gypsum quarries.

Table 6.5 Average slopes of topography in the quarries

QUARRY	AVERAGE SLOPE	
	%	**DEGREES**
Upper Quarry	45%	24°
Brooks Quarry	95%	44°
Cave Quarry	42%	23°
Bito Quarry	28%	16°
Halberstadt Quarry	44%	24°

Further analysis of the morphology shows that the shape of NNW-SSE trending valley, in which the Halberstadt quarry is located, is asymmetric (Figure 6.5). The southern side of the valley has a terrace level which coincides with the distribution of the gypsum deposits. The quarry boundary matches approximately the outlines of that terrace level. The terrace level slopes to the SSE with a gradient of approximately 30% (17°). Near cross-section A-A', this terrace lever is elevated approximately 40m above the unnamed drainage channel that runs parallels with it. To facilitate the discussion this drainage channel will henceforth be referred to as Halberstadt Quarry Gully. Because the gully channel has higher gradient than the terrace level, the elevation difference between the two increases in the downstream direction. Near cross-section B-B' the elevation between gully channel and the terrace level has increase to about 60m. Further to the south the average gradient of the Halberstadt Quarry Gully reduces significantly. The slope map indicates that between cross section B-B' and the confluence with the main channel the gully channel has a stepped longitudinal profile in which wider near flat section are separated by steeper near vertical sections.

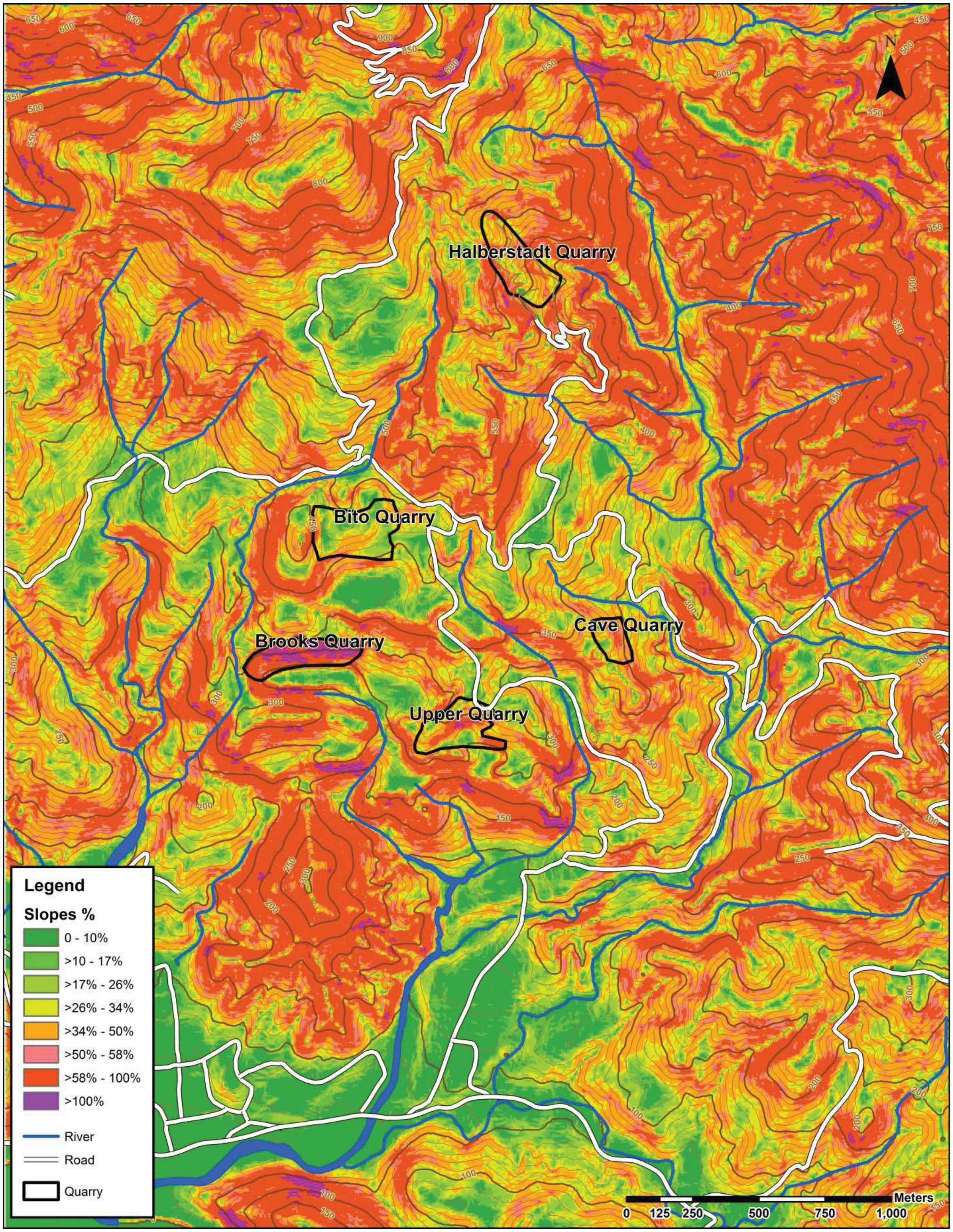


Figure 6.5 *Slope at quarries in vicinity of study area*

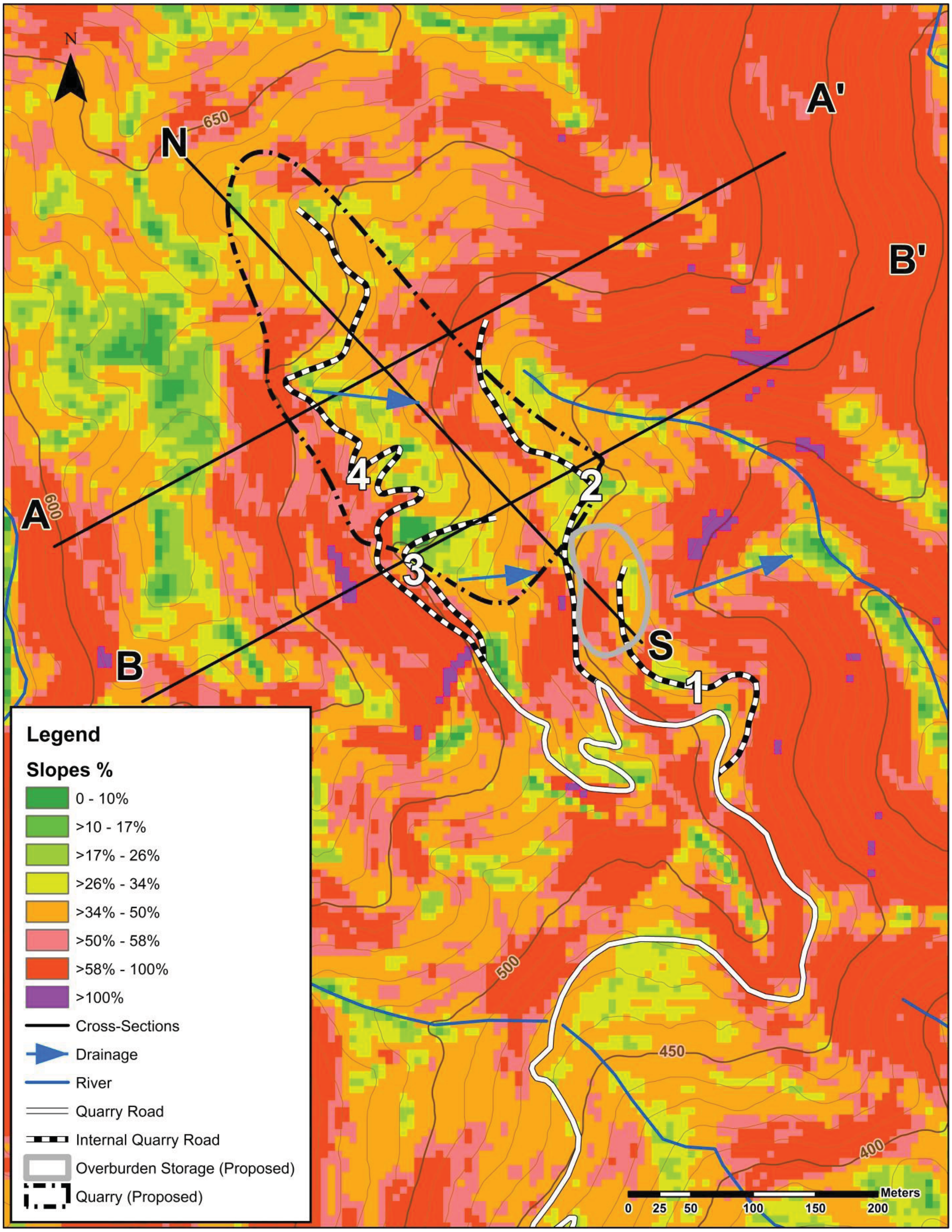


Figure 6.6 Slope at proposed site showing location of cross sections in Figure 6.7

Figure 6.7 Topographic cross-sections of the Halberstadt quarry

The natural drainage on the terrace level i.e. in the quarry is neither perpendicular nor parallel to the Halberstadt Quarry Gully. The natural drainage in the quarry flows generally in a W-E direction. All existing surface drainage from the proposed quarry site merges however with the Halberstadt Quarry Gully which exits in the main channel of the Bull Bay River.

The topographic map in the mining plan shows the proposed overburden storage area as a closed depression. This was verified in the field and was found to be incorrect. The area identified for the storage of the overburden is a mined out section of old Halberstadt quarry which can be accessed by the internal mining road #1. The topography of that area is characterized by an old quarry bench, which was abandoned without any form of restoration. The near vertical bench wall is about 20m high and the near flat bench floor is about 20m wide. The total length of the semi-circular bench is about 140m. This is about 50% longer than the length of proposed overburden storage area. Neither the bench wall nor the bench floor have been affected by significant landslide activity or show signs of instability. Secondary vegetation is fully re-established throughout the quarry area except on the steepest section of the bench wall. Gullying and minor landslide activity near the intersection with the main Quarry road have made the internal mining road #1 inaccessible for vehicular traffic.

There a two (2) drainage issues that currently affect the proposed overburden area and may need to be addressed to prevent unwanted mobilisation of the stored material:

- A small drainage channel of about 1m wide, which conveys the runoff from the slopes above the internal quarry road #2, passes through middle of the proposed overburden storage area.
- Seepage of water was observed near the southern edge of the proposed overburden storage area at the foot of the bench wall on internal mining road #1. This feature appears to line up with the piping feature near the intersection with the internal road #2. These features should be looked at together as it is not impossible that they may be connected.

6.1.2.3 Geotechnical Design Considerations

Mass movements triggered by the excavation activities in the quarry may impact areas at a considerable distance away from the actual excavation perimeter. To minimize this problem, the JGQ mining plan proposes to extract the ore using an average bench height of 8m and a minimum bench width of twice the bench height or 16m. This represents a maximum average slope of 50% (26°) per bench. Figure 6.8 shows the proposed design slope along the profile line A-A'. Although it is a theoretical slope design based on current knowledge of the extent of the deposit, it provides a vision of the shape of the quarry after the economic deposit have been exhausted but without considering proposed rehabilitation of the slope. The quarry slope in this drawing is between 80 to 90m high with a maximum slope of 50% (26°). In absence of any other data, the Geotechnical Classification of Jamaican Rocks recommends to design the slopes in the Newcastle Volcanic and the Wagwater Formation respectively not to exceed 33% (18°) and 50% (26°). No recommendations are provided for slopes in gypsum and anhydrite deposits. The slopes to the Newcastle formation to the southeast of the proposed quarry are considerable steeper with general gradient between 58 to 100% which suggest that slopes in that area can be expected to be stable at 50% (26°). In addition the experience with the existing benches in the gypsum and anhydrite deposits of the Halberstadt quarry is not in conflict with the proposed slope design. Based on the existing geotechnical knowledge of the area the proposed slope design of a 1:2 slope for the quarry appears to be acceptable.

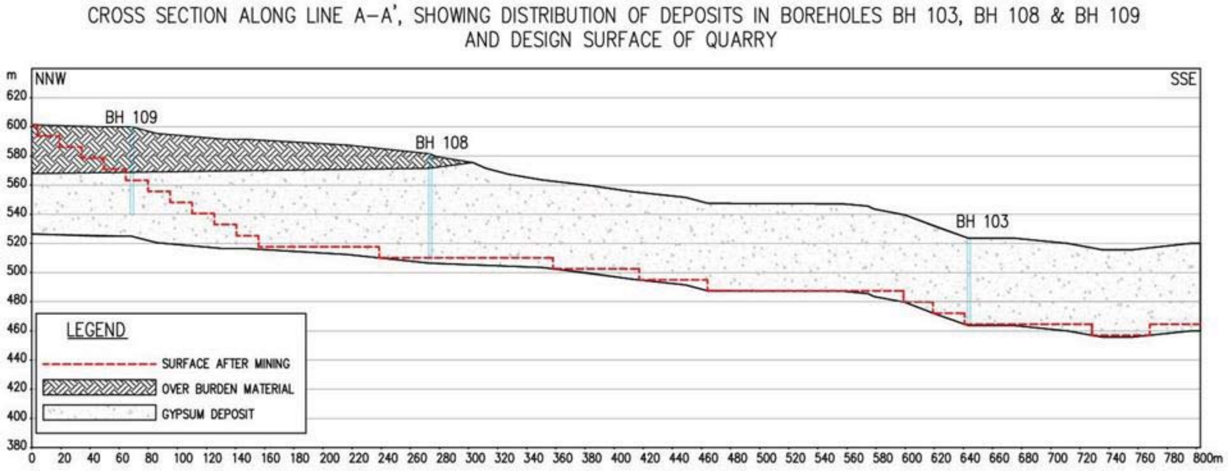


Figure 6.8 Design slope Halberstadt Quarry

The mining plan calls for the widening of the access road to the quarry. Since the access road lies almost over its entire length in the Newcastle formation, the cut slope will have to designed carefully and may require slope support to the prevent recurring slope failure. This is particular true for the last 300m near the quarry. In that area the access road passes through steep terrain with average slope gradient ranging from 58% to 100%. Selective widening in combination with an automated traffic management system may need to be considered in that section to avoid expensive slope remediation and/or extended down time because landslides are blocking the access to the quarry.

The Overburden which need be removed to access the gypsums and anhydride deposit is at same time a potential source of environmental degradation as an essential resource material for environmental restoration. The overburden is needed to assist in stabilizing the oversteepened benches in the mined out section of the quarry. The overburden material placed in front of the benches forms a manmade “talus” slope, which reduces the height of the benches and reduces the slopes in the quarry. When there is not enough overburden material to do this, the angle and height of the quarry walls or benches can be reduced by blasting the top sections of the benches to form rubble slopes in front of the benches and achieve the same effect of reducing the height and the angle of the slopes in the quarry. After the overburden has been removed and it has to be kept in storage until it can be used for the rehabilitation of the quarry. The entire bench at the end of the internal mining road # 1 could be used for overburden storage but a solution will have to be identified and implemented to address the minor drainage channel which passes through that area and the minor seepage which has been observed at the foot of the bench. It should be pointed out that not much more material can be held in that space than is needed to effectively restore that area unless artificial means are used such as gabions to hold the overburden material in place. At that point an assessment may have to be done to investigate the need and feasibility to construct a free draining dam to hold the overburden in the valley below the quarry bench. The size of the overburden storage area can and shall be minimized by the implementation of progressive rehabilitation program. While one section of the quarry is stripped of burden and is being extracted, another section of the quarry is been graded and rehabilitated. Filling in the bench on the internal quarry road #1 could be the first step to kick off the progressive rehabilitation programing in the Halberstadt quarry.

What will set the Halberstadt Quarry apart from the other gypsum quarries is that it will not need a tailing dump because all excavated material including the fines will be removed from the quarry and will be used in production (verbal communication Yhon Downie). Overburden and below grade gypsum ore will be used in the progressive rehabilitation of the Halberstadt quarry or in rehabilitation of the quarries that are to be closed or have been closed. This removes one of the more obvious negative impacts that this quarry could have had.

Because the quarry activities will unavoidably increase the amount of material that become available for transport in the form of overburden storage, small landslide etc., it is still advisable to construct some form of sedimentation trap, to minimize the sediment load of the Bull Bay when under extreme weather condition all lose material is flushed out of the quarry. Since all runoff from the quarry is captured by the Halberstadt quarry gully, one sediment trap constructed in that gully is needed to manage the sediment load of the entire quarry.

To minimize downtime and ensure the safe operation of the quarry, it is recommended that as part of the quarry rehabilitation efforts, a ground control management plan be implemented during the operation phase. This ground control management plan should include:

- production rate, excavations methods and equipment used, handling of ore and waste;
- layout and evolution of the layout of the mine, and including the location and conditions of haul and quarry roads;
- nearby physical features such as roads, pipelines and powerlines
- variations in the characteristics of the deposits (e.g., rock type, strength, structural features);
- identification tension cracking or any other indications of potential slope instability;
- occurrences of ground movements and landslides etc.;
- time dependent characteristics of the rock mass;
- an assessment of groundwater and surface water condition and a groundwater and surface water management plan; and
- inspections of benches and crests to identify Emergency action procedures.

The ground control management plan should be reviewed annually, or at any time changes in the quarry design are to be implemented to address safety or performance issues. Please see section 9.4 for further details.

6.1.3 Drainage Assessment

It must be noted that a detailed drainage assessment report was submitted separately in July 2013 and important aspects of this are summarised in the following sections. Please refer to “Drainage Assessment Report for Halberstadt Mine, St. Thomas” (CEAC Solutions Co. Ltd., July 2013) for the full report.

6.1.3.1 Hydrology

The Catchments

Terrain/Topography

Topographical data for the proposed project site was obtained from the client and further supplemented by the NASA world topographic dataset as well as digitized contours of 1:12,500 Jamaica map series data from the survey department. A digital elevation model (DEM) of the project area is shown in Figure 6.9.

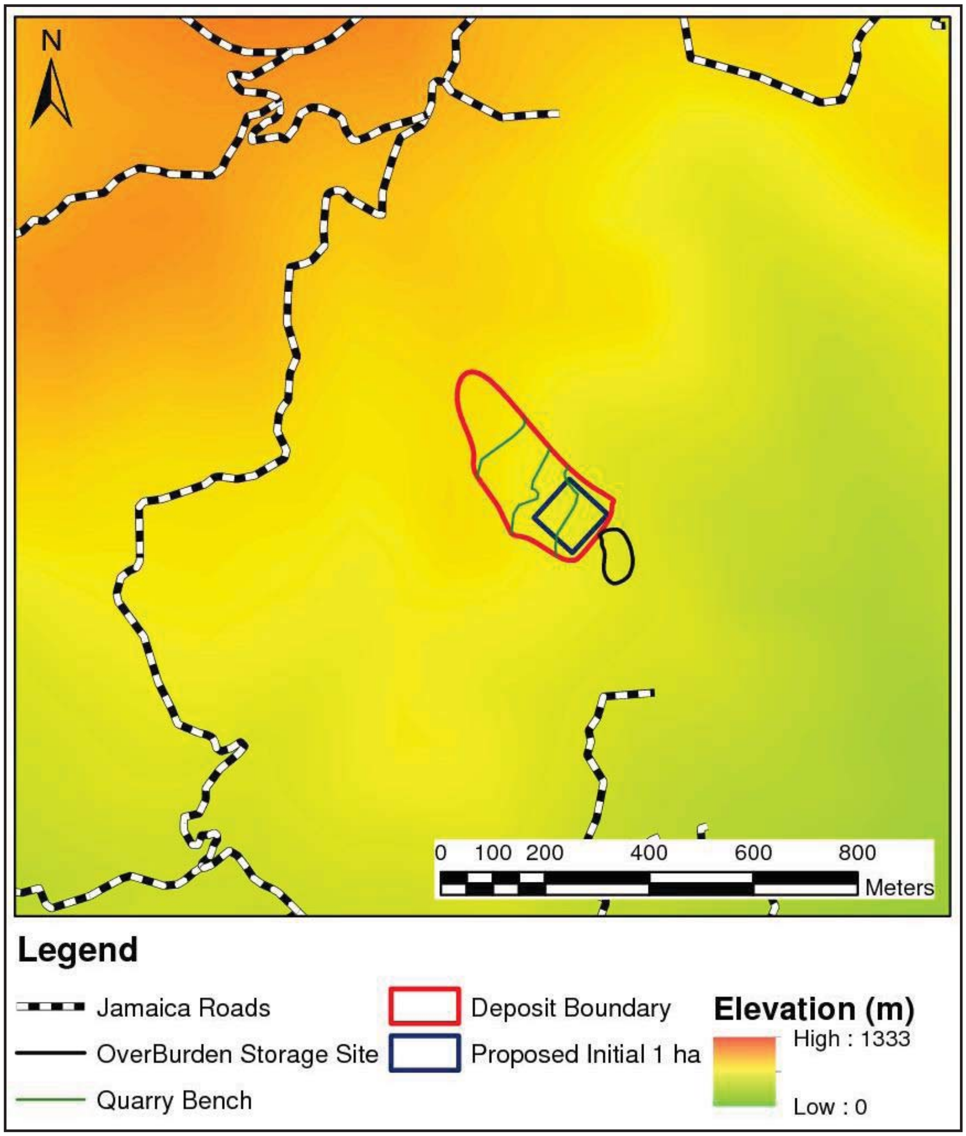


Figure 6.9 Halberstadt quarry features superimposed on Digital Elevation Map (DEM) of Jamaica

The contour data obtained revealed that the overall project area is mountainous and is sloping in a general North-west to South-east direction. The elevations across the project area vary from a low of 480 metres above Mean Sea Level (msl) to a high of 620m; Most of the project areas are found predominantly in the mid to high ranges.

The topography of the project area comprises of mountainous lands within the northern segments of the catchment (elevation = 620m above MSL) and steep sloping areas in the south with sharp increases/decreases in elevations.

Given that the intention of the project site is exclusively for mining purposes, it was necessary to assess the landslide vulnerability within the project area. A simplified approach was taken to assess the vulnerability of the proposed quarry site and immediate areas to landslides, by analysing a GIS susceptibility model create by CEAC engineers.

The landslide susceptibility map demonstrates that there is a group of highly vulnerable areas within the catchment which are prone to landslides. To be more specific, the southern 80% of the Halberstadt proposed deposit boundary is located within areas determined to have high susceptibility while the remaining regions are moderate. In addition, 50% of the over burden storage site is located with highly vulnerable zones. These overall areas within the proposed site and the wider catchment area can be classified as having moderate to high susceptibility (Figure 6.10).

The verification process was taken a step further and into the field. Using the landslide susceptibility map as a guide, highly vulnerable areas were explored and investigated in search of landslides. Three (3) landslides were identified along the parochial road leading to the Halberstadt site. According to the susceptibility map, two (2) of these landslides occurred in highly vulnerable areas while the other in a moderate zone of vulnerability. These landslides can be seen below in Plate 6.3 through Plate 6.5.

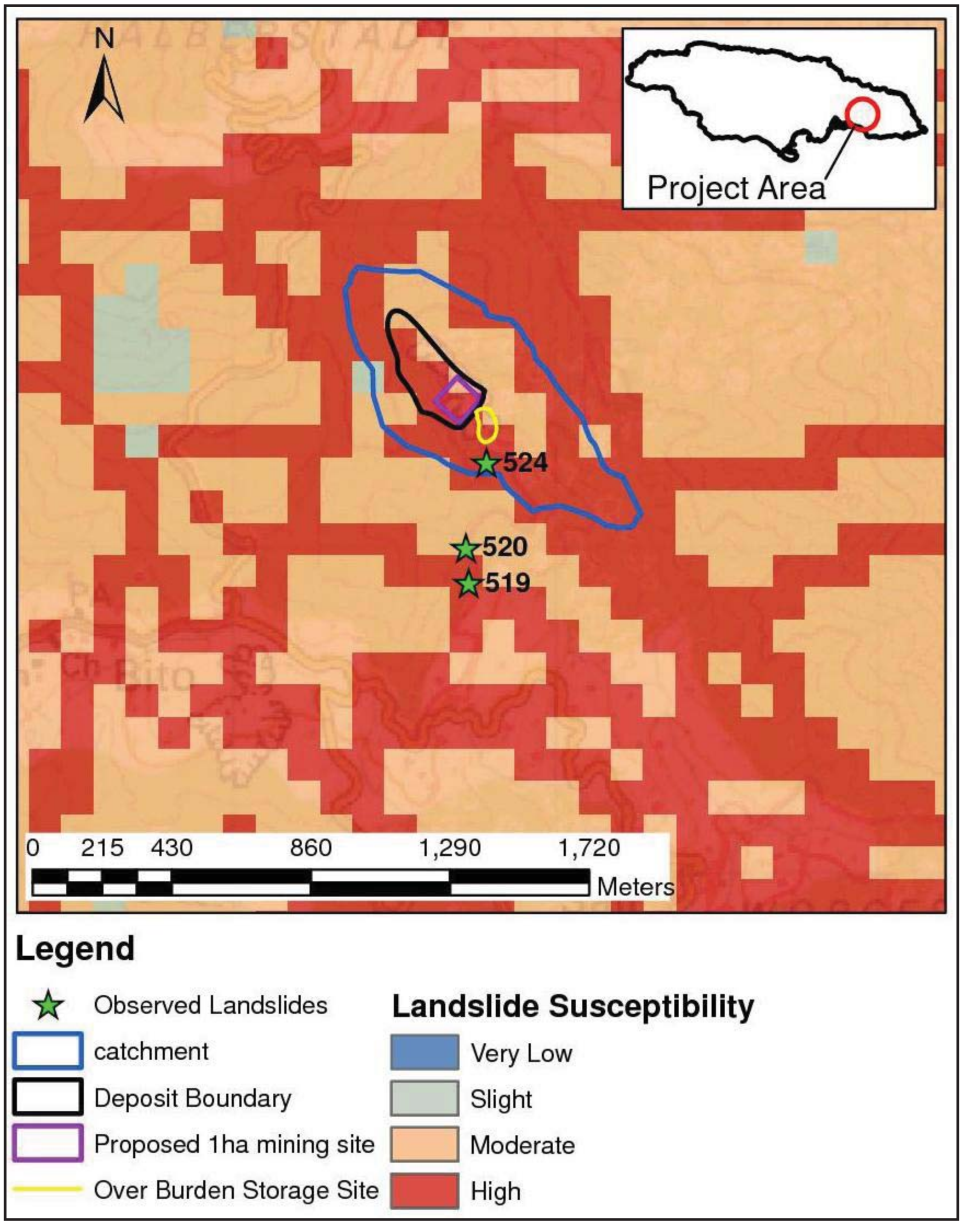


Figure 6.10 Halberstadt quarry features superimposed on landslide susceptibility map

Plate 6.3 First landslide encountered during site visit (#519)

Plate 6.4 Second landslide identified during field reconnaissance (#520)

Plate 6.5 Third landslide located during site visit (#524)

Soils

The catchment was superimposed on the ministry of Agriculture's soils map of Jamaica to identify the soils distribution within the catchment (see Figure 6.11). It was found that the catchment possesses high proportions of Clay loam and Sandy loam. The soil types are distributed across the catchments as follows:

1. The upper 10% catchment basin area of the project site has predominant concentrations of Gravelly sandy loam;
2. The lower 90% of the catchment is comprised of mainly clay loam.

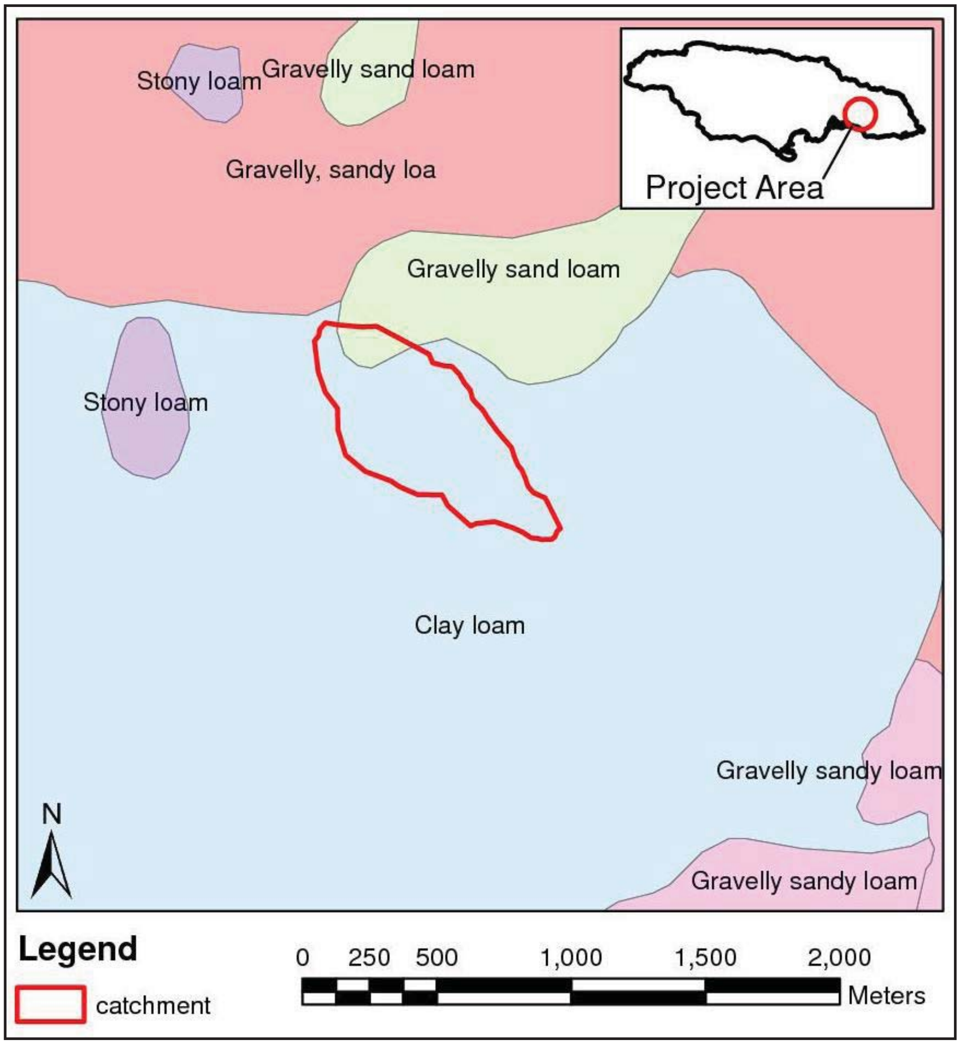


Figure 6.11 Catchment areas superimposed on soils map of Jamaica

Land Use

The land use for the catchment was determined from inspection of the Forestry Department land use map seen in Figure 6.12, as well as satellite imagery of the catchments. The following was noted:

3. The western 15% of the catchment is comprised primarily of disturbed broad leaf forests.
4. The remaining 85% of the catchment consists solely of disturbed broad leaf forests and fields.

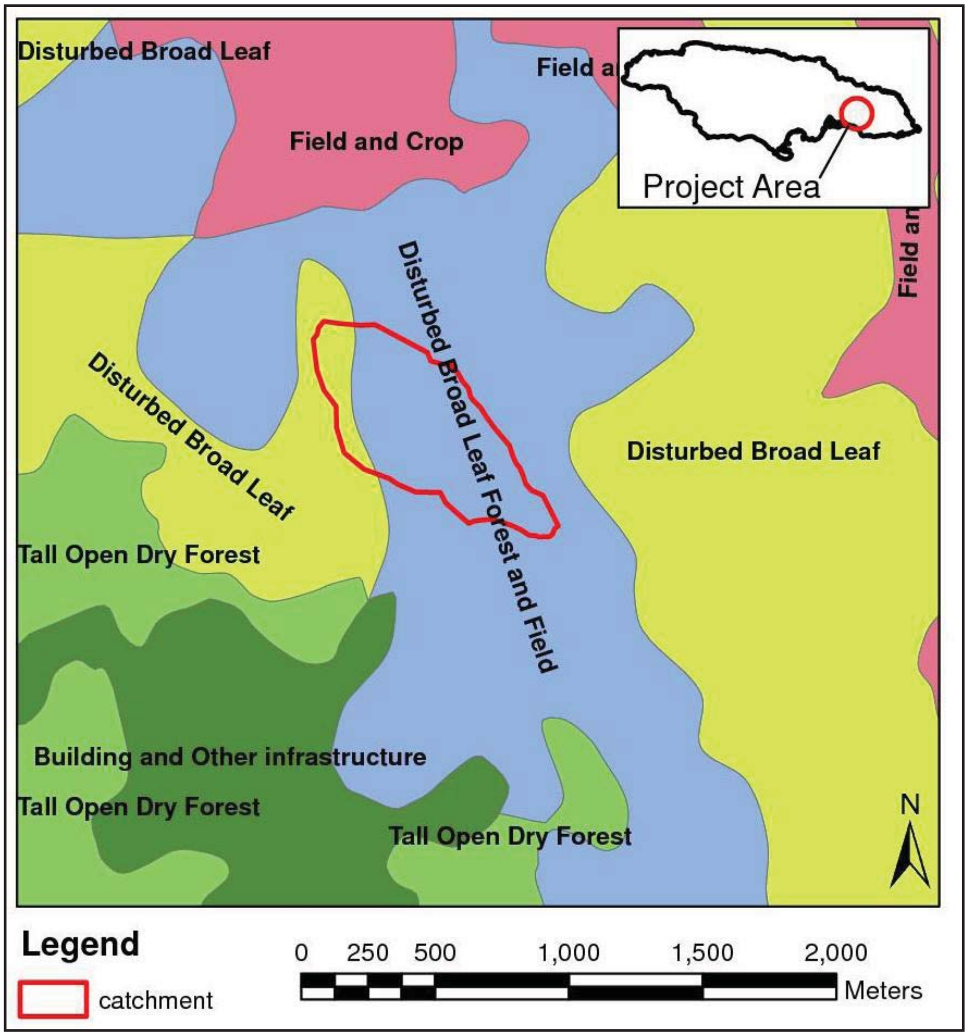


Figure 6.12 Land use map of Jamaica with the superimposed catchment

Meteorology

Long-term Rainfall and Temperature

As seen below in Table 6.6 and Figure 6.13, temperatures are greatest during the months of June to September. Lowest mean minimum temperature of 20.7 degrees Celsius is seen to occur in the month of February and the greatest mean maximum temperature of 31.9 occurs in July. Rainfall is seen to have a yearly peak of 306 mm in October. February and March are seen to be the driest months of the year.

Table 6.6 Mean Climatological Data for St. Thomas (1951-80) obtained from the Metrological Service

1951-80 MEAN CLIMATOLOGICAL DATA FOR SELECTED LOCATIONS							
Station (Altitude)	**Year**	**Max Temp. (C)**	**Min Temp. (C)**	**Rainfall (mm)**	**Rel. Hum.- 7am (%)**	**Rel. Hum.- 1pm (%)**	**Sunshine (Hrs.)**
Duckenfield (St. Thomas) (alt 15 metres)	**JAN**	28.7	21.2	92	85	68	7.1
	FEB	28.9	20.7	81	88	67	7.6
	MAR	29.1	21.0	64	88	70	7.5
	APR	30.1	21.5	94	86	67	8.0
	MAY	30.7	22.8	246	87	70	7.1
	JUN	31.3	23.8	177	87	72	7.3
	JUL	31.9	24.2	110	87	71	7.8
	AUG	31.8	23.3	178	87	67	7.6
	SEP	31.2	23.1	227	87	73	6.8
	OCT	30.8	22.4	306	90	75	6.7
	NOV	30.0	22.3	237	88	75	6.7
	DEC	29.2	21.9	158	84	73	6.3

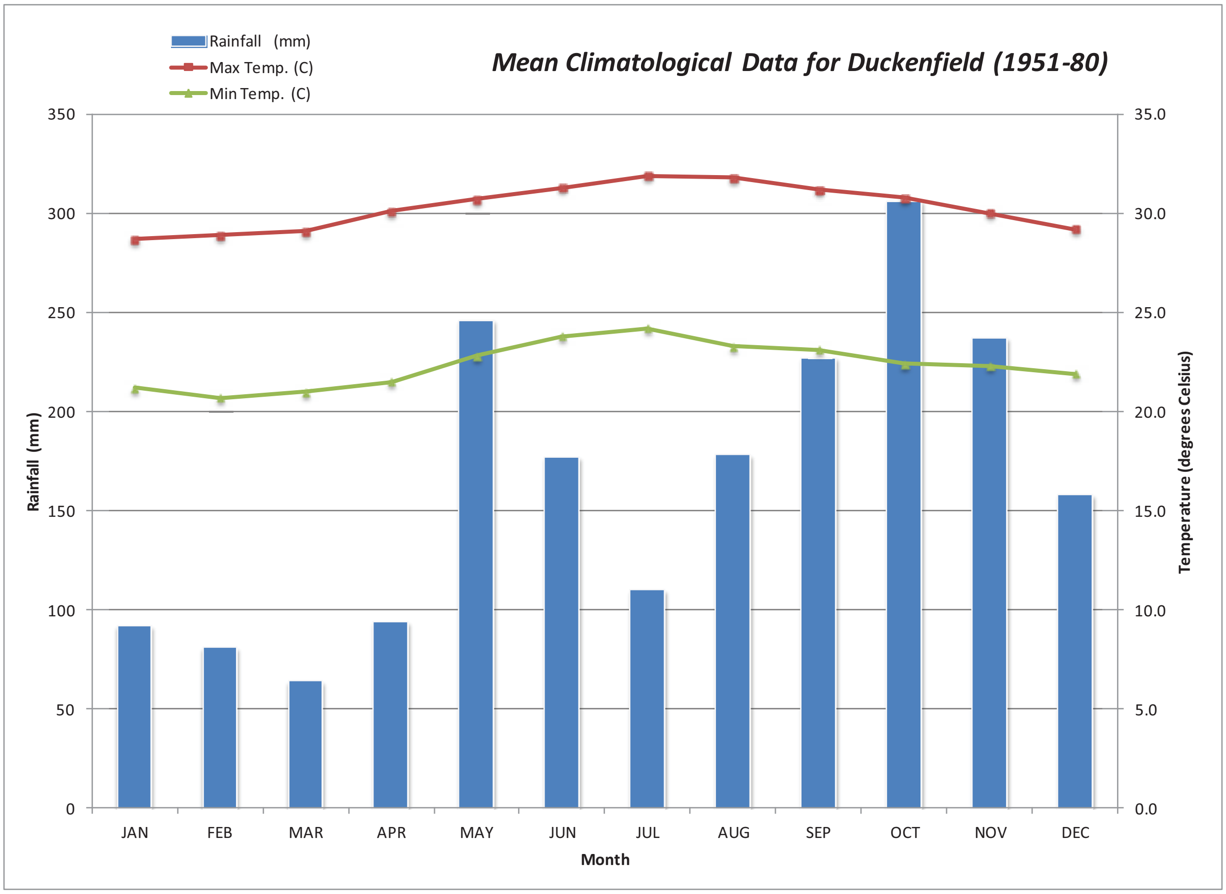


Figure 6.13 Mean Climatological Data for Duckenfield (1951-80) obtained from the Met Service

Extreme Rainfall

The rainfall data for gauges in Jamaica were obtained from the Meteorological Office of Jamaica. Information for the gauges spanned 1930 to 1980 and 1992 to 2008. Both sets of data were subjected to Weibull analysis for the extreme rainfall data ranging for the 2, 5, 10, 25, 50 and 100 year. Historical rainfall extremes for stations across the island for the period 1930 to 1988 were compared with the extremes determined for the period 1992 to 2008. Rainfall depths for corresponding return periods were subjected to comparative analysis in order to determine if there was an overall increase or decrease in extreme rainfall.

The analysis indicates that there has been an overall increase ranging from 11.7% (for the 2 year Return Period Event) to 1.5% (for the 100 year Return Period event) for all stations. This increase has occurred over a time frame of 21 years (1988 to 2009). This equates to 0.7% to 5.6% increase per decade. See and below:

Table 6.7 Overall increase in 24-hours rainfall intensity for the period between 1988 and 2009

	Return Period (yr)					
	2	**5**	**10**	**25**	**50**	**100**
Number of stations considered	117	117	117	117	117	116
Average increase (mm)	14.0	10.0	5.6	5.9	6.3	5.3
Average rainfall depth (mm) 1930 to 1988	119.8	175.0	217.7	268.2	307.8	345.7
Overall increase	11.7%	5.7%	2.6%	2.2%	2.1%	1.5%
Increase per decade	5.6%	2.7%	1.2%	1.0%	1.0%	0.7%

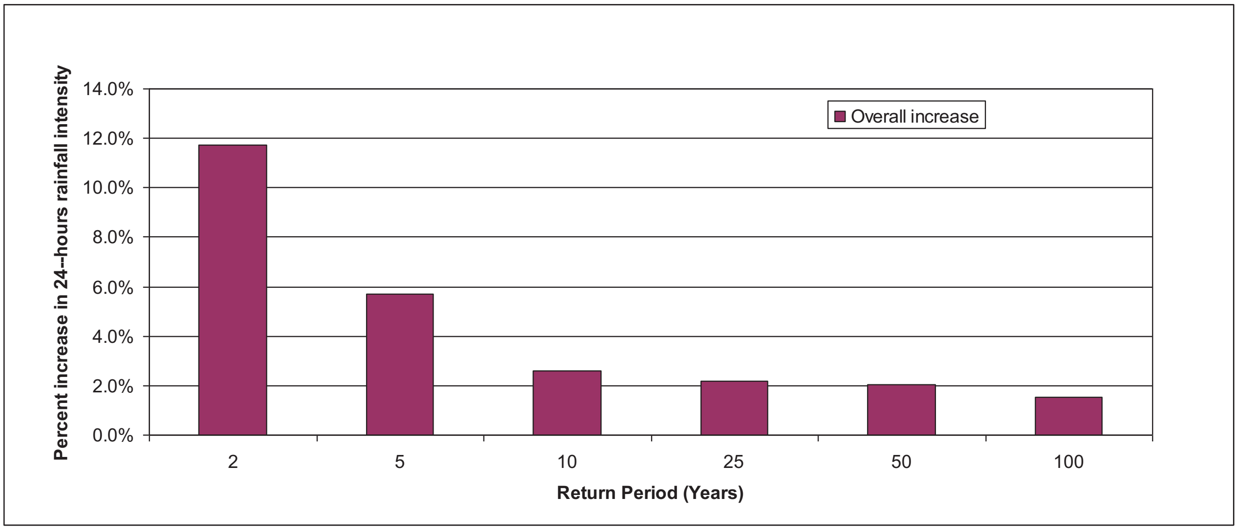


Figure 6.14 Overall increase in 24-hours rainfall intensity for the period between 1988 and 2009

Hydrological Model (SCS Model)

The methodology used for the analysis is as follows:

1. Data collection to include:
    a. Collection of soils information
    b. Collection of land use maps
    c. The topography of the catchments
    d. Anecdotal data collection
2. Delineating catchments and confirmation of streams/rivers
3. Calculating runoffs using the US Soil Conservation Service (SCS) method

SCS method is an empirical model for rainfall runoffs which is based on the potential for the soil to absorb a certain amount of moisture. On the basis of field observations, this potential storage, S, (millimetres or inches) was related to a 'curve number' *CN* which is a characteristic of the soil type, land use and the initial degree of saturation known as the antecedent moisture condition. Hydrological modelling of the watersheds encompassed three main elements:

- Precipitation
- Rainfall abstraction model (Curve number method)
- Runoff model (Dimensionless unit hydrograph)

The SCS curve number method was used to determine the rainfall excess P_e using the following equation:

$$P_e = \frac{(P^2 - I_a^2)}{P - I_a} + S$$

Where, P = precipitation

I_a = initial abstraction

S = Potential retention which is a measure of the retention capacity of the soil

The Maximum Potential retention, S, and the watershed characteristics are related through the Curve number CN.

$$S = \frac{25400 - (254 \times CN)}{CN}$$

Curve Numbers have been tabulated by the NRCS on the basis of soils group, soil cover or land use, and antecedent moisture conditions (initial degree of saturation).

6.1.3.2 Runoff Analysis

The peak runoffs were calculates using the type III rainfall distribution. The primary inputs into the model are as follows:

- Drainage area size (A) in square miles (square kilometres);
- Time of concentration (Tc) in hours;
- Weighted runoff curve number (RCN);
- Rainfall distribution (see Figure 6.15);
- Total design rainfall (P) in inches (millimetres).

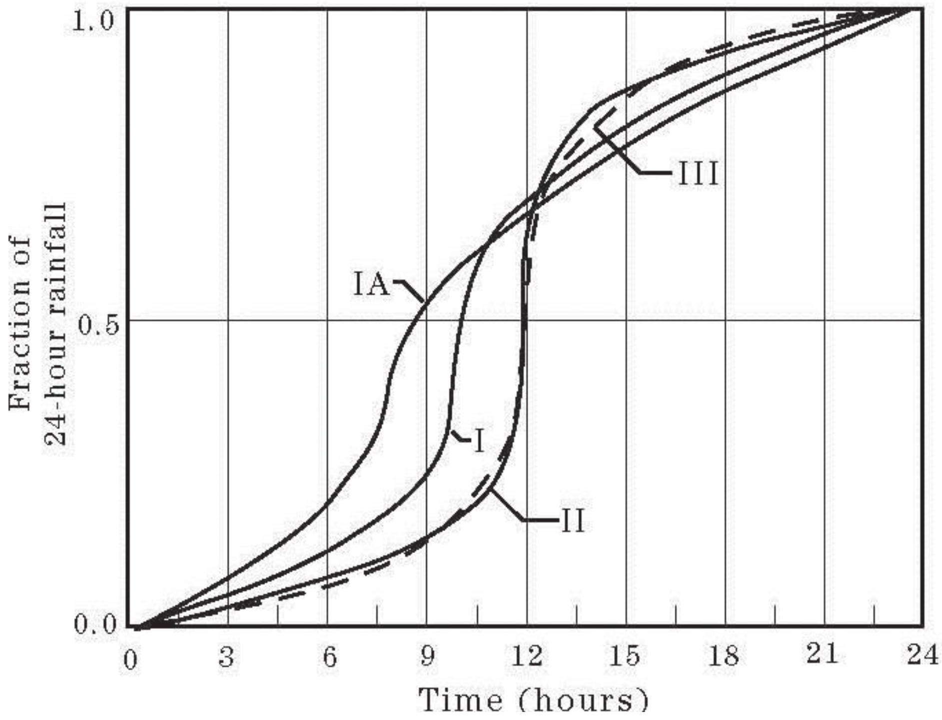


Figure 6.15 SCS 24-hour Rainfall Distributions

Proposed Halberstadt Site

Three (3) scenarios were modelled during the assessment: pre-development (existing), future conditions without any development and post development.

Existing and Post Development Conditions

The estimated peak runoffs were generated for the Halberstadt site catchment using the SCS method as described above. The peak runoffs ranged from 2.19 cubic metres per second to just below nine (8.82) cubic metres per second for the 2 year to 100 year return periods under existing conditions.

The post development condition showed a cumulative increase across the site catchment that is predicted to occur as a result of the clearing of vegetation and mining of the land surface; as the mining surface increases so does the surface runoff. The increases in peak runoffs that are estimated to occur are in the range of 0.18% to 0.68% for the 2 year to 100 year return periods under existing conditions (see Table 6.8). The corresponding 50 year return period peak runoffs are 7.63 cubic metres per second and 9.25 cubic metres per second under both existing and post development conditions respectively.

Table 6.8 Runoff generated for pre- and post-developmental conditions

Hydrology	**Units**	**Return Period**					
		1:2yr	**1:5yr**	**1:10yr**	**1:25yr**	**1:50yr**	**1:100yr**
Catchment area	HA	16.80	16.80	16.80	16.80	16.80	16.80
Catchment slope	%	23.86	23.86	23.86	23.86	23.86	23.86
Tc	hr	0.29	0.29	0.29	0.29	0.29	0.29
Peak runoff							
Existing Conditions	m^3/sec	2.19	3.68	4.84	6.42	7.63	8.82
Post Development	m^3/sec	3.68	5.30	6.49	8.07	9.25	10.42
Difference	%	0.68	0.44	0.34	0.26	0.21	0.18

Future Condition considering Climate Change

It was necessary to anticipate the impacts of climate change on the hydrology of the Halberstadt site. These impacts are to be taken into consideration given that it is recognized from our analysis as well as other international organisations that there is an increase in rainfall intensities. The rainfall intensities were therefore updated in accordance with Table 6.7 to reflect the impacts of climate change in the future. It is recommended that such parameters are implemented in designing the drainage system to ensure the subdivision is protected should these intense storms occur in the future.

The resulting flows from the catchment showed a maximum flow of 4.97 cubic metres per second to 10.81 cubic metres per second for the 2 year to 100 year return periods under post construction conditions with the consideration of climate change. These peak flows indicate an increase of between 0.04% and 0.35% respectively and can be attributed strictly to climate change (see Table 6.9).

Table 6.9 Runoff generated for the post-developmental conditions

Hydrology	Units	Return Period					
		1:2yr	1:5yr	1:10yr	1:25yr	1:50yr	1:100yr
Catchment area	HA	16.80	16.80	16.80	16.80	16.80	16.80
Catchment slope	%	23.86	23.86	23.86	23.86	23.86	23.86
Tc	hr	0.29	0.29	0.29	0.29	0.29	0.29
Peak runoff							
Post Development	m^3/sec	3.68	5.30	6.49	8.07	9.25	10.42
Post Development wit	m^3/sec	4.97	6.13	6.93	8.51	9.75	10.81
Difference	%	0.35	0.16	0.07	0.05	0.05	0.04

Bull Park River Catchment

Three (3) scenarios were also simulated during the evaluation of the overall catchment: pre-development (existing), post development without climate change and post development with climate change. The runoff generated for the bull park river catchment, under existing conditions, was determined to be 1,058 cubic metres per second for a 100-yr return period event. This value is based on an overall catchment with an approximate area of 2,197 hectares and a slope of 14.89%.

Future development within the catchment was then applied to the model without considering the effects of climate change. The expected runoff determined within the catchment is approximately 1,064 cubic metres per second considering further development within the catchment (see Table 6.10).

Climate change was then applied to the design rainfall to reflect future hydrological conditions with post development. The runoff that is predicted to be generated within the bull park river catchment is approximately 1,116 cubic metres per second considering climate change with further development.

Table 6.10 Runoff Analysis conducted for overall Bull Park River catchment

Bull Park River Catchmet				
Hydrology	Units	Existing Conditions	Post Development without Climate Change	Post Development with Climate Change
Catchment area	HA	2197	2197	2197
Design Rainfall	mm/24-hour	382	382	395
Return period	Years	100	100	100
Tc	hrs	1.42	1.42	1.42
Catchment slope	%	14.89%	14.89%	14.89%
Peak runoff	m^3/sec	1057.6	1064.2	1115.8

6.1.3.3 Runoff Impacts

Proposed Halberstadt Site

The following impacts are expected onsite when the quarry is reopened:

1. The peak flows will increase by 18.38 % from the current scenario.
2. The most significant impacts that the reopening of the quarry will have on drainage within the catchment and immediate area is the cutting off of natural drain channels and pathways that navigate the mountainous terrain. This will result in localized flooding in especially in areas with depressions.
3. There are numerous natural drainage paths which also cross the proposed roads leading to the Halberstadt site and some will need culvert openings.

A detailed drainage plan should be created for the post construction scenario for future conditions which shall include but not limited to:

a) Perimeter cut-off drains surrounding the proposed deposition area - minimise surface water run-off into the quarry workings. Where there are discharges of process water from quarry developments to surface watercourses, emission limits will be specified in the conditions of the discharge licence
b) Sediment basins – to allow deposition and storage of sediments preventing contamination and silting of Bull Park River.
c) Oil Interceptors - the drainage system of the fuelling area fitted with interceptor in the event of a spill.

Given the observed climate change trends, it is recommended that the design runoffs for the future scenario be used to implement all drainage infrastructures.

Bull Park River Catchment

The following impacts are expected throughout the overall catchment when the quarry is reopened:

1. The peak flows will increase by 0.62 % from the current scenario without considering climate change.
2. The Bull Bay area (Ten Miles) is identified as a flood prone area by the Office of Disaster and Emergency Management (ODPEM), will be affected by sediment transport from the quarry via the Bull Park River.

This minor increase (0.62%) in runoff can be attributed to the change in land cover of the Halberstadt site. This runoff increase will not be significant enough to cause any additional flooding, if any, to the downstream communities. A detailed study should be conducted to include historical flooding of all areas downstream of the proposed site. This should include flood plain analysis as well as sediment transport schematics.

6.1.3.4 Historical Considerations

Anecdotal Data Collection

ODPEM currently list Bull Bay (10 Miles) as a flood prone area. They have however not delineated the upstream areas that are more susceptible. CEAC Solutions therefore interviewed available residents while visiting the Benoa community, located approximately 1km from the deposit. The anecdotal information, along with our field observations, revealed that the most immediate community, Benoa, is not affected by runoff generated by the quarry site (see *Table 6.11*).

Table 6.11 Anecdotal data collected throughout the Benoa community

ID	Name of Interviewee	Age (years)	Time in Area (years)	Storm	Year	Flooding		Comments
						Interview location (WP#)	Depth of water (m)	
1	Roy Dickens	75	75	--	--	529	--	no drainage path; no flooding, dry gully; nearby soil drains quickly
2	Emilita Ambler	66	66	--	--	530	--	no flooding; runoff doesn't affect residents; sand deposited
3	Rohan Robinson	25	25	--	--	531	--	water or debris doesn't affect residents; sand is washed from road
4	Omar Gayle	19	19	--	--	532	--	road gets damaged during heavy rains
5	Adrian Gordon	33	33	--	--	533	--	flooding doesn't affect residence; no debris/silt

Desktop Literature Research

A literature review discusses published information in a particular subject area, and sometimes information in a particular subject area within a certain time period. Prior to data collection from the field, relevant literatures were analysed from the field relevant to environment, impact on the environment and mitigation measures, EIA, stone and sand quarry, and study area related journals, books, reports, etc. Information was also collected from different public and private organizations.

In recent years numerous publications have addressed issues related to quarrying activities in general, as well as issues specifically related to human impacts on the environment. Publications addressing the impacts of mining activities on the environment and relevant population including a report entitled The Issue of Borrow Pits Being Used in the Aggregate and Sand Industry (Delport, 2013); an extract from Swaziland Greenstone Quarry EIA and and Comprehensive Mitigation Plan (Swaziland National Trust Commision, 2013); a publication by Mid-America Regional Council (MARC) entitled Keep Sediment Out of Our Water (Mid-America Regional Council, 2013); a publication by US EPA entitled SPCC Requirements and Pollution Prevention Practices for Mines and Quarries (United States Environmental Protection Agency, 2012); a report entitled Landscape and Visual Impact Assessment (Hodgetts, 2012); documentation on Guidelines for Planning Authorities (Department of the Environment, Heritage and Local Government, 2004); a publication entitled Freshwater Ecosystems Biodiversity Management Issues (Department of Natural Resources and Environment (NRE), 2001); an extract from Impact on Quarries on Karst Groundwater Systems (EKMEKÇI, 1993); a report entitled Reducing the Environmental Effect of Aggregate Quarrying on the Water Environment (Thompson & Howarth, 2007); a publication on Potential Environmental Impacts of Quarrying Stone in Karst (Langer, 2001); a report entitled Quarry Hills PSP Integrated Water Management Strategy (CPG Australia Pty Ltd, 2012) and a report entitled Environmental Impact Assessment of the Proposed Limestone Mining Project at Rose Hall in Clarendon (EnviroPlanners Ltd, 2008). Few of the reports in the publications listed above are primarily concerned with quarrying in karst; however, those publications do illustrate the complexities of cause and effects of quarrying activities.

Although a relationship between environmental damage and quarrying of stone has been well documented for over fifty years (Thompson & Howarth, 2007), there are only a few reports that include major discussions of the environmental impacts of quarrying on surface waters and groundwater supply. These reports include Quarries and Ancillary Activities: Guidelines for Planning Authorities (Department of the Environment, Heritage and Local Government, 2004), Sedimentation of Rivers and Streams (Department of Natural Resources and Environment (NRE), 2001), Impact of Quarries on Karst Groundwater Systems (EKMEKÇI, 1993). There are a few individual reports scattered through the literature that address the recommended mitigation steps against the environmental impacts of quarrying (Thompson & Howarth, 2007). In addition, there are reports that describe environmental impacts on karst from mining resources other than gypsum, such as carbonate rock and limestone (Swaziland National Trust Commision, 2013). Theories about how extraction of gypsum can impact the environment can be extrapolated from some of these reports.

6.1.3.5 Limitations

Landslide susceptibility maps are compiled and derived from a variety of data sources. The landslide inventory includes existing data that have been verified in the field, and also data which was developed from aerial photo-interpretation. The accuracy and precision of the susceptibility map is therefore dependent on the original data, scale transformations, coordinate system and the process of map compilation. As with any map, scale is an important consideration. The methodology used for this project is mostly driven by the landslide inventory; therefore it will predict high landslide susceptibility for locations which share common properties with failed areas. However, this technique has both its strengths and weaknesses. The most important advantage is that this method does not require profuse or comprehensive geotechnical data. On the other hand, deficiencies in the landslide inventory may have an adverse effect on the final landslide susceptibility map.

6.1.3.6 Conclusions

The following could be concluded from the analysis conducted to date:

1. The catchment for site is primarily bounded by the natural topography in the area and drains in a south-east direction. The estimated 100 year peak flow from this catchment is expected to increase during the operation of the quarry by 0.62%.
2. The increases in flows are not expected to significantly affect the flows in the Bull Park River.
3. The reopening of quarry activities may increase sediment load in the Bull Park River which may lead to induced flooding.
4. There are no historical flood events on the Halberstadt site or within the Benoa community south of the proposed site.
5. The Halberstadt site is composed of mainly gravelly sandy loam and clay loam soil types.

6.1.4 Water Quality

6.1.4.1 Methodology

Water quality sampling was conducted on July 19th and 30th, 2013. Two freshwater stations (HWQ1, HWQ2) and four marine stations (HWQ3, HWQ4, HWQ5 and Background) were sampled. Table 6.12 lists the coordinates of the water quality stations, and Figure 6.16 illustrates their locations.

Samples were collected in pre-sterilized bottles, stored on ice and taken to Caribbean Environmental Testing and Monitoring Services Limited (CETMS Ltd.) for analysis of Fats Oil and Grease (FOG), Total Suspended Solids (TSS), phosphates, nitrates, and faecal coliform.

Temperature, conductivity, salinity, pH, Dissolved Oxygen (D.O.), turbidity, Total Dissolved Solids (TDS) and light irradiance (Photosynthetically Active Radiation – PAR) were measured in situ using a Hach Hydrolab DataSonde-5 multi probe water quality meter (see Appendix 8 Calibration Certificate).

The results of the data collected were compared with National Environment and Planning Agency (NEPA) and international standards where applicable.

Table 6.12 Location of water quality stations

Station	Type	Northing	Easting
Background	Marine	641855.68	784835.79
5		642984.25	785398.13
4		643033.15	785148.88
3		643158.92	784949.1
1	Freshwater	644354.4	786669.24
2		646106.68	786161.71

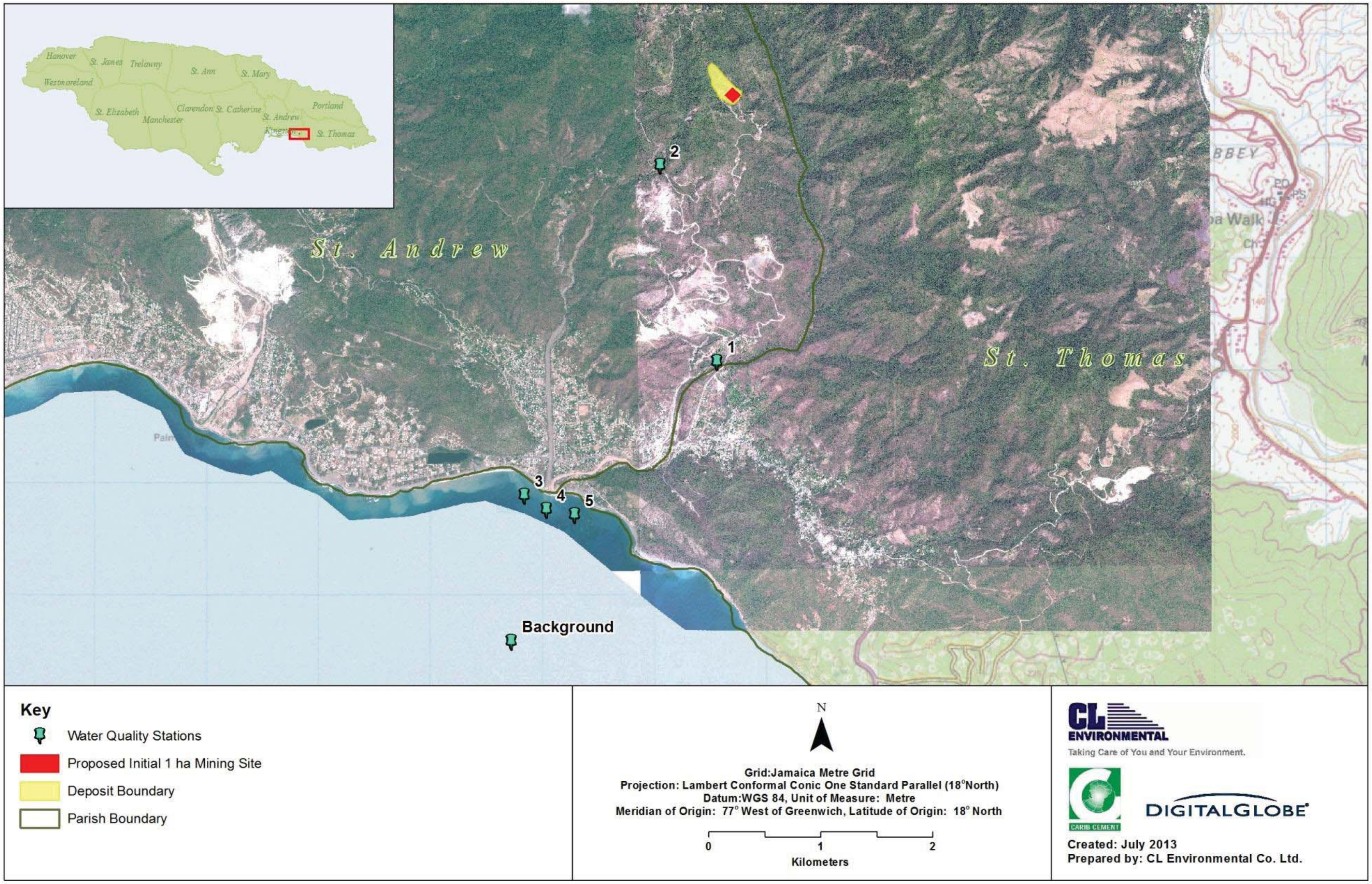


Figure 6.16 *Map depicting the water quality stations*

6.1.4.2 Results

The water quality results reflect the average values of two sampling occasions on July 19 and 30 20103 (Table 6.13, Table 6.14 and Table 6.15).

The freshwater stations sampled showed little variation in many of the physicochemical variables examined. However, faecal coliform, nitrate and phosphate levels were elevated at both stations. This would indicate the influx of organic matter into the freshwater systems sampled.

Table 6.13 Average values for physical parameters by depth at the marine stations

Stn.	Depth (m)	Temp. (C^{o})	SpC. (mS/cm)	Sal. (ppt)	pH	PAR (uE/m^2/s)	DO (mg/l)	Tur. (NTU)	TDS (mg/l)
3	0	28.93	52.68	34.8	7.94	1507.50	6.14	4.1	33.71
	1	28.93	52.65	34.77	7.94	1066.00	6.14	4.3	33.70
	2	28.92	52.63	34.77	7.94	730.50	6.11	4.55	33.69
	3	28.93	52.59	34.74	7.94	558.00	6.06	4.75	33.645
4	0	28.89	52.51	34.68	7.94	2168.50	5.98	4.05	33.61
	1	28.90	52.51	34.67	7.94	1821.00	5.99	4.35	33.60
	2	28.90	52.52	34.68	7.94	853.50	6.01	4.15	33.62
	3	28.88	52.53	34.68	7.94	1047.00	6.32	3.95	33.62
5	0	28.91	52.58	34.73	7.94	1024.00	6.05	2.85	33.65
	1	28.91	52.58	34.72	7.94	686.00	6.06	2.80	33.65
	2	28.92	52.58	34.73	7.94	1132.50	6.05	2.70	33.65
	3	28.92	52.59	34.73	7.94	1018.00	6.03	2.80	33.66
	4	28.91	52.58	34.73	7.94	550.5	6.08	2.95	33.65
Bckgd	0	29.00	52.45	34.66	7.94	1566.50	6.44	1.05	33.57
	1	29.00	52.46	34.63	7.94	1043.50	6.43	1.30	33.58
	2	29.00	52.48	34.66	7.94	887.5	6.44	1.4	33.59
	3	29.00	52.59	34.62	7.94	1173.50	6.45	1.25	33.59
	4	28.99	52.48	34.64	7.94	796.50	6.44	1.30	33.60
	5	28.99	52.48	34.66	7.95	729.50	6.42	1.40	33.60
	6	29.00	52.50	34.65	7.94	615.50	6.43	1.60	33.59
	7	28.99	52.48	34.65	7.95	682.50	6.43	1.80	33.60
	8	28.99	52.49	34.66	7.95	573.50	6.45	1.90	33.59
	9	28.99	52.49	34.67	7.95	560.00	6.43	2.05	33.59
	10	28.99	52.49	34.66	7.95	505.5	6.45	2.15	33.59
	15	28.985	52.495	34.66	7.95	362	6.44	2.3	33.595
	20	28.99	52.49	34.655	7.95	266.5	6.45	2.5	33.75

Table 6.14 Average values for physical parameters at freshwater stations

Stn.	Temp. (C^{o})	SpC. (uS/cm)	Sal. (ppt)	pH	DO (mg/l)	Turbidity. (NTU)	TDS (mg/l)
1	27.44	1.02	0.53	8.03	7.26	2.75	0.65
2	25.77	0.58	0.30	7.97	7.85	3.13	0.37

Table 6.15 Average results for biological and chemical parameters at all stations

	Stn.	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	FOG (mg/l)	F. Coli (MPN/ 100ml)
Freshwater stations	1	2	0.55	0.19	2.5	>230
	2	3.5	0.6	0.195	3	175
Marine stations	3	2	1.1	0.06	2.5	30.5
	4	1	1.05	0.045	3	<11
	5	1.5	0.85	0.04	1.5	<11
	Bckgd	0.5	0.95	0.04	2	<11

Temperature

Average temperature values for the marine stations varied little across the stations ranging from 28.88 – 29.00C. The highest temperature was reported at the background station and lowest temperature was at station HWQ4. Compared with depth, the temperature at each station varied little with most stations showing a decrease with depth (Figure 6.17). The background station showed a well-mixed layer up to 20m.

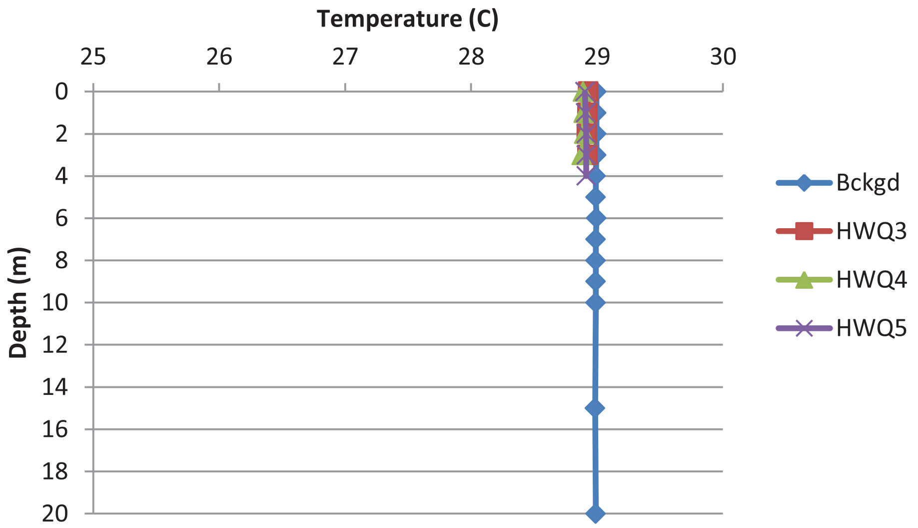


Figure 6.17 Average temperature variation across the marine sampling stations

Specific Conductivity

Average specific conductivity values for the marine stations varied little across the stations ranging from 52.45 – 52.68uS/cm. The lowest values were reported at station HWQ4 and the background station had the highest value. When compared with depth the conductivity varied little with most stations showing a slight increase.

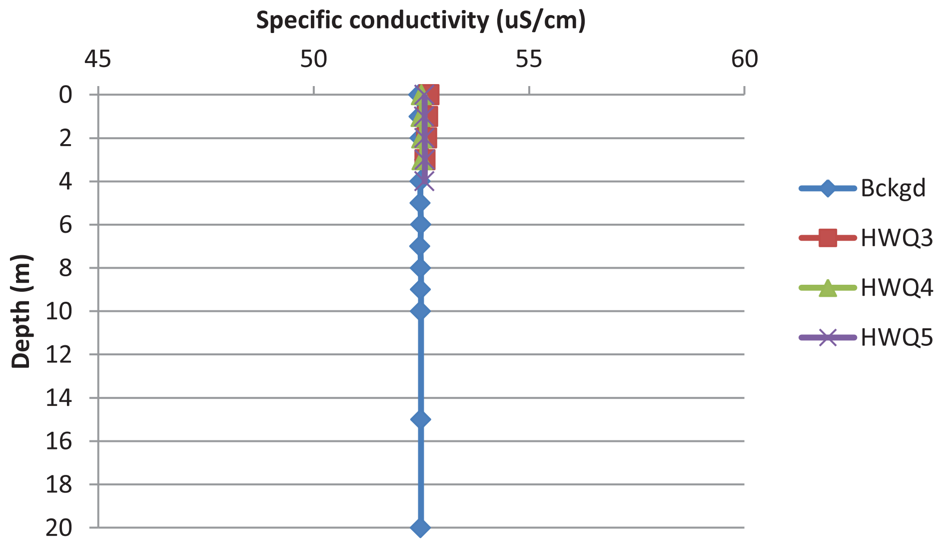


Figure 6.18 Average conductivity variation across the marine sampling stations

Salinity

Average salinity values varied little across the stations ranging from 34.62 – 34.77ppt. The background station reported the lowest value and the highest value were observed at station HWQ3. When compared to depth, the values at each station showed little variation indicating a well-mixed layer to 20m within the area (Figure 6.19).

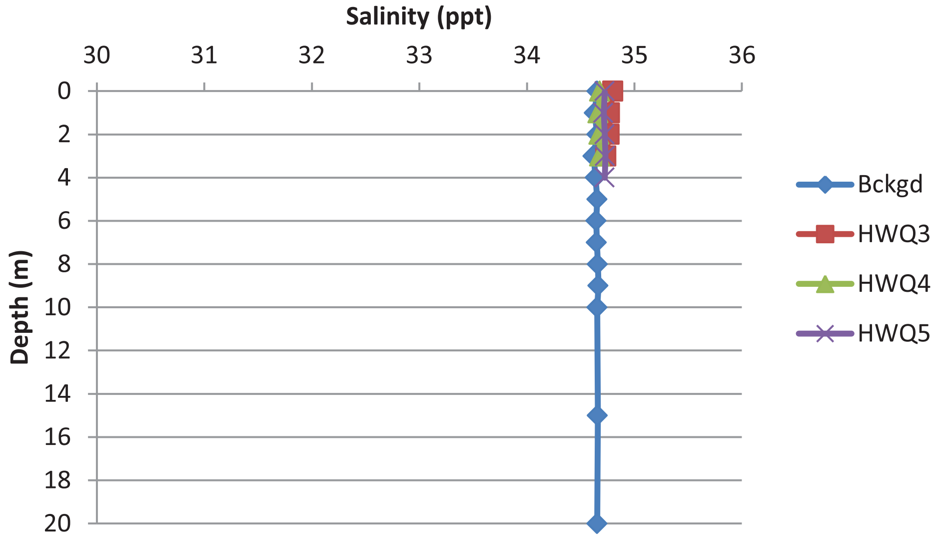


Figure 6.19 Salinity variation across the marine sampling stations

pH

Average pH values varied very little across stations ranging from 7.94 – 7.95. Low pH values were observed at all stations and the highest value was observed at the background station. When compared to depth the pH values at each station showed little variation (Figure 6.20).

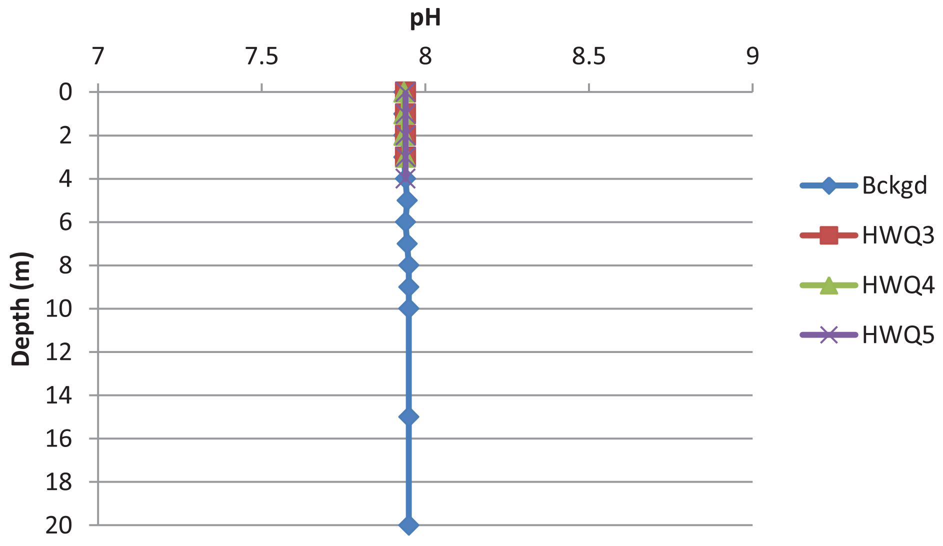


Figure 6.20 pH variation across the marine sampling stations

Photosynthetically Active Radiation (PAR)

Average PAR varied greatly across stations ranging from 505.5 – 1507.5uE/m²/s. The highest PAR values were observed at station HWQ3, whereas the lowest value was reported at the background station. When compared to depth, the PAR values showed a general decrease at each station (Figure 6.21). The decrease in PAR is expected as less light is able to penetrate with increasing depth. Cloud cover, time of day, and the presence of organic and inorganic material also affect the amount of PAR available.

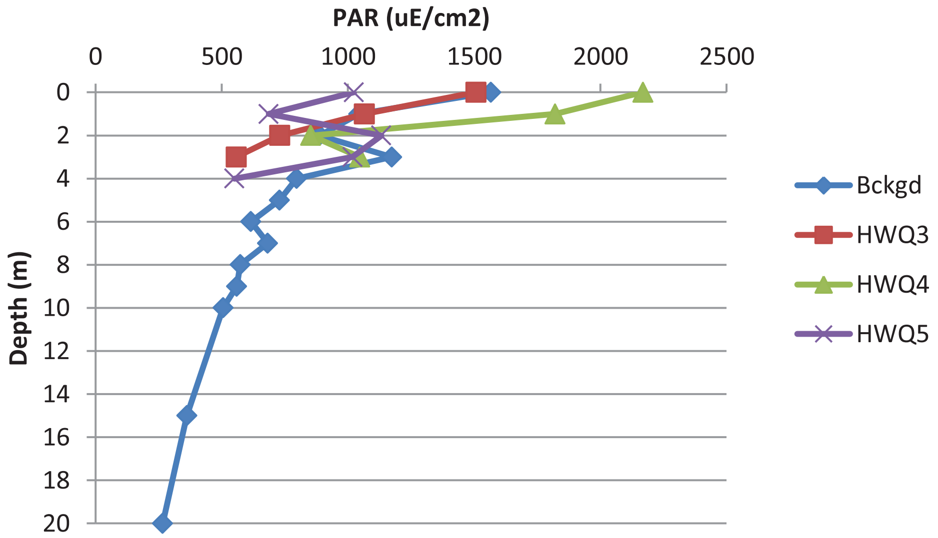


Figure 6.21 PAR variation across sampling stations

Light Extinction Coefficient

Average extinction coefficient values varied across the stations ranging from -0.11 – 0.33. The lowest coefficient value was obtained at the background station, which indicates the greatest light penetration. The highest EC value was obtained at station HWQ3 which showed the worst light penetration (Figure 6.22).

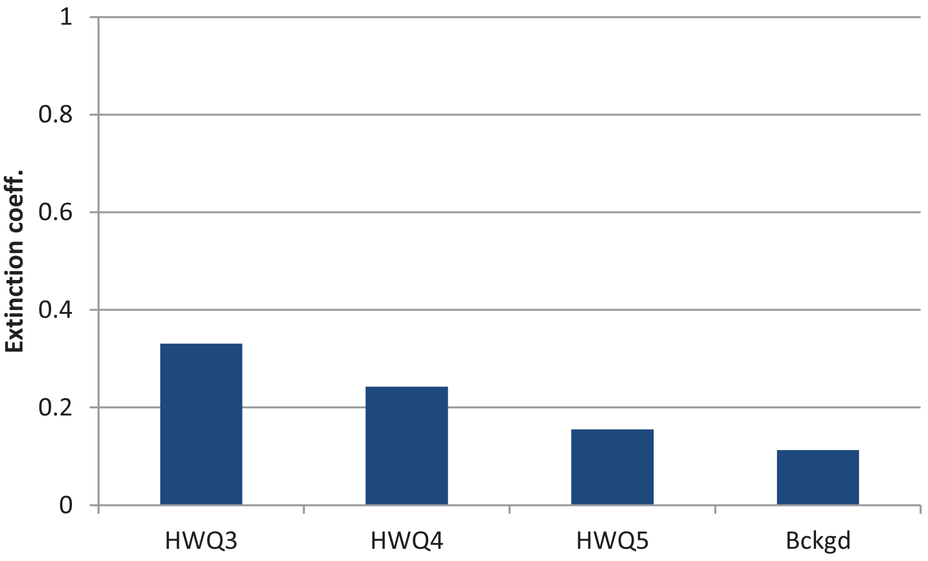


Figure 6.22 Average light extinction coefficient across sampling stations

Dissolved Oxygen (DO)

Average dissolved oxygen values varied across the stations ranging from 5.98 – 6.45mg/l. The highest DO values were reported at the background station and the lowest values were at station HWQ4. When compared to depth, the DO levels varied at each station with most stations showing a slight increase (Figure 6.23).

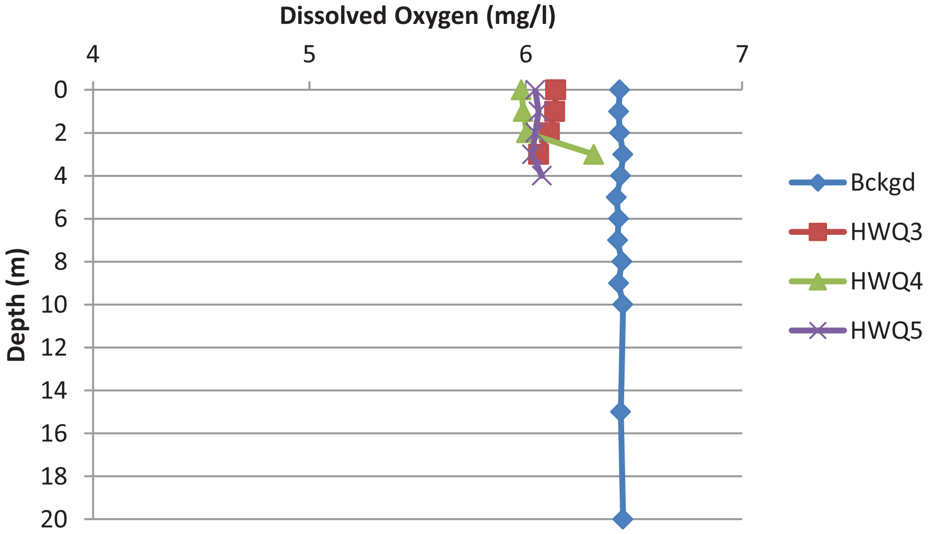


Figure 6.23 Average D.O. variation across the marine sampling stations

Turbidity

Average turbidity values varied across the stations ranging from 1.05 – 4.75NTU. The lowest turbidity values were reported at the background station and station HWQ3 had the highest value. Turbidity values varied when compared to depth at each station, with most stations showing an increase except station HWQ4 (Figure 6.24). The background station, had turbidity values less than 3NTU, which indicates little biological or non-biological factors affecting its turbidity in the first 20m. Stations HWQ3, 4 and 5 were located close to shore and near to the mouth of the river which would account for the slightly elevated turbidity values.

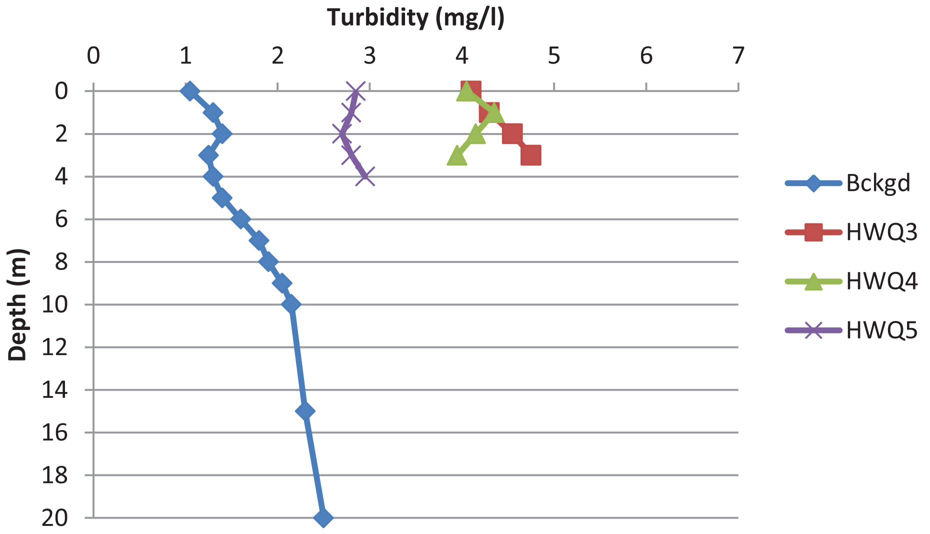


Figure 6.24 Average Turbidity variation across the marine sampling stations

Total Dissolved Solids (TDS)

Average TDS varied little across the stations ranging from 33.54 – 33.75g/l. Lowest TDS value was reported at station HWQ3 and the highest value was observed at the background station. When compared to depth at each station, the values showed little variation (Figure 6.25).

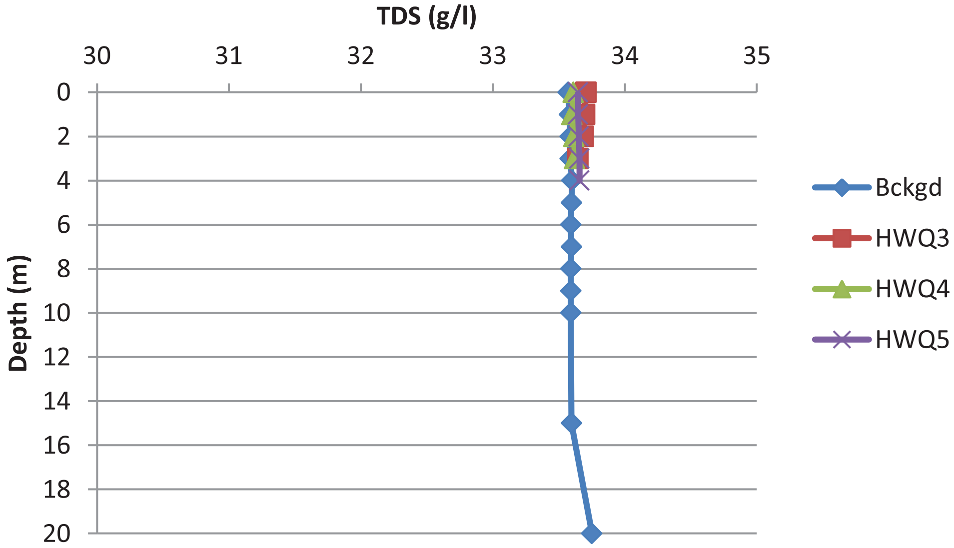


Figure 6.25 Average TDS variation across the marine sampling stations

Total Suspended Solids (TSS)

Average TSS values varied across the stations ranging from 1 – 3.5mg/l. The freshwater stations values were generally higher than the marine stations. Station HWQ2 (freshwater) reported the highest value and the lowest values were observed at the background station (Figure 6.26).

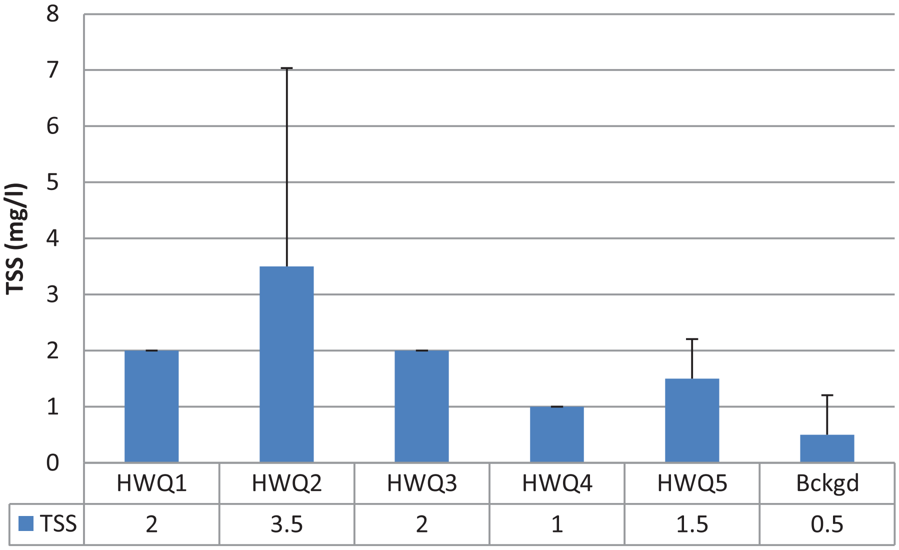


Figure 6.26 TSS variation across sampling stations with standard deviation

Nitrates

Average nitrate values varied little across the stations ranging from 055 – 1.1mg/l (Figure 6.27). The freshwater stations (HWQ1 and 2) had lower values when compared to the marine stations. This would indicate the input of nutrients from other sources into the marine environment. In comparison, a study by Webber *et al* (2003) in Kingston Harbour found a maximum nitrate concentration of 2.8mg/l. This could indicate the influx of nutrients from run off from the nearby rivers and gullies. All stations were above the Draft Jamaica National Ambient Water Quality Standard for Seawater for nitrates of 0.014mg/l.

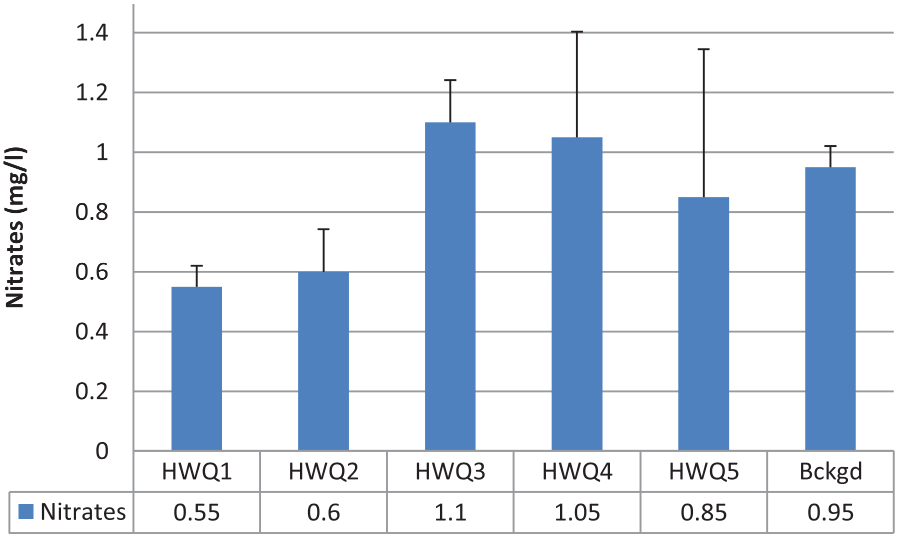


Figure 6.27 Nitrate variation across sampling stations with standard deviation

Phosphates

Phosphate values varied across the stations ranging from 0.04 – 0.195mg/l. Highest phosphate value was reported at station HWQ2 and the lowest value was observed at station HWQ5 and the background station (Figure 6.28). The freshwater stations had higher values when compared to the marine stations with the station HWQ3 having the highest value for the marine stations (0.06mg/l). These levels are comparable to phosphate levels found in Kingston Harbour by Webber *et al.* (2003), which found a maximum concentration of 0.06mg/l. This would indicate a source of nutrient loading to the area from run-off from the nearby town or from the numerous rivers in the area. All stations were above the Draft Jamaica National Ambient Water Quality Standard for Seawater for phosphates of 0.003mg/l.

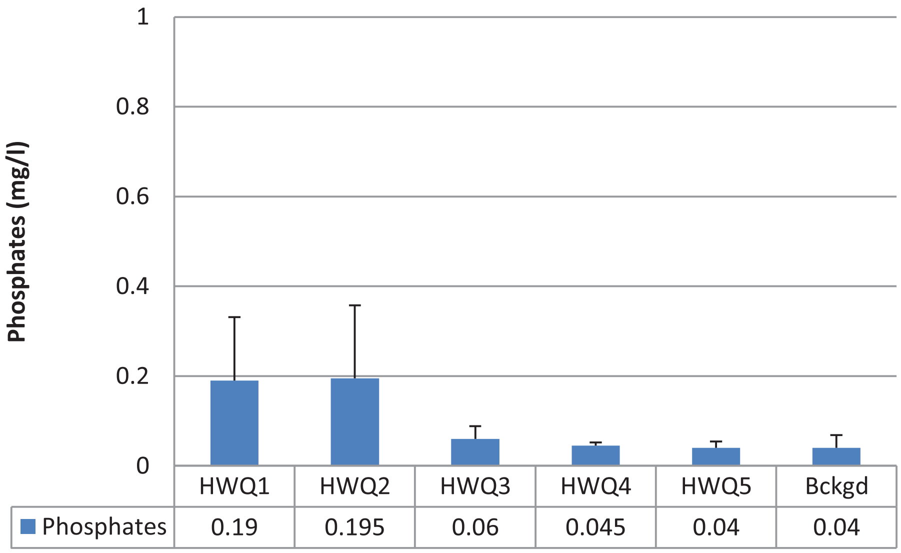


Figure 6.28 Phosphate variation across sampling stations with standard deviation

FOG

FOG values varied across the stations ranging from 1.5 – 3mg/l (Figure 6.29). Highest FOG value was reported at station HWQ2 and 4, whereas the lowest values were observed at station HWQ5.

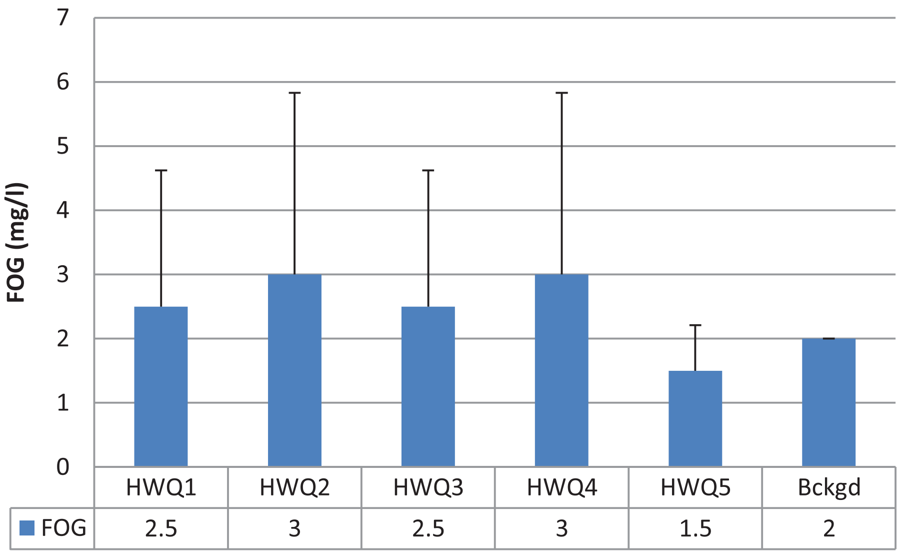


Figure 6.29 FOG variation across sampling stations with standard deviation

Faecal Coliform

Faecal coliform values for the marine stations were below the detectable limit of <11MPN/100ml except for station HWQ3. The two freshwater stations showed the highest values ranging above 150MPN/100ml (Figure 6.30). The freshwater stations were located in near proximity to residences and small ruminant farming which could account for the elevated levels observed at these stations. All marine stations were below the Draft Jamaica National Ambient Water Quality Standard for Seawater of 13MPN/100ml except station HWQ3.

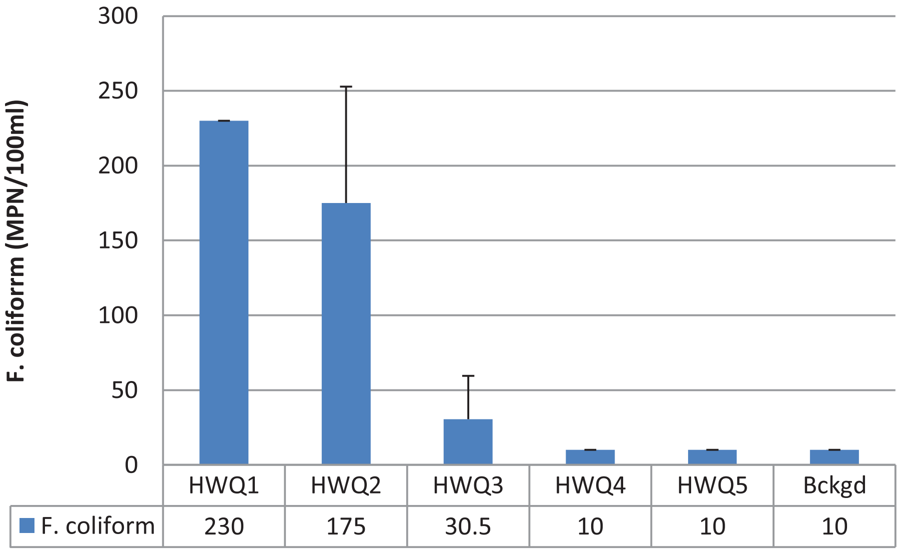


Figure 6.30 Faecal Coliform variation across sampling stations with standard deviation

6.1.5 Ambient Noise Climate

6.1.5.1 Methodology

A data logging noise survey exercise was conducted to establish baseline conditions at the boundaries of the proposed quarry site and its environs. The data logging exercise was conducted for seventy two (72) hours between 7:00 hrs Thursday 27th June, to 7:00 hrs Sunday 30th, June 2013. The readings were taken at eight (8) locations (Stations N1 – N8) listed below in Table 6.16 and depicted in Figure 6.31.

Table 6.16 Noise Station numbers and locations in JAD2001

STATION	LOCATION	JAD 2001	
		Northing (m)	Easting (m)
N1	NW Boundary	646775.22	786772.97
N2	NE Boundary	646775.22	786853.41
N3	SE Boundary	646700.97	786854.44
N4	SW Boundary	646699.94	786765.75
N5	Residential Community	644530.98	786822.67
N6	Residential Community	644405.51	786607.23
N7	Bull Bay All Age School	643799.86	786460.89
N8	Bito Primary and Infant School	645954.58	785508.11

Noise level readings were taken by using Quest Technologies SoundPro DL Type 1 hand held sound level meters with real time frequency analyser setup in outdoor monitoring kits. The octave band analysis was conducted concurrently with the noise level measurements. Measurements were taken in the third octave which provided thirty three (33) octave bands from 12.5 Hz to 20 kHz (low, medium and high frequency bands).

The noise meters were calibrated pre and post noise assessment by using a Quest QC - 10 sound calibrator (Appendix 9). The meters were programmed using the Quest suite Professional II (QSP II) software to collect third octave, average sound level (Leq) over the period, Lmin (The lowest level measured during the assessment) and Lmax (The highest level measured during the assessment) every ten (10) seconds.

Average noise levels over the period were calculated within the QSP II software using the formula:

$$\textbf{Average dBA} = 20 \log 1/N \sum_{j=1}^{N} 10^{(Lj/20)}$$

Where N = number of measurements
L_j = the jth sound level
$j = 1, 2, 3 \ldots. N$

A windscreen (sponge) was placed over the microphone to prevent measurement errors due to noise caused by wind blowing across the microphone. Plate 6.6 shows one of the noise monitoring outdoor kits.


06/26/2013

Plate 6.6 Photo showing noise meter at Station N7

.

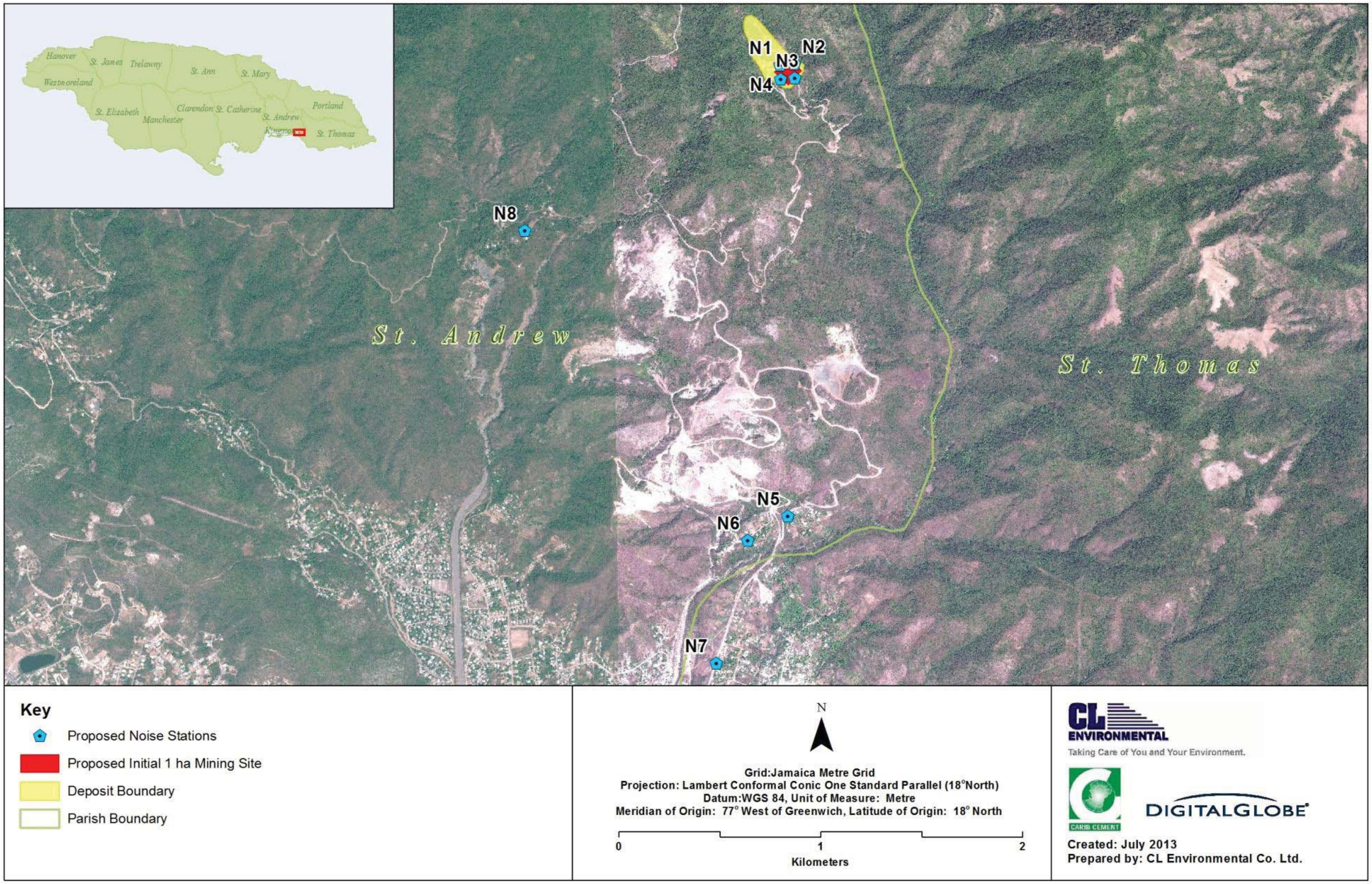


Figure 6.31 Map depicting the noise survey stations

6.1.5.2 Results

This section outlines the results of the seventy two (72) hour noise monitoring exercise at the eight (8) monitoring stations.

Station 1- NW Boundary

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 24.9 dBA to a high (Lmax) of 78.9 dBA. Average noise level for this period was 53.5 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 6.32.

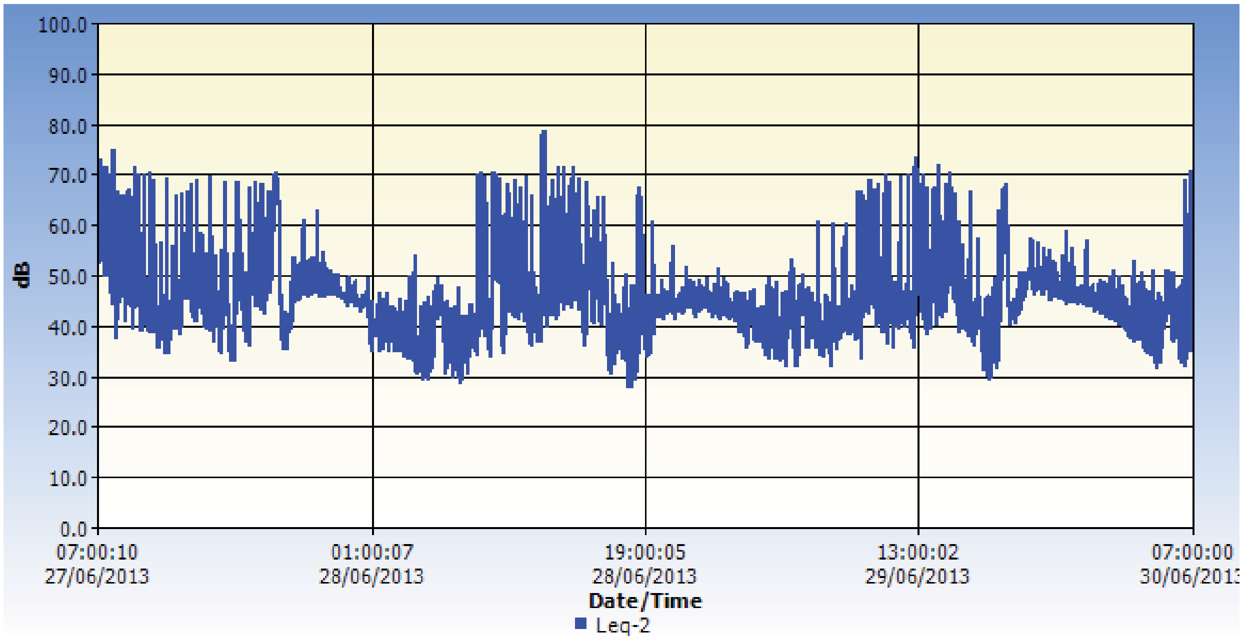


Figure 6.32 Noise fluctuation (Leq) over 72 hours at Station 1

Octave Band Analysis at Station 1

The noise at this station during the 72 hour period was in the high frequency band centred around the geometric mean frequency of 3.15 kHz. (octave frequency range is 2807 - 3534 Hz) (Figure 6.33).

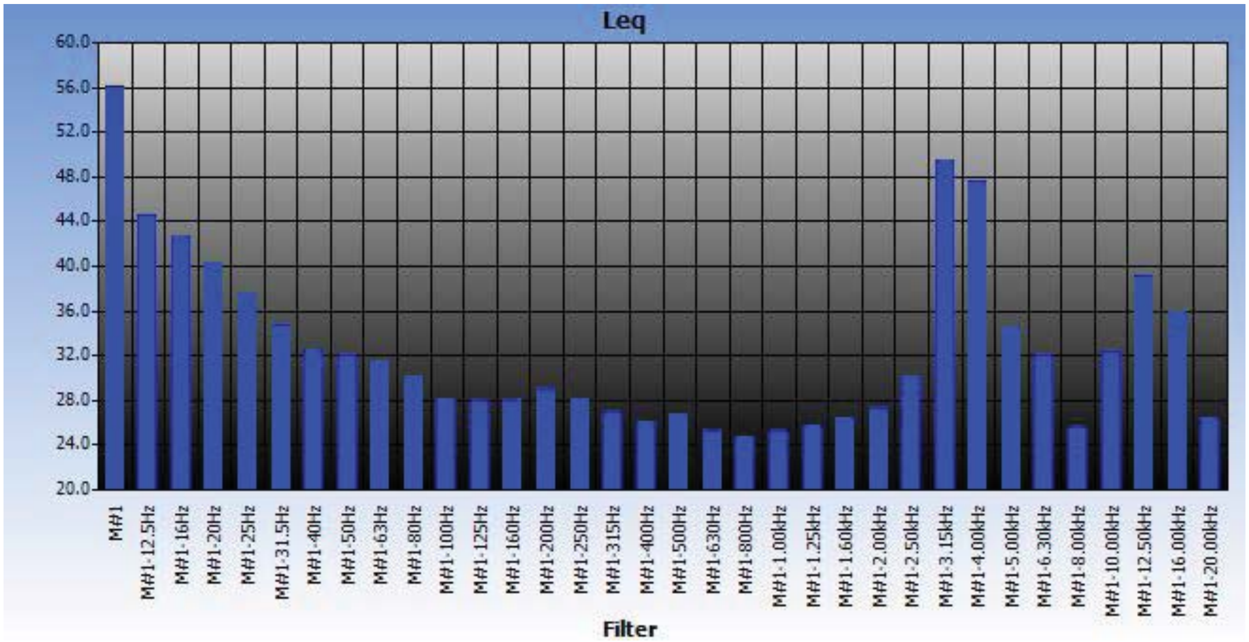


Figure 6.33 Octave band spectrum of noise at Station 1

L10 and L90 – Station 1

The two most common L_n values used are L_{10} and L_{90} and these are sometimes called the 'annoyance level' and 'background level' respectively. L_{10} is almost the only statistical value used for the descriptor of the higher levels, but L_{90}, is widely used to describe the ambient or background level. L10-L90 is often used to give a quantitative measure as to the spread or "how choppy" the sound was.

L10 is the noise level exceeded for 10% of the time of the measurement duration. This is often used to give an indication of the upper limit of fluctuating noise, such as that from road traffic. L90 is the noise level exceeded for 90% of the time of the measurement duration. The difference between L10 and L90 gives an indication of the noise climate. When the difference is < 5 dBA then it is considered that there are no significant fluctuations in the noise climate, moderate fluctuations 5-15 dBA and large fluctuations >15 dBA.

Figure 6.34 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) ≈59.7% of the time, no significant fluctuations (L10 – L90) ≈15.2% of the time and large fluctuations (L10 – L90) ≈25.1% of the time, in the noise climate at this station. The overall L10 and L90 at this station for the time assessed were 53.3 dBA and 36.5 dBA respectively.

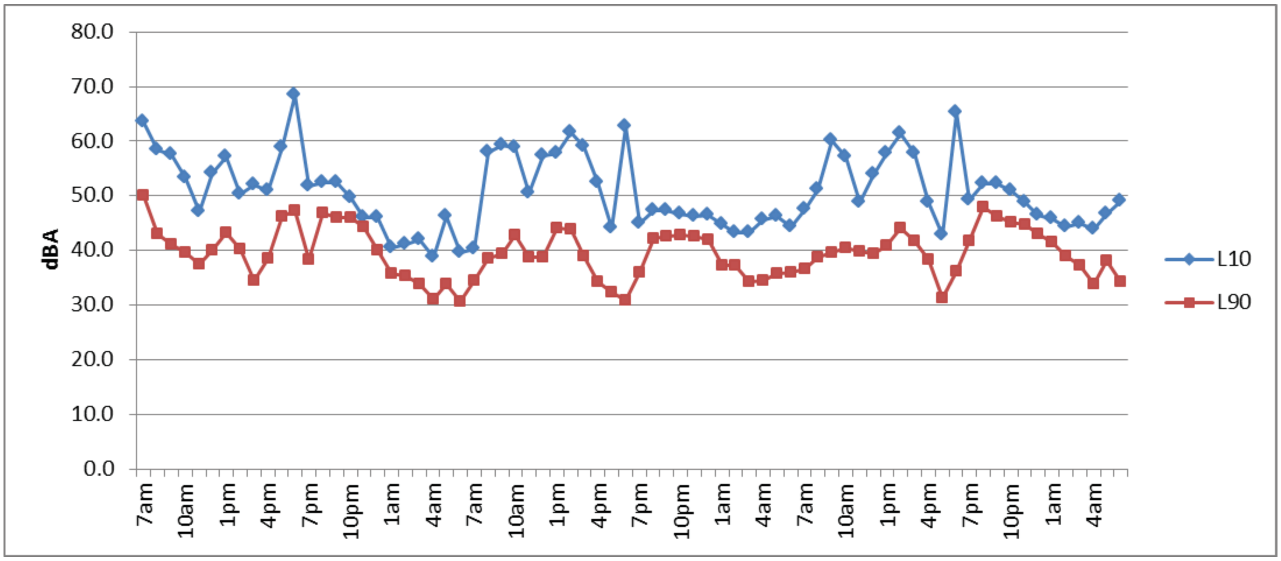


Figure 6.34 L10 and L90 for Station 1

Station 2 – NE Boundary

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 25.3 dBA to a high (Lmax) of 71.2 dBA. Average noise level for this period was 53.4 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 6.35.

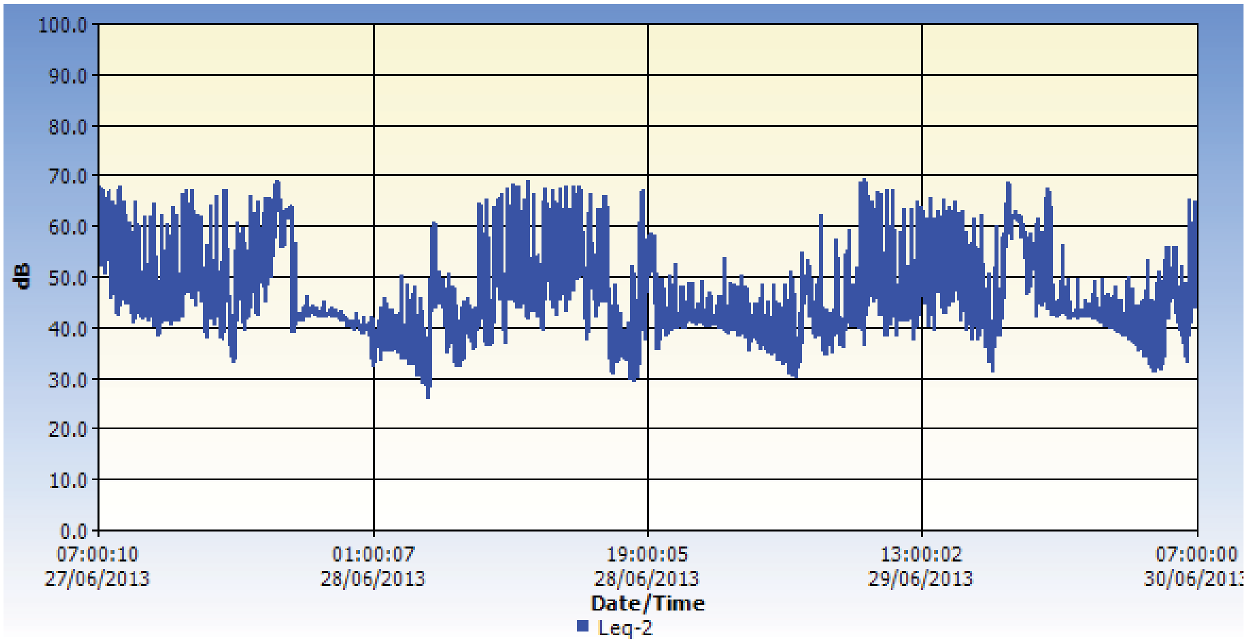


Figure 6.35 Noise fluctuation (Leq) over 72 hours at Station 2

Octave Band Analysis at Station 2

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz. (octave frequency range is 11 - 14Hz) (Figure 6.36).

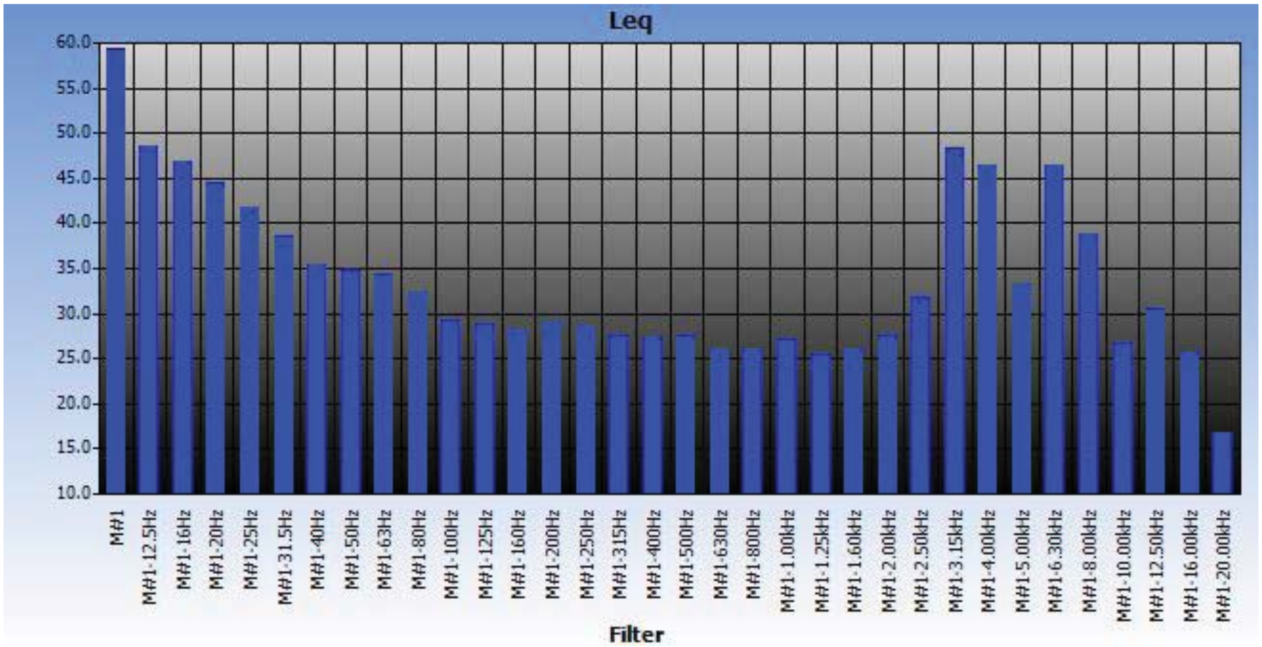


Figure 6.36 Octave band spectrum of noise at Station 2

L10 and L90 – Station 2

Figure 6.37 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations in the noise climate (L10 – L90) ≈51.5% of the time, no significant fluctuations (L10 – L90) ≈22.2% and large fluctuations (L10 – L90) ≈26.3% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 57 dBA and 36.5 dBA respectively.

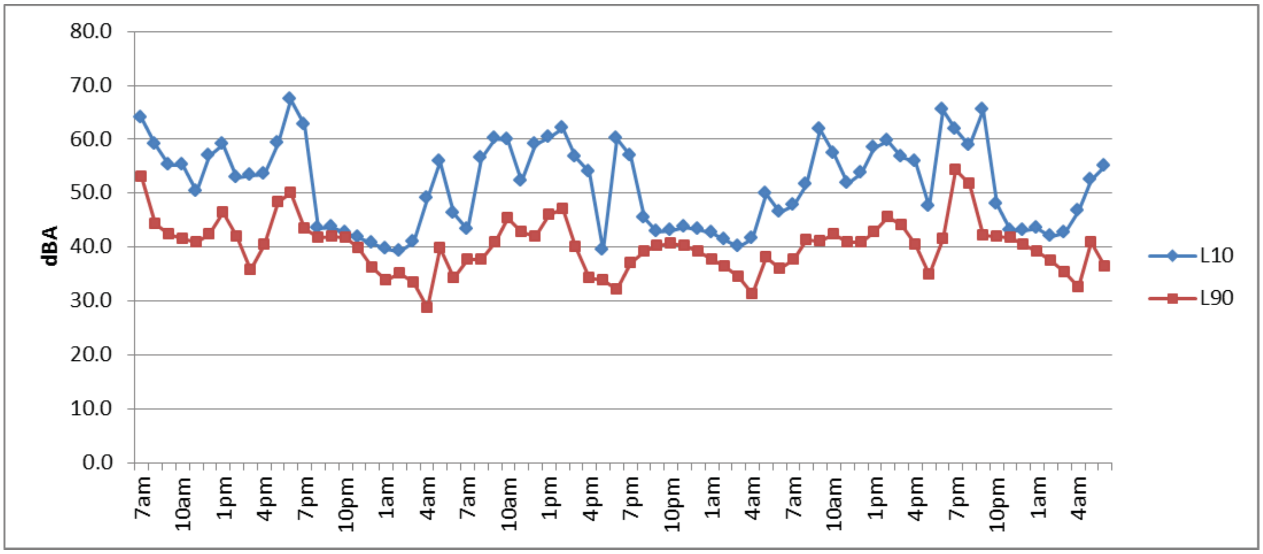


Figure 6.37 L10 and L90 for Station 2

Station 3 – SE Boundary

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 26.5 dBA to a high (Lmax) of 77.6 dBA. Average noise level for this period was 52.4 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 6.38.

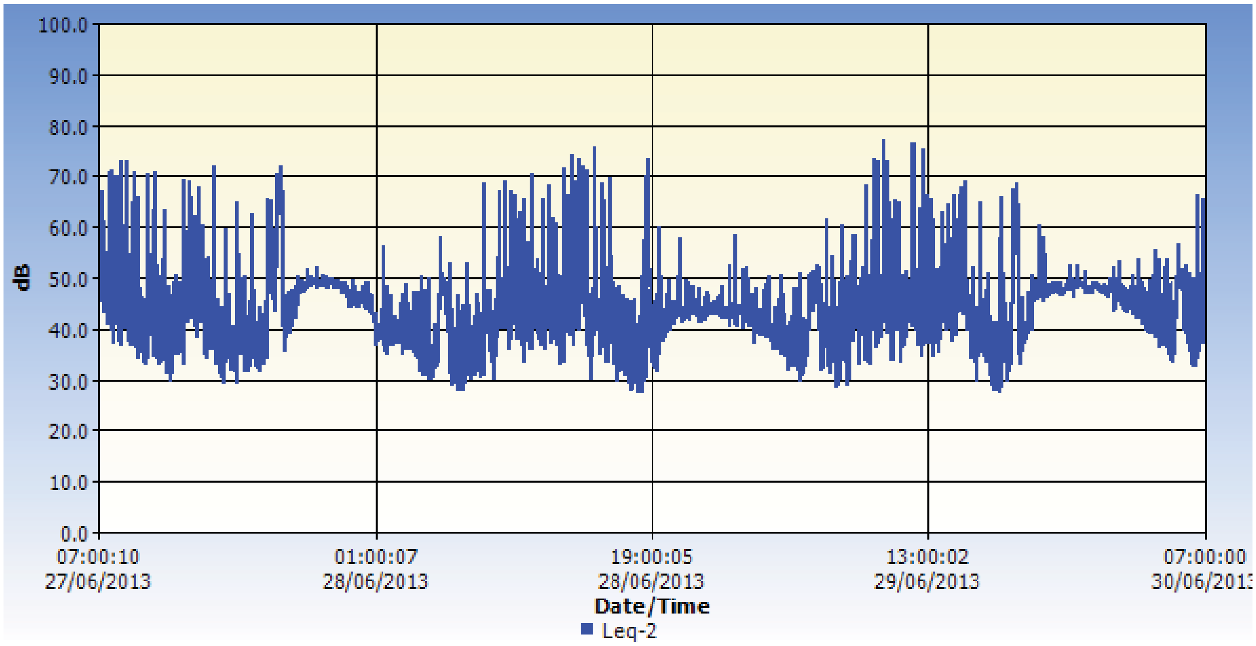


Figure 6.38 Noise fluctuation (Leq) over 72 hours at Station 3

Octave Band Analysis at Station 3

The noise at this station during the 72 hour period was in the high frequency band centred around the geometric mean frequency of 3.15 kHz. (octave frequency range is 2807 - 3534 Hz) (Figure 6.39).

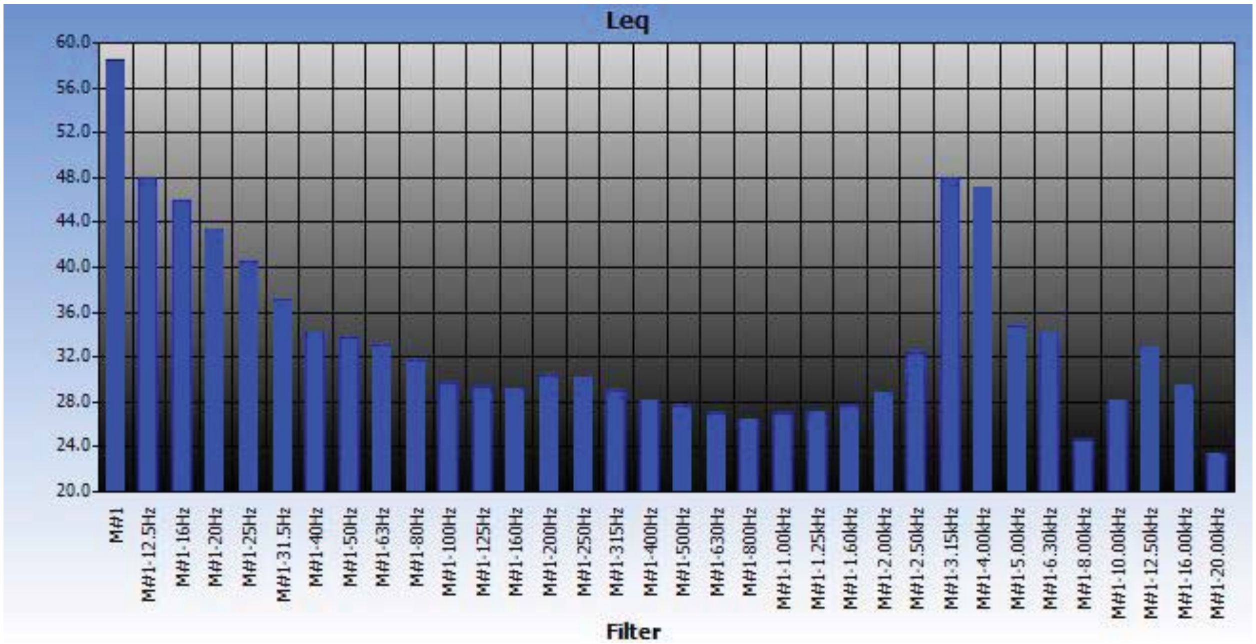


Figure 6.39 Octave band spectrum of noise at Station 3

L10 and L90 – Station 3

Figure 6.40 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows large fluctuations in the noise climate (L10 – L90) ≈18% of the time, moderate fluctuations in the noise climate (L10 – L90) ≈58.4% of the time and no significant fluctuations (L10 – L90) ≈23.6% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 49.7 dBA and 35.2 dBA respectively.

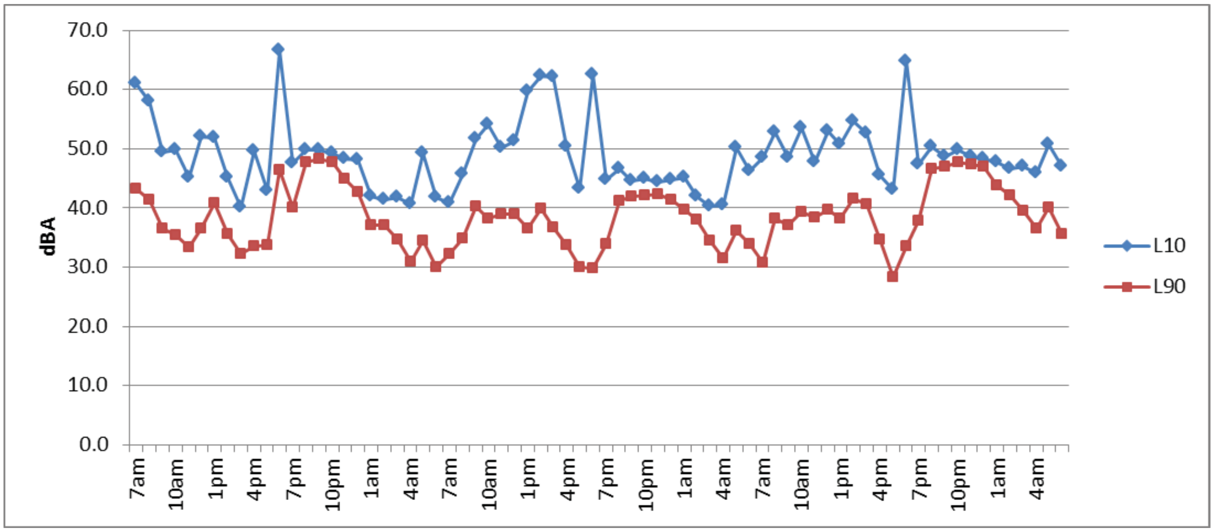


Figure 6.40 *L10 and L90 for Station 3*

Station 4 – SW Boundary

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 24.3 dBA to a high (Lmax) of 82.7 dBA. Average noise level for this period was 54.4 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 6.41.

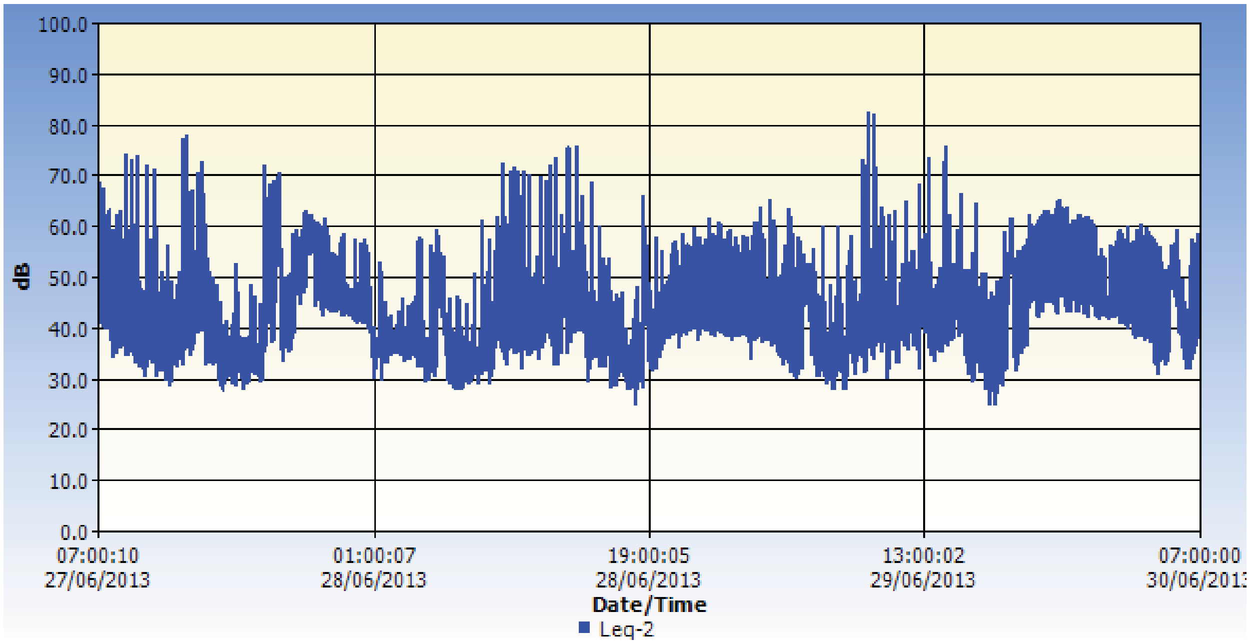


Figure 6.41 *Noise fluctuation (Leq) over 72 hours at Station 4*

Octave Band Analysis at Station 4

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz. (octave frequency range is 11 - 14 Hz) (Figure 6.42).

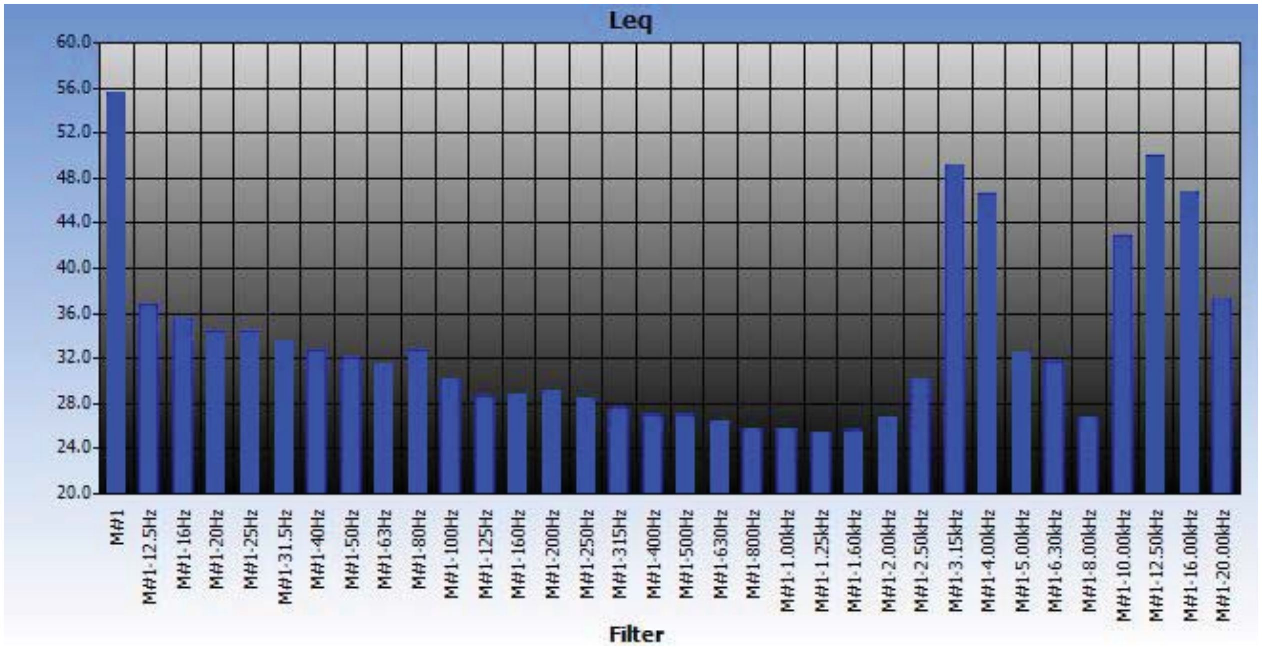


Figure 6.42 Octave band spectrum of noise at Station 4

L10 and L90 – Station 4

Figure 6.43 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations in the noise climate (L10 – L90) ≈50% of the time, no significant fluctuations (L10 – L90) ≈1.4% of the time and large fluctuations in the noise climate (L10 – L90) ≈48.6% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 56.6 dBA and 33.2 dBA respectively.

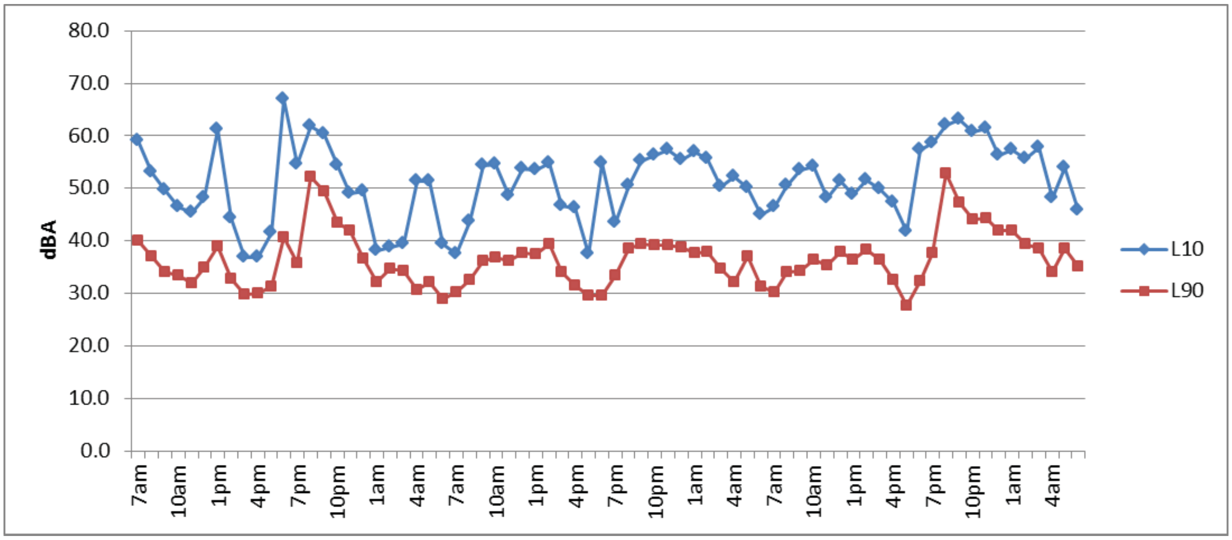


Figure 6.43 L10 and L90 for Station 4

Station 5 – Residential Community

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 29.7 dBA to a high (Lmax) of 99.2 dBA. Average noise level for this period was 61.8 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 6.44.

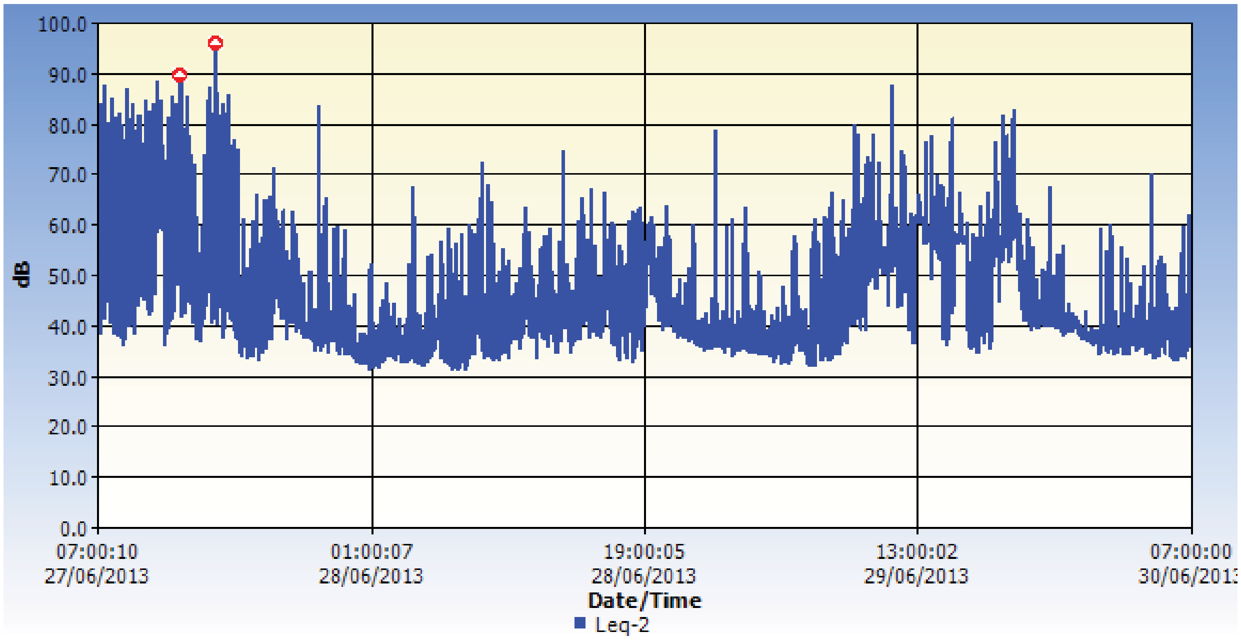


Figure 6.44 Noise fluctuation (Leq) over 72 hours at Station 5

Octave Band Analysis at Station 5

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz. (octave frequency range is 56 - 71 Hz) (Figure 6.45).

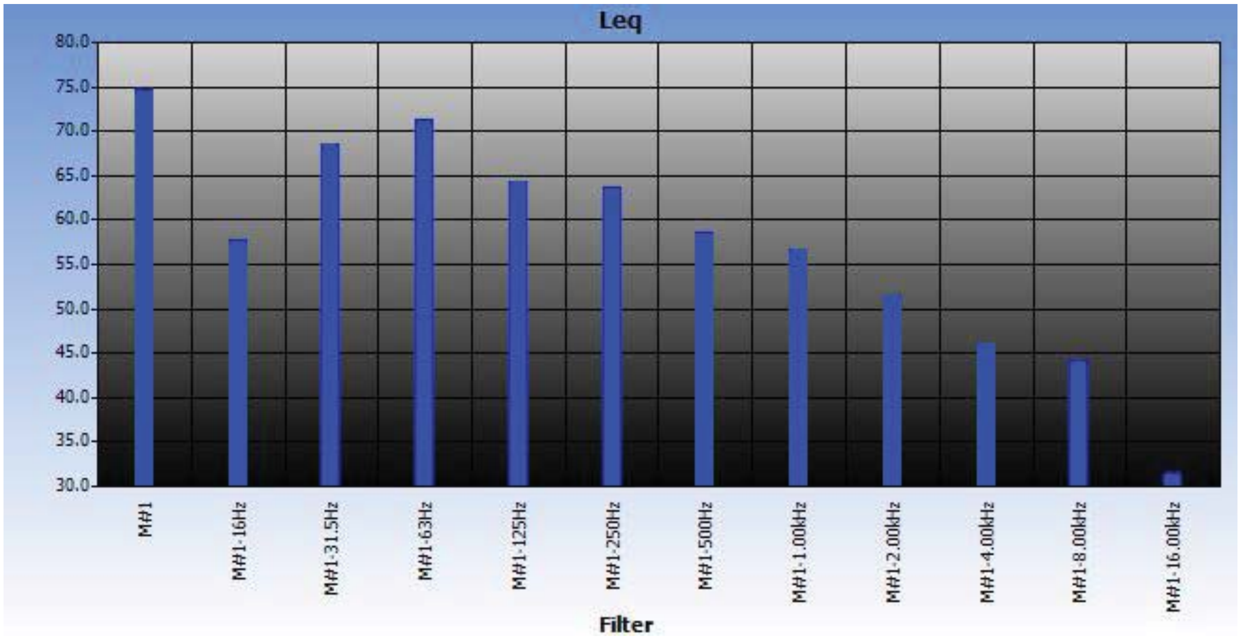


Figure 6.45 Octave band spectrum of noise at Station 5

L10 and L90 – Station 5

Figure 6.46 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations in the noise climate (L10 – L90) ≈47.3% of the time, large fluctuations in the noise climate (L10 – L90) ≈33.3% of the time and no significant fluctuations (L10 – L90) ≈19.4% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 58.6 dBA and 35.3 dBA respectively.

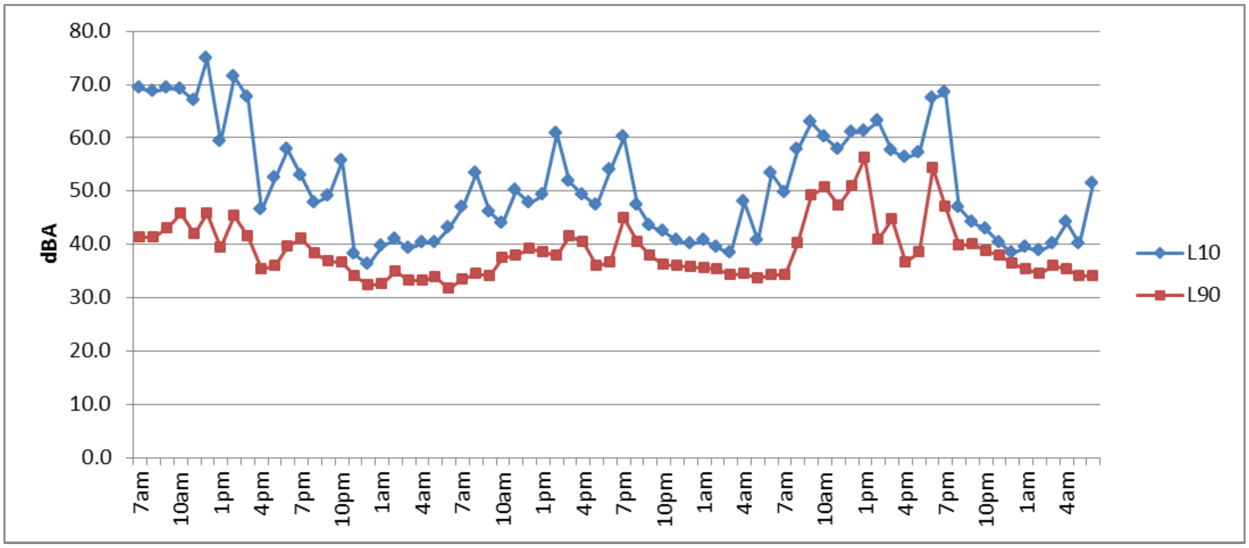


Figure 6.46 L10 and L90 for Station 5

Station 6 – Residential Community

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 30.1 to a high (Lmax) of 93.1 dBA. Average noise level for this period was 52.9 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 6.47.

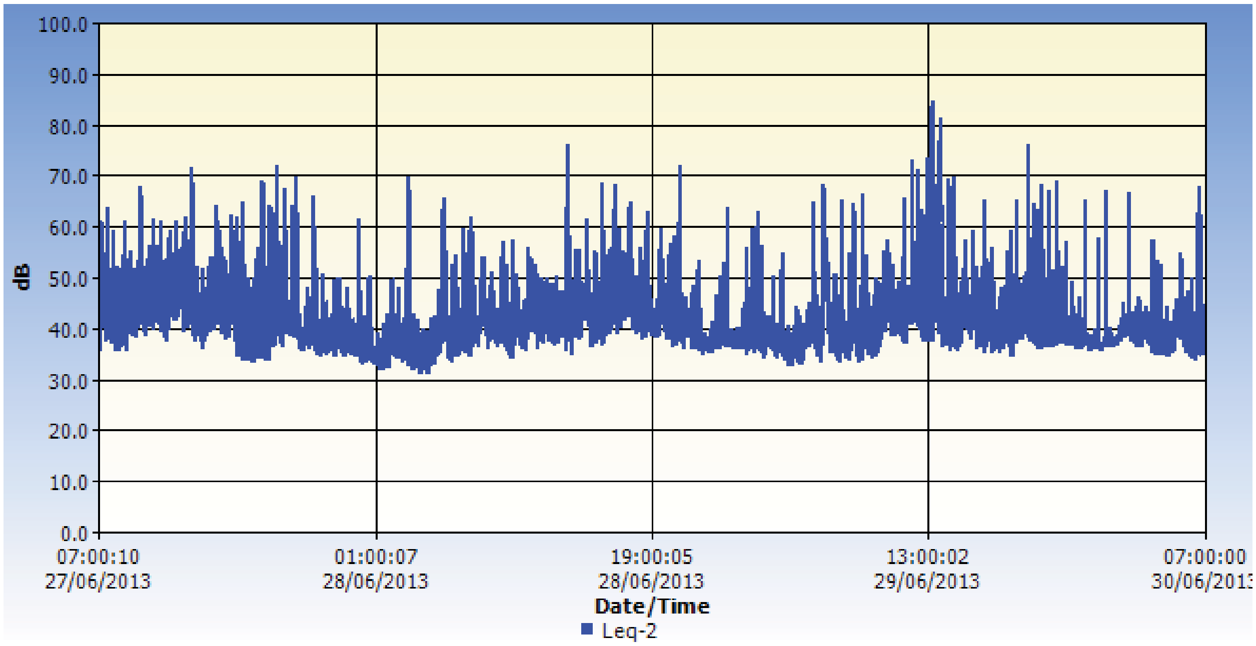


Figure 6.47 Noise fluctuation (Leq) over 72 hours at Station 6

Octave Band Analysis at Station 6

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz. (octave frequency range is 56 - 71 Hz) (Figure 6.48).

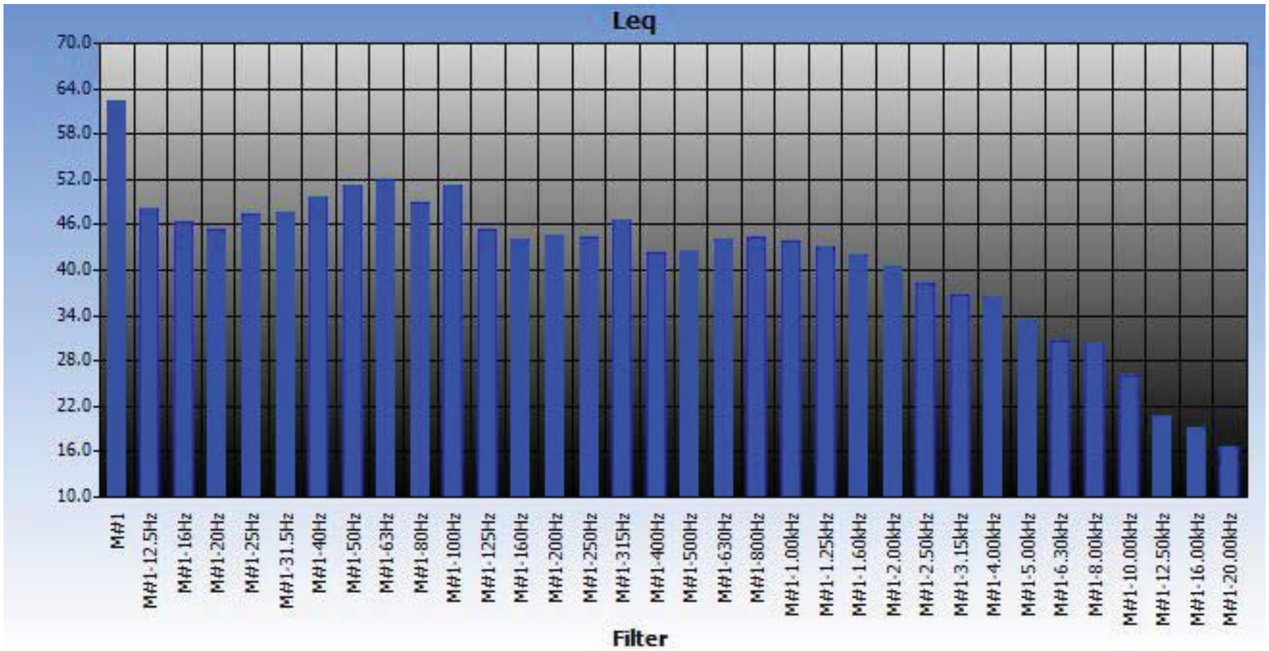


Figure 6.48 Octave band spectrum of noise at Station 6

L10 and L90 – Station 6

Figure 6.49 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations in the noise climate (L10 – L90) ≈70.9% of the time, no significant fluctuations (L10 – L90) ≈12.5% of the time and large fluctuations in the noise climate (L10 – L90) ≈16.6% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 48.9 dBA and 35.8 dBA respectively.

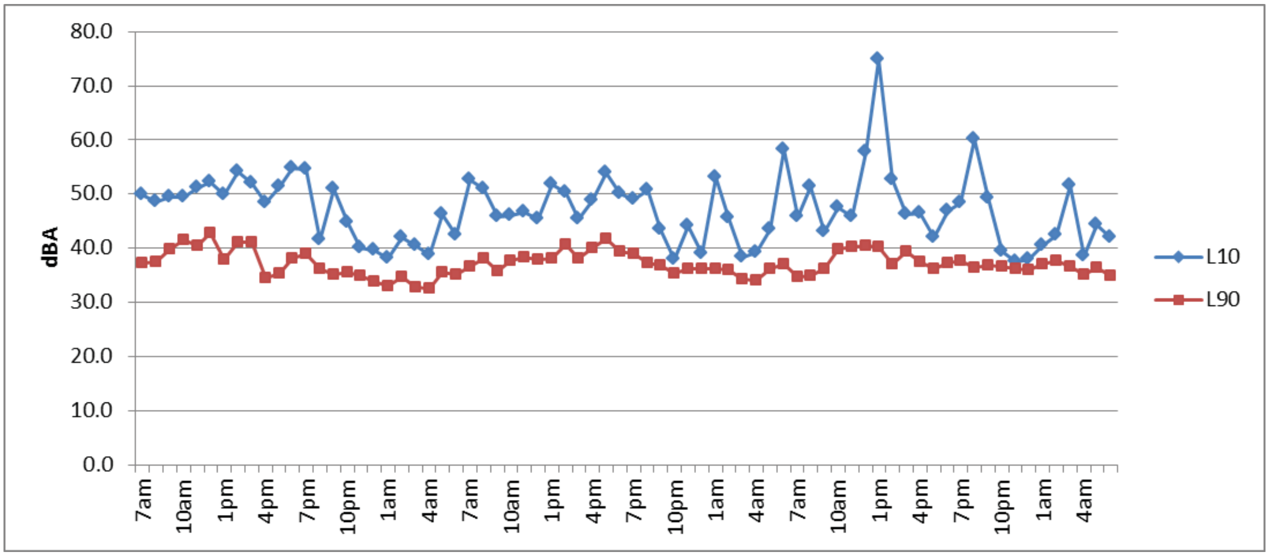


Figure 6.49 L10 and L90 for Station 6

Station 7 – Bull Bay All Age School

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 27.3 dBA to a high (Lmax) of 87 dBA. Average noise level for this period was 52 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 6.50.

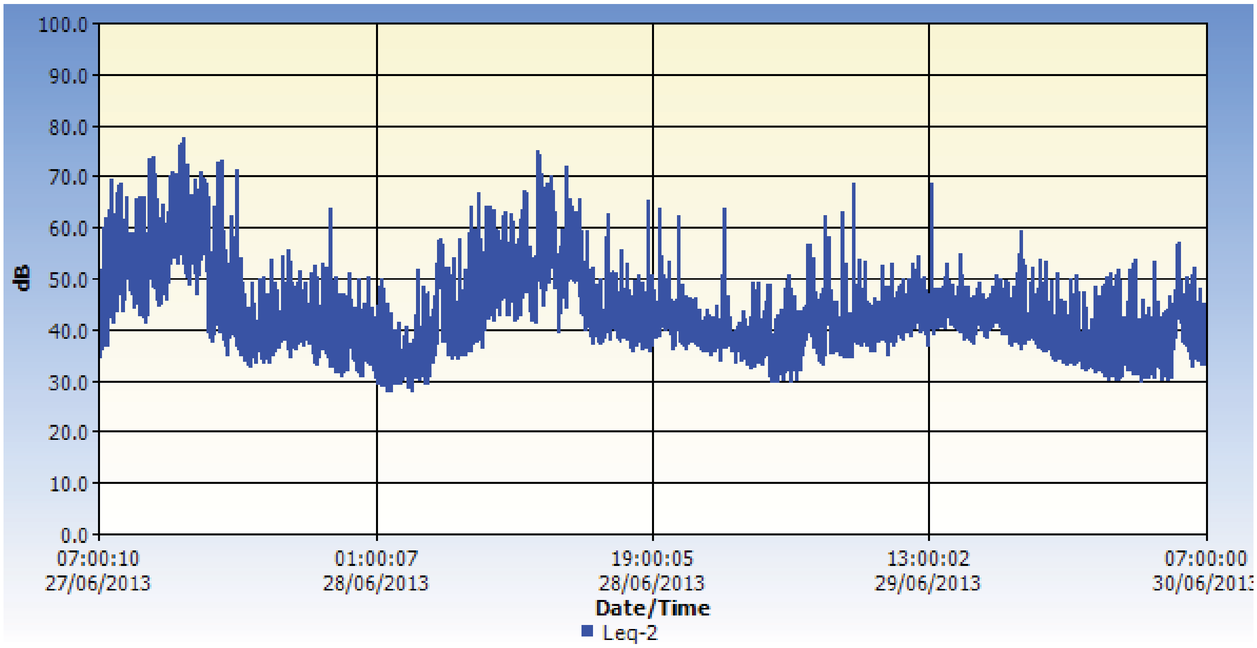


Figure 6.50 Noise fluctuation (Leq) over 72 hours at Station 7

Octave Band Analysis at Station 7

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz. (octave frequency range is 11 - 14 Hz) (Figure 6.51).

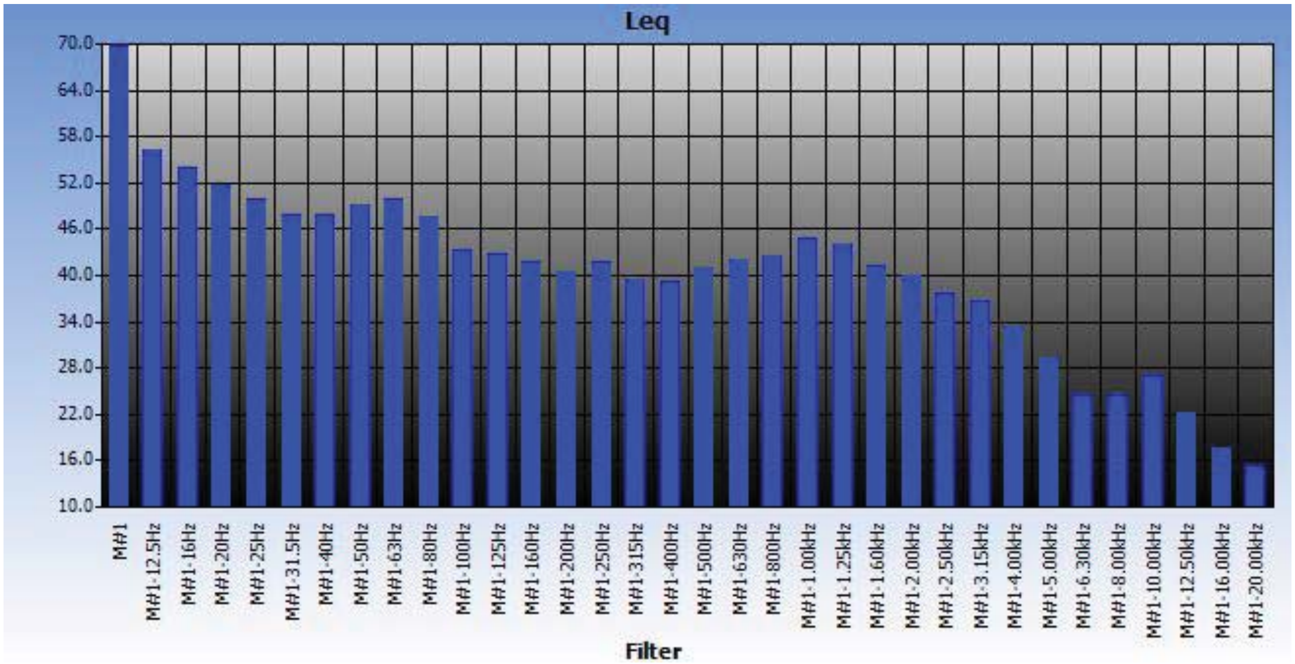


Figure 6.51 Octave band spectrum of noise at Station 7

L10 and L90 – Station 7

Figure 6.52 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations in the noise climate (L10 – L90) ≈80.7% of the time, no significant fluctuations (L10 – L90) ≈5.5% of the time and large fluctuations in the noise climate (L10 – L90) ≈13.8% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 54.1 dBA and 34.3 dBA respectively.

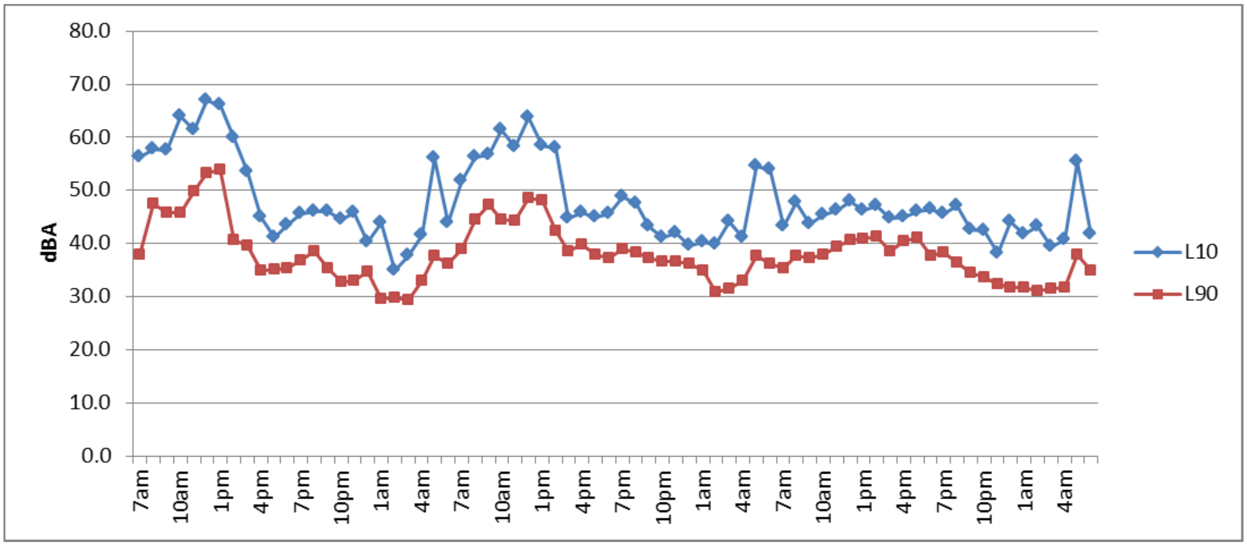


Figure 6.52 L10 and L90 for Station 7

Station 8 – Bito Primary and Infant School

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 28.3 dBA to a high (Lmax) of 85.8 dBA. Average noise level for this period was 54.6 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 6.53.

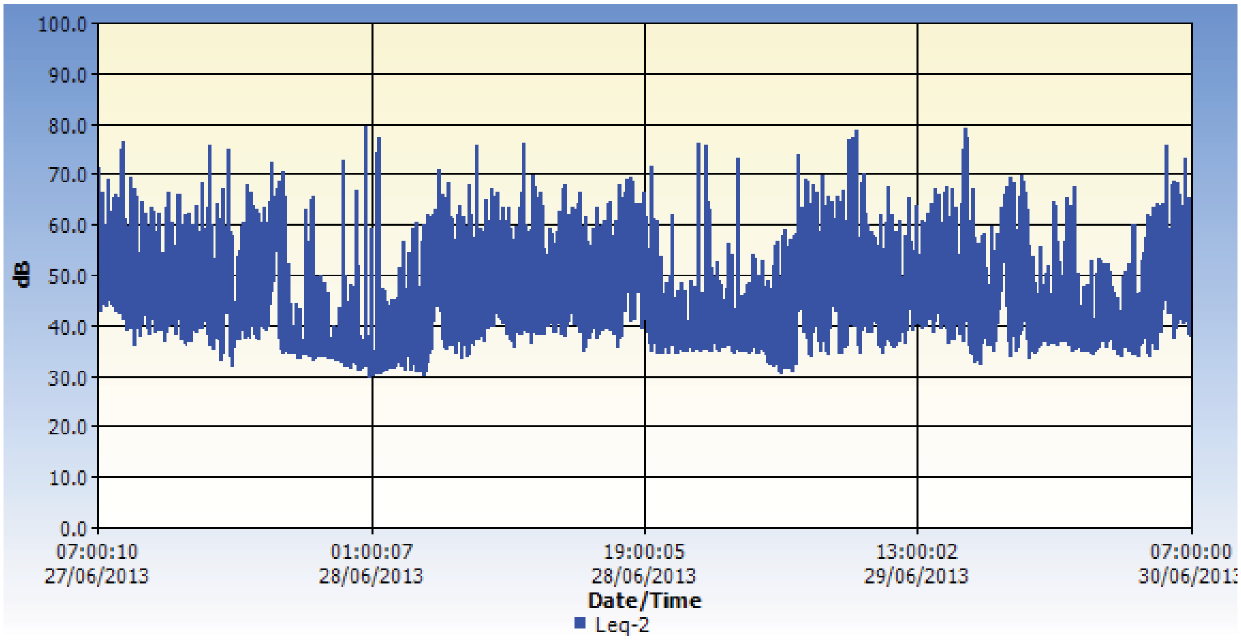


Figure 6.53 Noise fluctuation (Leq) over 72 hours at Station 8

Octave Band Analysis at Station 8

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz. (octave frequency range is 11 - 14 Hz) (Figure 6.54).

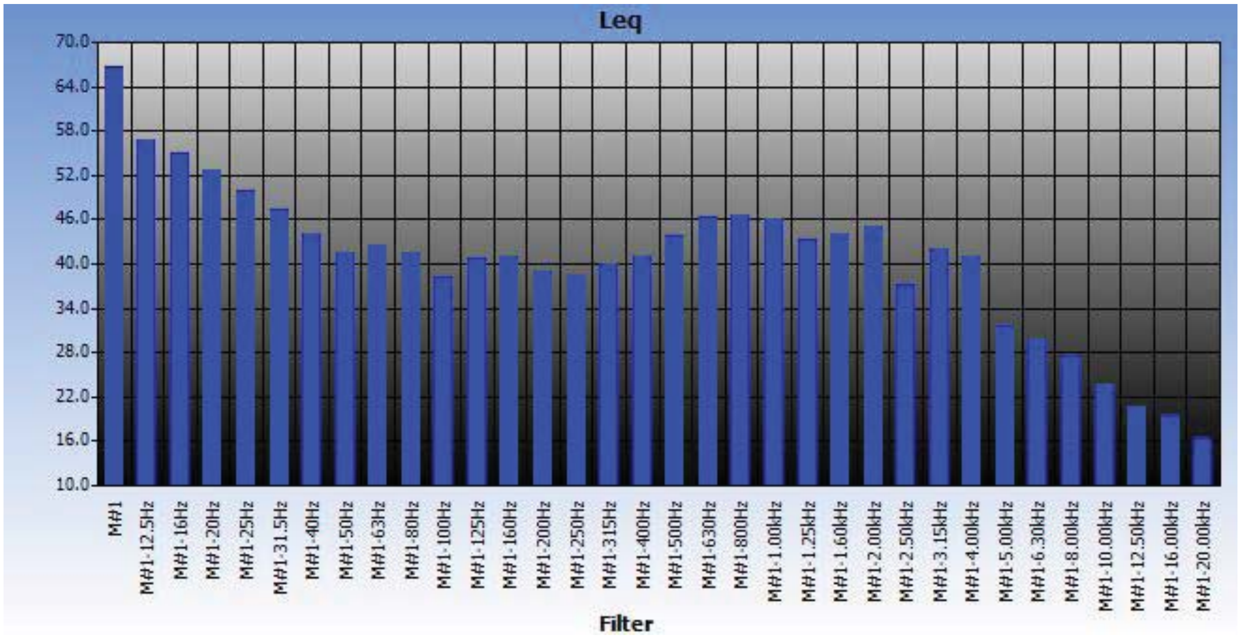


Figure 6.54 Octave band spectrum of noise at Station 8

L10 and L90 – Station 8

Figure 6.55 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations in the noise climate (L10 – L90) ≈51.5% of the time, no significant fluctuations (L10 – L90) ≈2.7% of the time and large fluctuations in the noise climate (L10 – L90) ≈45.8% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 56.3 dBA and 35.3 dBA respectively.

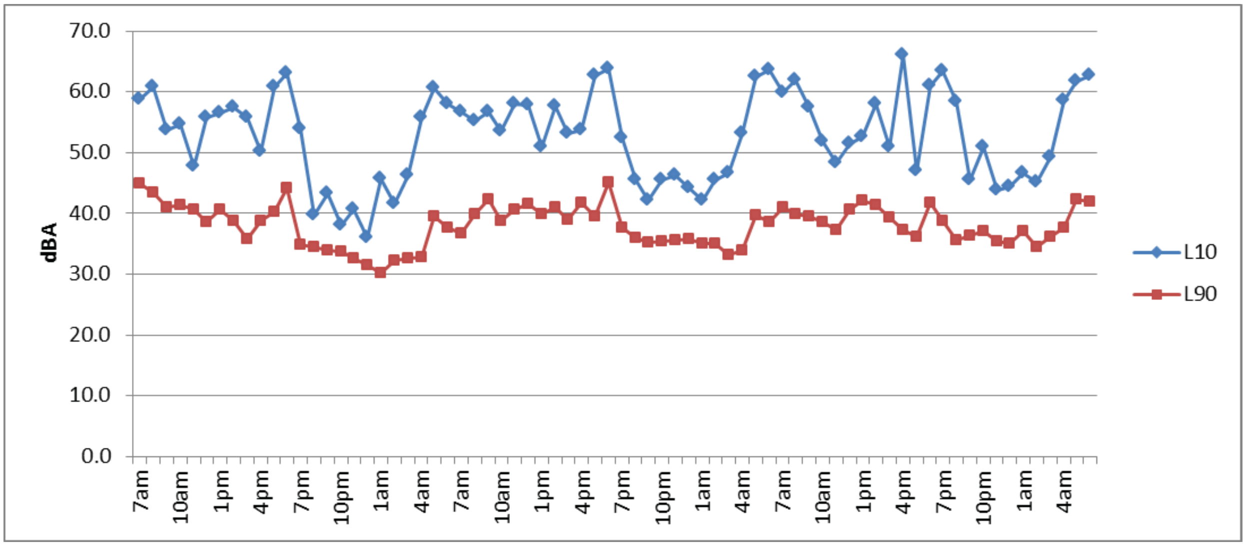


Figure 6.55 L10 and L90 for Station 8

6.1.5.3 Comparisons of Ambient Noise Levels with NEPA Guidelines

Comparison of the ambient noise levels in the study area with the National Environmental and Planning Agency (NEPA) guidelines are shown in Table 6.17. Three stations (N5, N7 and N8) were non-compliant with the NEPA noise guidelines during the daytime (7am – 10 pm). Station N5 is located next to the main road and numerous trucks transporting material uphill and downhill traverse this route daily, hence the reason for the elevated daytime noise level of 63.9 dBA. It is assumed that these are Jamaica Gypsum and Quarries trucks which go to and from the existing Bito gypsum quarry. During the night time two stations were non-compliant with the NEPA guidelines. These stations were N7 and N8.

Table 6.17 Comparison of noise levels at the stations with the NEPA guidelines

Stn.#	ZONE	7 am. - 10 pm (dBA)	NEPA Guideline (dBA)	10 pm. - 7 am (dBA)	NEPA Guideline (dBA)
N1	Industrial	55.4	70	44.5	70
N2	Industrial	55.3	70	44.3	70
N3	Industrial	54.2	70	45.3	70
N4	Industrial	55.7	70	50.8	70
N5	Residential	63.9	55	44.6	50
N6	Residential	54.6	55	45.5	50
N7	Silent	53.9	45	43.2	40
N8	Silent	55	45	53.8	40

NB. Numbers in red are non-compliant with the guideline

6.1.6 Ambient Air Quality (PM10 and PM2.5)

6.1.6.1 Methodology

PM2.5 and PM10 particulate sampling was conducted for 24 hours using both Tisch Environmental High Volume Ambient Samplers and Airmetrics Mini-Volume Tactical Air Samplers. A total of three (3) PM2.5 sampling events and three (3) PM10 sampling events were conducted, each on separate occasions for both high volume and mini volume samplers.

The first PM10 sampling exercise was conducted from 12:00am on July 17th, 2013 until 12:00am July 18th, 2013. The second PM10 sampling exercise was conducted from 12:00am on July 19th, 2013 until 12:00am July 20th, 2013. The third PM10 sampling exercise was conducted from 12:00am on July 21st, 2013 until 12:00am July 22nd, 2013.

The first PM2.5 sampling exercise was conducted from 12:00am on July 23rd, 2013 until 12:00am July 24th, 2013. The second PM2.5 sampling exercise was conducted from 12:00am on July 25th, 2013 until 12:00am July 26th, 2013. The third PM2.5 sampling exercise was conducted from 12:00am on July 27th, 2013 until 12:00am July 28th, 2013.

PM10 and PM2.5 ambient particulate measurements were conducted at two (2) locations using the high volume samplers, and at four (4) locations, at the boundaries of the proposed quarry site, using the mini volume samplers (Table 6.18, Table 6.19 and Figure 6.56).

Plate 6.7 and Plate 6.8 show photos of the two particuate samplers used.

Table 6.18 Sampling *locations using High Volume Samplers*

STATION	LOCATION	JAD 2001	
		Northing (m)	Easting (m)
P5	Residential Community	644530.98	786822.67
P7	Bito Primary and Infant School	645954.58	785508.11

Table 6.19 Sampling locations using Mini Volume Samplers

STATION	LOCATION	JAD 2001	
		Northing (m)	Easting (m)
P1	NW Boundary	646775.22	786772.97
P2	NE Boundary	646775.22	786853.41
P3	SE Boundary	646700.97	786854.44
P4	SW Boundary	646699.94	786765.75

Plate 6.7 Photo showing High Volume sampler at Station P7

Plate 6.8 Photo showing Mini Volume sampler at Station P4

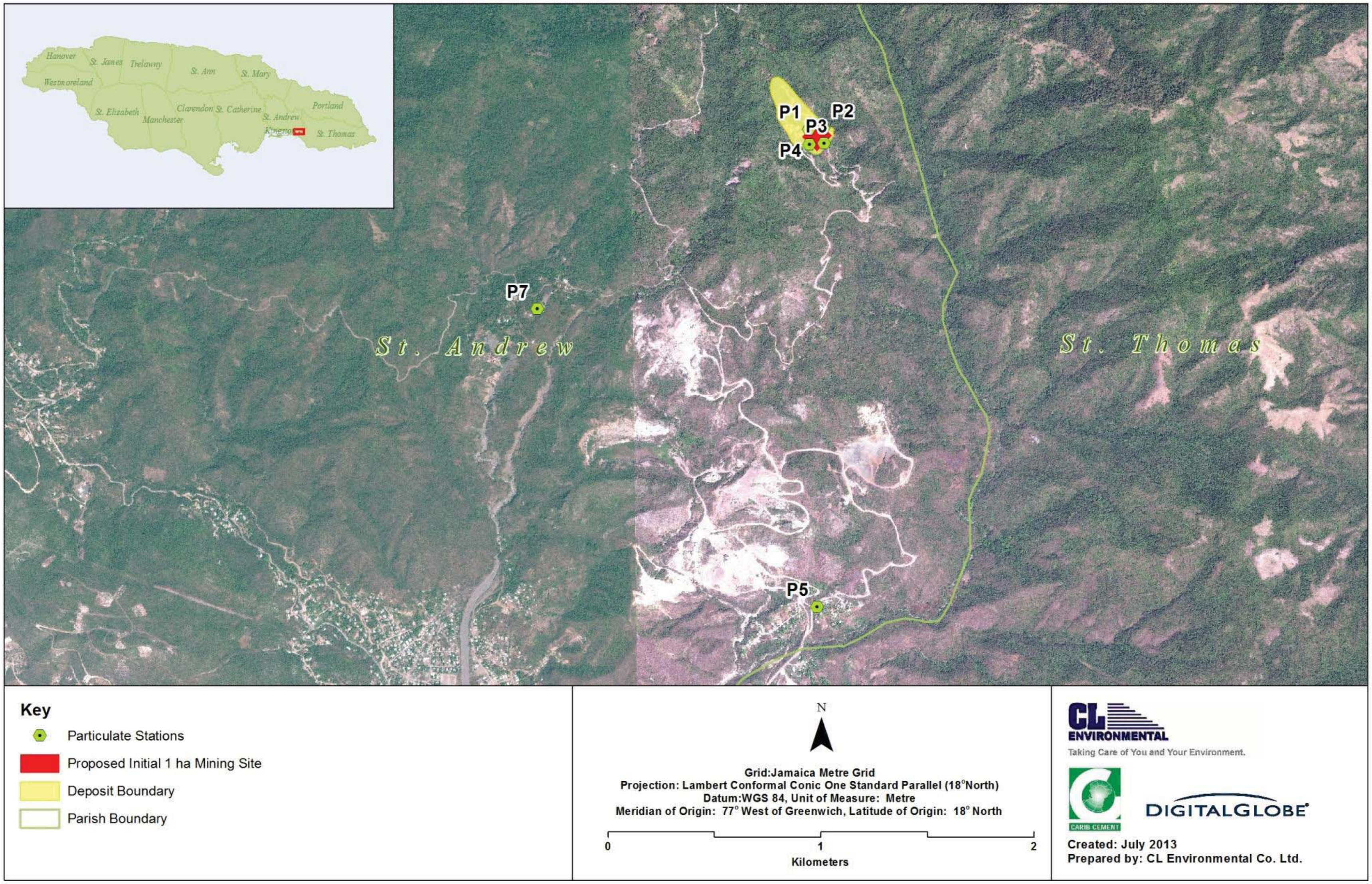


Figure 6.56 Map depicting the particulate sampling stations

6.1.6.2 Results

PM10

The mean PM10 results indicate that all locations had particulate values compliant with the 24-hour US EPA standard of 150 µg/m3. Results were similar for the locations at the boundaries of the proposed quarry site, with the two northern-most boundaries (P1 and P2) having the highest values. The residential area at station P5 had the highest overall mean PM10 value of 47.82 µg/m^3. This area is most affected by particulates as it is located next to the unpaved main road where numerous trucks transporting material uphill and downhill traverse daily. It is assumed that these are Jamaica Gypsum and Quarries trucks which go to and from the existing Bito gypsum quarry. This station is therefore prone to dust nuisance as sources of coarse PM10 particulates include crushing/grinding or quarrying operations, and dust stirred up by vehicles traveling on roads.

The results of the high and low volume PM10 sampling runs are shown in Table 6.20.

Table 6.20 PM10 Results using high and mini volume samplers

STATION	LOCATION	Range Result (µg/m^3)	Mean Result (µg/m^3)	US EPA Std. (µg/m^3)
		Mini Volume		
P1	NW Boundary	19.58 – 52.64	36.21	**150**
P2	NE Boundary	21.35 – 56.3	33.52	**150**
P3	SE Boundary	18.06 – 51.81	31.88	**150**
P4	SW Boundary	20 – 50.69	31.34	**150**
		High Volume		
P5	Residential Community	36.78 – 65.12	47.82	**150**
P7	Bito Primary and Infant School	19.93 – 51.8	31.14	**150**

PM2.5

The mean PM2.5 results indicate that all locations had particulate values compliant with the 24-hour US EPA standard of 35 µg/m^3. Results were somewhat similar for the locations at the boundaries of the proposed quarry site. Like the PM10 results, the two northern-most boundaries (P1 and P2) had the highest values. Stations P5 and P7 had the highest overall mean PM2.5 values of 17.21 µg/m^3 and 17.31 µg/m^3 respectively. Sources of fine PM2.5 particulates can include combustion from motor vehicles, residential wood burning, forest fires and agricultural burning.

Again station P5 is prone to fine particulates because of soot from combustion from the many trucks which pass by. Although no burning was observed, it is also possible that some minor burning may take place in the communities, which would lead to elevated PM2.5 particulate levels.

The results of the high and low volume PM2.5 sampling runs are shown in Table 6.21.

Table 6.21 PM2.5 Results using high and mini volume samplers

STATION	LOCATION	Range Result (µg/m3)	Mean Result (µg/m3)	US EPA Std. (µg/m3)
Mini Volume				
P1	NW Boundary	11.94 – 15.97	13.52	**35**
P2	NE Boundary	9.69 – 14.17	12.17	**35**
P3	SE Boundary	7.92 – 14.31	10.97	**35**
P4	SW Boundary	8.33 – 12.39	9.87	**35**
High Volume				
P5	Residential Community	8.44 – 25.18	17.21	**35**
P7	Bito Primary and Infant School	10 – 22.17	17.31	**35**

6.1.6.3 Other Particulate Data

Table 6.22 and Table 6.23 below shows PM10 and PM2.5 particulate data collected at the sample sites on dates where both high volume and mini volume samplers did NOT run simultaneously. Sampling was done on July 8th, 10th, 12th and 15th, 2013.

Table 6.22 PM10 Results using high and mini volume samplers

STATION	LOCATION	Range Result (µg/m3)	Mean Result (µg/m3)	US EPA Std. (µg/m3)
Mini Volume				
P1	NW Boundary	13.33 – 77.68	40.1	**150**
P2	NE Boundary	14.72 – 83.61	43.33	**150**
P3	SE Boundary	14.86 – 76.08	38.37	**150**
P4	SW Boundary	17.5 – 71.81	39.07	**150**
High Volume				
P5	Residential Community	-	86.48	**150**
P7	Bito Primary and Infant School	-	33.68	**150**

Table 6.23 PM2.5 Results using high and mini volume samplers

STATION	LOCATION	Range Result ($\mu g/m^3$)	Mean Result ($\mu g/m^3$)	US EPA Std. ($\mu g/m^3$)
Mini Volume				
P1	NW Boundary	-	12.36	**35**
P2	NE Boundary	-	12.64	**35**
P3	SE Boundary	-	10.28	**35**
P4	SW Boundary	-	6.53	**35**
High Volume				
P5	Residential Community	23.12 – 31.68	26.48	**35**
P7	Bito Primary and Infant School	8.84 – 20.11	13.48	**35**

6.1.7 Vibration

Vibrations consist of rapidly fluctuating motions in which there is no “net” movement. When an object vibrates, any point on the object is displaced from its initial “static” position equally in both directions so that the average of all its motion is zero. Any object can vibrate differently in three mutually independent directions; vertical, horizontal, and lateral. It is common to describe vibration levels in terms of velocity, which represents the instantaneous speed at a point on the object that is displaced.

Vibrations are transmitted from the source to the ground, and propagate through the ground to the receiver. Soil conditions have a strong influence on the levels of ground-borne vibration.

Stiff soils, such as some clay and rock, can transmit vibrations over substantial distances. Sandy soils, wetlands, and groundwater tend to absorb movement and thus reduce vibration transmission.

Ground borne vibration is caused when the individual particles making up the strata are caused to oscillate by the passage of a pressure wave. The resulting vibration can be summarized in terms of 4 main parameters:

a) **Velocity** – how fast the particles move when they are oscillating. Since the velocity of these particles continually change as the pressure wave passes the most useful value that is often reported is the maximum or peak particle velocity (PPV). PPVs are usually expressed in terms of ms-1 or mms-1.
b) **Acceleration** – is the rate at which the particle velocity changes during oscillation. It is usually measured in ms-2 mms-2 or “g’s”. 1g is that acceleration imparted to an object by the earth’s gravitational pull and is approximately 9.81 ms-2.

c) **Displacement** – is the distance moved by oscillating particles. This is usually very small and measured in mm or even µm.
d) **Frequency** – is the number of oscillations per second which a particle undergoes due to the passage of a vibration wave. It is measured in cycles per second or Hertz (Hz).

The movement of particles induced to oscillate by vibration waves are usually measured in three mutually perpendicular directions to fully describe the vibration intensity, as particles will be oscillating in three dimensions. These are:

a) **Longitudinal/Radial** – back and forth particle movement in the same direction that the vibration wave is travelling.
b) **Vertical** – up and down movement perpendicular to the direction the vibration wave is travelling.
c) **Transverse** – left and right particle movement perpendicular to the direction the vibration wave is travelling.

6.1.7.1 Methodology

Measurements were performed using Nomis Seismometer Type Mini Supergraph. The Mini Supergraph consisted of a 3-axis velocity transducer, an air over-pressure transducer, and a data acquisition and storage device. The transducer measures velocities on three mutually perpendicular axes (Vx, Vy, Vz) corresponding to a radial, vertical, and transverse component at a linear frequency response range from 2 Hz to 400 Hz.

The seismometer was set to summarize every hour at a sampling rate 1024/sec. Three (3) locations were monitored, each over a twenty four hour period. These were located at:

1) Residential community (at noise station N5/particulate station P5).
2) The proposed quarry site (at noise station N3/particulate station P3).
3) Closest residential community of Benoa, south of the proposed quarry site.

The readings were taken from 11:09 am July 24th – 12:40 pm July 25th, 2013 at Location 1; 1:16 pm July 25th – 1:49 pm July 26th, 2013 at Location 2; and 2:34 pm July 26th – 2:36 pm July 27th, 2013 at Location 3.

Plate 6.9 shows a photo of the vibration meter set up in the field.

Plate 6.9 Photo showing vibration meter set up

Vibration Criteria

Various governmental agencies have criteria regarding architectural and structural damage, as well as annoyance and acceptability of vibration.

In general, most of the criteria specify that for a PPV less than approximately 3.048 mms^{-1} (0.12 inches per second) the potential for architectural damage due to vibration is unlikely. For a PPV from approximately 3.048 mms^{-1} (0.12 inches per second) to 12.7 mms^{-1} (0.50 inches per second) there is potential for architectural damage due to vibration, and for a PPV greater than approximately 12.7 mms^{-1} (0.50 inches per second) the potential for architectural damage due to vibration is very likely.

The data collected will be compared with British standards for impact on persons; as well as guidelines used in the United States. Human beings are known to be very sensitive to vibration, the threshold of perception being typically in the PPV range of 0.14 mms^{-1} to 0.3 mms^{-1} (British Standard BS 5228-2:2009). Table 6.24 and Table 6.25 provides an indication of the effects of ground vibration on humans and buildings.

Table 6.24 Guidance on the effects of vibration on humans

VIBRATION LEVEL (PPV)	EFFECT
0.14 mms^{-1}	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mms^{-1}	Vibration might be just perceptible in residential environments.
1.0 mms^{-1}	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
>10 mms^{-1}	Vibration is likely to be intolerable for any more than a brief exposure to this level.

Source: (British Standard BS 5228-2:2009)

Table 6.25 Guidance on the effects of vibration on humans and buildings

PEAK PARTICLE VELOCITY (mms^{-1})	EFFECTS ON HUMANS	EFFECTS ON BUILDINGS
< 0.127	Imperceptible	No effect on buildings
0.127 – 0.381	Barely perceptible	No effect on buildings
0.508 – 1.27	Level at which continuous vibrations begin to annoy in buildings	No effect on buildings
2.54 – 12.7	Vibrations considered unacceptable for people exposed to continuous or long-term vibration	Minimal potential for damage to weak or sensitive structures
12.7 – 25.4	Vibrations considered bothersome by most people, however tolerable if short-term in length	Threshold at which there is a risk of architectural damage to buildings with plastered ceilings and walls. Some risk to ancient monuments and ruins.
25.4 – 50.8	Vibrations considered unpleasant by most people	U.S. Bureau of Mines data indicates that blasting vibration in this range will not harm most buildings. Most construction vibration limits are in this range.
>76.2	Vibration is unpleasant	Potential for architectural damage and possible minor structural damage

6.1.7.2 Results

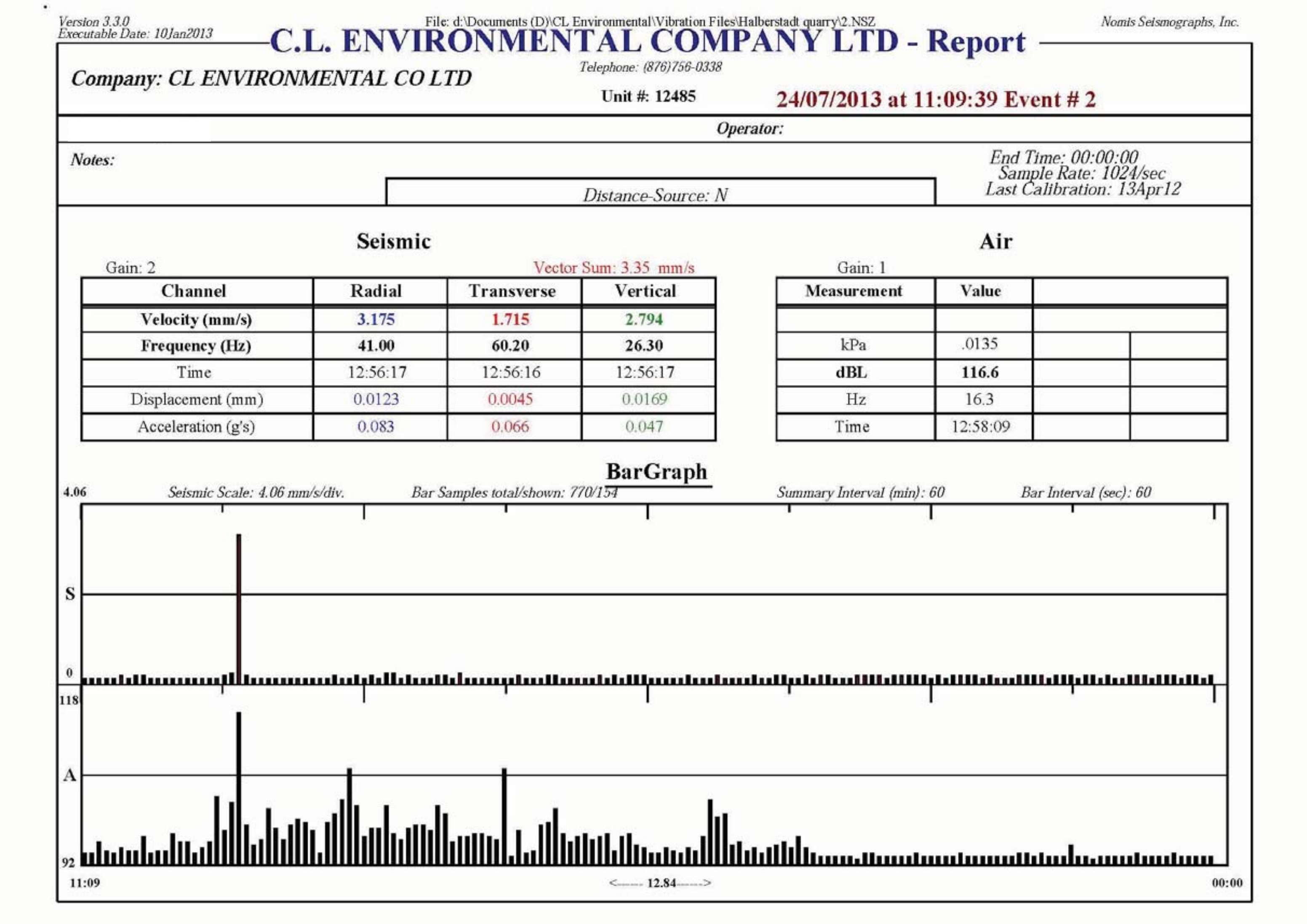
Table 6.26 outlines the results of the 24 hour vibration monitoring exercise conducted at each location.

The results indicate that vibration levels at Locations 2 and 3 are barely perceptible in residential environments and have no effect on building structures. At Location 1 however, between the hours of 11:09am – 00:00am, vibrations were at a level considered unacceptable for most persons exposed to it continuously, and will result in complaint. This however can be mitigated against if prior warning and explanation is given to residents. There is also the potential for minimal damage to weak or sensitive structures. Between the hours of 00:14am – 12:40pm, vibrations were at a level considered intolerable and unpleasant by residents and there is potential for architectural damage and minor structural damage. The cause of these vibration levels at this location is the numerous dump trucks loaded with material which traverse uphill and downhill along the main road throughout the day. It is assumed that these are Jamaica Gypsum and Quarries trucks which go to and from the existing Bito gypsum quarry.

Table 6.26 Vibration results

Location	Sampling Location	Time	Vibration Level PPV (mms^{-1})
1	Residential Community (Noise Stn. N5)	11:09am – 00:00am	3.175
		00:14am – 12:40pm	129.48
2	Proposed quarry site (Noise Stn. N3)	1:16pm – 00:02am	0.254
		00:16am – 1:49pm	0.635
3	Benoa Residential Community south of proposed quarry site	2:34pm – 00:03am	0.381
		00:17am – 2:36pm	0.254

Figure 6.57 through to Figure 6.62 show vibration summary charts for each reading conducted.



Version 3.3.0
Executable Date: 10Jan2013

File: d:\Documents (D)\CL Environmental\Vibration Files\Halberstadt quarry\2.NSZ

Nomis Seismographs, Inc.

C.L. ENVIRONMENTAL COMPANY LTD - Report

Company: CL ENVIRONMENTAL CO LTD

Telephone: (876)756-0338

Unit #: 12485

24/07/2013 at 11:09:39 Event # 2

Operator:

Notes:

Distance-Source: N

End Time: 00:00:00
Sample Rate: 1024/sec
Last Calibration: 13Apr12

Seismic

Gain: 2

Vector Sum: 3.35 mm/s

Channel	Radial	Transverse	Vertical
Velocity (mm/s)	3.175	1.715	2.794
Frequency (Hz)	41.00	60.20	26.30
Time	12:56:17	12:56:16	12:56:17
Displacement (mm)	0.0123	0.0045	0.0169
Acceleration (g's)	0.083	0.066	0.047

Air

Gain: 1

Measurement	Value	
kPa	.0135	
dBL	**116.6**	
Hz	16.3	
Time	12:58:09	

BarGraph

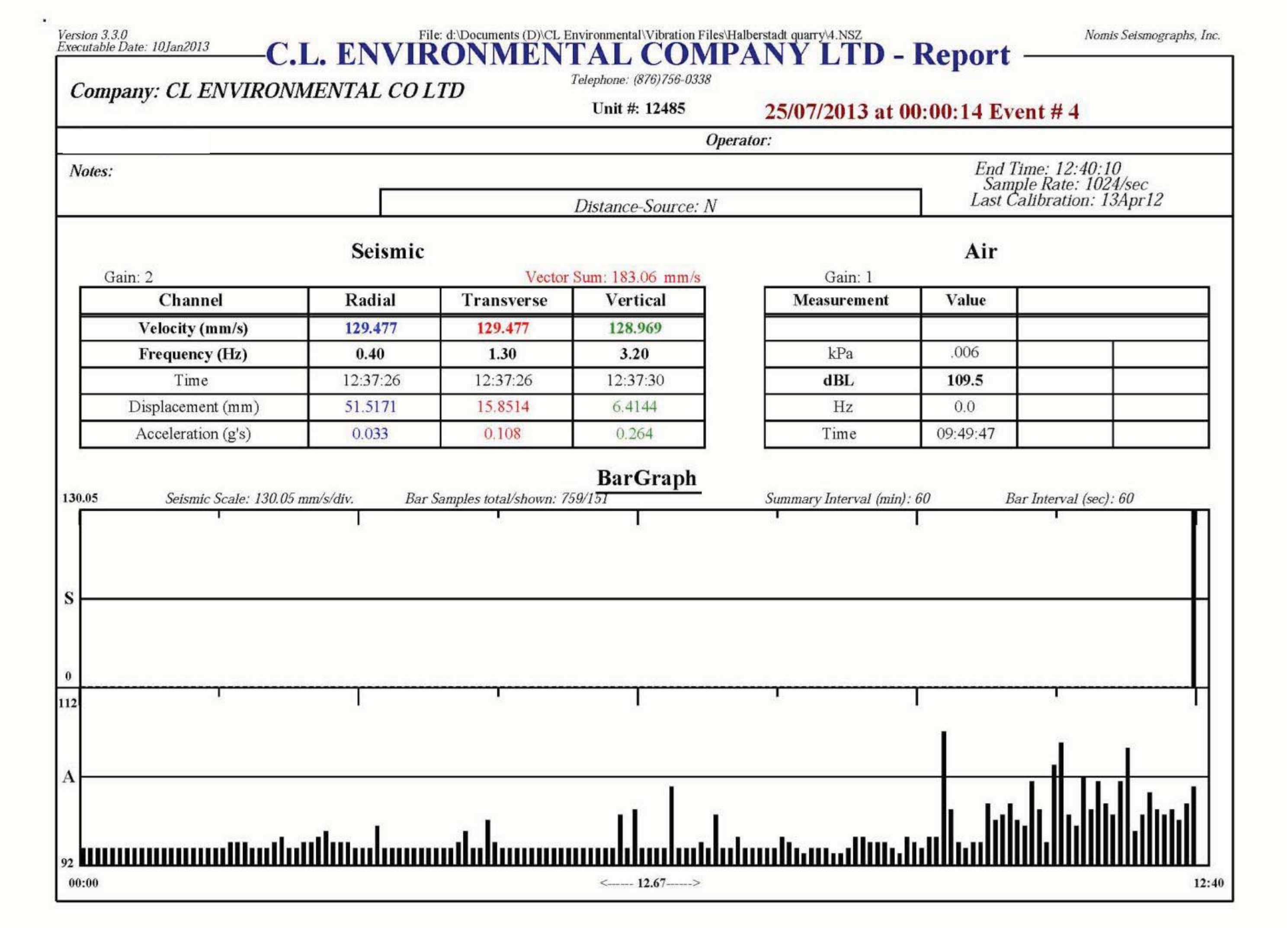
Seismic Scale: 4.06 mm/s/div.

Bar Samples total/shown: 770/154

Summary Interval (min): 60

Bar Interval (sec): 60

Figure 6.57 *Vibration Results for event #2 at Location 1 occurring from 11:09:39 am July 24 to 00:00am July 25, 2013*



Version 3.3.0
Executable Date: 10Jan2013

File: d:\Documents (D)\CL Environmental\Vibration Files\Halberstadt quarry\4.NSZ

Nomis Seismographs, Inc.

C.L. ENVIRONMENTAL COMPANY LTD - Report

Company: CL ENVIRONMENTAL CO LTD

Telephone: (876)756-0338

Unit #: 12485

25/07/2013 at 00:00:14 Event # 4

Operator:

Notes:

Distance-Source: N

End Time: 12:40:10
Sample Rate: 1024/sec
Last Calibration: 13Apr12

Seismic

Gain: 2

Vector Sum: 183.06 mm/s

Channel	Radial	Transverse	Vertical
Velocity (mm/s)	**129.477**	**129.477**	**128.969**
Frequency (Hz)	**0.40**	**1.30**	**3.20**
Time	12:37:26	12:37:26	12:37:30
Displacement (mm)	51.5171	15.8514	6.4144
Acceleration (g's)	0.033	0.108	0.264

Air

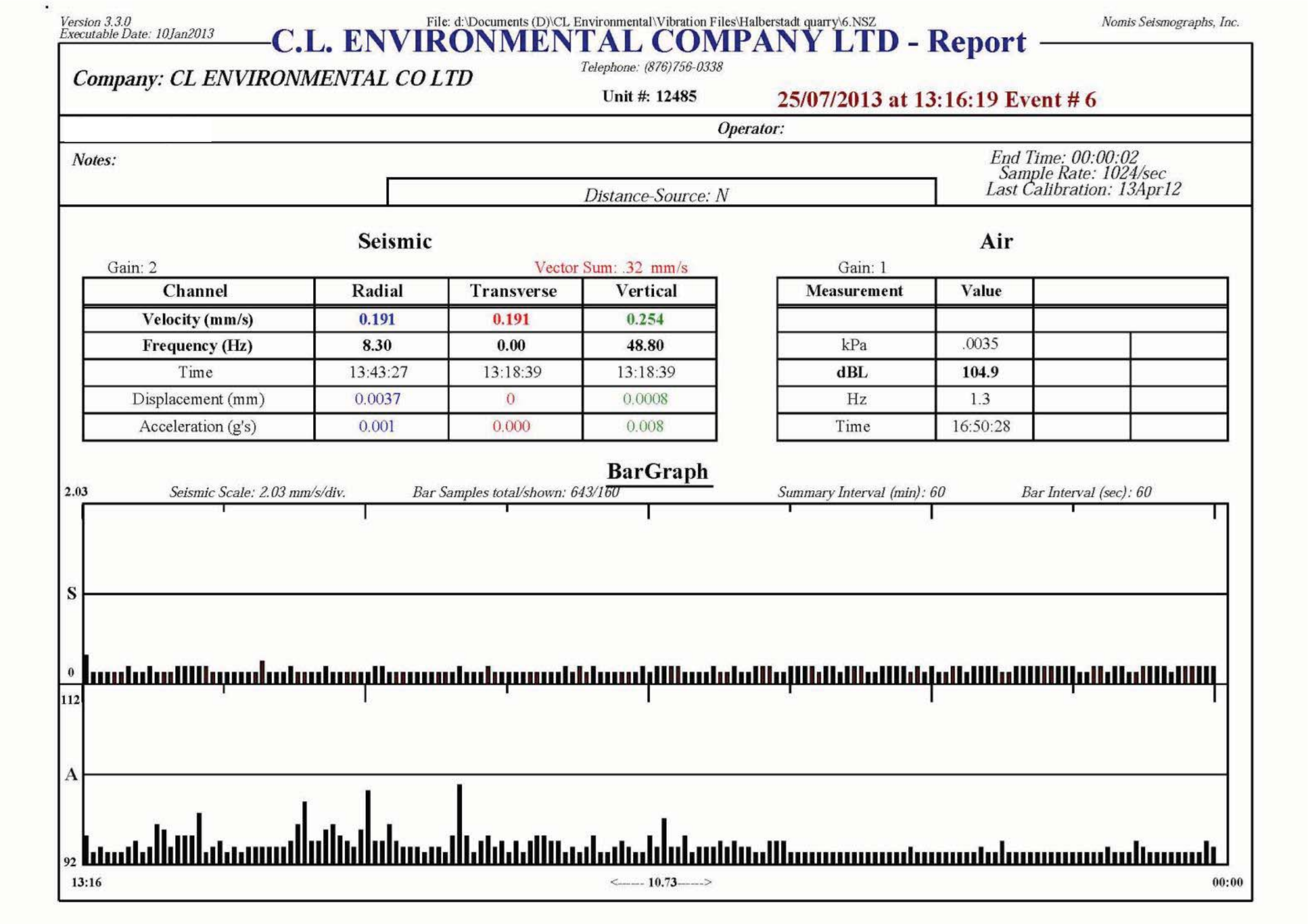
Gain: 1

Measurement	Value		
kPa	.006		
dBL	**109.5**		
Hz	0.0		
Time	09:49:47		

BarGraph

Seismic Scale: 130.05 mm/s/div.
Bar Samples total/shown: 759/151
Summary Interval (min): 60
Bar Interval (sec): 60

Figure 6.58 Vibration Results for event #4 at Location 1 occurring from 00:00:14 am July 25 to 12:40pm July 25, 2013



Version 3.3.0
Executable Date: 10Jan2013

File: d:\Documents (D)\CL Environmental\Vibration Files\Halberstadt quarry\6.NSZ

Nomis Seismographs, Inc.

C.L. ENVIRONMENTAL COMPANY LTD - Report

Company: CL ENVIRONMENTAL CO LTD

Telephone: (876)756-0338

Unit #: 12485

25/07/2013 at 13:16:19 Event # 6

Operator:

Notes:

Distance-Source: N

End Time: 00:00:02
Sample Rate: 1024/sec
Last Calibration: 13Apr12

Seismic

Gain: 2

Vector Sum: .32 mm/s

Channel	Radial	Transverse	Vertical
Velocity (mm/s)	0.191	0.191	0.254
Frequency (Hz)	8.30	0.00	48.80
Time	13:43:27	13:18:39	13:18:39
Displacement (mm)	0.0037	0	0.0008
Acceleration (g's)	0.001	0.000	0.008

Air

Gain: 1

Measurement	Value
kPa	.0035
dBL	**104.9**
Hz	1.3
Time	16:50:28

BarGraph

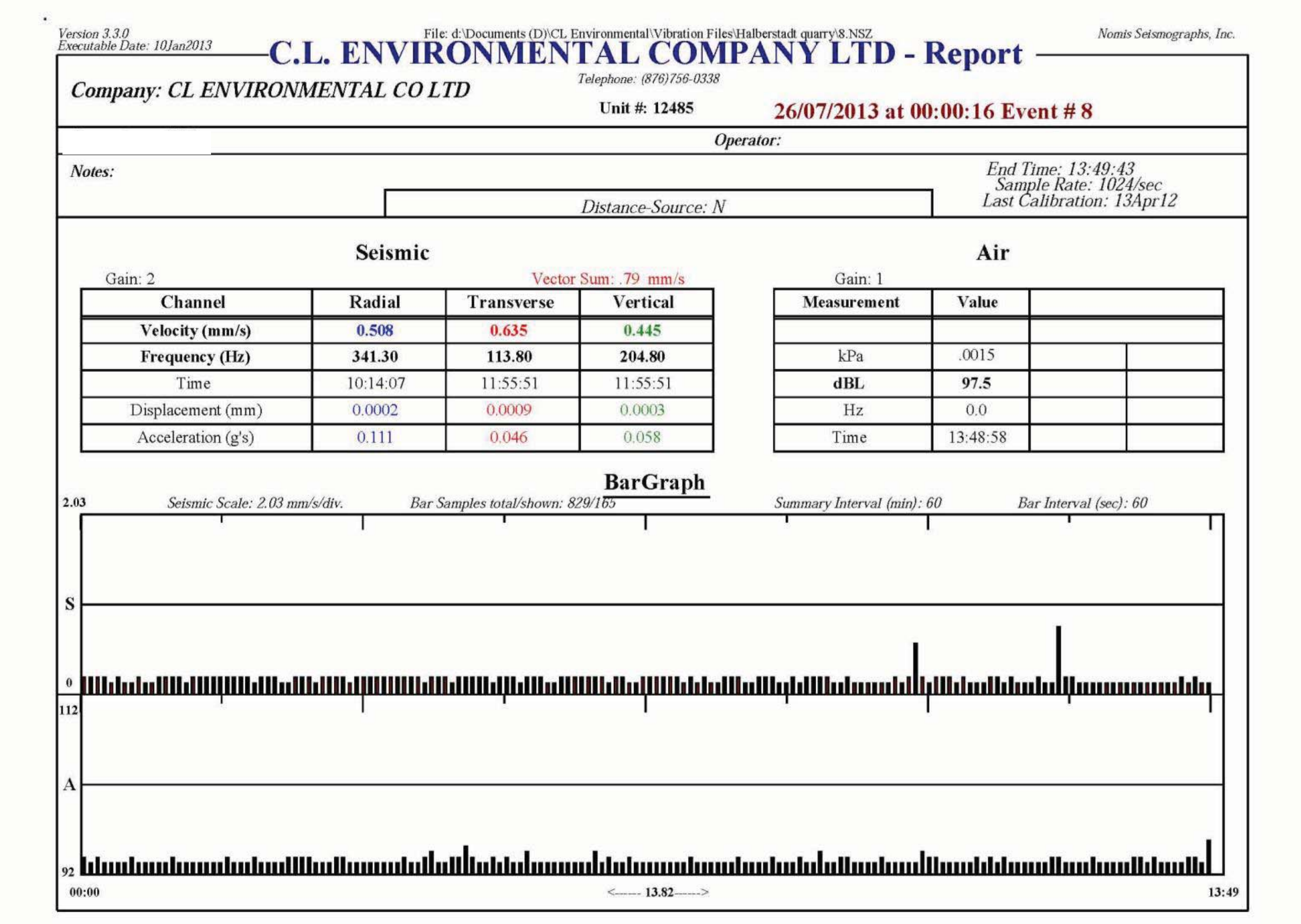
Seismic Scale: 2.03 mm/s/div.

Bar Samples total/shown: 643/160

Summary Interval (min): 60

Bar Interval (sec): 60

Figure 6.59 Vibration Results for event #6 at Location 2 occurring from 13:16:19 pm July 25 to 00:00:02 am July 26, 2013



Version 3.3.0
Executable Date: 10Jan2013

File: d:\Documents (D)\CL Environmental\Vibration Files\Halberstadt quarry\8.NSZ

Nomis Seismographs, Inc.

C.L. ENVIRONMENTAL COMPANY LTD - Report

Company: CL ENVIRONMENTAL CO LTD

Telephone: (876)756-0338

Unit #: 12485

26/07/2013 at 00:00:16 Event # 8

Operator:

Notes:

Distance-Source: N

End Time: 13:49:43
Sample Rate: 1024/sec
Last Calibration: 13Apr12

Seismic

Gain: 2

Vector Sum: .79 mm/s

Channel	Radial	Transverse	Vertical
Velocity (mm/s)	**0.508**	**0.635**	**0.445**
Frequency (Hz)	**341.30**	**113.80**	**204.80**
Time	10:14:07	11:55:51	11:55:51
Displacement (mm)	0.0002	0.0009	0.0003
Acceleration (g's)	0.111	0.046	0.058

Air

Gain: 1

Measurement	Value		
kPa	.0015		
dBL	**97.5**		
Hz	0.0		
Time	13:48:58		

BarGraph

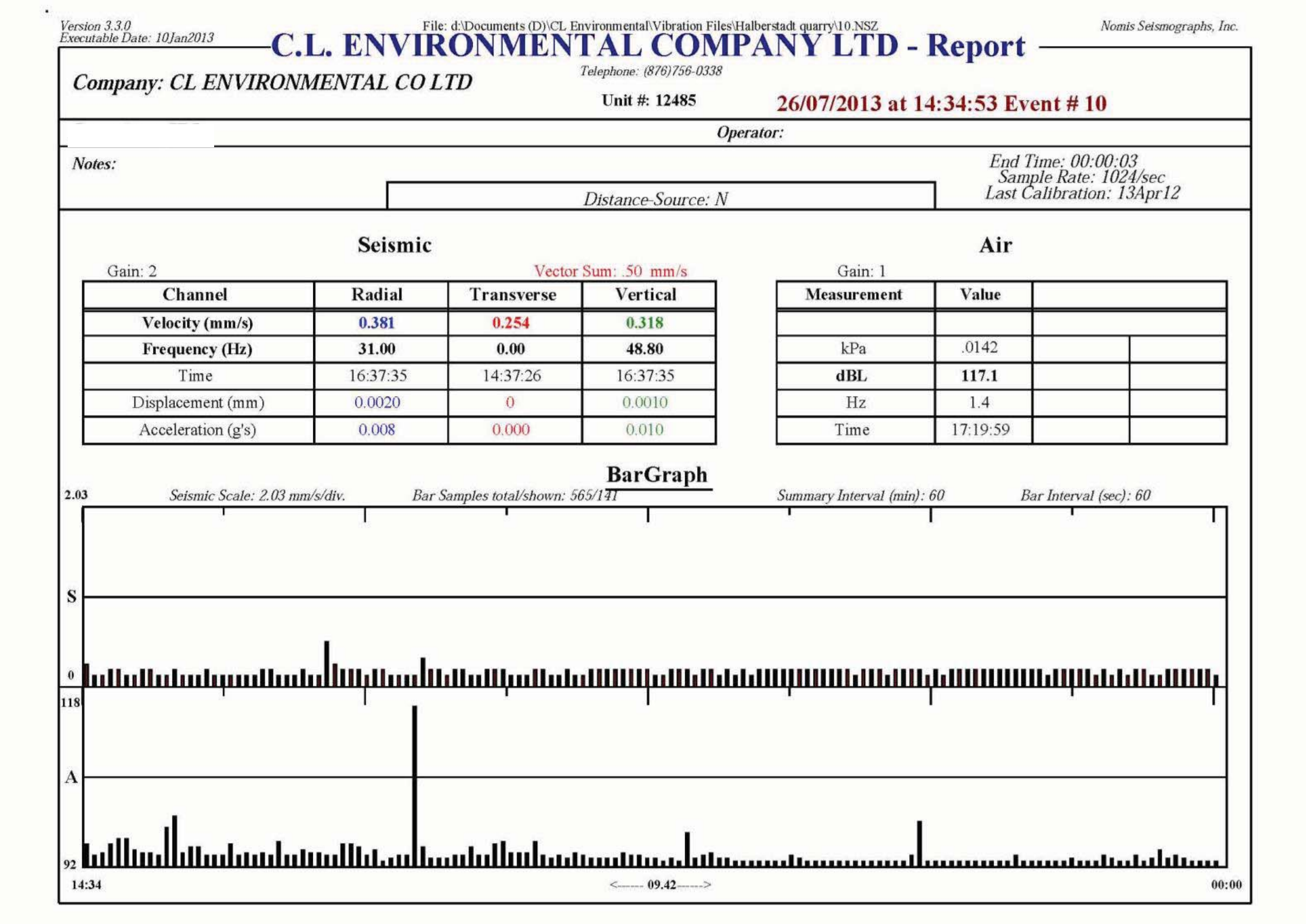
Seismic Scale: 2.03 mm/s/div.

Bar Samples total/shown: 829/165

Summary Interval (min): 60

Bar Interval (sec): 60

Figure 6.60 Vibration Results for event #8 at Location 2 occurring from 00:00:16 am July 26 to 13:49:43 pm July 26, 2013



Version 3.3.0
Executable Date: 10Jan2013

File: d:\Documents (D)\CL Environmental\Vibration Files\Halberstadt quarry\10.NSZ

Nomis Seismographs, Inc.

C.L. ENVIRONMENTAL COMPANY LTD - Report

Company: CL ENVIRONMENTAL CO LTD

Telephone: (876)756-0338

Unit #: 12485

26/07/2013 at 14:34:53 Event # 10

Operator:

Notes:

End Time: 00:00:03
Sample Rate: 1024/sec
Last Calibration: 13Apr12

Distance-Source: N

Seismic

Gain: 2

Vector Sum: .50 mm/s

Channel	Radial	Transverse	Vertical
Velocity (mm/s)	**0.381**	**0.254**	**0.318**
Frequency (Hz)	**31.00**	**0.00**	**48.80**
Time	16:37:35	14:37:26	16:37:35
Displacement (mm)	0.0020	0	0.0010
Acceleration (g's)	0.008	0.000	0.010

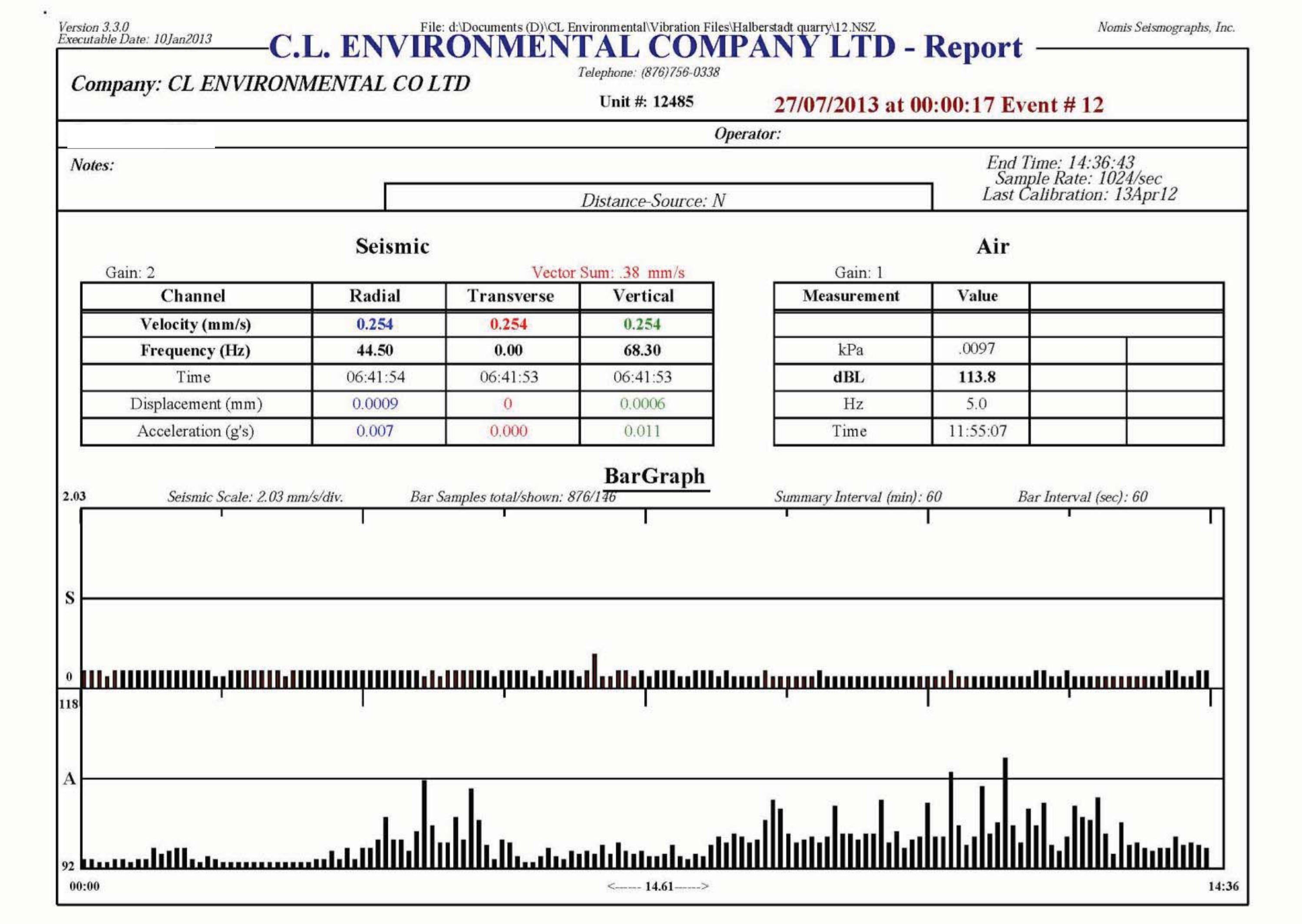
Air

Gain: 1

Measurement	Value
kPa	.0142
dBL	**117.1**
Hz	1.4
Time	17:19:59

BarGraph

Figure 6.61 Vibration Results for event #10 at Location 3 occurring from 14:34:53 pm July 26 to 00:00:03am July 27, 2013



Version 3.3.0
Executable Date: 10Jan2013

File: d:\Documents (D)\CL Environmental\Vibration Files\Halberstadt quarry\12.NSZ

Nomis Seismographs, Inc.

C.L. ENVIRONMENTAL COMPANY LTD - Report

Company: CL ENVIRONMENTAL CO LTD

Telephone: (876)756-0338

Unit #: 12485

27/07/2013 at 00:00:17 Event # 12

Operator:

Notes:

Distance-Source: N

End Time: 14:36:43
Sample Rate: 1024/sec
Last Calibration: 13Apr12

Seismic

Gain: 2

Vector Sum: .38 mm/s

Channel	Radial	Transverse	Vertical
Velocity (mm/s)	**0.254**	**0.254**	**0.254**
Frequency (Hz)	**44.50**	**0.00**	**68.30**
Time	06:41:54	06:41:53	06:41:53
Displacement (mm)	0.0009	0	0.0006
Acceleration (g's)	0.007	0.000	0.011

Air

Gain: 1

Measurement	Value		
kPa	.0097		
dBL	**113.8**		
Hz	5.0		
Time	11:55:07		

BarGraph

Seismic Scale: 2.03 mm/s/div.

Bar Samples total/shown: 876/146

Summary Interval (min): 60

Bar Interval (sec): 60

Figure 6.62 Vibration Results for event #12 at Location 3 occurring from 00:00:17 am July 27 to 14:36:43 pm July 27, 2013

6.1.8 Air Dispersion Modelling

6.1.8.1 Introduction

An air dispersion modelling exercise was conducted by Air Quality Consultants Limited (AQC), the results of which determine the maximum predicted ground level concentrations based on the proposed operations.

The proposed re-opening of the Quarry would produce 126, 400 tonnes of gypsum over the next five years, and this average amount was used in the air dispersion modelling analyses. The quarry facility will have unpaved haul roads, loading and unloading operations, a storage pile, as well as crushing activities using a mobile crusher. The main air pollutants of concern at the proposed quarry operations would be total suspended particulates (TSP) and particulate matter with a diameter of less than ten microns (PM10).

The following sections highlight the predicted maximum ambient TSP and PM10 concentrations as a result of the proposed operations, as well as the cumulative impact within 10km from the proposed facility. These concentrations are then compared with the Jamaican National Ambient Air Quality Standards (JNAAQS) to determine compliance.

6.1.8.2 Methodology/Approach

Modelling Approach

The assessment methodology for the air dispersion modelling exercise follows the guidance specified in the Natural Resources Conservation Authority (NRCA) Ambient Air Quality Guideline Document of 2006.

The detailed model recommended in the Ambient Air Quality Guideline Document is AERMOD. The model of selection was the commercially available AERMOD View air dispersion model (Version 8.05), developed by Lakes Environmental. This model is used extensively to assess pollution concentration and deposition from a wide variety of sources. AERMOD View is a true, native Microsoft Windows application and runs in Windows applications. The **A**MS/**E**PA **R**egulatory **Mod**el (AERMOD) was specially designed to support the EPA's regulatory modelling programs. AERMOD is a regulatory steady-state plume modelling system with three separate components: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD Terrain Preprocessor), and AERMET (AERMOD Meteorological Preprocessor). The AERMOD model includes a wide range of options for modelling air quality impacts of pollution sources, making it a popular choice among the modelling community for a variety of applications. Some of the modelling capabilities of AERMOD include the following:

- The model may be used to analyse primary pollutants and continuous releases of toxic and hazardous waste pollutants.
- Source emission rates can be treated as constant or may be varied by month, season, hour-of-day, or other optional periods of variation. These variable emission rate factors may be specified for a single source or for a group of sources. For this project all emission rates were treated as constant.
- The model can account for the effects of aerodynamic downwash due to buildings that are nearby point source emissions.
- Receptor locations can be specified as gridded and/or discrete receptors in a Cartesian or polar coordinate system.
- For applications involving elevated terrain, the U.S. EPA AERMAP terrain pre-processing program is incorporated into the model to generate hill height scales as well as terrain elevations for all receptor locations.
- The model contains algorithms for modelling the effects of settling and removal (through dry and wet deposition) of large particulates and for modelling the effects of precipitation scavenging for gases or particulates.
- AERMOD requires two types of meteorological data files, a file containing surface scalar parameters and a file containing vertical profiles. These two files are provided by the U.S. EPA AERMET meteorological preprocessor programme.

Model Inputs

Source Emissions

A critical step for conducting air dispersion modelling is to quantify the emissions from the various sources at a facility. The emission rates from the sources identified were estimated in accordance with the recommendation outlined in the Ambient Air Quality Guideline Document. According to Davis & Associates (2006), emission rates should be estimated in the following order of preference:

- Continuous emissions monitoring data
- Stack Emission Testing data
- Manufacturer's emission data
- Mass balance calculations
- Emission factors
- Engineering calculations

Table 6.27 shows the source information data determined for the proposed quarry facility, while Table 6.28 displays the source emission rates that were calculated based on the use of published USEPA emission factors, proposed production data, meteorological data and other project information, and these emission rates may also be found in Appendix 5. It should be noted that the emission calculations for the unpaved haul roads contemplate the roads being sprayed with water as a control measure.

The locations of the sources at the proposed quarry facility are reflected in Figure 6.63.

Other source information data and emission rates for facilities nearby the proposed quarry operations are identified in Table 6.29 through Table 6.31. These data were based on information obtained from the Air Dispersion Modelling Report for Jamaica Ethanol Processing Limited that was conducted in 2009.

According to the Natural Resources Conservation Authority (Air Quality) Regulations, there are no specific mass-based emission limits for quarry operations. Hence, no direct comparison can be made with the emission rates for the proposed quarry operations at Halberstadt.

Table 6.27 Source information data for proposed quarry

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Release Height, m	Length of Side, m	Vertical Dimension, m	Length of Y Side, m
RL	LINE VOLUME	Road emissions with loaded trucks	324844.2	1987781.2	608.0	8.5			
RE	LINE VOLUME	Road emissions with empty trucks	324844.2	1987781.2	608.0	8.5			
RL1	LINE VOLUME	Road emissions with loaded trucks	324898.4	1987699.8	597.0	8.5			
RE1	LINE VOLUME	Road emissions with empty trucks	324898.4	1987699.8	597.0	8.5			
RL2	LINE VOLUME	Road emissions with loaded trucks	324950.0	1987611.2	576.0	8.5			
RE2	LINE VOLUME	Road emissions with empty trucks	324950.0	1987611.2	576.0	8.5			
RL3	LINE VOLUME	Road emissions with loaded trucks	325104.6	1987483.7	533.0	8.5			
RE3	LINE VOLUME	Road emissions with empty trucks	325104.6	1987483.7	533.0	8.5			
LQ	VOLUME	Loading trucks at Quarry	324935.0	1987689.0	560.7	10	20	10	
USP	VOLUME	Unloading at Storage Pile	325101.0	1987562.0	487.4	10	20	10	
GSP	AREA	Gypsum Storage Pile	325070.0	1987518.0	516.7	20	55		90
MC	VOLUME	Mobile Crusher	324935.0	1987689.0	560.7	10	20	10	

Table 6.28 Air pollutant emission rates for proposed quarry

Source ID	Description	TSP Emission (g/s)	PM_{10} Emission (g/s)
RL	Road emissions with loaded trucks	0.14	0.04
RE	Road emissions with empty trucks	0.08	0.0225
RL1	Road emissions with loaded trucks	0.14	0.04
RE1	Road emissions with empty trucks	0.08	0.0225
RL2	Road emissions with loaded trucks	0.14	0.04
RE2	Road emissions with empty trucks	0.08	0.0225
RL3	Road emissions with loaded trucks	0.14	0.04
RE3	Road emissions with empty trucks	0.08	0.0225
LQ	Loading trucks at Quarry	0.15	0.07
USP	Unloading at Storage Pile	0.15	0.07
GSP	Gypsum Storage Pile	0.27	0.27
MC	Mobile Crusher	0.0108	0.0048

Table 6.29 Air Pollutant emission rates for JGQ port modelling

Source ID	Description	TSP Emission (g/s)	PM_{10} Emission (g/s)
RL	Road emissions with loaded trucks	0.17	0.04
RE	Road emissions with empty trucks	0.1	0.02
RL1	Road emissions with loaded 3rd party trucks	0.24	0.06
RE1	Road emissions with empty 3rd party trucks	0.13	0.03
CHUTE	Drag Chain Conveyor loading over a Chute	0.17	0.08
TMSP	Transfer of Material at Storage Piles	0.25	0.12

Table 6.30 Area source locations and emissions for the CCCL facility

Source	Stack ID	UTME (m)	UTMN (m)	Elevation (m)	Release Height (m)	PM/PM_{10} Emissions (g/s)	Area (m^2)
CCC Clinker Storage Yard	CSY	316,654	1,988,137	44.1	6	1.6915	1600
CCC Gypsum Storage Yard	GSY	316,550	1,988,240	8.1	6	0.0933	100
CCC Coal Storage Yard	Coal	316,195	1,987,147	7.1	6	0.0157	3000
CCC Quarry	Quarry	317,350	1,987,115	227.6	6	2.544	250000

Table 6.31 Stack parameters for CCCL point sources

Plant	Stack ID	UTME (m)	UTMN (m)	Elev (m)	Stack Height (m)	Stack Dia. (m)	Stack Vel. (m/s)	Stack Temp. (K)	PM/PM$_{10}$ Emissions (g/s)
Quarry Hammer Mill	QHM	316,695	1,987,479	200.0	15.0	2.26	0.1	303	0.0033
Coal Mill A	COALA	316,691	1,987,304	6.3	2.4	0.91	11.6	363	0.0003
Coal Mill B	COALB	316,691	1,987,290	6.3	2.4	0.91	11.6	363	0.0003
Main EP discharge	K4EPDIS	316,580	1,987,317	15.0	39.6	0.34	25	303	0.0853
Homogenizing silo vent	4HOMSILV	316,549	1,987,313	15.2	26.0	0.91	33	303	0.2721
Homogenizing silo discharge	4HOMSILD	316,533	1,987,307	15.2	4.5	0.34	21	303	0.0595
Clinker silo belts	CSBELTS	316,657	1,987,285	6.1	14.0	1.38	3.2	303	0.0583
Clinker storage silos (top)	CSSTOP	316,660	1,987,376	22.0	41.0	1.38	2.2	303	0.2285
Gypsum Hammer crusher	GYPHM	316,647	1,987,161	4.0	2.0	0.2	12	303	0.0009
Clinker storage silos (bottom belts)	CSSBOTM	316,660	1,987,369	22.0	12.5	0.2	13	303	0.0583
Cement mill 3 vent	CMILL3	316,688	1,987,208	4.6	10.7	1.38	6	363	0.2502
Cement mill 4 vent	CMILL4	316,681	1,987,172	4.8	20.0	1.38	7	363	0.1327
Cement mill 4 separator vent	CMILL4SV	316,681	1,987,166	3.4	16.8	1.38	5	333	0.4861
Cement silo 1 - 4	CSILO124	316,793	1,987,165	9	36.5	1.03	3	303	0.1371
Cement silo 5 - 8	CSILO528	316,812	1,987,165	9	36.5	1.03	3	303	0.1384
Cement silo 9 vent (bags 6X101")	CEMENT9	316,801	1,987,052	2.3	36.5	1.03	3	303	0.1632
Cement silo 10 vent (bags 6X101")	CEMENT10	316,819	1,987,051	2.3	36.5	1.03	3	303	0.1632
Distribution bin	DISTBIN	316,783	1,987,049	2.3	36.5	1.03	3	303	0.5222
Transfer station	XFERSTN	316,793	1,987,175	9	36.5	1.03	3	303	0.1306
Big bag loading (bags 6X99")	BAGLOAD	316,772	1,987,079	2.8	10.5	1.03	5	303	0.1306
Packer 4 (bags 6X99")	PACK4	316,765	1,987,066	2.3	10.5	0.91	5	303	0.1306
Packer 5 (bags 6X129")	PACK5	316,764	1,987,054	2.5	10.5	0.91	5	303	0.1306
Cement silo 9 and 10 discharge	CS9&10D	316,790	1,987,044	2.4	10.5	0.91	5	333	0.1667
Raw mill bin feed belt	K5RMFB20	316,737	1,987,325	19.3	3.0	0.25	14	303	0.0255

Plant	Stack ID	UTME (m)	UTMN (m)	Elev (m)	Stack Height (m)	Stack Dia. (m)	Stack Vel. (m/s)	Stack Temp. (K)	PM/PM_{10} Emissions (g/s)
Raw mill bin feed belt	K5RMFB30	316,737	1,987,356	21.3	10.0	0.25	14	303	0.0255
Raw mill bins	K5RMBINS	316,933	1,987,448	39.4	30.0	0.40	15	303	0.0664
Raw mill feed belt	5RMBEL91	316,920	1,987,450	38.0	10.0	0.40	14	303	0.0638
Raw mill feed belt	5RMBEL97	316,859	1,987,460	38.0	24.0	0.30	17	303	0.0426
Raw mill system fugitive	5RMSYSFG	316,853	1,987,474	38.0	10.0	0.40	14	303	0.063
Raw mill cyclone fugitive	5RMCYCFG	316,834	1,987,462	38.0	10.0	0.30	16	303	0.0409
Homogenizing silo vent	5HOMSILV	316,807	1,987,460	38.0	34.0	0.45	15	303	0.0851
Homogenizing silo discharge	5HOMSILD	316,809	1,987,466	38.0	10.0	0.45	15	303	0.0851
Kiln feed vent	K5FEEDV	316,809	1,987,466	38.0	95.0	0.40	14	303	0.0654
Clinker cooler vent	CLC5	316,751	1,987,438	34.0	29.0	1.8	13	394	0.9368
Kiln 5 main fabric filter	CCK5	316,790	1,987,425	38.0	117.5	2.6	17	381	2.72
New CSSBOTM	CBOTMNEW	316780	1987137	34.78	12.5	0.2	13	303	0.0583
New CSBELTS	CSBELNEW	316712	1987673	290.2	14	1.38	3.2	303	0.0583
New CSSTOP	CSTOPNEW	316786	1987142	37.18	41	1.38	2.2	303	0.2285

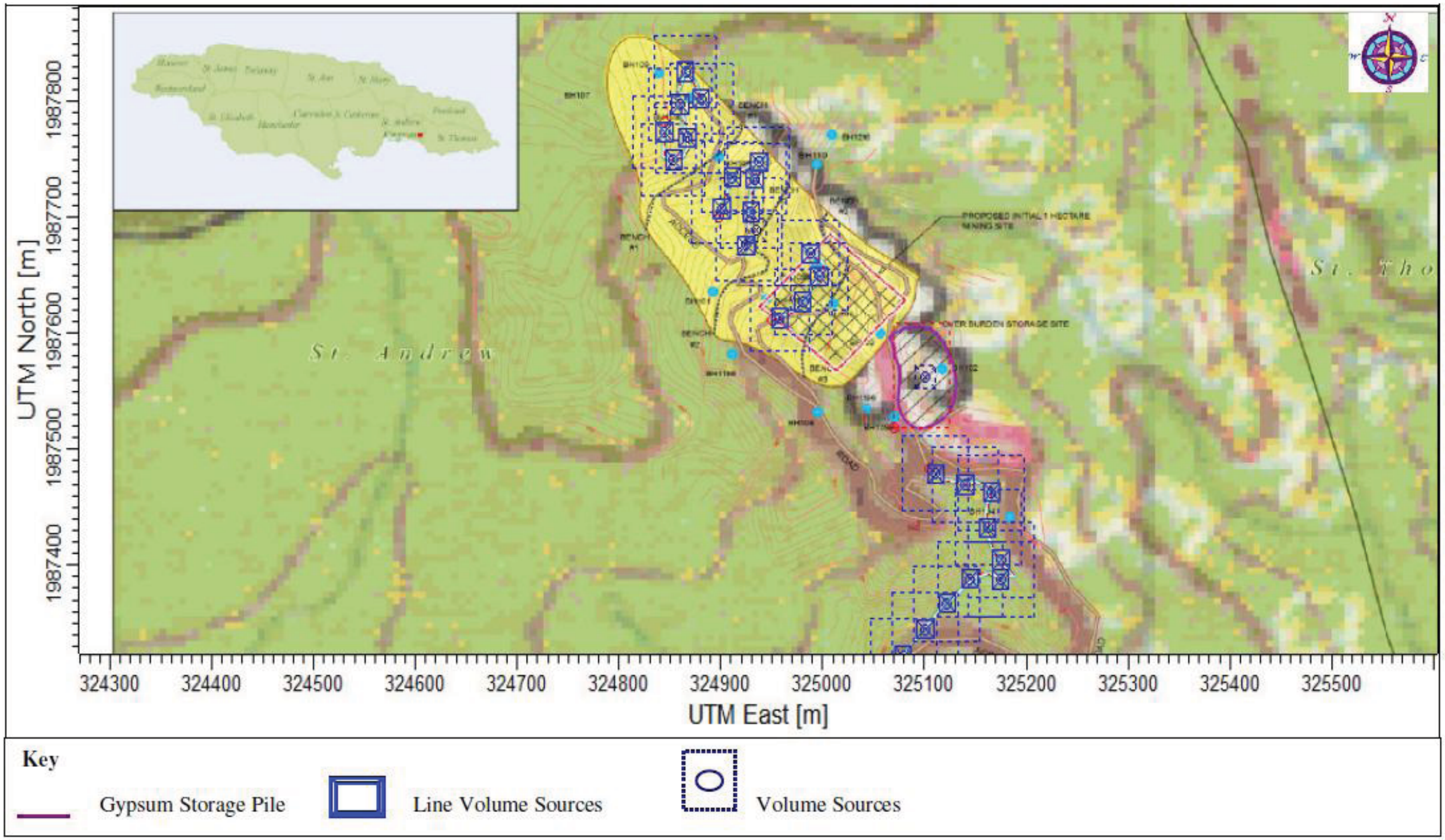


Figure 6.63 *Map showing the plant sources*

Meteorological Data

The AERMOD model requires hourly surface data values for wind speed, wind direction, temperature, rainfall, relative humidity, pressure, cloud cover and ceiling height and solar radiation and at least once daily mixing height data. MM5 surface data for years 2007 through 2011 were obtained and utilized for the Norman Manley International Airport (NMIA). These surface data were complimented by the acquisition and use of MM5 upper air data for the similar years (2007 through 2011) to generate the required mixing heights for the AERMOD model.

Both data files for the surface and upper air were then used to generate the meteorological file required by the AERMOD dispersion model using the AERMET meteorological preprocessor programme. This AERMET programme has three stages to process the data. The first stage extracts meteorological data and assesses data quality through a series of quality assessment checks. The second stage merges all data available for 24-hour periods and writes these data together in a single intermediate file. The third and final stage reads the merged meteorological data and estimates the necessary boundary layer parameters for dispersion calculations by AERMOD.

The 2007 through 2011 meteorological pre-processed data was used to determine its corresponding Wind Rose plot (see Figure 6.64). The Wind rose show that the most predominant wind direction blows from the southeast, with the secondary wind direction being from the east-southeast. This means that the emissions plume will be dispersed mainly in the north-western direction, and secondarily in the west-northwest direction from the plant site.

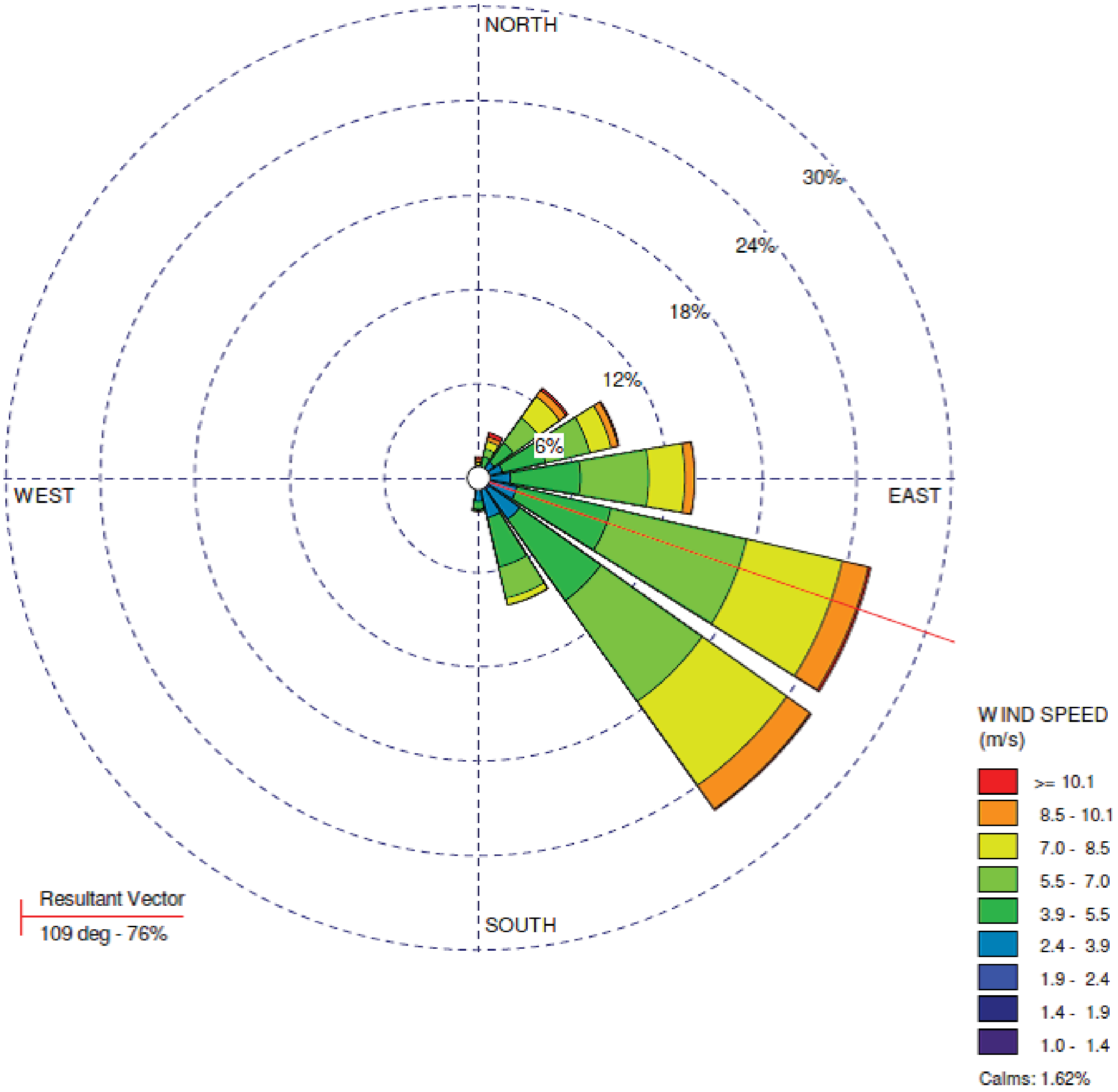


Figure 6.64 Wind rose plot (2007 through 2011) meteorological data

Model Domain, Receptor Network and Terrain Considerations

The selected model domain was 20 km in the east-west and 20 km in the north-south directions, with the centre of the domain being the centre of the sources identified at the proposed quarry facility, with coordinates 324,970 m UTME and 1,987,635 m UTMN. Figure 6.65 shows the model domain that was utilized in the project, including the receptor grid and the plant boundary. The model domain is overlain on a Jamaica Metric Grid 1:50,000 topographic map.

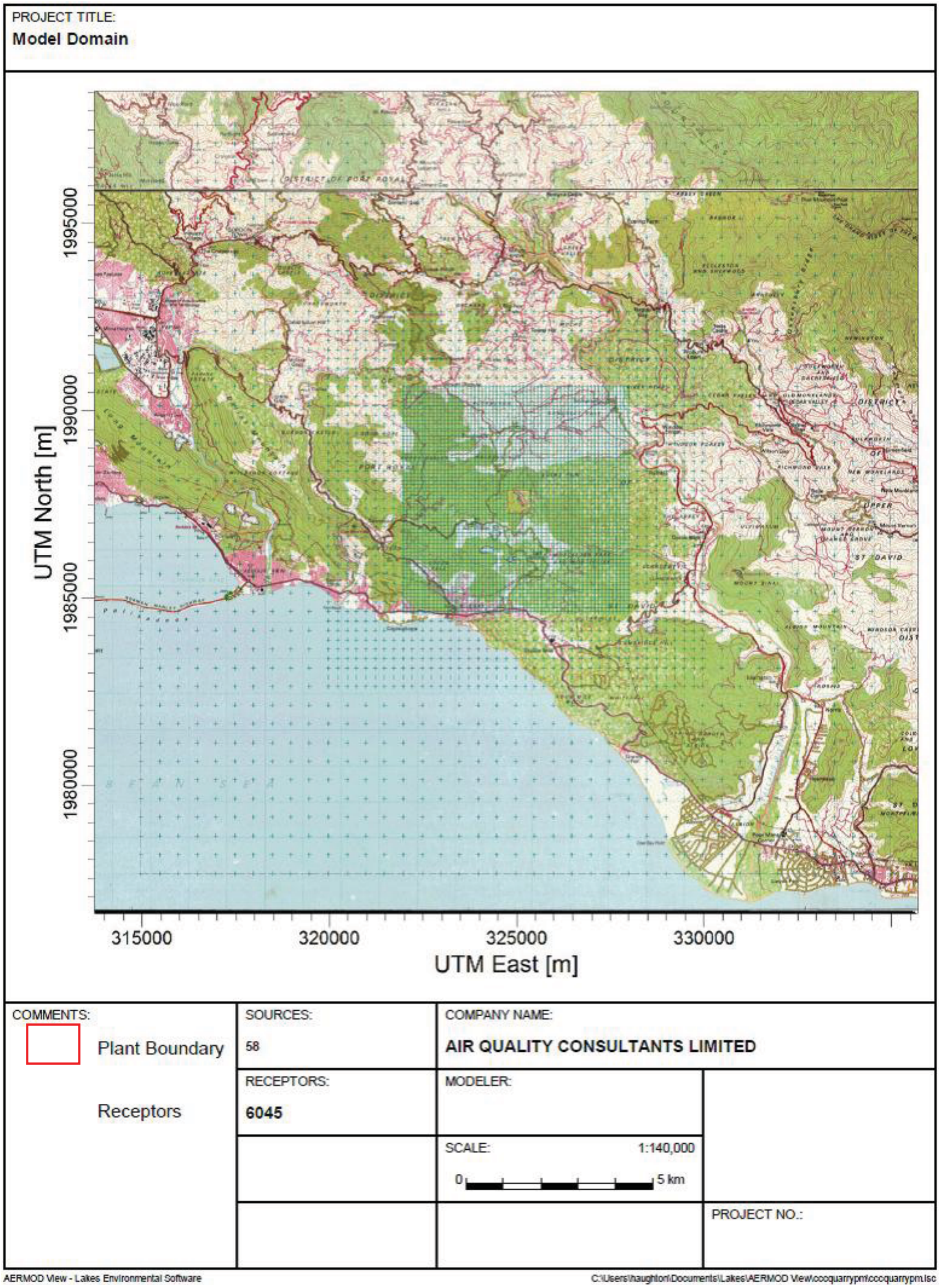


Figure 6.65 Model domain showing receptor network

Receptor Network

The selection and location of the receptor network are important in determining the maximum impact from a source and the area where there is significant air quality impact. The locations were identified beyond the air pollutant sources boundary and were chosen in accordance with the NRCA Ambient Air Quality Guideline Document (2006). Receptor locations were selected as a multi-tier grid that is defined by discrete Cartesian receptors, square in shape, and with origin at the centre of the sources at the quarry operations. Certain special receptor locations such as schools, health centres, churches, police stations, postal offices, and hospitality attractions were also included in the receptor network.

The entire receptor network locations include the following:

- A 100-meter spaced grid within 3 km from the centre of the proposed facility sources;
- A 250-meter spaced grid between 3 and 5 km from the centre of the proposed facility sources;
- A 500-meter spaced grid between 5 and 10 km from the centre of the proposed facility sources; and
- 26 special receptors that include schools, health centres, churches, police stations, postal offices, and hospitality attractions (see Table 6.32).

A total of 6,045 receptors were considered, and they are graphically depicted in Figure 6.65.

Table 6.32 Special receptors

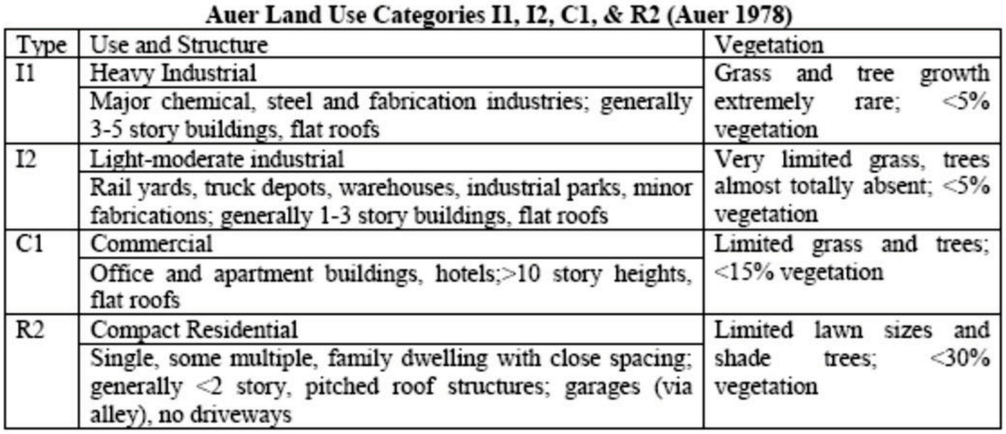
Description	**X Coordinate, m**	**Y Coordinate, m**	**Elevation, m**
Bull Bay Police Station	323181	1984543	44.02
Bull Bay Health Centre	323337.1	1984723	29.89
Church at Bull Bay	324574.2	1984741	50.38
Bull Bay All Age School	324604.2	1984934	64.64
Bull Bay Post Office	324213.9	1984615	31.69
Church at Cocoa Walk	329906.9	1986423	165.65
Woburn Lawn Primary School	329967	1991696	621.11
Somerset All Age & Infant School	327462.8	1990218	388.19
Church at Somerset	327618.9	1990056	349.3
Tower Hill Postal Agency	325198.8	1992260	894.72
Tower Hill Primary School	324970.6	1991984	891.75
Church at Lime Tree	324039.7	1991263	951.66
Bloxburgh Primary & Infant School	325000.6	1989588	925.66
Church at Bloxburgh	324934.5	1989540	908.85
Bito Primary &Infant School	323763.5	1986903	389.02

Description	X Coordinate, m	Y Coordinate, m	Elevation, m
Church at Bito	323817.5	1986975	391.21
Bito Postal Agency	323895.6	1987047	424.49
Cane River Falls	320646.7	1986921	220.92
Church at Newstead	321379.4	1986453	187.96
St. Benedict's Primary School	321571.6	1986069	183.57
Harbour View Primary School	318228	1985194	6.48
Harbour View Health Centre	317850	1985573	14
Harbour View Police Station	318257	1985485	10.91
Harbour View Post Office	317879	1985806	19.53
Harbour View Church	317530	1986301	37.07
Mineral Bath	316221	1987350	6

Terrain Considerations

The classification of the land use in the vicinity of the existing facility is needed because dispersion rates differ between urban and rural areas. In general, urban areas cause greater rates of dispersion because of increased turbulent and buoyancy-induced mixing. This is due to the combination of greater surface roughness caused by more buildings and structures and greater amounts of heat released from concrete and similar surfaces. The USEPA guidance provides two procedures to determine whether the character of an area is predominantly urban or rural. One procedure is based on land-use type, and the other is based on population density. Both procedures require an evaluation of characteristics within a 3-km radius from the subject source, but the land-use methodology is considered more accurate. Hence, this method was applied and it was determined that the rural dispersion coefficient be selected for this modelling project.

According to the land-use type methodology, a 3 km radius circle was circumscribed about the centre of the sources at the facility. Then using the Auer land use types, only 5% (less than the 50% threshold) of the 3 km radius area around the project site matches the urban zones of I1, I2, C1, and R2 (Figure 6.66). The majority of the area was forested land, and hence the rural option was selected.

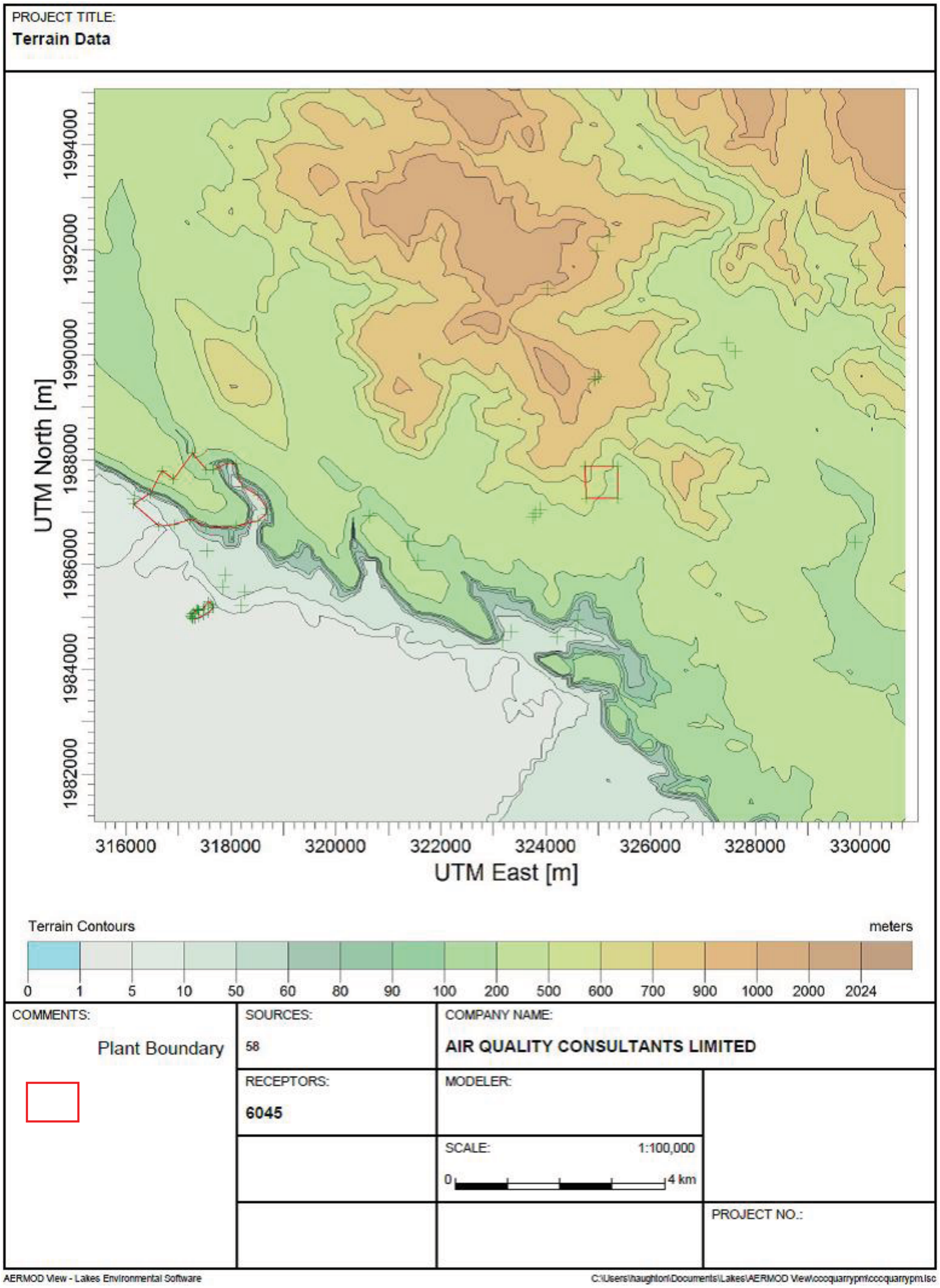


Auer Land Use Categories I1, I2, C1, & R2 (Auer 1978)

Type	Use and Structure	Vegetation
I1	Heavy Industrial Major chemical, steel and fabrication industries; generally 3-5 story buildings, flat roofs	Grass and tree growth extremely rare; <5% vegetation
I2	Light-moderate industrial Rail yards, truck depots, warehouses, industrial parks, minor fabrications; generally 1-3 story buildings, flat roofs	Very limited grass, trees almost totally absent; <5% vegetation
C1	Commercial Office and apartment buildings, hotels;>10 story heights, flat roofs	Limited grass and trees; <15% vegetation
R2	Compact Residential Single, some multiple, family dwelling with close spacing; generally <2 story, pitched roof structures; garages (via alley), no driveways	Limited lawn sizes and shade trees; <30% vegetation

Figure 6.66 Land use categories

Additionally, the topography in the region of the proposed quarry facility is defined as complex terrain (terrain above the plume release heights). Terrain data in the area surrounding the proposed facility were obtained from Digital Elevation Maps derived from the Mona Informatix Limited. It was determined that the topography from west northwest through to the north north-eastern directions from the proposed quarry operations are for the most part greater than 500m (Figure 6.67). Therefore, since terrain elevations extend above the facility's highest release height, complex terrain algorithms were included as part of the dispersion modelling analyses



PROJECT TITLE:
Terrain Data

COMMENTS:
Plant Boundary 🟥

SOURCES:
58

RECEPTORS:
6045

COMPANY NAME:
AIR QUALITY CONSULTANTS LIMITED

MODELER:

SCALE: 1:100,000
0 4 km

PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\Users\haughton\Documents\Lakes\AERMOD View\cccquarrypm\cccquarrypm.isc

Figure 6.67 Terrain data surrounding the proposed facility

6.1.8.3 Results and Discussion

With the various sources identified, a model domain established of 20 km in the east-west direction and 20 km in the north-south direction and centred in the middle of all the sources at the proposed quarry facility, and the necessary input files created, model predictions were made for the pollutants TSP and PM10 for averaging periods for which there are JNAAQS.

Results for Proposed Quarry Facility

Table 6.33 summarizes the maximum predicted concentrations for the proposed quarry facility, and their comparison with the JNAAQS. The results revealed that the maximum predicted ground level concentration for all the sources at the proposed quarry plus the background concentrations (as recommended in the NRCA Ambient Air Quality Guideline Document) were in compliance with the respective JNAAQS. Hence, there is no need for any additional mitigation measures, other than for the unpaved haul roads to be sprayed with water during the operation of the quarry.

Table 6.33 Air dispersion model results

Pollutant	Avg. Period	Background (μg/m³)	Jamaican NAAQS (μg/m³)	Proposed Quarry Sources		
				Max Conc (μg/m³)	UTME (m)	UTMN (m)
TSP	24-hr	14	150	79.9	325270.06	1987235.63
	Annual	20	60	9.7	324749.73	1987876.89
PM_{10}	24-hr	9	150	68.2	325470.06	1988135.63
	Annual	20	50	3.4	324749.73	1987876.89

Figure 6.68 through to Figure 6.71 show the pollutant contour plot-files for TSP and PM10. The plot files show the most impacted areas based on the predicted pollutant concentrations generated by the model runs. The colour coded scale in the figures indicates the various impact concentrations obtained up to the maximum predicted concentrations achieved.

6.1.8.4 Conclusions

The following conclusions may be made as a result of the conduct of the air dispersion modelling analyses for the proposed quarry facility:

- The model predictions for the proposed quarry facility revealed compliance with the standards for all averaging periods for TSP and PM_{10}.
- Hence, there is no need for any additional mitigation measures other than the spraying of the unpaved haul roads with water.

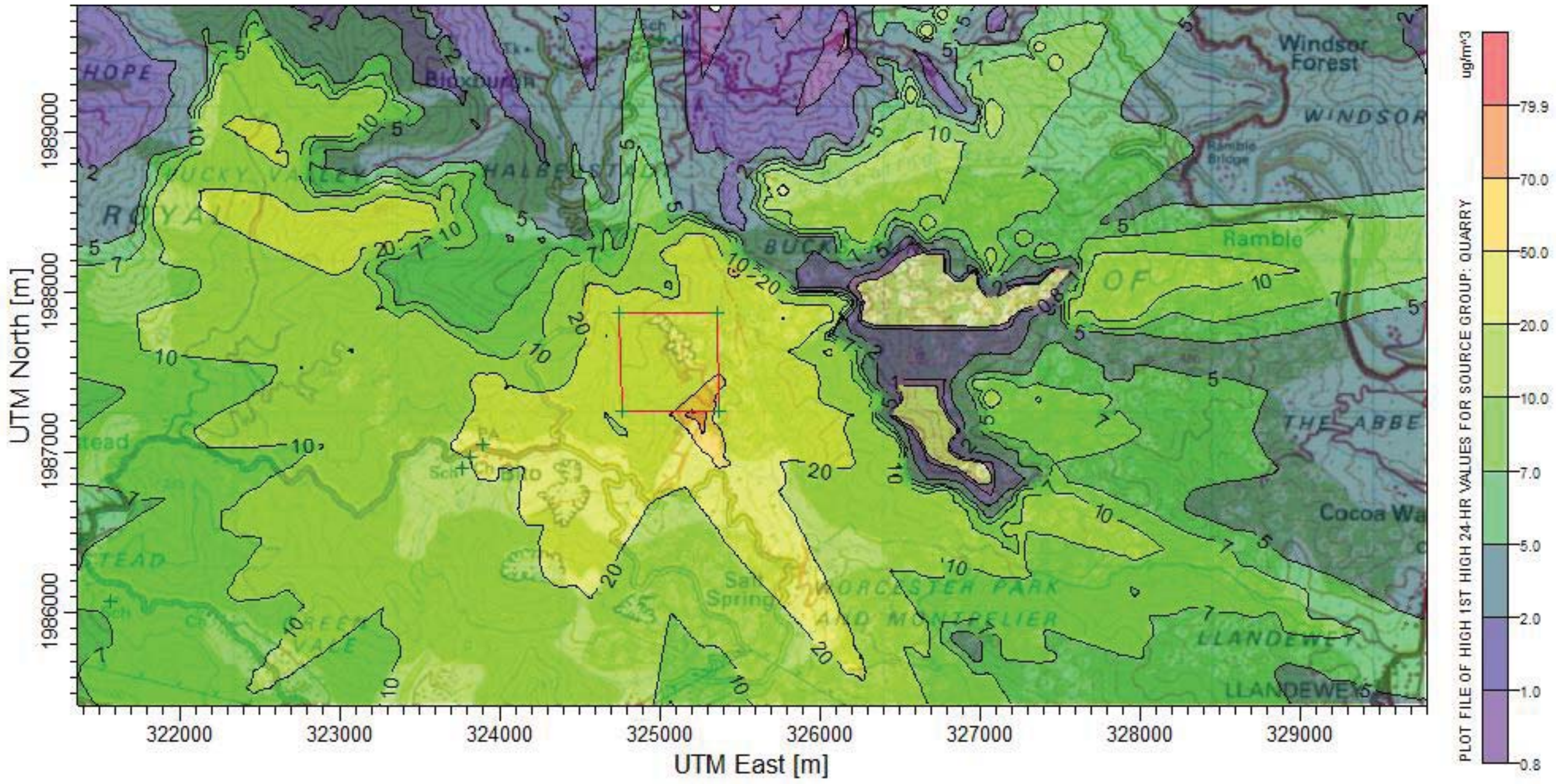


Figure 6.68 Predicted 24-h TSP concentrations

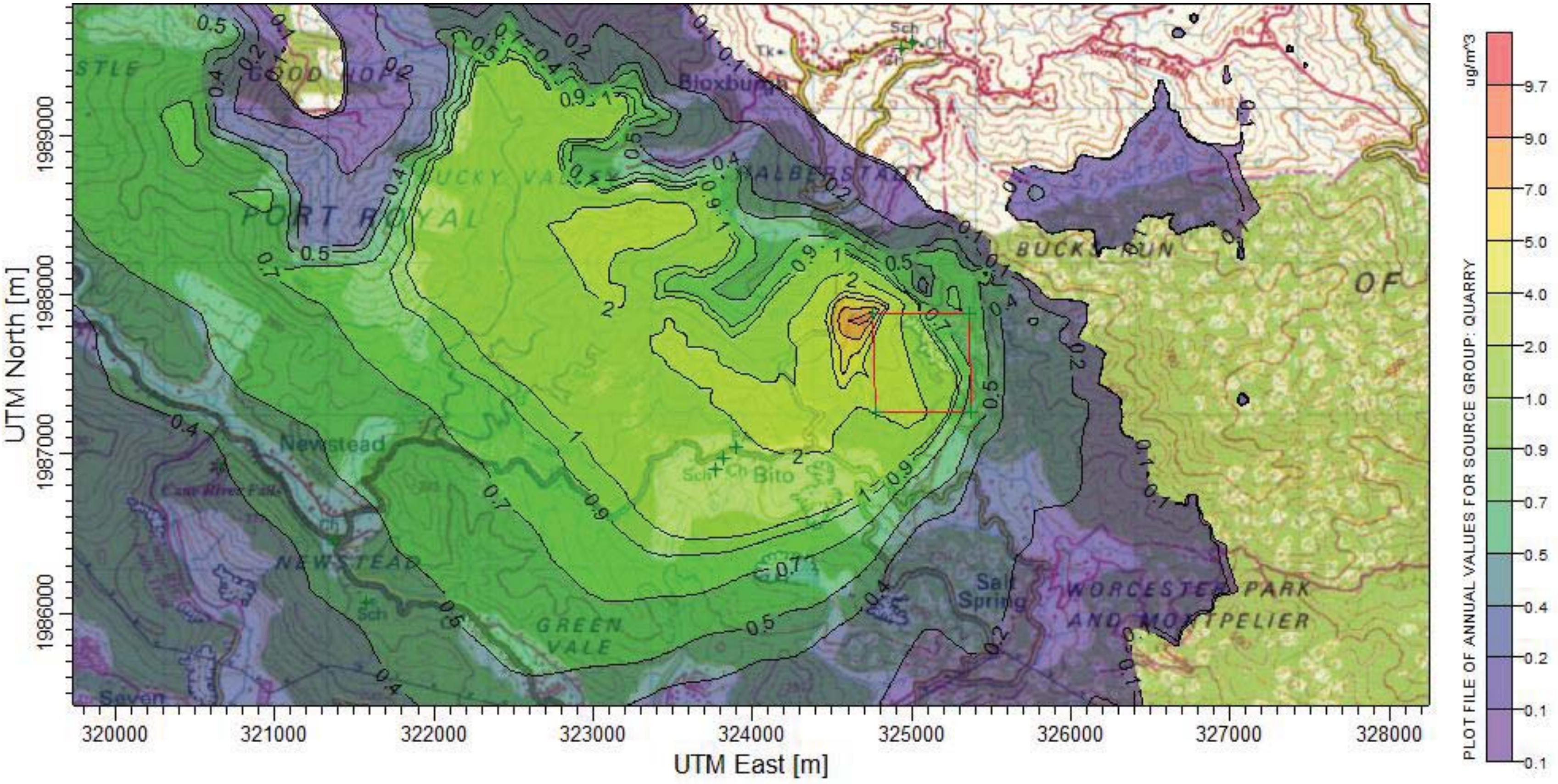


Figure 6.69 Predicted annual TSP concentrations

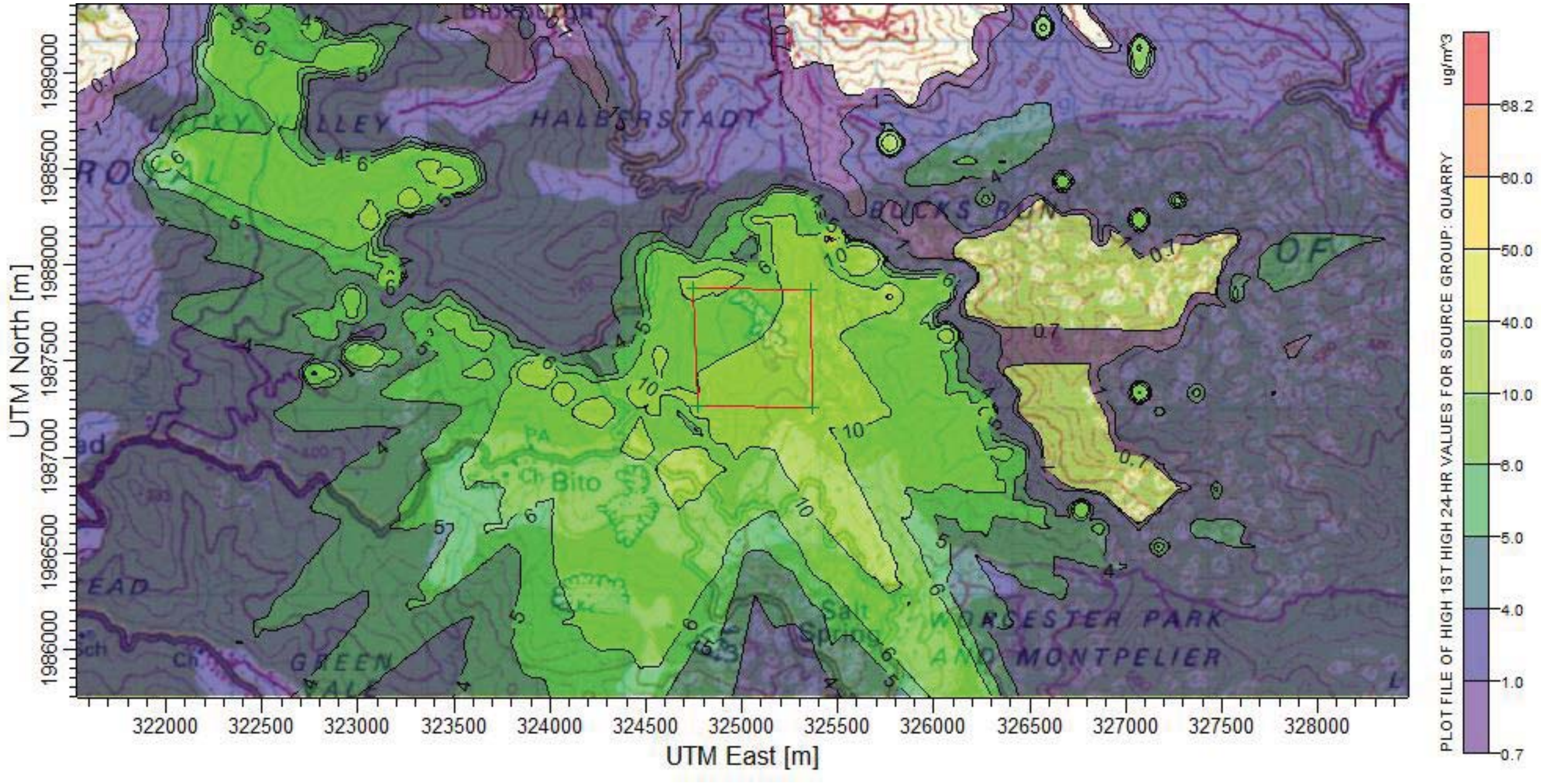


Figure 6.70 *Predicted 24-h PM10 concentrations*

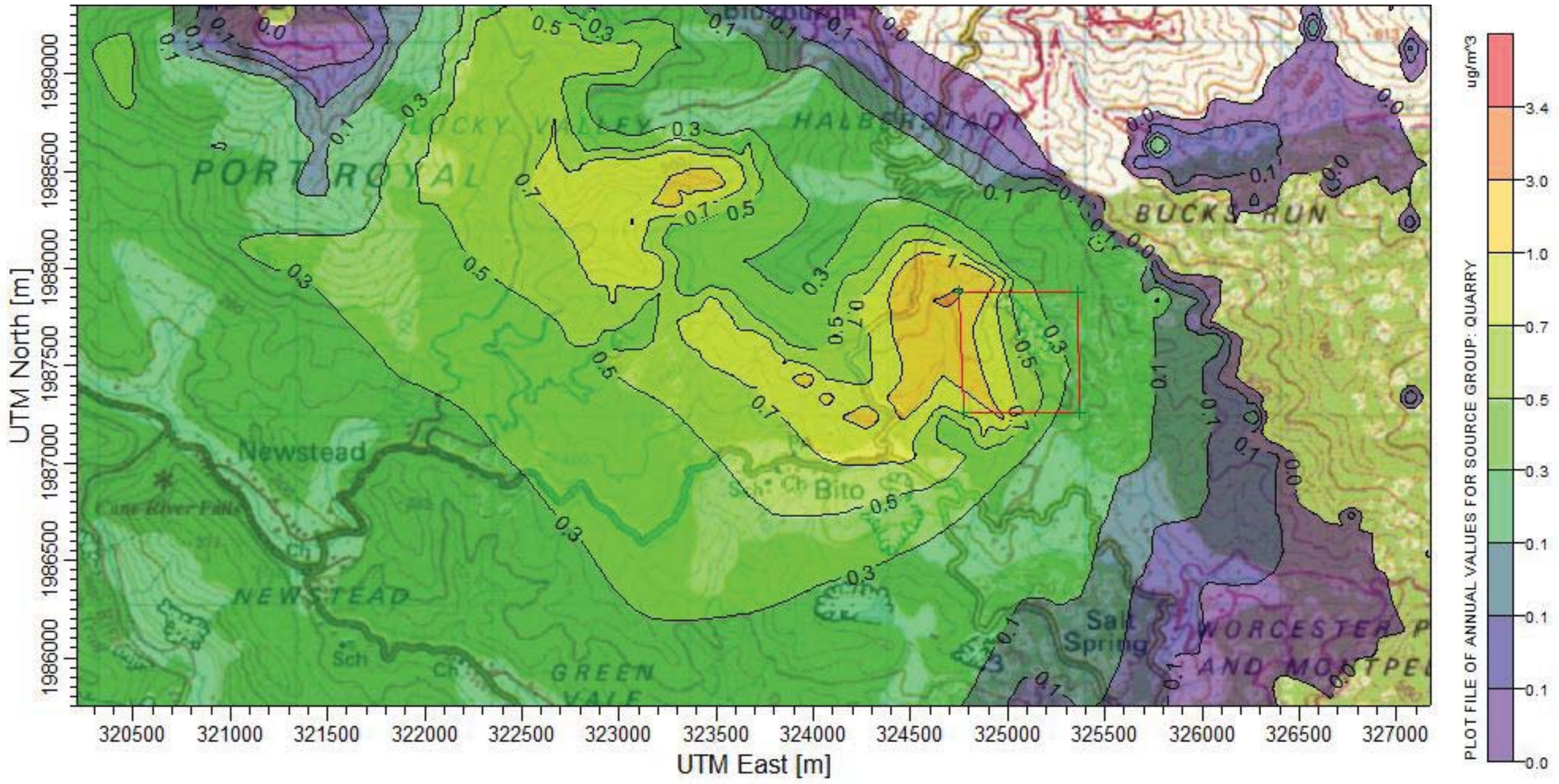


Figure 6.71 *Predicted annual PM10 concentrations*

6.2 Biological Environment

6.2.1 Terrestrial Flora

6.2.1.1 Introduction

This section entails the results and recommendations derived from inland vegetation surveys conducted July 13 & 18, 2013 at the proposed site, located in the Port Royal Mountains – a subordinate range of ridges extending southwards from the main Blue Mountain Range (Plate 6.10).

Plate 6.10 View from a section of the Halberstadt Quarry looking towards Morant Bay (18/07/2013)

The developers have reported that the site was previously quarried and left dormant for several years. The area is currently well re-vegetated (Plate 6.11): the terrestrial community growing over a substrate composed of clays, sands and gravels, clayey shales, sandstones as well as gypsum/anhydrite deposits (CCCL pers. comm.). The loose substrate structure, coupled with steep slopes, may leave the deforested areas in this area subject to erosion (Asprey & Robbins 1953).

Plate 6.11 Panoramic view of a section of the study area (13/07/2013)

In an attempt to adhere to TOR, the floral study will entail the generation of baseline data to aid in the description of the biological environment. A detailed account of the terrestrial flora encountered will be presented, with special emphasis on rare, endemic, protected or endangered species. Other factors such as community structure, species richness and evenness will also be presented. This study will further attempt to distinguish between significant positive, negative, direct and indirect impacts and provide recommendations on mitigating these impacts.

6.2.1.2 Methodology/Approach

The methodology employed consisted of two walk-through surveys. Here paths and the main roadway were utilised to access the vegetation present. Notes were made on the plant species encountered, their growth form (presented in a non-technical manner) and perceived dominance. This dominance was graded based on a subjective DAFOR scale (i.e. dominant, abundant, frequent, occasional and rare). Community characteristics such as mean vegetation height and diameter at breast height (DBH) were noted as was the general level of disturbance in the community. Most species were identified in-situ; however, if this was not possible, specimens were collected for later identification at the University of the West Indies (UWI) Herbarium (Mona, Kingston).

The procedure, although subjective, was deemed appropriate as the often steep terrain (with slopes of approximately 40 to 90 degrees in several instances) negated the efficient use of plot-based methods. The approach also allowed for a more thorough investigation of the flora's species composition. Surveys were focused in and around the 1 ha area to be initially mined as well as the adjacent overburden area. They were later expanded to assess the surrounding vegetation in the wider 5.7 ha study area.

Literature by Asprey & Robbins (1953), Adams (1972) and Parker (2003) were also used to assist in plant identification and vegetation classification. The entire sampling process was aided by a Trimble GeoExplorer™ 6000 Series GeoXT™ handheld GPS unit programmed with the boundaries of the proposed project.

6.2.1.3 Results and Discussion

The vegetation within the Halberstadt Quarry area showed signs of notable anthropogenic disturbance. Evidence of vegetation clearing was observed with the occurrence of fire-damaged trees (Plate 6.12); the remnants of a small charcoal-heap (Plate 6.13); and the presence of a 2 – 4 m wide, semi-maintained (unpaved) access road that was cut and graded into the slopes. The latter often revealed a dense root mat that penetrated the loose, upper-substrate to only 0.6 to 1 m (Plate 6.14). The substrate appeared to be composed of gravely sedimentary deposits such as shale, sandstones and gypsum. Steep slopes (40° or greater in some areas) and loose soil rendered vehicular and pedestrian access challenging at times.

Plate 6.12 Section of study area with fire damaged trees. Note the regeneration of the ground-layer vegetation, consisting mainly of herbaceous plants (18/07/2013)

Plate 6.13 Sole evidence of minor charcoal burning on site (18/07/2013)

Plate 6.14 A bank of excavated roadway showing associated vegetation and exposed root-mat system (18/07/2013)

The slope-faces bordering the proposed overburden area and a section of the 1 ha initial site showed signs of prior excavation as their aspect appeared near-vertical and the rock strata exposed. Along access routes and clearings the herbaceous and shrubby components of the flora also appeared to have been cropped. This process was possibly aided by domestic goats observed foraging the area. There were no dwellings or signs of subsistence agriculture found within the study area, however the main access road linked the site such human communities. These occurred at lower altitudes. In general the study area was estimated to be 95% vegetated.

The flora consisted mainly of early successional species with several of the constituents appearing to have escaped from cultivation in the lowlands. Their occurrence was likely aided by continued anthropogenic incursions into the area. As a result, the site may be described as being species-rich with a total of 122 species encountered. The overall dominance of any one species was difficult to determine. This was due to the high number of species found of which the major constituents occurred frequently and appeared evenly distributed.

Herbs dominated and when combined with the herbaceous running and climbing constituents, they accounted for 50% of the flora (Figure 6.72). Plants such as *Alternanthera ficoidea* (Crab Withe), *Catharanthus roseus* (Perrywinkle), *Leonotis nepetifolia* (Christmas Candle Stick), *Panicum maximum* (Guinea Grass) and *Pluchea carolinensis* (Wild Tobacco) were ubiquitous, especially along access routes. This herbaceous component ranged in height from 0.3 m to 1.1 m, with *P. maximum* capable of attaining conspicuous heights of over 2 m on shaded, less disturbed slopes. A majority of the herbs were found within the 1 ha initial site, overburden area and roadway (Plate 6.15).

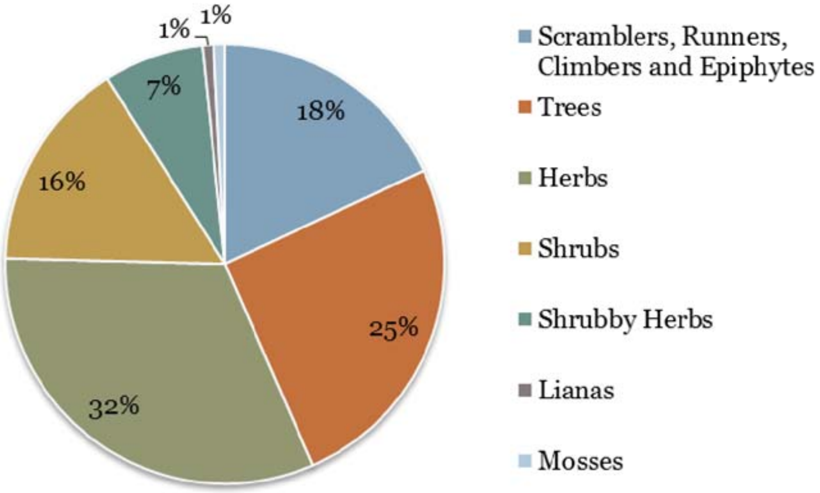


Figure 6.72 Percentage number of species (richness) in the Halberstadt Quarry area by growth form

Plate 6.15 Section of overburden area dominated by herbaceous vegetation (18/07/2013)

Herbaceous climbers and runners were less abundant than the free-standing herbs yet they were still an important component (Figure 6.72). Common species included the vines *Cissus sicyoides* (Snake Withe), *Mikania micrantha* (Guaco) and *Morinda charantia* (Wild Cerasee). The endemic *Hyolocereus triangularis* (God Okra), normally epiphytic, was conspicuously found at ground level along sections of the roadway and clearings. An unidentified bryophyte species was also encountered.

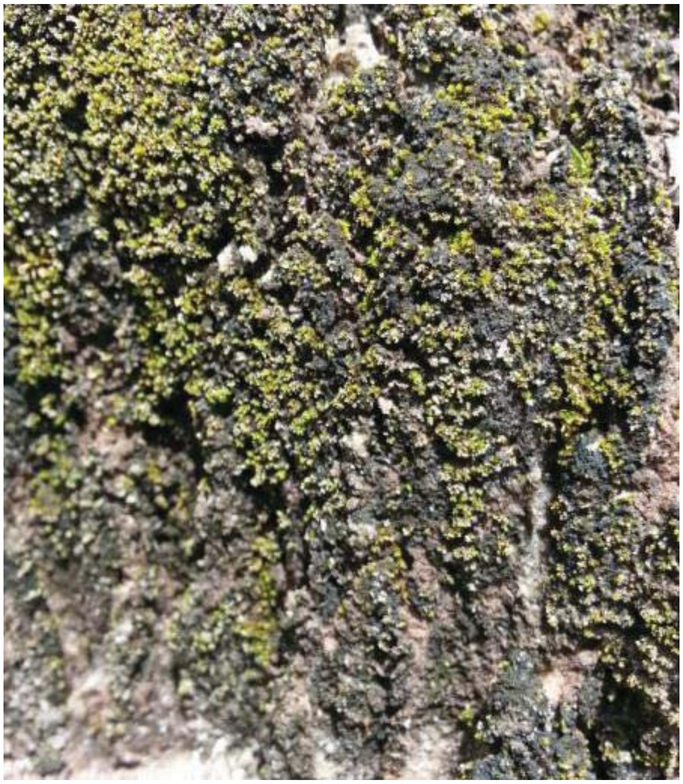


Plate 6.16 Unidentified moss growing on mineral outcropping (13/07/2013)

The sole liana, *Pisonea aculeata* (Cockspur) was also quite frequent. It tended to occur along vegetation margins, where its many recurved thorns rendered negotiating the community difficult at times.

Shrubs, inclusive of shrubby-herbs (small, tough-stemmed herbs with notable woody composition), accounted for 21% of the species encountered (Figure 6.72 & Plate 6.17). Members of the genus *Sida* were well represented as was the aromatic plant, *Lantana camara* (Wild Sage). These accounted for the majority of the shrubby-herbs identified. Another aromatic plant, *Chromolaena odorata* (formerly *Eupatorium odorata* – Christmas Bush), and the Castor Oil plant (*Ricinus communis*) were dominant shrub species. However, wide-spreading shrubs, such as *Melochia nodiflora*, *Solanum torvum* (Susumber) and *Tecoma stans*, were also quite frequent. Shrubby-herbs tended to range in height up to a maximum of 0.4 m while shrubs ranged from this height to a maximum of 2.5 m. The arborescent grass, *Bambusa vulgaris* (Common Bamboo) was an exception, emerging well above the shrub canopy to around 8 m in some locales.

Plate 6.17 Section of vegetation located on the 1 ha study site. Note the steep terrain and mix of herbaceous and shrubby species (13/07/2013)

The most abundant tree species were *Acacia farnesiana* (Cassie Flower) and *Guazuma ulmifolia* (Bastard Cedar) and together with the other phanerophytes constituted the second major grouping within the flora (in terms of species richness). Other frequent constituents were *Comocladia pinnatifolia* (Maiden Plum), *Erythroxylum areolatum* (Coca Shrub), *Eugenia maleolens*, *Metopium brownei* (Burn Wood), *Piscidia piscipula* (Dogwood), *Simarouba glauca* (Bitter Damson) and *Trichilia hirta* (Wild Mahogany). They tended to populate mainly the areas surrounding the 1 ha site and overburden area; constituting an often interrupted tree canopy. Average tree height ranged from a diminutive 2 – 2.5 m (in shrub-crowded locations) to approximately 4 – 5 m in tree-stands isolated by the roadway and clearings. Diameter at breast height (DBH) rarely exceeded 20 cm. However, emergents such as *Samanea saman* (Guango), *Ceiba pentandra* (Silk Cotton) were conspicuous with greater DBH values.

Four endemic species were found: the herb *Croton humilis* var. *adenophyllus* (Pepper Rod), the aforementioned epiphyte *H. triangularis* (Plate 6.18), the shrub *Notoptera hirsuta* and the tree *Trichilia reticulata*. Their frequency of occurrence was low and tended to be scattered throughout the vegetation. Two other species *Agave* sp. and *Piper amalago* are considered here as potential endemics as species and varieties within the respective genera are endemic. However, these plants did not display enough key characteristics (e.g. inflorescences) at the time of this survey to make a definite determination.

Plate 6.18 Endemic epiphyte Hyolocereus triangularis (God Okra) occurring at ground level

Other species of note were those introduced to the area. According to Adams (1972) and Asprey & Robbins (1953), these include the aforementioned *B. vulgaris*, *C. roseus*, *P. maximum*, and *S. Saman*. However, *Mangifera indica* (Mango) and *Peltophorum pterocarpum* were also found scattered throughout the flora.

A comprehensive listing of the plant species encountered, according to location and growth form can be found in Appendix 10.

6.2.1.4 Conclusions

From the surveys conducted and the data garnered, it could be concluded that the vegetation on the quarry site was typical in structure and composition to those described by Asprey & Robbins (1953): that is (disturbed) vegetation occurring on lower shale hills. This vegetation type is explained as consisting of a thin canopy of spindly shrubs and trees broken by emergent *C. pentandra* trees. Some of the vegetation present appeared to have been introduced from cultivation in the lowlands. Their occurrence, they explain, was likely aided by continued anthropogenic incursions into the area.

Asprey & Robbins suggest that these hillsides were once covered by sparse mesophytic forests, the composition of which (they estimate) may be found in and around lowland, dormant stream beds. They further explain that the upper soil layers of the substrate tend to be susceptible to erosion, especially after deforestation, due to burning and shifting subsistence cultivation. The issue of erosion is exacerbated due to the steep topography.

6.2.2 Fauna

6.2.2.1 Literature Review

Few studies have been carried out in St. Thomas and its environs but have been limited to disturbed areas. In the Morant Bay area, which was slated for a housing development, an avifaunal survey in 2002 found the presence of seventeen (17) species of birds which included one (1) endemic species and three (3) endemic subspecies. Similarly in 2005, CL Environmental surveying along the Yallahs River noted only nine (9) species of birds during their survey. They were found to be common residents within Jamaica and no endemic species were found. The low numbers of bird species in both studies were attributed to the disturbed nature of the area whereby many of the natural forested areas have been stripped of naturally occurring forests along with the absence of important feeding trees.

Butterflies were also found in low numbers within this region. In the 2002 study for the NHDC, eight (8) species were observed which included the endemic Blue Swallowtail butterfly. This species is reported to be known to breed only in St Thomas (Jamaica Naturalist Vol 4 Dec 1994). However, in a study by ESL (2005), at the Caribbean Cement Company, twelve (12) species of butterflies were noted with no threatened or endangered species observed. These species are usually found in open land and dry coastal areas.

The endemic reptiles, *Anolis lineatopus* and *Anolis garmani* have been observed and reported in the NHDC (2002) EIA in the Morant Bay area and are common throughout Jamaica. They however reported low numbers.

6.2.2.2 Avifauna Survey

Methodology

Due to the size of the area, the presence of a road network and the hilly nature of the area, the line transect method was the main survey method utilised in the study. In addition, point surveys were carried out in areas which had a good vantage point in hilly areas which could not be reached. The survey was carried out in one day in the morning and evening.

Result and discussion

Twenty two bird species were observed during the bird assessment. Of the 22 species 3 are migrants, 13 residents and 5 endemics. The forest type in the area is dry limestone forest and bird species typical of a dry limestone forest in Jamaica such as Columbids (Common Ground Dove, Caribbean Dove and White-crowned Pigeon); Olive throated Parakeet and Jamaica Oriole was identified in the assessment.

Table 6.34 Bird species identified during the bird survey for the proposed Quarry in Bull Bay. The DAFOR scale used Dominant (Number of birds ≥ 20), Abundant (N= 15- 19), Frequent (N=10-14), Odd (N= 5-9) and Rare (N<4).

Proper Name	Code Used	Scientific Name	Status	DAFOR
Antillean Nighthawk	ANNI	*Chordeiles gundlachii*	Migrant	R
American Kestrel	MAKE	*Falco sparverius*	Resident	R
Bananaquit	BANA	*Coereba flaveola*	Resident	O
Black-Whiskered Vireo	BWVI	*Vireo altiloquus*	(Summer) Migrant	R
Caribbean Dove	CADO	*Leptotila jamaicensis*	Resident	R
Common Ground Dove	COGD	*Columbina passerine*	Resident	O
Gray Kingbird	GRKI	*Tyrannus dominicensis*	Migrant	O
Jamaican Euphonia	**JAEU**	***Euphonia Jamaica***	**Endemic**	**R**
Jamaican Oriole	**JAOR**	***Icterus leucopteryx***	**Endemic**	**R**
Jamaican Vireo	**JAVI**	***Vireo modestus***	**Endemic**	**R**
Loggerhead Kingbird	LOKI	*Tyrannus caudifasciatus*	Resident	O
Northern Mockingbird	NOMO	*Mimus polyglottos*	Resident	R

Proper Name	Code Used	Scientific Name	Status	DAFOR
Olive-throated Parakeet	OTPA	*Aratinga nana*	Endemic sub-species	R
Red-billed Streamertail	**RBST**	***Trochilus polytmus***	**Endemic**	**R**
Turkey Vulture	TUVU	*Carthartes aura*	Resident	O
Smooth billed Ani	SBAN	*Crotophaga ani*	Resident	F
Vervain Hummingbird	VEHU	*Mellisuga minima*	Resident	R
White Crowned Pigeon	WCPI	*Columba leucocephala*	Resident	F
Yellow-faced Grassquit	YEFC	*Tiaris olivacea*	Resident	O
Yellow-shouldered Grassquit	**YSGR**	***Loxipasser anoxanthus***	**Endemic**	**R**
Zenaida Dove	ZEDO	*Zenaida aurita*	Resident	O
Mangrove Cuckoo	MACU	*Coccyzus minor*	Resident	R

Only 5 of the 29 endemic birds on the island were observed on the property. None of the species observed are forest dependent species (Table 6.34). Although this was expected since the area is highly disturbed.

No migrant warblers were observed during the assessment as a result of the time of year the assessment was carried out. Migrant warblers are known to arrive on the island as early as September. Hence, the bird species diversity will increase in the forested areas as a result of the arrival of the migrant warblers.

It is also possible that a few nocturnal bird species such as owls could be present in the area. No nocturnal bird survey was carried out in the area.

6.2.2.3 Invertebrate Fauna Survey

Methods

Larger specimens such as butterflies and spiders were recorded directly. Flight nets, sweep nets, beating tray, and direct search of quadrats were used to sample other groups. Specimens collected were taken back to the laboratory for identification. Material was identified using appropriate literature or the collections at the University of the West Indies. A DAFOR rating was established for all recorded species.

Results and Discussion

Thirty-three species of Arthropods were recorded (Table 6.35 and Table 6.36); this included twelve species of butterflies and ten species of plant bugs. The number of individuals in each species was generally low. This was not unexpected as the area is quite harsh with low rainfall and limestone substrate. Young leaves, flowers and herbs which for the food and larval hosts for most insect was therefore not in abundance, but rather rare.

Table 6.35 Insects recorded from the proposed Quarry in Bull Bay (Class: INSECTA)

ORDER & FAMILY	GENUS & SPECIES	COMMON NAME	DAFOR RATING	COMMENTS
LEPIDOPTERA: Lycaenidae	*Hemiargus hanno ceraunus*	The Hanno Blue	A/F	Also occur on Hispaniola
Heliconiidae	*Dryas iulia delia*	Julia	F/O	
	Heliconius charitonius simulator	The Jamaican Zebra	R	also found in Cayman island
Pieridae	*Ascia monuste eubotea*	The Antillean Great White	F	Common throughout C'bean
	Phoebis sennae sennae	The Cloudless sulphur	F	Found throughout Caribbean
	Eurema lisa euterpe	The Little Yellow Sulphur	F	West Indies, Central America, Canada
Nymphalidae	*Mestra dorcas*	Dorcas	O	Jamaican endemic
	Precis evarete zonalis	The West Indian Buckeye	O	
Hesperiidae	*Pyrgus oileus*	Syrichtus	F/O	West Indies, southern U.S. and Mexico
	I sp. Unidentified (small black)		R	
Papilionidae	*Battus polydamas jamaicensis*	The Jamaican Polydamas	R	Endemic Jamaican sub species
Arctiidae/Noctuidae	*Utetheisa ornatrix venusta*	Pink Handkerchief	R	
DIPTERA: Bombyliidae	*Poecilanthrax lucifer*		O	
	1 sp. Black, speckled unidentified		R	
Hymenoptera: Apidae	*Apis mellifera*	The Honey Bee	A	Common throughout world
Vespidae	*Polistes crinitus*	Paper wasp	A	
ODONATA: ZYGOPTERA	1 small blue damselfly		O	
ANISOPTERA	Red dragonfly		F	
	small brown dragonfly			
Hymenoptera: Formicidae	1 sp. Black Ants	Mad ants	A	

ORDER & FAMILY	GENUS & SPECIES	COMMON NAME	DAFOR RATING	COMMENTS
Hemiptera: Alydidae	*Megalatomus jamaicensis*		R	
Pentatomidae	*Euschistus bifibulbus*		O	
Homoptera: Issidae	1 sp. unidentified		R	
Membracidae	1 sp.		R	
Cicadellidaesd	1 sp.		R	
	1 sp.		R	
Cixiiidae	1 sp.		R	
Orthoptera: Acrididae	1 sp.		R	
Coleoptera: Coccinellidae	1 sp.		R	

Table 6.36 Arachnids recorded from the proposed Quarry in Bull Bay (Class: ARACHNIDA, Order: Araneae)

FAMILY	GENUS & SPECIES	COMMON NAME	DAFOR RATING	COMMENTS
Oxyopidae	1 sp. unidentified		R	
Tetragnathidae	1 sp. unidentified		F	
Thomisidae	1 sp. unidentified		R	

6.3 Human and Social

6.3.1 Introduction

The Social Impact Area (SIA) for this study was demarcated as two (2) kilometres from the proposed deposit boundary. As seen in Figure 6.73, this impact area encompasses the settlements of Bito, located 1.2 km southwest of the proposed project location, Bloxborough 1.5 km north and Salt Spring, 1.5 km south southeast of the quarry. By means of socio-economic data, an understanding of the SIA population can be gleaned and used to develop an appreciation for the potential human and social impacts of the proposed project.

6.3.2 Methodology

Population data were extracted from the STATIN 2011 and 2001 Population Census database for the SIA by enumeration district. This was undertaken using Geographic Information Systems (GIS) methodologies, which were also used to derive visual representations of the data. In order to derive information from the census data the following computations were made:

- ***Population growth*** - was calculated using the formula [$i_2 = i_1 (1 + p)^x$]; where i_1 = initial population, i_2 = final population, p = actual growth rate and x = number of years.
- ***Population density*** – was derived by dividing the population by the land area. This is useful for determining the locations of greater concentrations of population.
- ***Dependency ratio*** – was calculated using the formula [child population + aged population /working population X 100], where the child population is between ages 0-14, the aged population is 65 & over and the working population is between ages 15-64 years. This ratio is useful for understanding the economic burden being borne by the working population.
- ***Male sex ratio*** – was calculated by using the formula [male population / female population X 100]. This in effect denotes the amount of males there are to every 100 females and is useful for determining the predominant gender in a particular area.
- ***Domestic water consumption*** - was calculated based on the assumption that water usage is 227.12 litres/capita/day and sewage generation at 80% of water consumption. Water consumption for workers in Jamaica is calculated at 19 litres/capita/day and sewage generation at 100% water consumption.
- ***Domestic garbage generation*** - was calculated at 4.11 kg/household/day (National Solid Waste Management Authority).

It is important to note that the 2011 Census data forms the basis of the Demography information presented in the subsequent section; however 2011 data for Education, Employment, Housing, Land Tenure and Infrastructure was not available and as such 2001 Census data was utilised for these sections. In addition, data is also gleaned from the Social Development Commission (SDC), and specifically Community Profiles for two communities within the SIA (Bito and Bloxborough) that are based on a socio-economic survey conducted by the SDC in 2009[4].

---

[4] http://sdc.gov.jm/communities/bito/
http://sdc.gov.jm/communities/bloxborough/

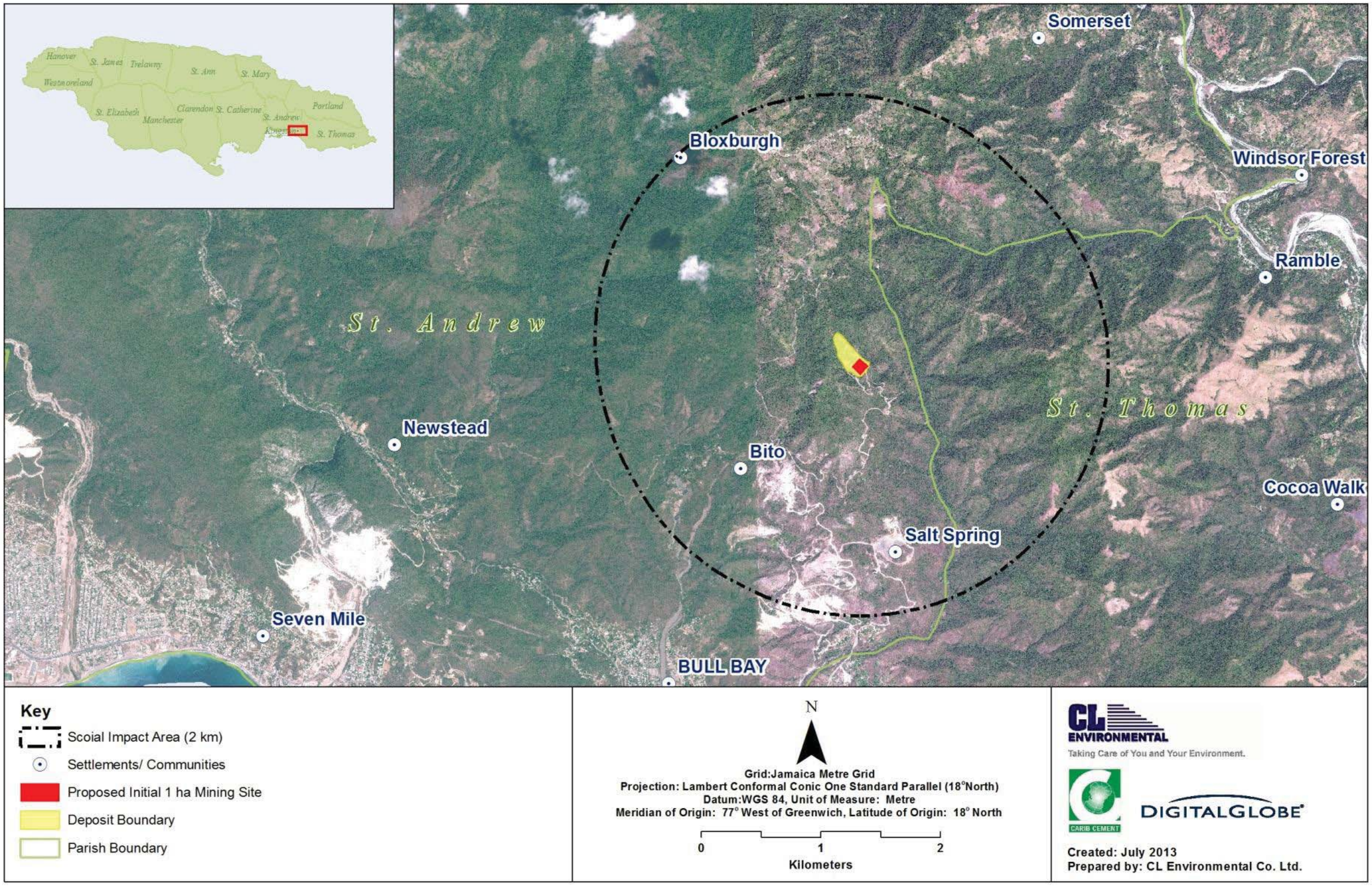


Figure 6.73 Map showing the Social Impact Area (SIA)

6.3.3 Demography

Please note that information presented in subsequent sections is taken from the 2011 Census data.

6.3.3.1 Population Growth Rate

The total population within the SIA in 2011 was approximately 990 persons (STATIN 2011 Population Census). Examination of the 2001 population data showed that there were approximately 1,144 persons within the 2 km radius of the proposed plant location in 2001. From this population, and that calculated for the year 2011 (990 persons), it was estimated that the actual growth within the SIA between 2001 and 2011 was approximately -1.44% per annum. Based on this decline, at the time of this study (2013), the population was approximately 961 persons and is expected to reach 669 persons over the next twenty five years if the current population growth rate remains the same.

This negative annual growth rate for the SIA of -1.44% is dissimilar to the regional rates of 0.33% and 0.26% for St. Andrew and St. Thomas respectively. Applying a growth rate similar to regional values to the SIA (0.3%), it is estimated that at the time of the study, the population was 996 persons, and in the next twenty five years it will be approximately 1,073 persons.

6.3.3.2 Age & Sex Ratio

Table 6.37 shows the percentage composition of each age category to the population. This is compared on a national, regional and local level. The data show that the percentage contribution to the population for each category was comparable.

Table 6.37 Age categories as a percentage of the population for the year 2011

Age Categories	Jamaica	St. Andrew	St. Thomas	SIA
0-14	26%	23%	27%	26%
15 - 64	66%	70%	64%	68%
65 & Over	8%	8%	9%	7%

Source: STATIN Population Census 2011

The 15-64 years age category accounted for 68% of the 2011 population for the SIA, with the age 0-14 years (26%) and the age 65 and over category accounting for 7%. The segment of a population that is considered more vulnerable are the young (children less than five years old) and the elderly (65 years and over). In this population, approximately 7% were in the young category and this is similar to the 7% within the 65 years and older category as mentioned previously.

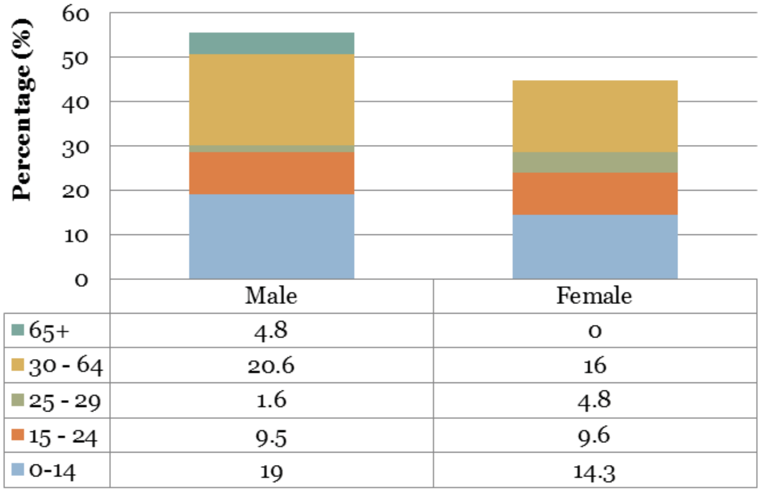
Percentage age distribution is comparable between the SIA and national figures for the 0-14 years age cohort (26%); however less children were reported for the parish of St. Andrew (23%) and more for St. Thomas (27%). Elderly persons of 65+ years are typically less than 10% for all extents; however the SIA has the least percentage of 7%, compared to St. Thomas with the highest percentage of 9%. The 15-64 years age cohort (working age) had the highest percentage in the parish of St. Andrew (70%), followed by the SIA having 68%.

As mentioned previously, SDC Community Profiles exist for two communities within the SIA, namely Bito and Bloxborough[5] that are based on socio-economic survey conducted by the SDC in 2009. For both communities (2009), the populations can be considered as a working age population with 62.1% and 68.1% of the population in Bito and Bloxborough respectively being between the ages of 15-64 years. Bito and Bloxborough also had significant youth populations with 33.3% and 27.4% respectively being 14 years or younger; the latter percentage for Bloxborough is comparable to St. Thomas regional percentages, however Bito's young population is by far the greatest of all population grouping explored here. The percentage of elderly persons (65 years and over are cohort) for both Bito and Bloxborough (4.8% and 4.6% respectively) are seen to be less than the national, regional and SIA figures shown in Table 6.37.

The available data for the community for Bito indicated that there were noticeably more males for all age cohorts, with the exception of the 25-29 years cohort in which there were more females, and the 15-24years in which there were comparable percentages (Figure 6.75). Overall, there were a higher percentage of males (55.5%) than females (44.7%) and this is similar to Bloxborough, where there were less females (45.4%) than males (54.7%), with the major disparity being seen within the 30-64 years age cohort (Figure 6.75).

---

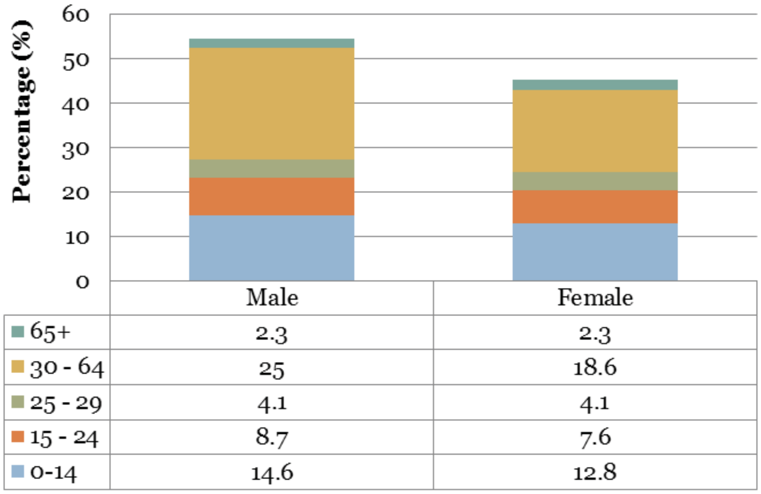
[5] http://sdc.gov.jm/communities/bito/
http://sdc.gov.jm/communities/bloxborough/



	Male	Female
🟩 65+	4.8	0
🟨 30 - 64	20.6	16
▨ 25 - 29	1.6	4.8
🟧 15 - 24	9.5	9.6
🟦 0-14	19	14.3

Source data: Social Development Commission, 2009

Figure 6.74 Male and female percentage population by age category for the community of Bito in 2009

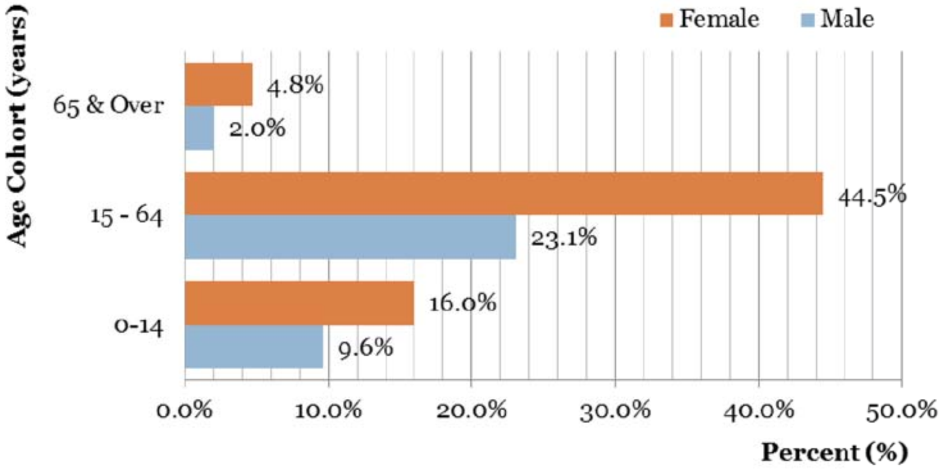


	Male	Female
🟩 65+	2.3	2.3
🟨 30 - 64	25	18.6
▨ 25 - 29	4.1	4.1
🟧 15 - 24	8.7	7.6
🟦 0-14	14.6	12.8

Source data: Social Development Commission, 2009

Figure 6.75 Male and female percentage population by age category for the community of Bloxborough in 2009

On the other hand, male and female populations in the SIA differ from that of Bito and Bloxborough, in that there were a greater total percentage of females (65%) versus males (35%), with no age category having more males than females (Figure 6.76). The sex ratio (males per one hundred females) in the SIA in 2011 was 53.33, which indicates that a higher percentage of the population in the SIA were females. This sex ratio is less than the national ratio for Jamaica (97.9) and regional (St. Andrew – 91.7 and St. Thomas – 100.0) indicating that the national and regional populations have a higher level of males, which is in general agreement with the SDC data for communities in vicinity of the proposed site (Bito and Bloxborough).



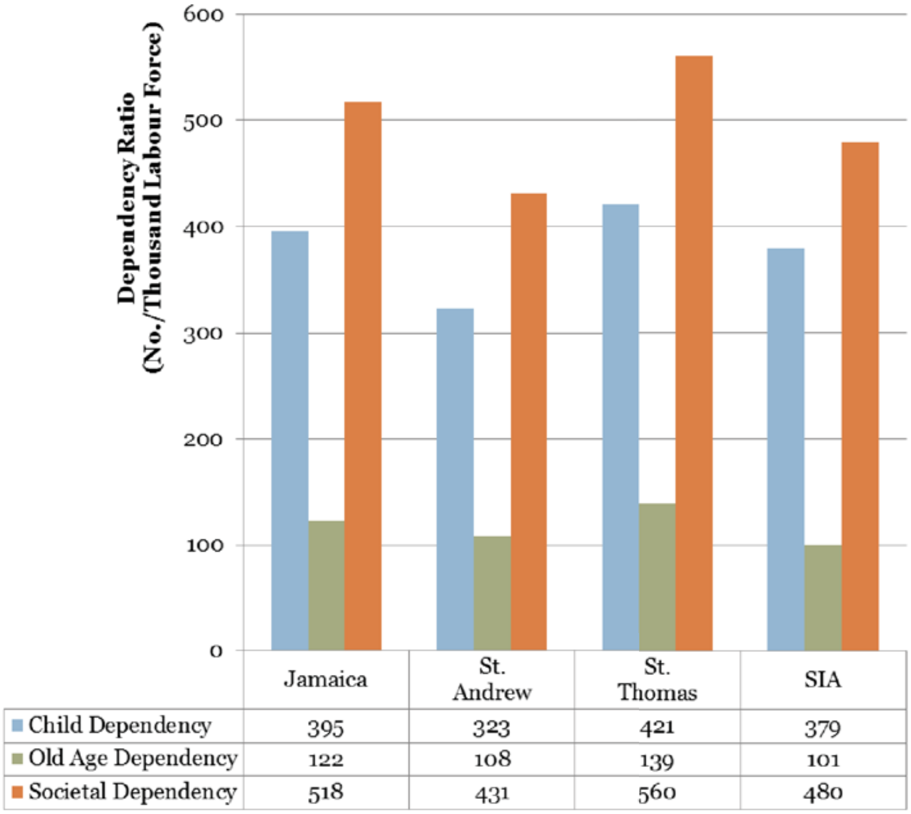
Source: STATIN Population Census 2011

Figure 6.76 Female and male population in the SIA by age category for the year 2011

6.3.3.3 Dependency Ratios

The child dependency ratio for the SIA in 2011 was 379 per 1000 persons of labour force age; old age dependency ratio stood at 101 per 1000 persons of labour force age; and societal dependency ratio of 480 per 1000 persons of labour force. This indicates that the youth (child dependency) is more dependent on the labour force for support when compared with the elderly.

Comparisons of the dependency ratios at varying extents indicate that the child dependency ratio for the study area (SIA) was lower than the national and regional St. Thomas figures, yet greater than that for St. Andrew (Figure 6.77). Conversely, the old age dependency ratio for the study area is lower than both regional and national figures.



	Jamaica	St. Andrew	St. Thomas	SIA
■ Child Dependency	395	323	421	379
■ Old Age Dependency	122	108	139	101
■ Societal Dependency	518	431	560	480

Source: STATIN Population Census 2011

Figure 6.77 Comparison of dependency ratios for the year 2011

6.3.3.4 Population Density

The land area within the SIA was calculated to be approximately 14,597,712.6 m^{2} (14.6 km^{2}). With a population of 990 persons, the overall population density was calculated to be 68 persons/km^{2}. This population density is considerably lower than the regional level for the parishes of St. Andrew, which is approximately 1,321 persons/km^{2} and St. Thomas, 127 persons/km^{2}, as well as the national figure of 246 persons/ km^{2}).

Table 6.38 Comparison of population densities for the year 2011

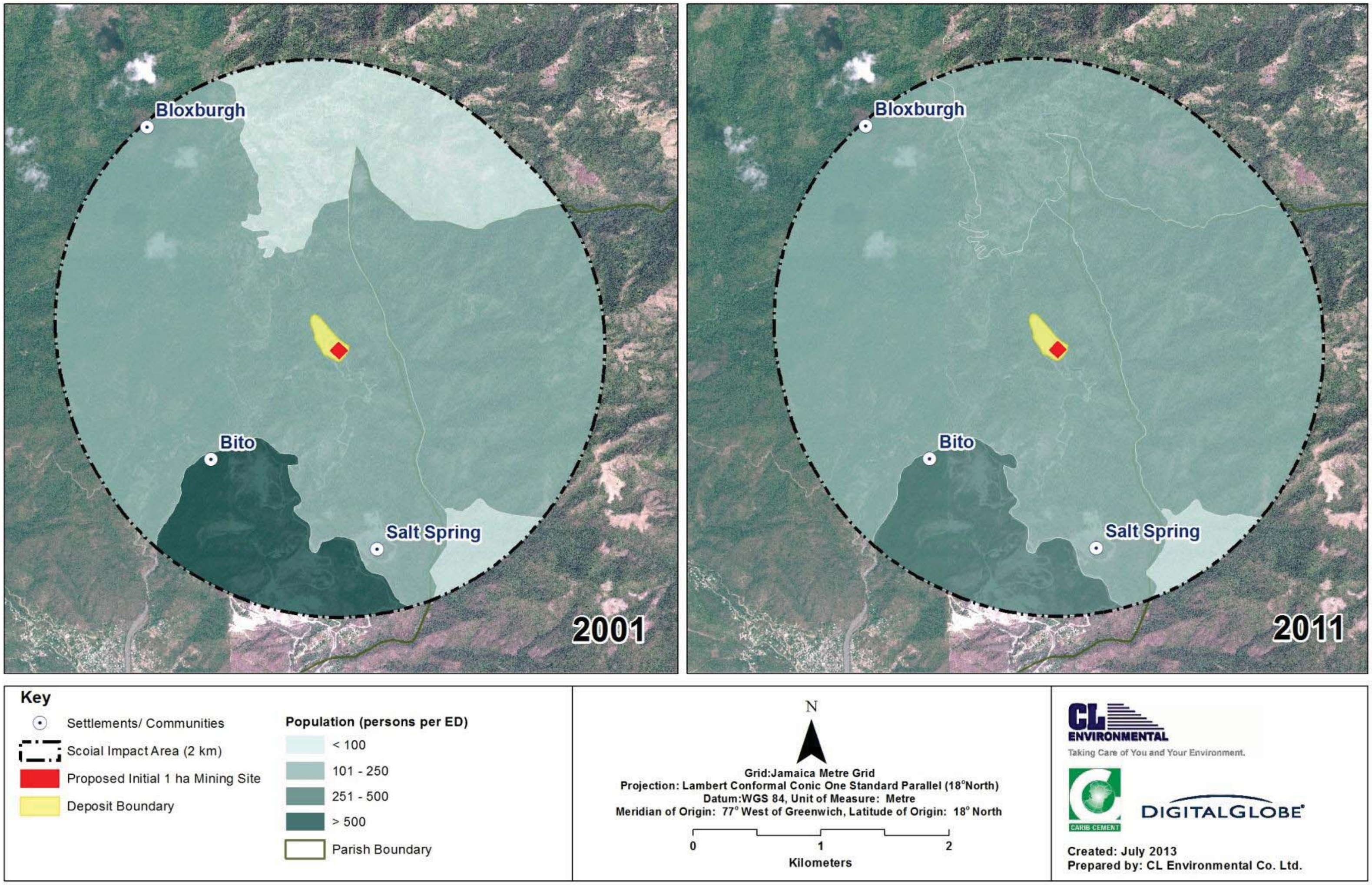
Category	**Jamaica**	**St. Andrew**	**St. Thomas**	**SIA**
Land Area (km^{2})	10,991	433.9	742.2	14.6
Population	2,697,983	573,369	93,902	990
Population Density	246	1,321	127	68

Source: STATIN Population Census 2011

Figure 6.78 demonstrates that the largest concentration of the SIA population is located south of the Halberstadt quarry in the vicinity of Bito and Salt Spring, with 351 persons residing within the Enumeration District (ED) between these settlements (according to 2011 Census data). The Halberstadt quarry is located within an area of relatively population within the SIA, with 222 persons residing within the respective ED.

6.3.3.5 Population Growth Areas

Figure 6.78 depicts the population within each enumeration district (ED) for the years 2001 and 2011. Total SIA population decreased from 1,144 persons to 990 persons within this ten year timeframe. Generally, the population in the immediate vicinity remained constant between these years, however population increases to the north and decreases to the southwest are observed.



Source: STATIN Population Census 2011 and 2001

Figure 6.78 SIA 2001 and 2011 population data represented in enumeration districts

6.3.4 Education

The educational attainment of persons in 2001 for the national, regional and SIA extents are represented in Table 6.37. When educational attainment within the SIA is calculated as a percentage, it becomes evident that there is a propensity towards the attainment of a primary and secondary school education. Most persons within the SIA attained a secondary school education (68.0%) followed by those attaining a primary education (20.7%). Secondary educational attainment is higher in the SIA than the parishes of St. Andrew and St. Thomas and the island; however, there were noticeably lower percentages of those attaining a university, other tertiary or other educational level. Statistics for pre-primary and no education are similar amongst all extents examined.

Table 6.39 Educational attainment as a percentage for the year 2001

Category	Jamaica	St. Andrew	St. Thomas	SIA
Pre-Primary	4.7%	4.3%	4.7%	4.8%
Primary	31.2%	23.4%	36.5%	20.7%
Secondary	49.7%	50.8%	47.9%	68.0%
University	3.1%	7.4%	1.2%	0.6%
Other Tertiary	5.9%	8.0%	4.4%	3.8%
Other	2.8%	3.0%	3.0%	0.7%
Not Stated	1.8%	2.4%	1.6%	0.8%
None	0.9%	0.7%	0.8%	0.6%

The relatively high proportion of the population in proximity to the quarry location attaining a secondary education suggests that the labour pool is relatively educated, and as such, there should be no problem in obtaining non-technical workers from the community. This is shown in Figure 6.79 which also depicts the location of schools in proximity to the proposed location. Two schools, namely Bloxburgh All Age and Bito All Age are found within the 2 km buffer SIA, with two additional All Age schools situated between 4 and 5 km southwest and southeast of the proposed site boundary.

As reported by SDC from their 2009 survey, a large majority of the household heads had not attained academic qualification in Bito (90.0%) [6]and Bloxborough (95.5%)[7] and this is comparable to the low percentages of tertiary educational attainment seen in Table 6.39 for the SIA.

---

[6] http://sdc.gov.jm/communities/bito/

[7] http://sdc.gov.jm/communities/bloxborough/

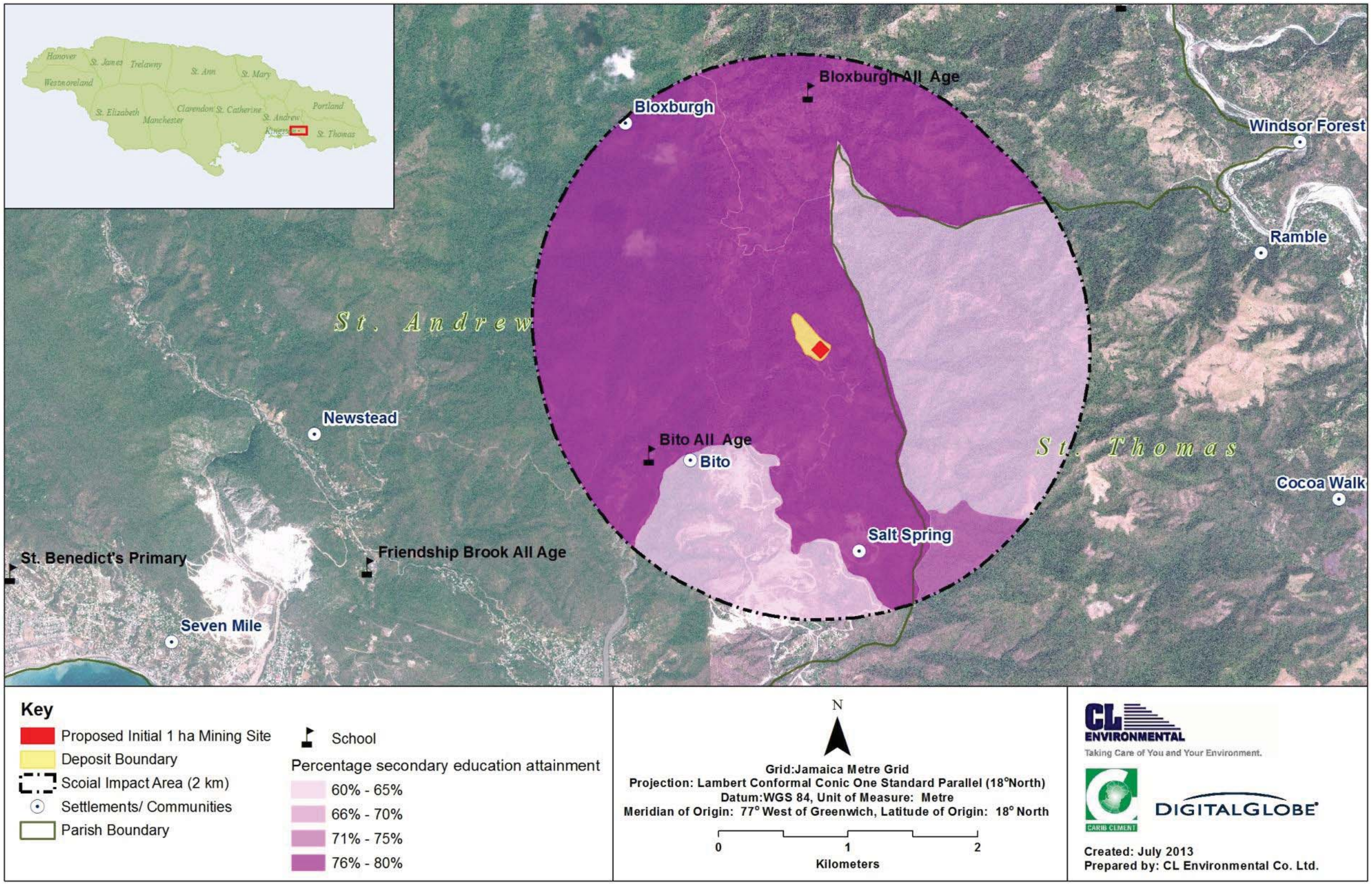


Figure 6.79 *Percentage population attaining a secondary education*

6.3.5 Employment

The SDC 2009 Community Profile data revealed that 45% of the Bito community households were headed by unemployed persons. In contrast, only 6% of households were headed by unemployed persons in the community of Bloxborough.

6.3.6 Housing

6.3.6.1 Housing Ratios and Household Size

For the purposes of this study the definition of housing unit, dwelling and household are those used in the population census conducted by the Statistical Institute of Jamaica (STATIN). The definition states that:

- A **housing unit** is a building or buildings used for living purposes at the time of the census.
- A **dwelling** is any building or separate and independent part of a building in which a person or group of persons lived at the time of the census". The essential features of a dwelling unit are both "separateness and independence". Occupiers of a dwelling unit must have free access to the street by their own separate and independent entrance(s) without having to pass through the living quarters of another household. Private dwellings are those in which private households reside. Examples are single houses, flats, apartments and part of commercial buildings and boarding houses catering for less than six boarders.

There were 272 housing units, 291 dwellings and 293 households within the SIA in 2001. The average number of dwellings in each housing unit was 1.1 and the average household to each dwelling was 1.0. The average household size in the SIA was 3.9 persons/ household (Table 6.40). Comparisons of the SIA with national and regional ratios indicate that they were generally similar except for the higher SIA average household size.

Table 6.40 Comparison of national, regional and SIA housing ratios for 2001

	Jamaica	**St. Andrew**	**St. Thomas**	**SIA**
Dwelling/Housing Unit	1.2	1.4	1.1	1.1
Households/Dwelling	1.0	1.1	1.0	1.0
Average Household Size	3.5	3.4	3.2	3.9

Source: STATIN Population Census 2001

Approximately 97.9% of the housing units in the SIA were of the separate detached type, 0.5% were attached, 0.9% improvised housing and 0.7% did not state.

More than three quarters (79.8%) of the households in the SIA in 2001 used 1-2 rooms for sleeping (Figure 6.80). Approximately 13.1% of the households occupied three rooms, 4.6% used four rooms, 1.9% used five rooms and 0.5% did not report the number of rooms used for sleeping. Most of the households (46.4%) used one room for sleeping.

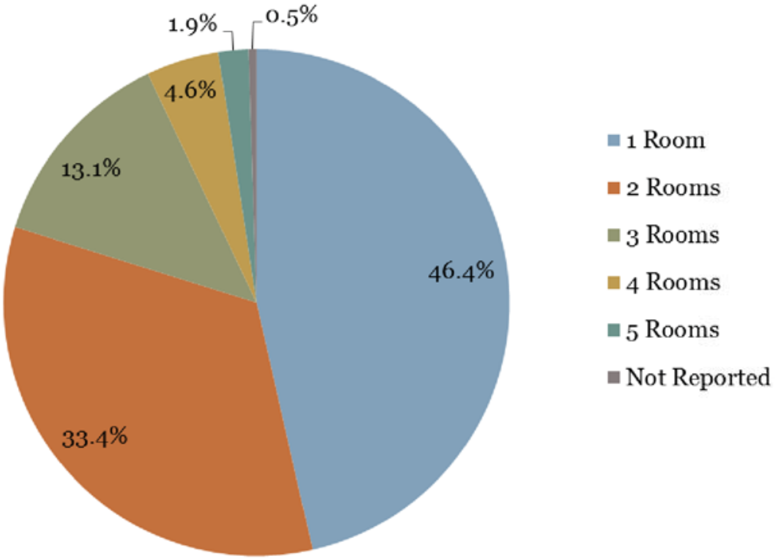


Figure 6.80 Rooms used for sleeping in the SIA as percentage of population

6.3.6.2 Household Headship

In 2009, the percentage of male household heads in the community of Bito was 58% and 60.4% in Bloxborough (SDC). This finding slightly contrasts with national presentation in the Jamaica Survey of Living Conditions (JSLC) 2007, where slightly fewer males (53.4%) were heading households in Jamaica (SDC 2007).

6.3.6.3 Land Tenure

In 2001, 35.9% of the households in the SIA owned the land on which they lived. Approximately 6.6% leased the land on which they were, 16.1% rented, 24.5% lived rent free, 9.7% "squatted" and 0.1% had other arrangements. Compared to higher percentages of no reports for the national (21.9%) and St. Andrew (35.2%) extents, the SIA had a very low percentage (7.1%) of persons not reporting the type of ownership arrangements they had. The relatively higher percentage of households in the SIA living rent free and squatting indicates that there were a higher percentage of households in the SIA compared to the national and regional setting with temporary living arrangements.

As shown in Figure 6.82, areas to the east of the quarry site in the SIA are recorded to have higher percentages of land ownership (> 50%), and lower percentages to the north and south (< 30%).

	Jamaica	St. Andrew	St. Thomas	SIA
■ Not Reported	21.9%	35.2%	7.7%	7.1%
■ Other	0.9%	1.0%	1.3%	0.1%
■ Squatted	2.9%	2.6%	3.3%	9.7%
■ Rent free	17.0%	10.8%	24.4%	24.5%
■ Rented	14.8%	17.9%	15.9%	16.1%
■ Leased	5.0%	5.4%	9.8%	6.6%
■ Owned	37.5%	27.2%	37.5%	35.9%

Source: STATIN Population Census 2001

Figure 6.81 Percentage household tenure nationally, parish and SIA in 2001

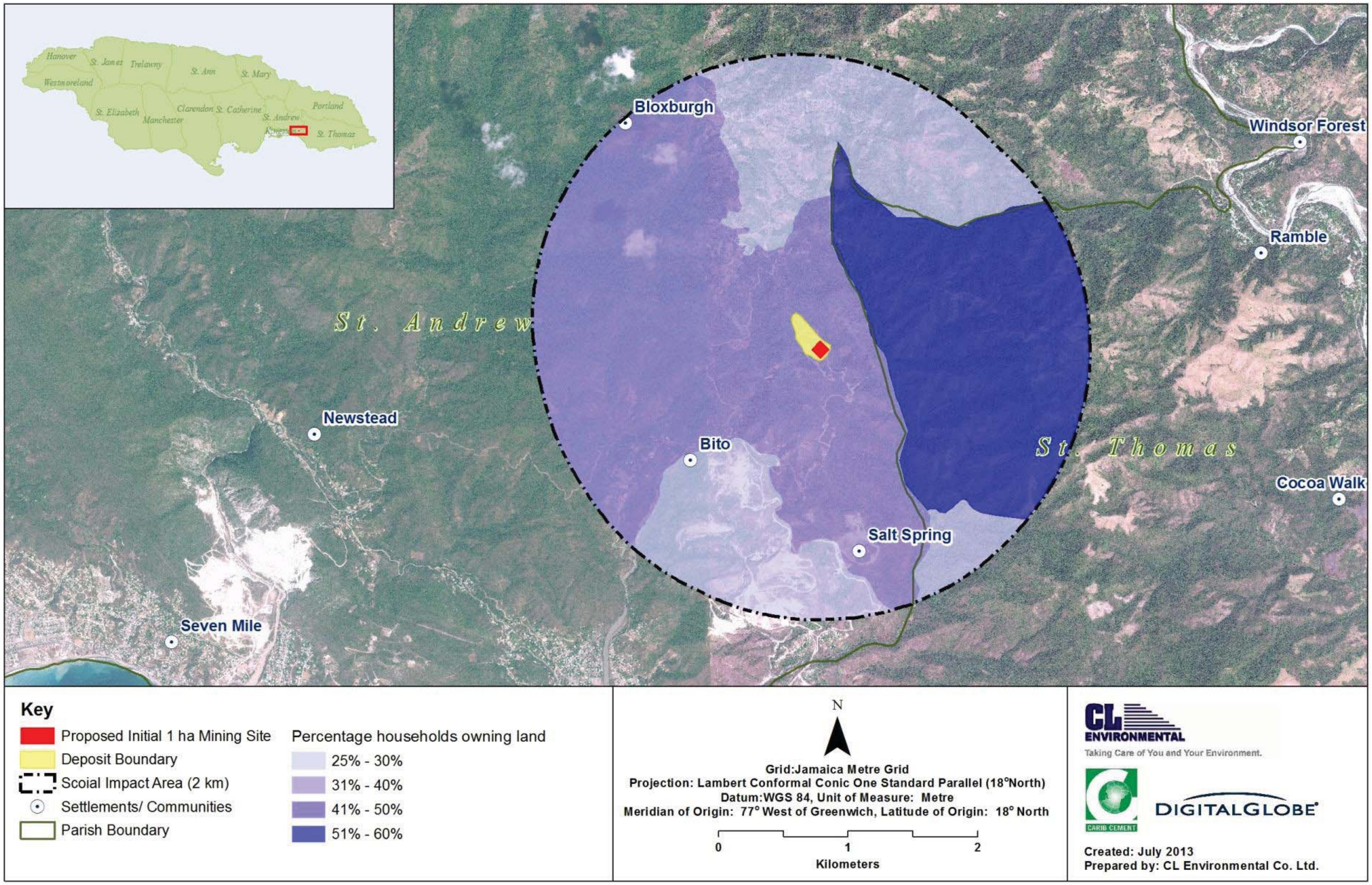


Figure 6.82 *Percent land ownership within the SIA for the year 2001*

6.3.7 Infrastructure

6.3.7.1 Lighting

There was at latest a threefold increase in the households using kerosene as their main means of lighting in the SIA, when compared with the national and regional context. While the national and regional data were generally similar for electricity usage, it is notable that there were a much lower percentage of households in the SIA using electricity when compared with the national and regional households. In the community of Bito, 64.5% of residents used electricity for lighting whilst in Bloxborough, 66% used this source of lighting (SDC 2009 socioeconomic survey). These figures are comparable with those estimated for the SIA (61.9%).

Table 6.41 details the percentage of households using a particular category of lighting and Figure 6.83 depicts the percentage households in the SIA using electricity.

Table 6.41 - Percentage households by source of lighting

Category	Jamaica	St. Andrew	St. Thomas	SIA
Electricity	87.0%	95.5%	84.2%	61.9%
Kerosene	10.6%	2.0%	7.9%	34.1%
Other	0.4%	0.3%	0.0%	1.2%
Not reported	2.0%	2.2%	7.9%	2.8%

Source: STATIN Population Census 2001

6.3.7.2 Telephone/Telecommunications

The parishes of St. Andrew and St. Thomas, as well as the study area are served with landlines provided by LIME Jamaica Limited. Wireless communication (cellular) is provided by LIME and Digicel Jamaica Limited. A network to support internet connectivity is also provided by LIME and Flow.

It was reported by SDC that over 95% of the residents in the communities of Bito and Bloxborough utilise cellular services for communication in 2009.

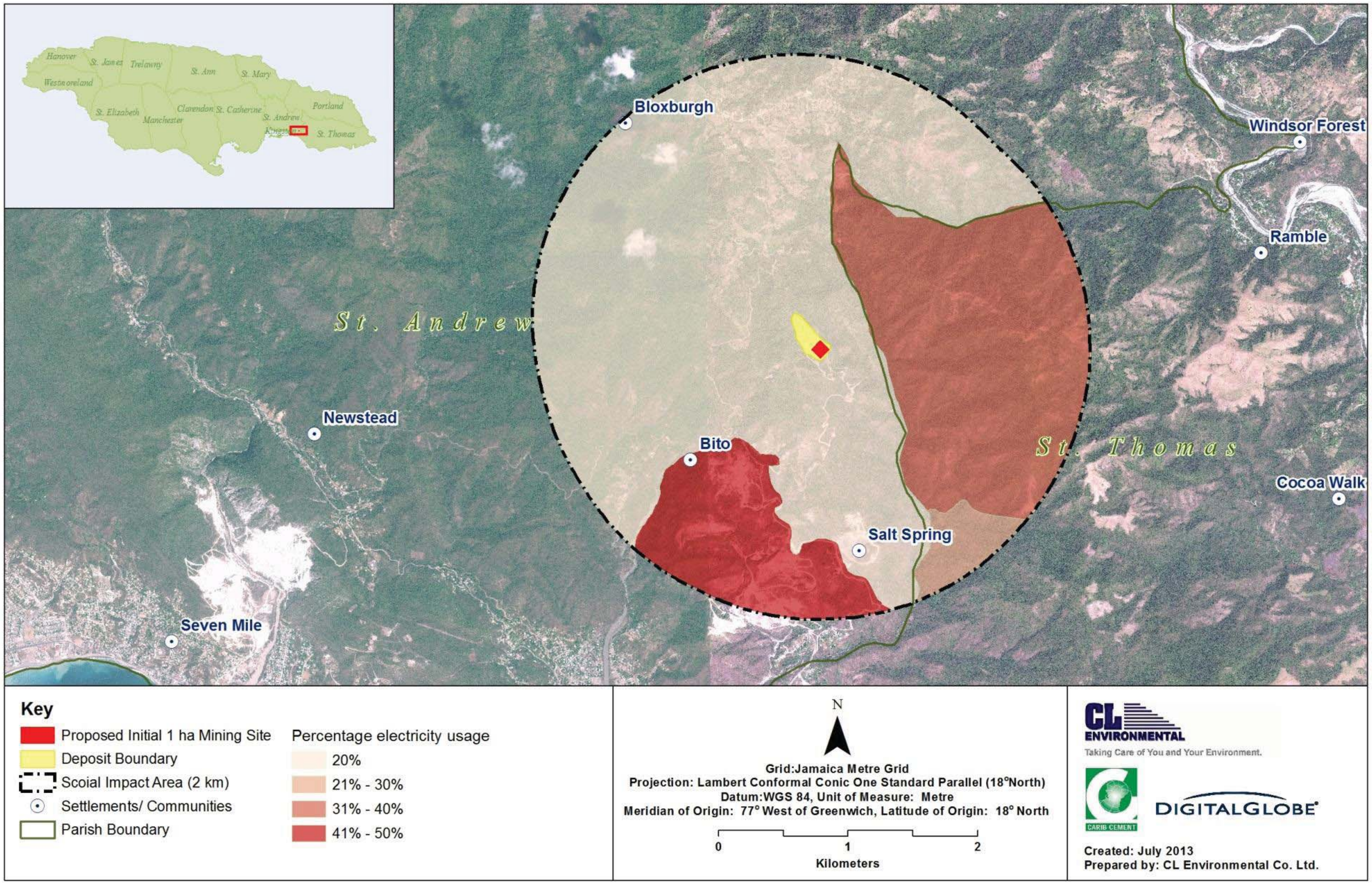


Figure 6.83 Percentage dwelling with electricity within the SIA for the year 2011

6.3.7.3 Domestic Water Supply

Sixty-three percent (62.7%) of the households within the SIA received their domestic water supply from the National Water Commission (NWC) in 2001 (Table 6.42). This public agency is responsible for providing Jamaica's domestic water supply.

Table 6.42 Percentage of households by water supply for the year 2001

	Category	**Jamaica**	**St. Andrew**	**St. Thomas**	**SIA**
Public Source	Piped in Dwelling	43.8%	66.4%	32.9%	12.4%
	Piped in Yard	16.3%	18.3%	17.8%	12.8%
	Stand Pipe	10.5%	3.8%	30.8%	35.4%
	Catchment	1.9%	0.4%	1.1%	1.0%
Private Source	Into Dwelling	6.3%	5.0%	4.4%	10.0%
	Catchment	9.9%	0.7%	1.2%	3.7%
	Spring/ River	4.6%	1.0%	4.9%	14.4%
	Other	4.5%	1.6%	5.4%	8.7%
	Not Reported	2.2%	2.7%	1.4%	1.6%

Source: STATIN Population Census 2001

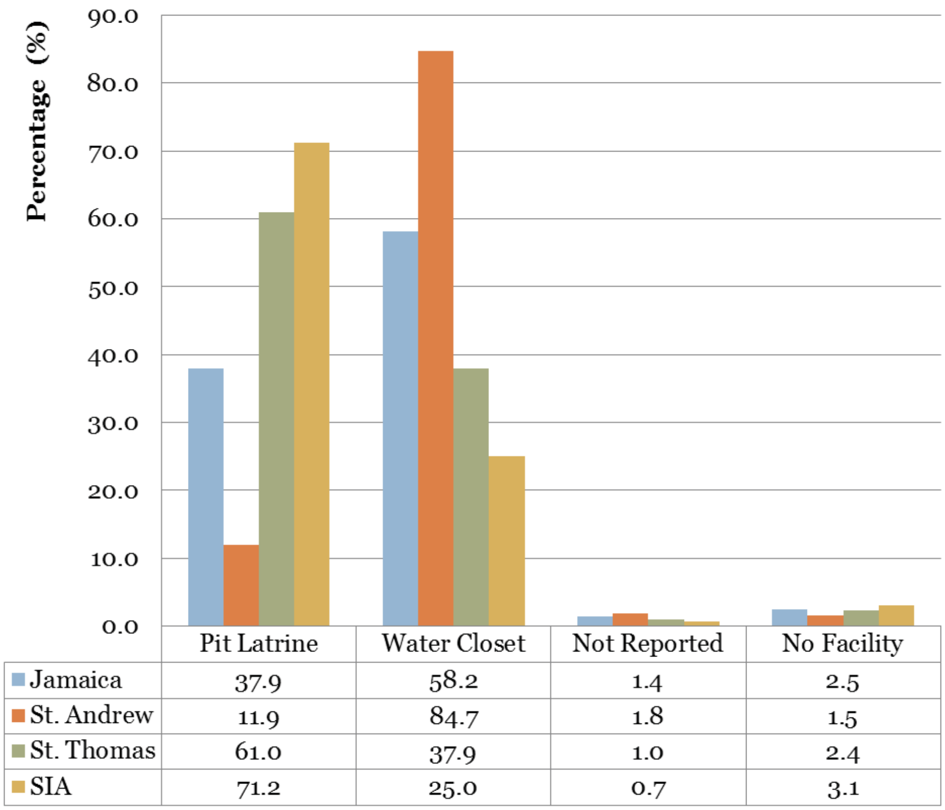
Water demand for the SIA in 2013 is estimated to be 218,262.3 litres/day (~ 57,658.8 2 gals/day) and is expected to decrease to 151,943.3 litres/day (~ 40,139.2 2 gals/day) over the next twenty five years based on population growth rates calculated previously (Section 6.3.3.1).

As reported by SDC from their 2009 socioeconomic survey, 56.3% of residents in the community of Bito and 49.5% in Bloxborough received water from springs, rivers or streams. These figures are both greater than that estimated from the Census 2001 data for the SIA (14.4%)

6.3.7.4 Wastewater Generation and Disposal

It is estimated that approximately 174,609.9 litres/day (~46,127.1 gals/day) of wastewater is generated within the study area (for 2013) and is expected to decrease to 121,554.6 litres/day (~32,111.3 gals/day) over the next twenty five years based on calculated growth rates.

Within the SIA, a higher percentage of households used pit latrines (71.2%) or had no facilities when compared to the national and parish data (Figure 6.84). This relatively high percentage of pit latrine usage was also reported in 2009 for the communities of Bito and Bloxborough by the SDC (75% and 79% respectively). Further, percentage of households with water closet disposal methods was far less in the SIA when compared to regional and national figures.



	Pit Latrine	Water Closet	Not Reported	No Facility
🟦 Jamaica	37.9	58.2	1.4	2.5
🟧 St. Andrew	11.9	84.7	1.8	1.5
🟩 St. Thomas	61.0	37.9	1.0	2.4
🟨 SIA	71.2	25.0	0.7	3.1

Source: STATIN Population Census 2001

Figure 6.84 Sewage disposal methods as a percentage of the households for 2001

According to the SDC 2007 Community Profile of Old Harbour Bay, a significant number of households in the Community used pit latrine (48%), water closet linked to sewer (36%), water closet not linked to sewer (13.6%) and 6.4% soakaways (percentage won't add up as multiple responses were allowed). 15.7% of the households shared toilet facilities. On average these facilities were shared with approximately four other families.

6.3.7.5 Solid Waste Generation and Disposal

The National Solid Waste Management Authority is responsible for domestic solid waste collection within the SIA. Presently, collection is done once per week in residential areas. This service is provided free (partial covered by property taxes) for the households within the area. Solid waste collection for commercial and industrial facilities is done by arrangements by these entities with private contractors.

It is estimated that households in the study area generated approximately 1,204.2 kg (~1.2 tonnes) of solid waste in 2001. Based on the population growth, it has been estimated that at the time of this study (20123), approximately 1,171.4 kg (~1.17 tonnes) of solid waste was being generated and it is expected that within the next twenty five years, if the annual population growth rate remains the same (-1.44%), the amount will be 813.8 kg (~0.8 tonnes).

The 2001 census data indicated that only 12.9% of the households in the SIA had their garbage collected by public means (MPM Waste Management Ltd.), compared to dramatically higher percentages at the parish and national levels. It also showed that the most preferred method of disposal in the SIA was by burning (70.7%) and this was much higher than the national and regional figures (Table 6.43, Figure 6.85).

Table 6.43 Percentage households by method of garbage disposal

Disposal Method	Jamaica	St. Andrew	St. Thomas	SIA
Public Collection	47.7	80.9	37.1	12.9
Private Collection	0.5	0.6	0.3	0.0
Burn	43.0	11.2	53.1	70.7
Bury	1.2	0.4	1.4	0.9
Dump	6.0	4.5	7.0	13.2
Other Method	0.3	0.2	0.4	0.1
Not reported	1.3	2.2	0.8	2.1

Source: STATIN Population Census 2001

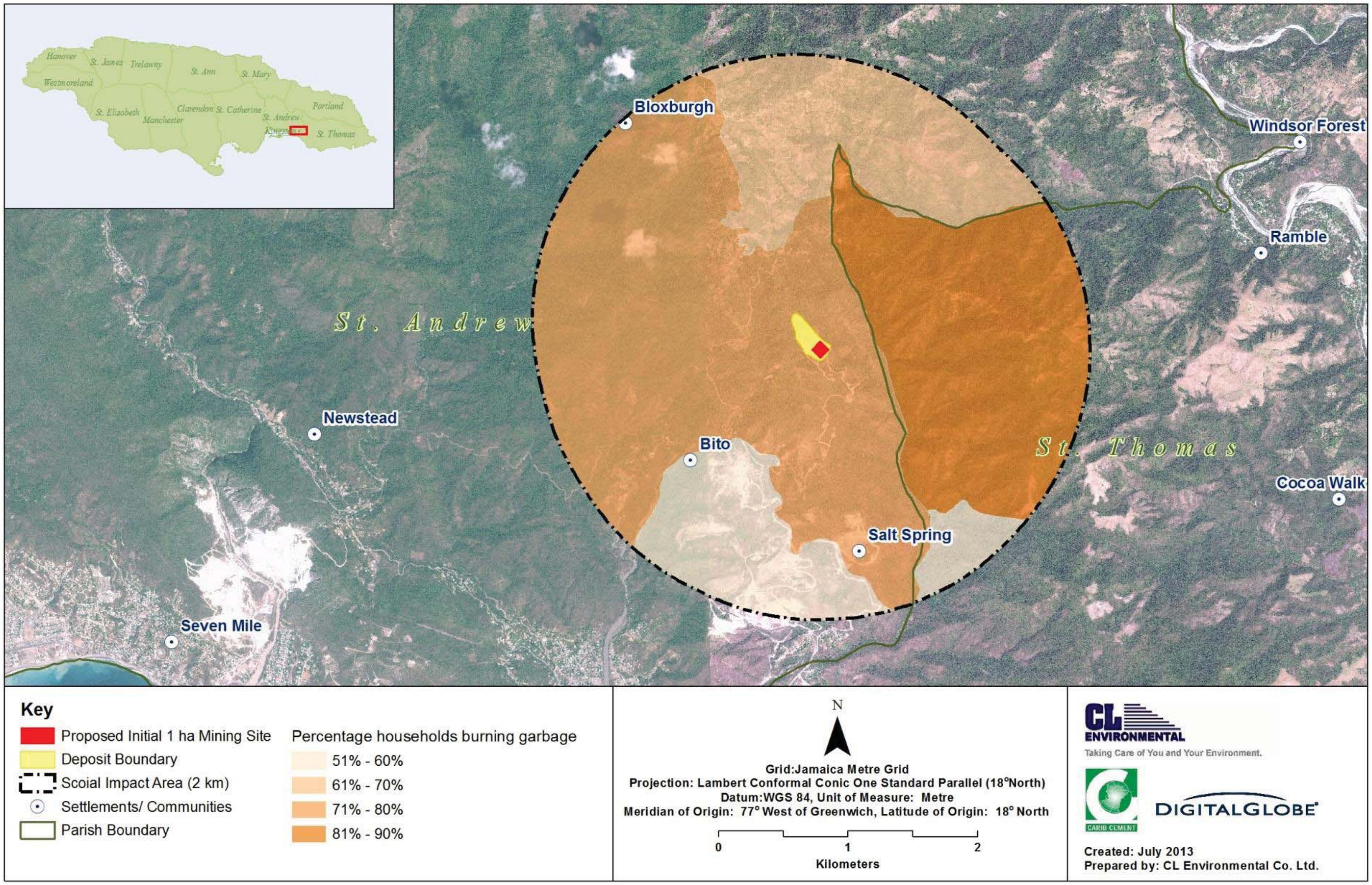


Figure 6.85 Percentage households in the SIA burning garbage for the year 2001

6.3.8 Services

6.3.8.1 *Health*

There are no hospitals or health centres within the SIA (Figure 6.86). Bull Bay Health Centre is the closest health centre, and this is located approximately 3.6 km southwest of the quarry site. This centre is a Type II facility, serviced by a visiting Doctor and Nurse Practitioner. Typical services include family health (including antenatal, postnatal, child health, nutrition, family planning & immunization); curative, dental, environmental health, Sexually Transmitted Infections (STIs) treatment, counselling & contact investigation; child guidance, mental health and pharmacy.

The hospitals closest to the site are located 9.8 km west of the site at the University of the West Indies in Mona, St. Andrew:

- University Hospital of the West Indies (UHWI) - Type A Hospital, a multi-disciplinary institution providing both secondary and tertiary care
- Hope Institute – Type S (Specialist), providing care for terminally ill cancer patients.
- Sir John Golding Rehabilitation Centre - Type S (Specialist), specializing in physical rehabilitation.

6.3.8.2 *Fire Stations*

There are no fire stations located within the SIA. That closest to the quarry location is situated in New Port East, Kingston, approximately 12 km east of the study area (Figure 6.86).

6.3.8.3 *Police Stations*

There are no police stations situated within the SIA. Bull Police Station is the closest, about 3.7 km southwest of the Halberstadt quarry.

6.3.8.4 *Post Offices*

There are no post offices located within the demarcated SIA; however the Bull Bay Ten Miles Post Office would likely serve the area in proximity to the quarry.

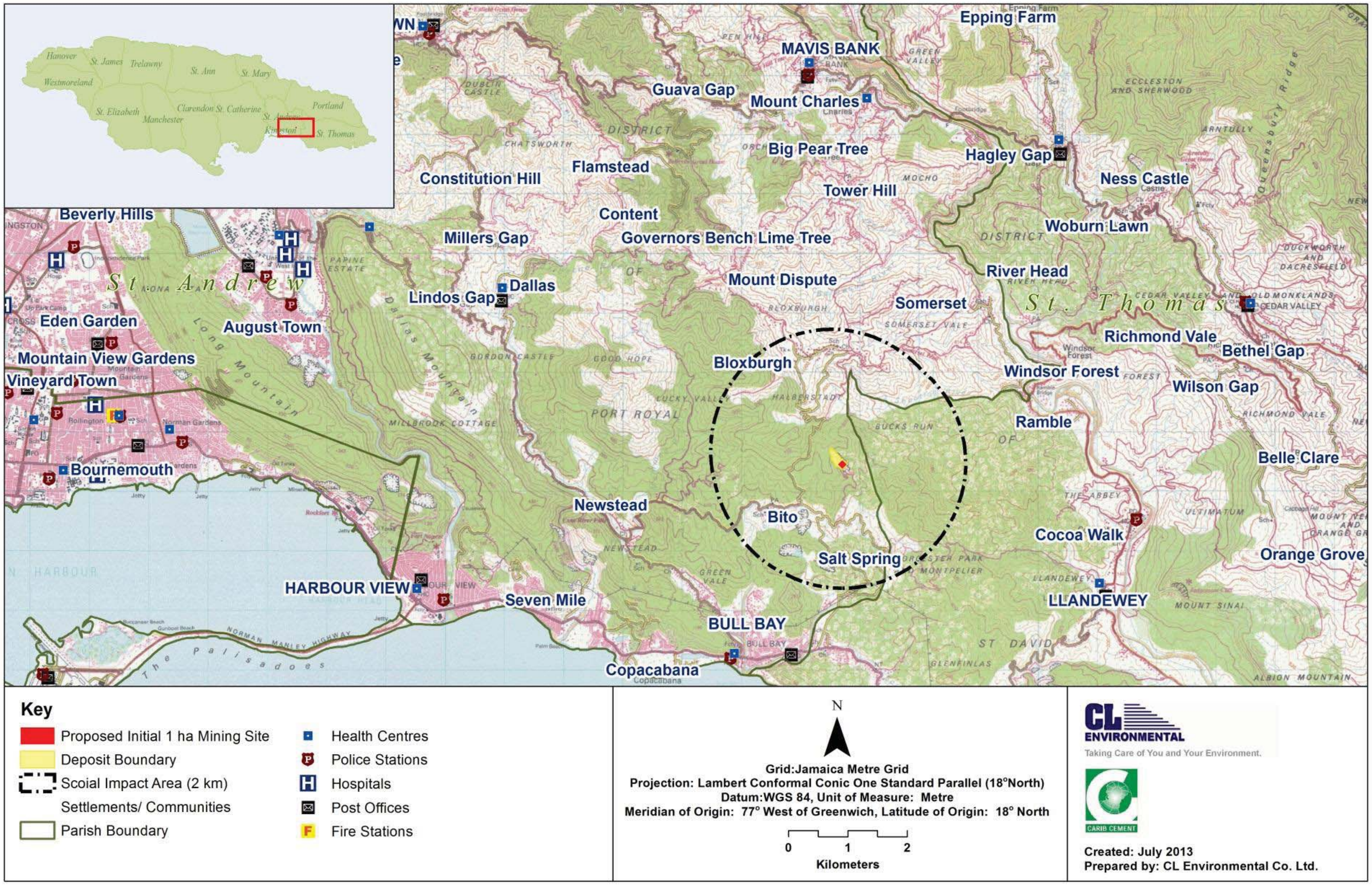


Figure 6.86 *Services located in vicinity of SIA*

6.3.9 Community Perception

6.3.9.1 Introduction

On August 30 and 31, 2013 sixty (60) community questionnaires (Appendix 11) were administered within the three kilometre SIA (Figure 6.73). 40.0% respondents were female and 60.0% were male.

Of the sixty (60) respondents age cohort distribution was as follows; 20.0 % were age 18-25 years , 26.7% were age 26-33 years, 15.0 % were age 34-41 years, 15.0 % were age 42 – 50 years, 10.0 % were age 51-60 years and 13.3 % were older than sixty years of age. 53.3 % of respondents were employed, 38.3% unemployed and 8.4 % of respondents were retired. Of the 53.3 % of employed respondents 68.8% indicated they were self-employed and 31.2 % of respondents indicated they had an employer

Eight main communities were visited. These communities were Jack Vale (upper and lower), Bull Bay (Eleven Miles, Ten Miles, Nine Miles, Seven Miles), Bloxburgh, Benoa, Tank Well Road, Bito, Gypsum Drive and Gypsum Road.

6.3.9.2 Results and Findings

Approximately 91.7 % of all respondents had heard of the Jamaica Gypsum and Quarries Limited while 8.3 % of respondents indicated they had never heard of the company. Based on interviewees' comments and responses, it was thought that some respondents were aware of the gypsum company but could not categorically confirm the name of the company. 100 % of respondents indicated awareness of the Caribbean Cement Company.

As it related to respondents awareness of the proposal to reopen the Halberstadt Quarry to mine gypsum for the manufacture of cement, 50 % of respondents were aware of the proposal and 50 % of respondents were not aware.

On the issue of concerns and comments related to the project, there were a series of mixed opinions. 58.3 % of respondents indicated that they did not have any concerns regarding the reopening of the quarry while 41.7 % of respondents expressed concerns. In general, concerns highlighted, related to the increase in noise and dust, employment opportunities for individuals in communities nearby the quarry, the possible need for relocation , the increase in siltation of gullies and flooding, the need for Jamaica Gypsum to be more involved in the community, the need for improvement of the existing roads and the increased chance of damage to homes as a result of anticipated blasting associated with quarrying activities.

46.7 % of respondents indicated that they thought the reopening of the quarry would affect their lives while 53.3 % of respondents indicated that they did not expect their lives to be affected. Of the 46.7 % of interviewees indicating an expectation of the quarry reopening to affect their lives, 44.4 % of respondents anticipated a negative impact while 55.6 % of respondents anticipated a positive effect. Positive impact was anticipated in the areas of income generation and work and business opportunities.

Please note that the percentages presented for the following community respondents are for the total number of respondents.

Tank Weld Road

3.3 % of respondents were interviewed in the Tank Weld Road area. 100 % of the respondents indicated that they had heard of Jamaica Gypsum and Quarries Limited. 50 % of respondents stated they were aware of the proposed quarry reopening and mining of gypsum. Regarding project concerns, respondents indicated that they did not have any concerns about the project. 50 % of respondents did not think the project would affect their lives in any way while 50 % anticipated an effect on their lives but a negative impact in the form of increased dust.

Bloxburgh

3.4% of respondents were interviewed in the Bloxburgh area. All respondents indicated that they had heard of Jamaica Gypsum and Quarries Limited, the Caribbean Cement Company and indicated that they were aware of the proposal to reopen the quarry to allow for the mining of gypsum. Regarding project concerns, 50 % of all respondents expressed no concern about the project. 50 % of respondents expressed some concern about the project. Of the 50 % of respondents indicating concern, all indicated concern relating to the possibility of being employed once the quarry reopens. 50% of respondents indicated an expectation for the project to impact on their lives positively, specifically in the area of employment.

Bito

5 % of respondents were interviewed in the Bito Community. All respondents from Bito indicated that they had heard both the Gypsum and Cement Companies. 33.3 % of respondents were not aware of the proposed quarry reopening project, while 66.7 % indicated awareness. On the issue of project concerns, 66.7% of respondents did not express any concern while 33.3% expressed concern. Of the 33.3 % of respondents expressing concern, all expressed concern regarding the dust nuisance associated with quarry activities. 33.3 % of respondents indicated their expectation of a positive impact from the project. Positive impact was associated with interviewees forecasting employment opportunities.

Gypsum Road

13.3 % of respondents interviewed were from Gypsum Road. 87.5 % of respondents had heard of Jamaica Gypsum and Quarries Limited while 12.5 % indicated they had not. All respondents indicated awareness of the Caribbean Cement Company. 50 % of those interviewed in Gypsum Road were not aware of the proposal to reopen the quarry while 50 % were aware of the proposal. Regarding project concerns, 37.5 % expressed that they had a concern. Of the 37.5 % of respondents expressing concern, 66.7% were concerned about the possibilities for employment and 33.3 % were concerned about the dust nuisance associated with quarrying and subsequent health issues that may arise. 12.5 % of interviewees anticipated a positive impact from the project as it was anticipated that there would be an increase in income for small business operators.

Gypsum Drive

15 % of respondents interviewed were from Gypsum Drive. 100 % of respondents had heard of Jamaica Gypsum and Quarries Limited and the Caribbean Cement Company. 66.7 % of those interviewed in Gypsum Drive were not aware of the proposal to reopen the quarry while 33.3 % were aware of the proposal. Regarding project concerns, 55.5 % expressed that they had a concern. Of the 55.5 % of respondents expressing concern, 80% were concerned about the possibilities for employment and 40 % were concerned about the dust nuisance associated with quarrying and the poor road condition as part of the road was paved and part was not. 55.6 % of interviewees anticipated an impact from the project, 33.3 % anticipated no impact and 1.1 % of respondents were non-committal. Of the 55.6 % of

respondents indicating an impact from the project, 60 % anticipated a positive impact and 40 % anticipated a negative impact. Respondents anticipating a positive impact anticipated employment opportunities (66.7 %) as well as the opportunity to sell more farm produce (33.3 %). Respondents anticipating a negative effect anticipated noise and dust pollution and possible health issues arising as a result of the dust.

Benoa

5 % of respondents interviewed were from Benoa. 100 % of respondents had heard of Jamaica Gypsum and Quarries Limited and the Caribbean Cement Company. 33.3 % of those interviewed in Benoa were not aware of the proposal to reopen the quarry while 66.7 % were aware of the proposal. Benoa respondents aware of the meeting indicated that a meeting was held in early 2013 but the actual date and convener of the meeting was not known. Regarding project concerns, 66.7 % expressed that they had a concern. Of the 66.7 % of respondents expressing concern, 50% were concerned about the possible benefits to be derived and 50 % were concerned about the possible need to relocate and the increase in the financial strain if relocation is to be realized. The area has numerous fruit trees, such as ackee, breadfruit and guinep. Respondents indicating an effect on their livelihood made mention that they harvest fruits from fruit trees and sell them. Therefore they anticipated that quarrying activities would result in the loss of fruit trees and by extension impact their livelihood. However it should be noted here that the mining/quarry activity will not impact these fruit trees. All interviewees anticipated an impact from the project, 66.7 % anticipated a negative impact and 33.3 % of respondents anticipated a positive impact. Interviewees indicating negative impact indicated that relocation would be negative for them. Respondents anticipating a positive impact anticipated employment opportunities.

Jack Vale

25 % of respondents interviewed were from Jack Vale. 93.3 % of respondents had heard of Jamaica Gypsum and Quarries Limited and 100 % of respondents indicated awareness of the Caribbean Cement Company. 26.7 % of those interviewed in Jack Vale were not aware of the proposal to reopen the quarry while 73.3 % were aware of the proposal. Regarding project concerns, 40 % expressed that they had a concern. Of the 40 % of respondents expressing concern, 33.3% were concerned about the possibilities for employment and 50 % were

concerned about the dust and noise and 16.7 % were concerned about how long it would take for the quarry to be reopened. Other concerns raised were erosion and landslides and the need for Jamaica Gypsum to look at ways to assist the communities and not just mine the community of it gypsum resource (16.7 %). 40 % of interviewees anticipated an impact from the project, 53.3 % anticipated no impact and 6.7 % of respondents were non-committal. Of the 40 % of respondents indicating an impact from the project, 33.3 % anticipated a positive impact and 66.7 % anticipated a negative impact. Respondents anticipating a positive impact anticipated an improvement in the community (50%) and job security as closure of the previous quarry resulted in lay-offs (50%). Respondents anticipating a negative effect anticipated noise and dust pollution (75 %) and possible health issues arising, specifically asthma, as a result of the dust (25 %).

Bull Bay

30 % of respondents interviewed were from Bull Bay. 94.4 % of respondents had heard of Jamaica Gypsum and Quarries Limited and 100 % of interviewees indicated awareness of the Caribbean Cement Company. 72.2 % of those interviewed in Bull Bay were not aware of the proposal to reopen the quarry while 27.8 % were aware of the proposal. Regarding project concerns, 44.4 % expressed that they had a concern. Of the 44.4 % of respondents expressing concern, 37.5% were concerned about the increased chance of gullies being blocked and 25 % were concerned about possibility for employment opportunities for community members and 12.5 % respectively expressed concern relating to dust and its effect on children, blasting and the possible damage to houses and the company's willingness to help the community. 55.6 % of interviewees anticipated an impact from the project, 44.5 % anticipated no impact. Of the 55.6 % of respondents indicating an impact from the project, 60 % anticipated a positive impact and 40 % anticipated a negative impact. Respondents anticipating a positive impact anticipated employment opportunities as well as an increase in business opportunities. Respondents anticipating a negative effect anticipated noise and dust pollution and possible health issues arising as a result of the dust.

6.3.9.3 General Comments

It was realized during the administering of questionnaires that the survey area has an issue with potable water supply. Respondents indicated that their water source was "Tank Weld Water". Respondents clearly indicated that this water was not treated water and in times of heavy rainfall the water is high in turbidity and cannot be used. Interviewees indicated that there was a connection to the "Tank Weld Water", however the legitimacy of the connection could not be verified. It was also implied that potable water used to be in the Bito area, but the mains were destroyed during quarrying activities and were never repaired. Again this could not be verified as the Bito community is small.

Both water closets and pit latrines are present in the survey area, but it was noticed that pit latrines were used in the areas where there was no water, including no connection to "Tank Weld Water".

On the issue of electricity, respondents indicated electricity for lighting, however many irregular connections were observed and some respondents indicated that their electricity supply was not legitimate as the utility company has not installed power poles to facilitate legal connections.

As mentioned previously, an overall total of 58.3 % of respondents (from all communities) indicated that they did not have any concerns regarding the reopening of the quarry while 41.7 % of respondents expressed concerns. Concerns from various communities included the increase in noise and dust; employment opportunities; the possible need for relocation and potential financial strain if relocation is to be realized; increase in siltation of gullies and flooding; the need for Jamaica Gypsum to be more involved in the community; the need for improvement of the existing roads; and the increased chance of damage to homes as a result of anticipated blasting associated with quarrying activities.

6.4 Land Use

As shown in Figure 6.87, the Halberstadt deposit and proposed quarry location is situated within an established quarry zone, namely the Bito quarry zone. As defined by the Mines and Geology Division (MGD), quarry zoning is the "designation of specific areas wherein quarrying and related activities may take place."[8] The MGD is guided by the Quarries Control Act (1983) and has established quarry zones based

---

[8] http://www.mgd.gov.jm/general-infromation/projects/quarry-zone.html

on proximity to developing centres, major townships and ports. Additionally, the JGQ has been mining in the Bito area since 1949.

In the vicinity of the proposed quarry location, mixed land use exists. The proposed site and surrounding area is currently vegetated by shrubs and trees, with signs of anthropogenic disturbance. Residential areas, including those in Bito, Salt Spring, Benoa and Bloxburgh, as well as two schools, namely Bloxburgh All Age and Bito All Age are within 2 kilometres of the proposed quarry location. Further, subsistence farming is known to take place in the vicinity of the proposed Halberstadt quarry.

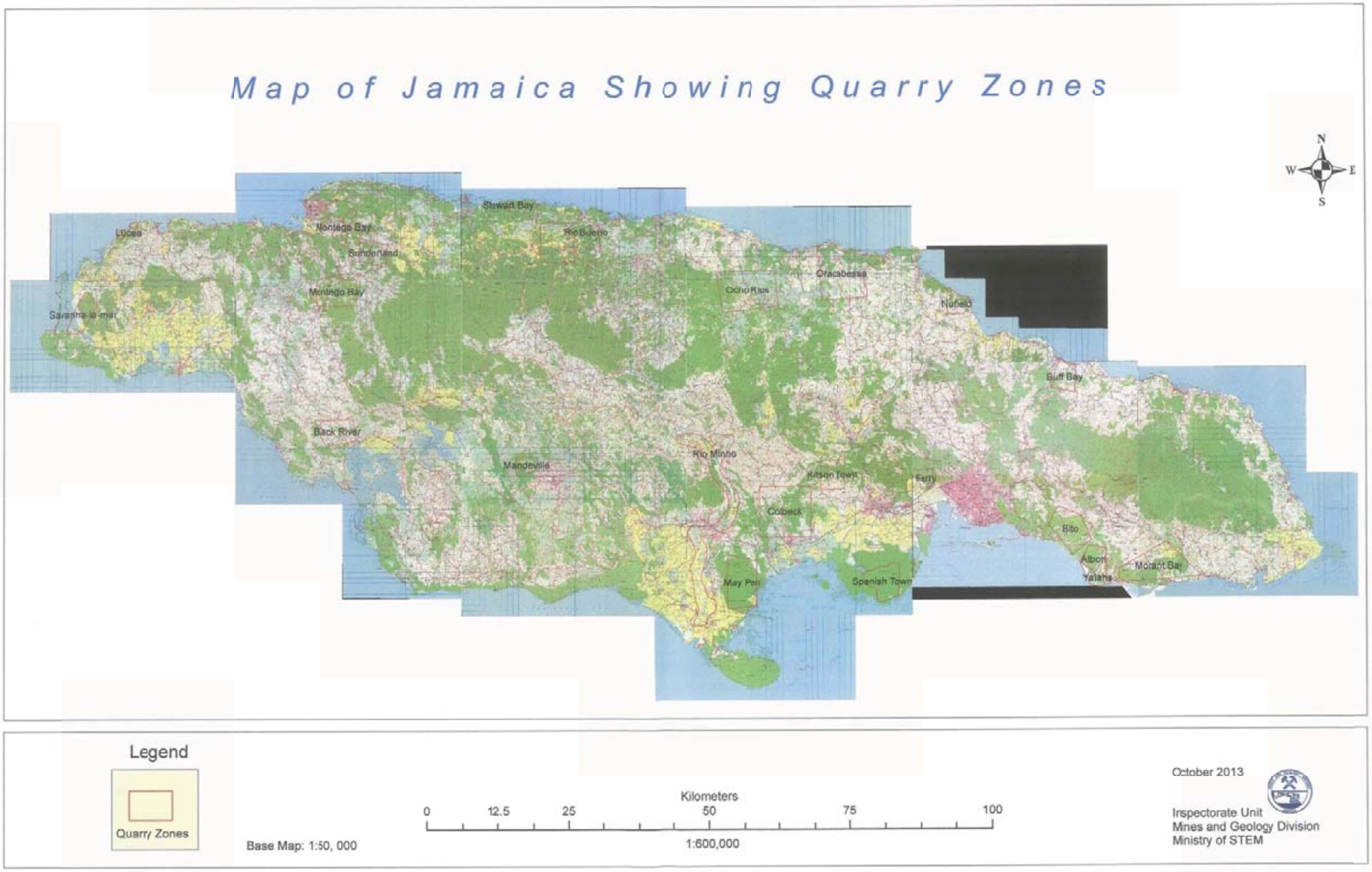


Figure 6.87 *Map of Jamaica showing quarry zones across the island*

6.5 Heritage and Cultural (Archaeological Assessment)

During August 27-29, 2013 a team of archaeologists from the Jamaica National Heritage Trust (JNHT) conducted an Archaeological Impact Assessment at the CCCL quarry located at Halberstadt.

Halberstadt is named after a town in Germany. The Tainos were the first occupants of the area evidenced by the find of a cave containing the skeletal remains of at least 34 individuals and other artefacts in 1895. The Halberstadt property has seen various land uses over the past centuries. In 1763 sugar was the main produce but by 1811 the estate was producing 6, 588 bushels of coffee. In 1824 the estate possessed 156 enslaved persons. The estate has passed through several owners such as Jakob Kellerman, John Mais, John Weiss and Beresford Gossett.

The proposed quarry is located in the southern section of the historical Halberstadt property and is owned by Caribbean Cement Company Limited. The area is of rugged terrain with steep gradients of 45°- 60° angles some parts being inaccessible. Large deposits of shale and gypsum are present.

Plate 6.19 Photographs showing rugged terrain

Plate 6.20 Photographs showing gypsum and shale deposits

The historic map shows that the location of the quarry was once the provision grounds, Guinea grass and ruinate. As in the historical period the site is found to be in ruinate and Guinea grass piece. This clearly accounts for the absence of archaeological features and artefact assemblages.

Plate 6.21 Photographs showing vegetation cover

6.6 Aesthetics

Due to the topography of the area, the proposed Halberstadt deposit is situated behind a hill, away from view of the coastal main road. Therefore, the proposed quarry is not expected to have a negative visual impact being viewed from the Bull Bay area.

7.0 IDENTIFICATION AND ASSESSMENT OF POTENTIAL DIRECT AND INDIRECT IMPACTS

Impact matrices for the site preparation and operational phases were created utilising the following criteria[9]:

- **Magnitude of Impact:** This is defined by the severity of each potential impact and indicates whether the impact is irreversible or, reversible and estimated potential rate of recovery. The magnitude of an impact cannot be considered high if a major adverse impact can be mitigated.
- **Extent of Impact:** The spatial extent or the zone of influence of the impact should always be determined. An impact can be site-specific or limited to the project area; a locally occurring impact within the locality of the proposed project; a regional impact that may extend beyond the local area and a national impact affecting resources on a national scale and sometimes trans-boundary impacts, which might be international.
- **Duration of Impact:** Environmental impacts have a temporal dimension and needs to be considered in an EIA. Impacts arising at different phases of the project cycle may need to be considered.
- **Significance of the Impact:** This refers to the value or amount of the impact. Once an impact has been predicted, its significance must be evaluated using an appropriate choice of criteria. The most important forms of criterion are:
    - Specific legal requirements e.g. national laws, standards, international agreements and conventions, relevant policies etc.
    - Public views and complaints
    - Threat to sensitive ecosystems and resources e.g. can lead to extinction of species and depletion of resources, which can result, into conflicts.

---

[9] Taken from - Ogola, P. F. A. 2007. Environmental Impact Assessment General Procedures, presented at Short Course II on Surface Exploration for Geothermal Resources, organized by UNU-GTP and KenGen, at Lake Naivasha, Kenya, 2-17 November, 2007

- Geographical extent of the impact e.g. has trans-boundary implications.
- Cost of mitigation
- Duration (time period over which they will occur)
- Likelihood or probability of occurrence (very likely, unlikely, etc.)
- Reversibility of impact (natural recovery or aided by human intervention)
- Number (and characteristics) of people likely to be affected and their locations
- Cumulative impacts e.g. adding more impacts to existing ones.
- Uncertainty in prediction due to lack of accurate data or complex systems. Precautionary principle is advocated in this scenario.

Table 7.1 Impact matrix for site preparation phases

ACTIVITY /IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE			EXTENT			SIGNIFICANCE		
	Pos	**Neg**	**Long**	**Short**	**Direct**	**Indirect**	**High**	**Moderate**	**Low**	**National**	**Regional**	**Local**	**Large**	**Medium**	**Small**
1. Site Clearance and Preparation															
Biological Impacts:															
Vegetation clearance (habitat destruction)		X	X		X		X					X			X
Effect of habitat fragmentation on plants		X	X		X				X			X			X
Soil erosion due to vegetation removal		X		X		X		X				X	X		
Effect of dust on vegetation		X		X		X		X				X		X	
Increased human & invasive spp. access		X	X			X	X					X			X
Avifauna (removal of habitats)		X	X	X	X	X	X					X			X
Invertebrate fauna (removal of habitats)		X	X	X	X	X		X				X			X
Habitat Destruction		X	X		X		X					X			X
Effect of habitat fragmentation on fauna		X	X		X				X			X			X
Effect of dust on Fauna		X		X		X		X				X		X	
Increased human & invasive spp. access		X	X			X	X					X			X
Physical Impacts:															
Increased pollutants in the air shed		X	X		X		X				X			X	
Increased noise pollution		X	X		X			X				X		X	
Excavation works (soil removal and rock blasting)		X		X	X			X				X		X	
Soil erosion and siltation		X	X		X		X					X	X		
Water resources															
Increased water pollution		X	X		X			X			X			X	
Land use:															
Change in land use (no change)	NO IMPACT														
2. Construction Works															

ACTIVITY /IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE			EXTENT			SIGNIFICANCE		
	Pos	Neg	Long	Short	Direct	Indirect	High	Moderate	Low	National	Regional	Local	Large	Medium	Small
Water demand and supply		X		X	X				X			X			X
Refuelling of vehicles and fuel storage onsite		X		X		X			X			X			X
Increased accident potentials		X		X	X			X				X	X		
Repair of vehicles onsite		X		X	X			X				X			X
3. Material Storage and Transport															
Potential spillage		X		X	X			X				X		X	
Traffic congestion, road wear		X		X	X			X				X		X	
Dusting and Spillage		X		X		X			X			X			X
Suspended solid runoff		X		X		X		X				X	X		
Effect on vegetation		X		X	X			X				X		X	
4. Construction Crew															
Sewage/wastewater generation		X		X	X				X			X			X
Solid waste management		X		X	X				X			X			X
Workers safety		X		X	X				X			X		X	
5. Socioeconomics															
Employment	X			X	X				X			X			X
Traffic flow and access roads		X		X	X				X			X			X
Commercial activity (potential increase)	X			X		X			X			X			X
Community fragmentation	NO IMPACT														
6. Cultural and Historical															
Historic sites	NO IMPACT														

Table 7.2 *Impact matrix for operation phase*

ACTIVITY /IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE			EXTENT			SIGNIFICANCE		
	Pos	**Neg**	**Long**	**Short**	**Direct**	**Indirect**	**High**	**Moderate**	**Low**	**National**	**Regional**	**Local**	**Large**	**Medium**	**Small**
1. Quarrying Operations															
Biological Impacts:															
Vegetation clearance (Habitat Destruction)		X	X		X				X			X			X
Effect of habitat fragmentation on plants		X	X		X				X			X			X
Soil erosion due to vegetation removal		X		X		X		X				X	X		
Effect of dust on vegetation		X		X		X	X					X		X	
Increased human & invasive spp. access		X	X			X	X					X			X
Fauna Habitat Destruction		X	X		X				X			X			X
Effect of habitat fragmentation on avifauna		X	X		X				X			X			X
Effect of habitat fragmentation on invertebrate fauna		X	X		X				X			X			X
Effect of dust on fauna		X		X		X	X					X		X	
Increased human & invasive spp. access		X	X			X	X					X			X
Physical Impacts:															
Increased runoff and flooding hazard		X	X		X			X				X	X		
Soil erosion and siltation		X	X		X		X					X	X		
Increased air pollutants in the air shed		X	X		X			X			X			X	
Increased noise pollution		X	X		X			X				X		X	
Vibration		X		X	X				X			X		X	
Increased potential for oil spills		X	X		X			X				X		X	
Improper solid waste disposal		X	X		X			X				X			X
Water demand and supply		X	X		X			X				X		X	

ACTIVITY /IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE			EXTENT			SIGNIFICANCE		
	Pos	Neg	Long	Short	Direct	Indirect	High	Moderate	Low	National	Regional	Local	Large	Medium	Small
Refueling of vehicles and fuel storage onsite		X	X		X			X				X		X	
Repair of vehicles onsite		X	X		X				X			X			X
2. Material Transport and Storage															
Dusting and spillage		X	X		X			X			X			X	
Traffic congestion, road wear		X	X		X		X			X			X		
Suspended solid runoff		X	X		X				X			X			X
Effect on vegetation		X		X	X				X			X			X
3. Operational Crew															
Sewage/wastewater generation		X	X		X				X			X			X
Solid waste management		X	X		X				X			X			X
Increased potential for accidents		X	X		X			X				X	X		
4. Socioeconomics															
Employment	X		X		X			X				X		X	
Traffic flow and access roads	X		X		X			X				X		X	
Commercial activity (potential increase)	X		X			X		X				X		X	
5. Cultural and Historical															
Historic sites	NO IMPACT														
6. Aesthetics		X	X		X				X			X			X

7.1 Physical

7.1.1 Air Dispersion and Quality

The only potential direct impact from the proposed quarry operations as it relates to air quality is dust emissions. The amount of dust emissions to be generated were calculated and these were subjected to an air dispersion modelling exercise that revealed predicted maximum dust (TSP and PM_{10}) concentrations to be in compliance with the stipulated ambient dust standards.

Site preparation has the potential to have a two-folded direct negative impact on air quality. The first impact is air pollution generated from the construction equipment and transportation. The second is from fugitive dust from the proposed construction areas and raw materials stored on site. Fugitive dust has the potential to affect the health of construction workers, the resident population and the vegetation.

7.1.2 Noise Pollution

Site clearance and operational activities for the proposed quarry necessitates the use of heavy equipment to carry out the job. These equipment include bulldozers, backhoes, excavators, graders, crushers and dumper trucks etc., additionally some blasting will be carried out. They possess the potential to have a direct negative impact on the climate. Noise directly attributable to site clearance and operational activity should not result in noise levels in the residential areas to exceed 55dBA during day time (7am – 10 pm) and 50dBA during night time (10 pm – 7 am). Where the baseline levels are above the stated levels then it should not result in an increase of the baseline levels by more than 3dBA.

7.1.3 Rock Blasting

Blasting is expected to be concentrated mainly within the deposition boundary of the Halberstadt site. The main concerns are:

- Fragments of rocks will be propelled into the air by explosions on site. These rocks will create hazards if they are propelled into nearby residences resulting in harm or death.
- Fumes (toxic and non-toxic) are released into the atmosphere as a result of using explosives for blasting. Residences may be affected by dust and fumes within 100 metres.

- Deposited dust may affect local residents as cars, homes or any surface may have visible deposition.
- Another concern is vibrations caused by blasting that will affect structures within close proximity to the blasting location.

7.1.4 Vibration

Ground vibration will occur during quarry operations given that mining of relative hard-rock deposits will occur and blasting will be the primary extraction method. The large earth moving equipment and haul trucks will also add to the level of ground vibration emanating from this quarry.

7.1.5 Drainage

The following subsections describe impacts regarding soil loss, flooding and water pollution. Please note that the "Drainage Assessment Report for Halberstadt Mine, St. Thomas" (CEAC Solutions Co. Ltd., July 2013) may be referred to for additional details.

7.1.5.1 Soil Loss

The steep sided slopes of the Halberstadt site suggest that in times of heavy rainfall, the possibility of landslides is high. All areas influenced by the mining operation should be either benched or geotechnically engineered to prevent downslope movement of material.

One of the most widely used and accepted equations for estimating soil erosion is the Universal Soil Loss Equation (USLE), an empirical equation developed by the U.S. Department of Agriculture. The USLE estimates the annual tonnage of soil eroded from the site attributed only to a sheet and rill erosion. However, not all eroded soil qualifies as soil loss due to the fact that eroded soil may be re-deposited before it leaves a slope and therefore does not factor into soil loss quantity.

Methodology

The method for estimating the average annual soil loss involves the evaluation of all six factors in the USLE. In the USLE, there are five factors (soil erodibility: K, slope length: L, steepness: S, cover management: C, and support practice: P) derived from the surface characteristics and one factor (rainfall erosivity: R), which reflects the raindrop effect and the runoff rate, derived from the rainfall data. Each factor was evaluated in GIS environment and a map of the average soil loss plotted. The total soil loss for a year for the catchment was then computed using map algebra, by multiplying the rate of soil loss by the area of each cell within the catchment and summing. Each of the factors was evaluated as follows:

R-factor

R or rainfall erosivity factor is related to the annual average rainfall by the equation:

$$R = 0.0483 \times P^{1.61}$$

Where P is the annual average rainfall in mm/yr. A rainfall raster map was created using rainfall data from the rainfall station across the island. A raster calculator function was then used to create a R-factor raster map using the equation.

K-factor

The soil erodibility factor k is dependent on soil type. A database of various soil types across the island were obtained from the Ministry of Agriculture. Each soil type was assigned an erosive number which the level of erosion expected in such soils. These erosive numbers were then given corresponding K-factors ranging from 0.01 for very low erodibility to 0.65 for highly erodible. The K-factors were then used to create a raster map.

L-factor and S-factor

Both factors are topographic factors and thus can be combined as the LS-factor. The factor is derived though analysis of the digital elevation model (DEM) of Jamaica. The following equation links the two:

$$LS = L \times S\left(10{,}000 + \frac{10{,}000}{s^2}\right)$$

Where,

s is the percent rise of the calculated slope

S is the S-factor, $S = \frac{0.43+0.30s+0.043s^2}{6.613}$

L is the L-factor, $L = \left(\frac{30}{22}\right)^m$

The slope gradient, S, was calculated using the slope percent rise analysis of the 30m DEM. The resulting raster map was then converted from percentage to decimal using map algebra. this percent rise raster was then used to calculate the S-factor using map algebra. The L-factor was the calculated using the equation given where m = 0.5 for slopes > 5%, m = 0.4 for slopes 3.5% and 4.5% and m = 0.3 for slopes< 3%.

C-factor

The cover and management factor was determined for the various types of land cover. A land cover map from the Forestry Department was used to assign the C-factors to the various type of land cover. Table 7.3 below shows the C-factor for the various land covers across the island. According to the land cover map, the site falls in an area which is covered by distributed broad leaf forest and field.

Table 7.3 Summary table of land cover types and associated C-factors

Land Cover Type	**C-factor**
Bamboo	0.013
Bamboo and Disturbed Broad Leaf Forest	0.042
Bamboo and Field	0.003
Bare Rock	0
Bauxite Extraction	0.5
Bauxite Extraction and Disturbed Broad Leaf Forest	0.45
Building and Other infrastructure	0
Closed Broad Leaves	0.083
Disturbed Broad Leaf	0.14
Disturbed Broad Leaf Forest and Field	0.085
Field and Crop	0.011
Fields and Disturbed Broad Leaf Forest	0.081
Fields or Disturbed Broad Leaf Forest and Pine Plantations	0.13
Herbaceous Wetlands	0
Mangrove	0
Plantations	0.3
Short Open Dry Forest	0.17
Swamp	0
Tall Open Dry Forest	0.19

Results

Pre-construction

The site is located in an area with soil loss rate of between 16- 30 tons/acre/year. Given the size of the catchment is 376,958 m2, the annual soil loss was found to be 1,828 tons. this soil loss translates to an overall loss of 3mm of soil over the catchment. Figure 7.1 below shows the pre-construction soil loss map generated.

Post Construction

The post construction scenario would involve the clearing of the site which would affect the cover factor. The present land cover of distributed broad leaf forest will be changed and the most closely associated land cover for the quarry would be that of bauxite extraction, which has a cover factor of 0.5 (see Table 7.3). This change in the cover factor raises the total annual soil loss from the catchment to 3,064 ton. The overall increase in the depth of soil lost over the catchment would be increase by 2mm to 5mm per year. The post construction soil loss map generated is shown below in Figure 7.2. From the map we can see the increase in the soil loss rate indicated by the orange sections inside the catchment.

Summary

Table 7.4 Summary table of the soil loss across the catchment

	Area (m^2)	**Soil loss/year (kg/year)**	**Soil loss/year (ton/year)**	**Soil Loss (mm/year)**
Present				
Site	58,637.90	274,542.31	274.54	2.94
Catchment	376,957.66	1,827,906.30	1,827.91	
Future				
Site	58,637.90	1,509,982.80	1,509.98	4.93
Catchment	376,957.66	3,063,346.79	3,063.35	
Difference		1,235,440.49	1,235.44	1.99
% increase				
Site		550%		
Catchment		168%		67.7%

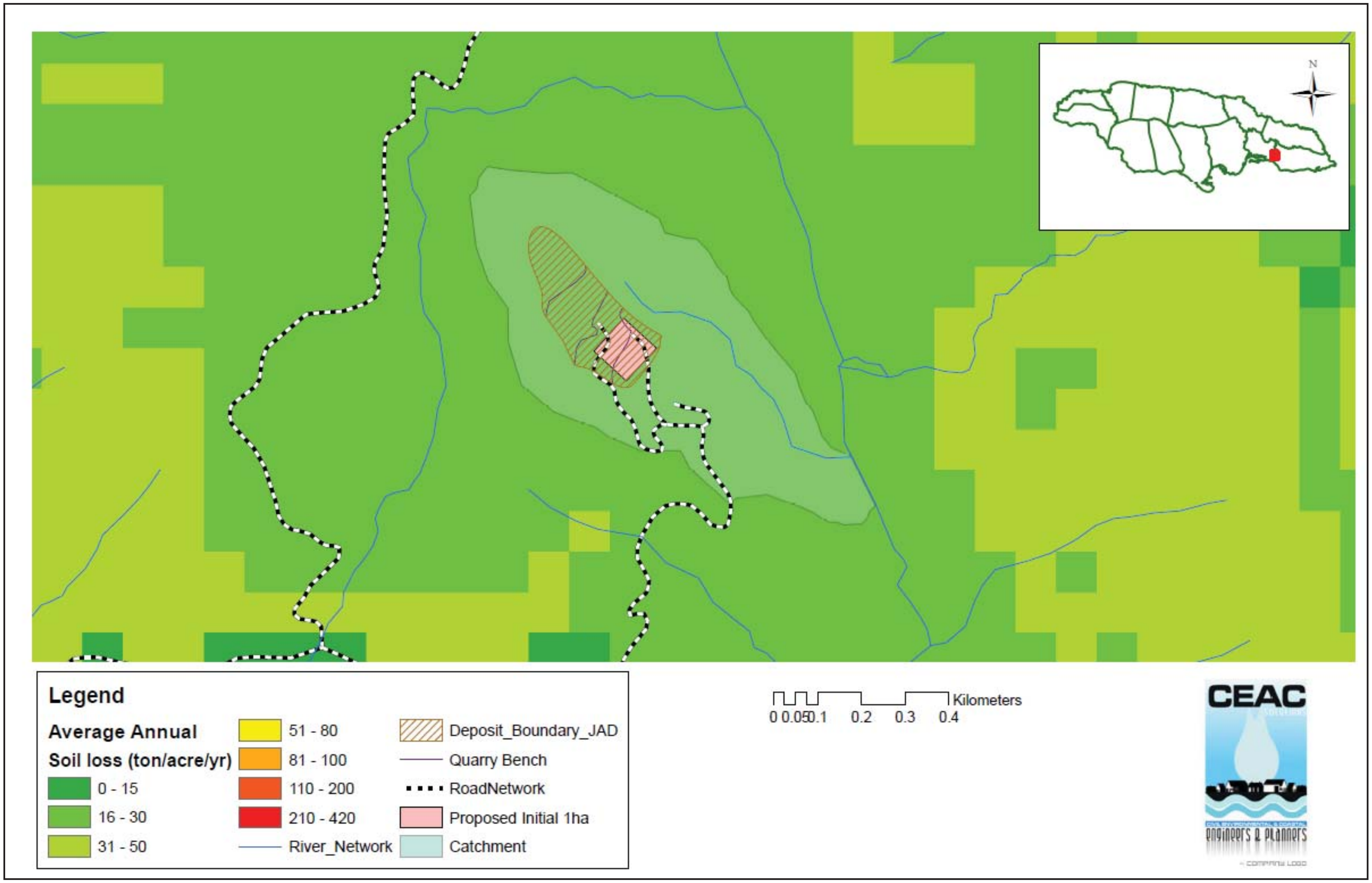


Figure 7.1 Pre-construction soil loss map

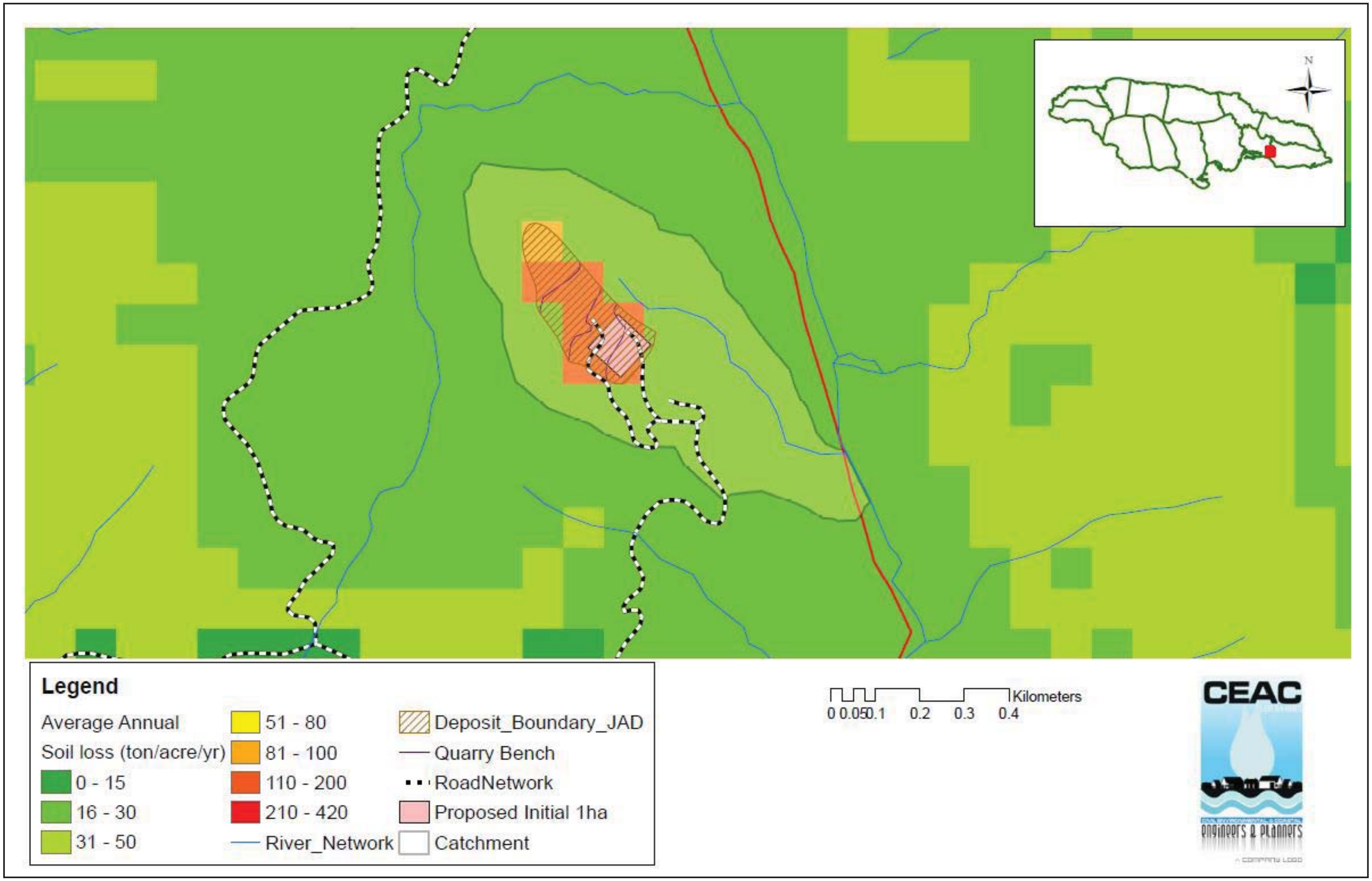


Figure 7.2 *Post construction soil loss map*

7.1.5.2 Flooding

The topography of the site shows that the eastern boundary of the deposit is drained by the Bull Park River so mitigation steps should be taken to facilitate in the prevention of silt accumulating in the channel of the river. This increase in sediment load, generated by the quarry, will result in a shallower river channel which may induce flooding in areas downstream. This will more likely be evident where there exists a bend in the river channel or the river enters the sea due to the slowing down of the water within the channel. Some adverse effects of sediment loading are:

- Alters the natural flow of water and reduces water depth within a water course;
- Clogs storm drains and catch basins which transport water away from roads and structures – increases potential flooding;
- Nutrients transported by sediments negatively affect the ecosystem of the river.

The site is drained toward the boundaries and ultimately south-east via overland sheet flow and shallow concentrated flows to the existing gullies and roads. When the Halberstadt quarry is reopened and in full operation, the runoff will increase due to vegetation being removed. The runoff from quarry surfaces will generally be faster and increased in volume. This can be attributed to the exposed hillslopes with little or no vegetation to reduce the flow. The more vegetation that is removed, the more the increase in storm water runoff and the more impacts it will have. The immediate community south of the proposed site does not experience flooding according to anecdotal information received, however, the communities downstream in proximity to 10 miles Bull Bay might be affected by this increase.

7.1.5.3 Surface /Subsurface Water Pollution

Run-off from the quarry is a problem and as a result has adverse impacts on the communities on the flood plain of the Bull Park River.

The quantity and quality (physical, chemical) of both surface waters as well as groundwater may be affected by quarrying activities - may be contaminated by runoff or dust from the quarry. The removal of topsoil, overburden and aggregates may affect the quality of water recharging of an aquifer. Regardless of the volume of a quarried outcrop, the result of removing the protective cover (filter) of an aquifer may cause severe pollution of the groundwater. Another impact is that groundwater flow patterns may change due to manmade effects, such as blasting; the flow path may change direction and contribute to another karst subsystem or spring. This will either increase or decrease the recharge flows into the aquifer.

The designers should take into consideration debris flow when designing culverts and drains. In the designing process, the freeboard acts as the volume occupied by the debris usually 20% - 25%. This allows some leniency when debris starts to flow in heavy water bodies.

Containment of drainage from operating sections of the quarry is recommended to prevent oil spills from entering storm drains or navigable waters. Due to the potential of spills from the mobile equipment on the Halberstadt site, appropriate containment areas should be erected.

7.1.6 Transportation and Roads (Onsite/Offsite)

7.1.6.1 Roads Classification and Capacity

The development and operation of the Halberstadt quarry will have some impact on traffic in the area. Vehicles will access the site from the South coast main road via a parish council road which is only paved for approximately 450 metres from the intersection with the main road (see Plate 8.1).

The NWA classifies the main road as a Class-A main road in its island-wide road network. The existing PC road is listed as a part of the NWA network (see Figure 7.3). Based on the NWA system of classification, the main Road should typically have over 1000 cars per day whereas the PC should be able to handle less than a thousand.

Inspection of the roads indicated the width of the main road varies between 5-6 metres in the vicinity of the intersection as opposed to the 7.2m width that is recommended in the Development Manual10 prepared by the Office of the Prime Minister.

---

[10] Development and investment Manual, Vol 3, Section 1 Roads, Infrastructure, Drainage and Traffic Management, p.4

Plate 7.1 Photo taken on Bull Bay main road showing the intersection of the main road with the local road.

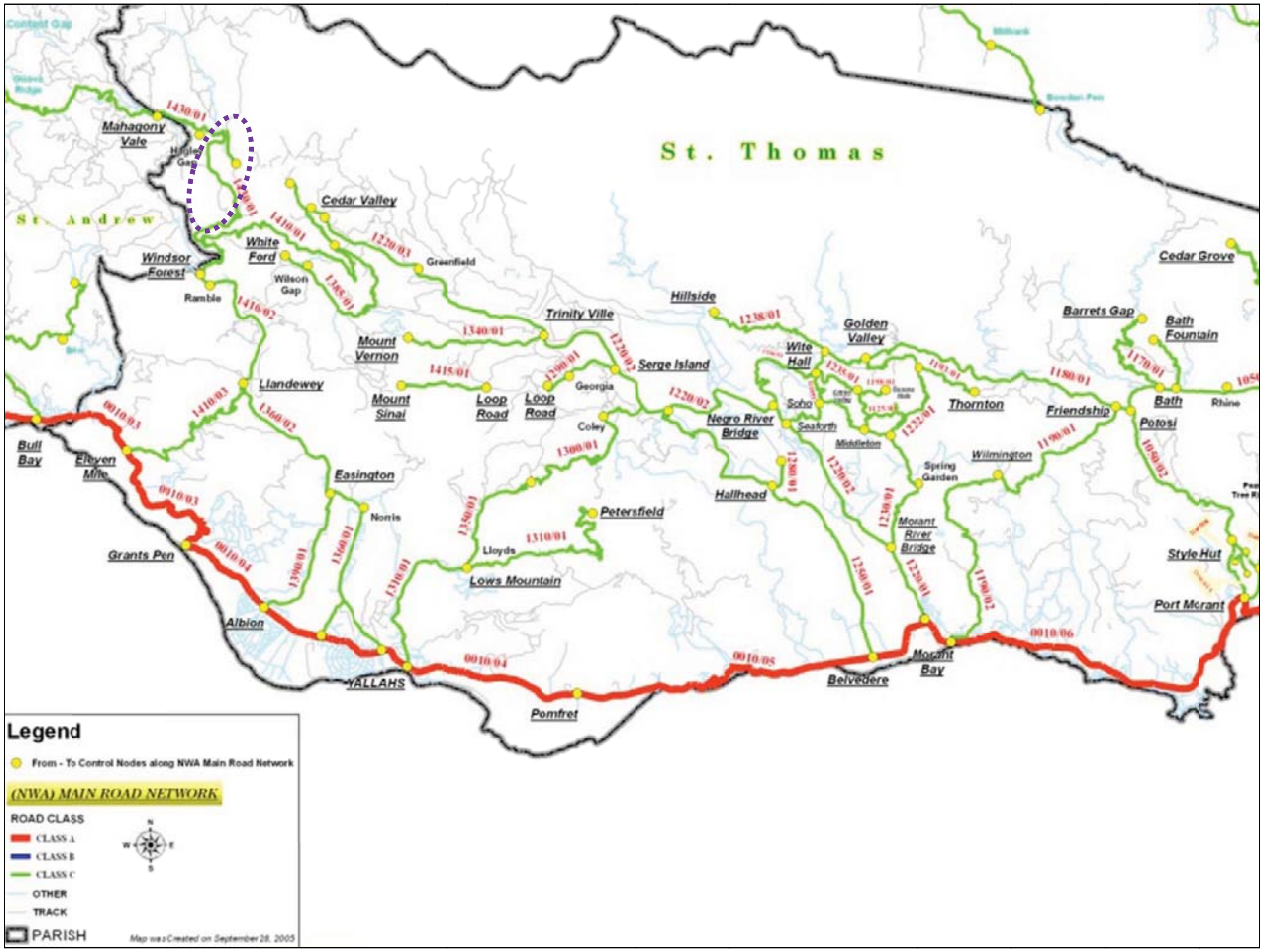


Figure 7.3 Illustrating the classification of roads surrounding project area

7.1.6.2 Existing Trip Volumes

The most recent counts in the area were done by the NWA in 2012. They revealed the average daily traffic on the Bull Bay main road is in the order of 5000 with peak morning and evening volumes of 524 and 426 respectively. Similarly the estimated traffic on the PC road is 250 for ADT and 20 and 15Veh/hr for morning and evening peaks respectively. The values for the PC road also include the numbers trips that were observed to be generated by the Bito Quarry. The Bito quarry typically generates no more than four trips per hour. It was observed that vehicles using the intersection had sufficient space and time to manoeuvre, no backups or congestion was observed during the peak hour traffic times.

7.1.6.3 Traffic Impacts

Congestion

Construction traffic will be mostly trucks delivering equipment to the site. There will not be any removal of rubbish from the site down to the main road. All un-useable material will be stockpiled onsite to be used for fill in mined out areas or where depressions need filling for roads or even drainage embankments. There will therefore not be any significant or sustained movement of traffic on the PC roads during this time save for an anticipated 5 or less utility vehicles driven by construction specialists to install the equipment. The equipment will be delivered from the Kingston Ports. Vehicles accessing the site will be doing so from the western approach unto the slip road. Trips generated by the development will only have the potential to contribute to or cause congestion at the intersection with the main road when they are leaving the development. There is no anticipated congestion on the PC road leading from the development to the main Road.

Safety

The increase in traffic (extra-long and heavy vehicles) at the intersection during the construction phase will reduce the safety level for motorist's that traverse this route.

Deterioration of Road Surface

The increase in the number of heavy vehicle along the roadways entering and leaving the site will add significant stresses to the base and sub-base of the road. This will affect the structural integrity of the paved roads which may result in failure. Secondly, the unpaved sections of the PC roads will deteriorate much further especially when it rains.

7.1.7 Material Storage

7.1.7.1 Quarry Material

A set of management guidelines should be implemented in order to curtail the impact of stored quarried material, identify formalized storage sites and for the appropriate management using quarried material. The storage and use of stored material is required to be managed to:

- Efficiently utilize material previously quarried;
- Minimise the spread of environmental pathogens (infectious);
- Ensure legal requirements are met for storing quarried material.

The storage of quarried material will be facilitated by a 980 front end loader and Dumper trucks with a capacity of 20 – 35t. The material will be transported to the Jamaica Gypsum Quarry port for storage. Use of covered storage for material sized less than 3mm with side enclosure on 3 sides taking account of prevailing wind direction.

It is recommended that storage of quarried material at registered sites is recorded. Information on where the material was quarried, what volumes are to be stored, where is the material being used, what type of material and estimated volumes remaining at completion of the project is also required. In addition, quarry operators should ensure, by securing their site entrance and boundaries, that illegal disposal of waste by third parties does not occur.

7.1.7.2 Fuel

The impacts of improperly stored fuel and other chemicals could prove detrimental if these fluids infiltrate the surface waters or groundwater systems. Management guidelines should be implemented in order to regulate and document the use of explosives, chemicals and fuels within the quarry site. Operators should express due caution when it comes to the refuelling of equipment on site, as an accidental oil spill is more likely to occur during these activities.

7.1.8 Solid Waste Generation

During this construction phase of the proposed project, solid waste generation may occur mainly from two points:

i. From the construction campsite.
ii. From construction activities such as site clearance and excavation.

7.1.9 Wastewater Generation and Disposal

Workers should be provided with sanitary conveniences during the construction process. The disposal of the wastewater generated at the campsite has the potential to have a minor negative impact on groundwater. During quarry operation however, the septic tank and tile field for 12 persons being designed by CEAC Solutions will be used.

7.2 Biological

7.2.1 Flora

The impacts and possible mitigations for the development are outlined below. As with any development, the options of not to develop and the use of alternate sites should always be considered.

7.2.1.1 Habitat Destruction

Creating the pits or quarries requires the removal of virtually all natural vegetation, topsoil and subsoil to reach the aggregate underneath leading to a significant loss in plant and interdependent animal diversity. Additionally, adjacent communities may be affected by dust generated. At the end of life for the mine, the area could become more susceptible to invasive or introduced species if left fallow as well as the potential for land slippage is amplified. There would also be a permanent change in the structure, aesthetics and composition of the flora after mining operations have ceased.

7.2.1.2 Habitat Fragmentation

Habitat fragmentation may also be another result of quarrying. This is a process whereby a large, continuous area of habitat is both reduced in size and divided into two or more fragments by human constructs (Primack, 2006). These fragments are often isolated from each other by a highly modified or degraded landscape and their edges experience an altered set of microclimate conditions called “edge-effect”. However, the effect of this phenomenon on the flora of Halberstadt is expected to be minimal due to pre-existing conditions. The road network present already contributes to this issue and the proposed mine would not completely isolate sections of the surrounding vegetation.

7.2.1.3 Accidental or intentional removal of important plant species

Over 120 plant species were encountered during the field excursion including four known endemics. Therefore, the area could be considered species rich with an indigenous component, important to the local environment and the natural history of the country.

7.2.1.4 Increased soil/substrate erosion:

Quarries, particularly those on steep slopes with unstable rocks, increase landslides and other mass movements with consequent destruction of natural habitats and biodiversity. Removing the topmost soil layer and surface rock material also multiplies the vulnerability of groundwater contamination (Darwish et al., 2008).

The potential for land slippage is greatly increased as a result of vegetation removal. A plant's roots act as a mesh within the substrate increasing its cohesiveness and improving water percolation and drainage. Areas where bare ground is exposed tend to erode faster than areas inhabited by plants. Therefore, there could also be a resulting shift in the level of the water table as a result of plant removal.

It is the strong opinion of the flora consultant that the unplanned, wide-scale removal of vegetation, may be detrimental to the ecosystem and possibly to the human communities at lower altitudes. This outlook is based on the increased potential for surface water runoff and land slippage that such actions may manifest in projects such as this.

7.2.1.5 Increased Effects of airborne particulates or dust

The dust is normally generated as a result of blasting, loading and vehicle movement in the quarry. Periodic earth works to remove and stockpile the overburden of soil will also result in dust emissions. The major environmental hazard from the quarry, especially on the flora surrounding the site, is the effect of dust (Lameed & Ayodele 2010).

Dust particles have the potential to block and damage the stomata of plants, impairing photosynthesis and respiration. Other effects are shading and light scattering by airborne particulates, which may also lead to a reduction in photosynthetic capacity. Over time even the cuticles and underlying layers may become worn due to abrasion (Lameed & Ayodele 2010; Langer 2001). Airborne pollutants will be produced at the quarry and these may get deposited on the plants and affect their physiology; leading to retarded growth and death (Lameed & Ayodele 2010).

7.2.1.6 Storage of overburden and other waste

Plant growth and health can be significantly affected by dust, grime and toxic emissions from machinery. Leachates from storage areas can disturb the pH balance in the soil and result in plant loss.

Also at the development and operation stages, soil will need to be removed for road maintenance as well as from the quarry area as it gradually expands. However it is important to conserve this topsoil wherever possible for later rehabilitation.

7.2.1.7 Increased human and invasive species access

As in any development, the clearing of natural vegetation allows the intrusion of invasive plant and animal species into the development site.

7.2.2 Fauna

7.2.2.1 Avifauna

The proposed limestone quarry will most likely have a negative impact on the bird population in the area. The removal of the present vegetation will have a deleterious effect on the bird population in the area as follows:

- Removal of vegetation will cause habitat loss including food resources.
- Noise from the heavy machinery and from the explosive will force several of the birds to leave the area.
- The dust nuisance will cause several of the birds to find a new refuge.

Birds will subsequently be forced to use the habitat in close proximity to the proposed site. This will have a negative impact on the bird population since they would have to compete with resident birds in the adjacent areas for limited resources in the area.

It should be noted that birds requiring special conservation protection were not encountered during the assessment.

7.2.2.2 Invertebrate fauna

None of the species identified merited special conservation status; they were wide spread across Jamaica and were generalists occurring in a wide range of environments. Some species were generally numerous enough in other parts of Jamaica to be considered pests species. While species will be displaced from this area there is not likely to be significant impact on the overall Jamaican populations.

7.3 Human/Social

7.3.1 Employment

There is the potential for increase employment; it is anticipated that approximately 38 persons will be employed directly, including permanent, casual and contractual types of employment. All mining and haulage activities at Halberstadt Quarry will be outsourced to qualified contractors with JGQ maintaining oversight and management of the mining.

7.4 Heritage

The archaeological survey revealed the site to be of no archaeological significance.

7.5 Aesthetics

Due to the topography of the area, the proposed Halberstadt deposit is situated behind a hill, away from view of the coastal main road. Therefore, the proposed quarry is not expected to have a negative visual impact being viewed from the Bull Bay area. Persons living within the community nearby the quarries however, will be visually affected.

8.0 CUMULATIVE ENVIRONMENTAL IMPACTS

8.1 Air Quality

There exists numerous sources of dust nuisances within quarries (in addition to Bito gypsum quarry operations), including but not limited to:

- wind blowing across site;
- the grubbing (stripping) of topsoil;
- the excavation of sand and/or gravel;
- the crushing and screening of aggregates; and
- the transport of quarried material – fine materials deposited along public roads during transit.

Table 8.1 shows the maximum predicted concentrations for the All Sources (including those at the proposed quarry operations) scenario, and their comparison with the JNAAQS. The results revealed that the maximum predicted ground level concentrations for all the sources within the air shed plus the background concentrations (as recommended in the NRCA Ambient Air Quality Guideline Document) exceeded the respective JNAAQS. It should be observed that the main contributor to the cumulative air quality (TSP and PM_{10}) impact concentration is CCCL, which have a number of instruments monitoring the particulate concentration within the air shed, for which reports are being submitted to NEPA.

Table 8.1 Model cumulative results

Pollutant	**Avg. Period**	**Background (μg/m³)**	**Jamaican NAAQS (μg/m³)**	**All Sources**		
				Max Conc (μg/m³)	**UTME (m)**	**UTMN (m)**
TSP	24-hr	14	150	362.2	316970.06	1986635.63
	Annual	20	60	48.1	316469.24	1987354.56
PM_{10}	24-hr	9	150	360.7	316970.06	1986635.63
	Annual	20	50	48.3	316469.24	1987354.56

Figure 8.1 through Figure 8.4 show the pollutant contour plot-files for TSP and PM_{10} within the entire air shed for the All Sources category. The plot files show the most impacted areas based on the predicted pollutant concentrations generated by the model runs. The colour coded scale in

each figure indicates the various impact concentrations obtained up to the maximum predicted concentrations achieved.

Dust particles deemed respirable (less than 10 micrometres in diameter) have the potential to cause negative effects on human health depending on exposure levels. In addition to this air quality concern, there are also potential visual impacts of dust, including:

- coating/soiling of personal property with dust;
- coating of vegetation;
- contamination of soils (water pollution, altered pH balances);
- change in plant species composition; and
- increased inputs of mineral nutrients.

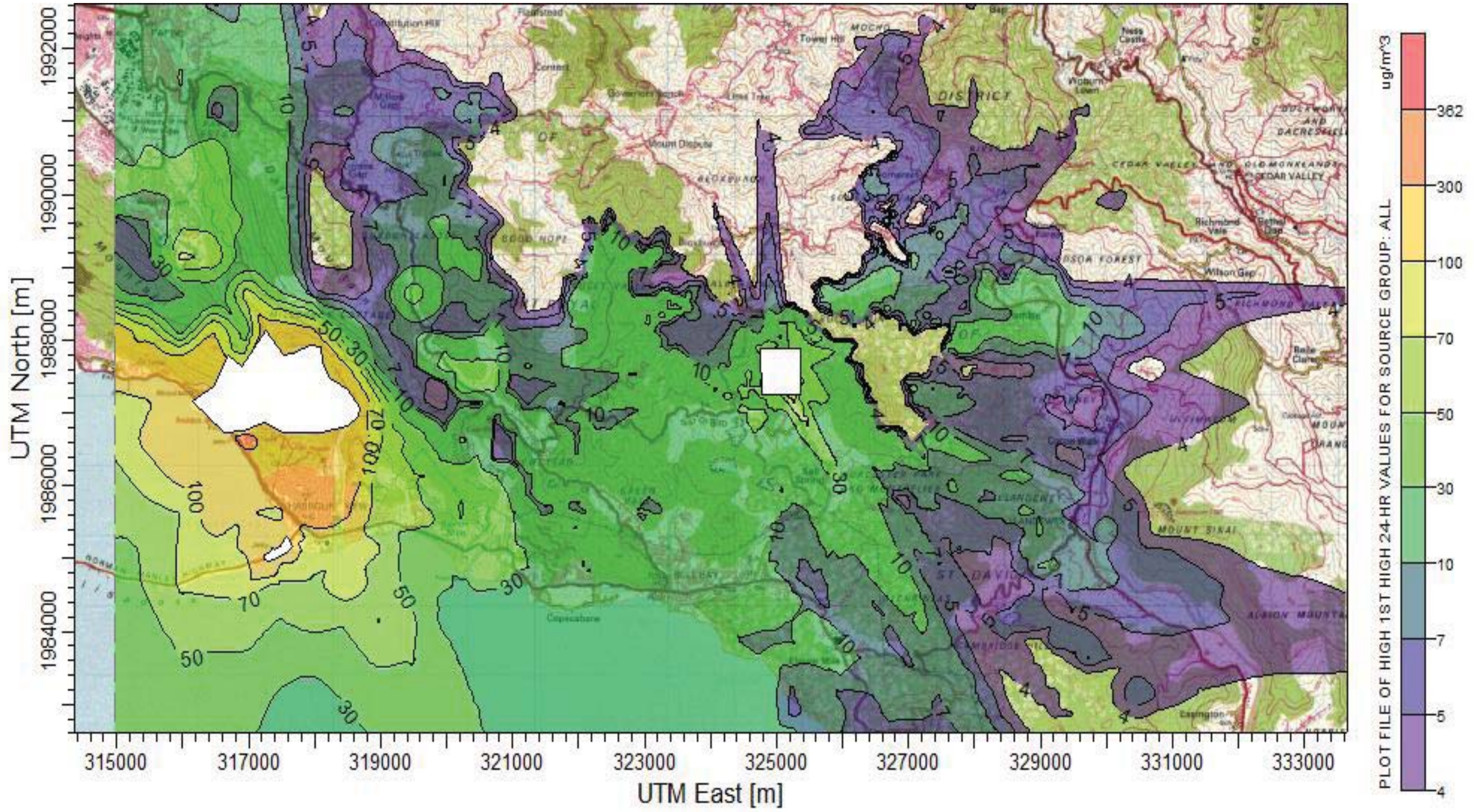


Figure 8.1 *Predicted cumulative 24-h TSP concentrations*

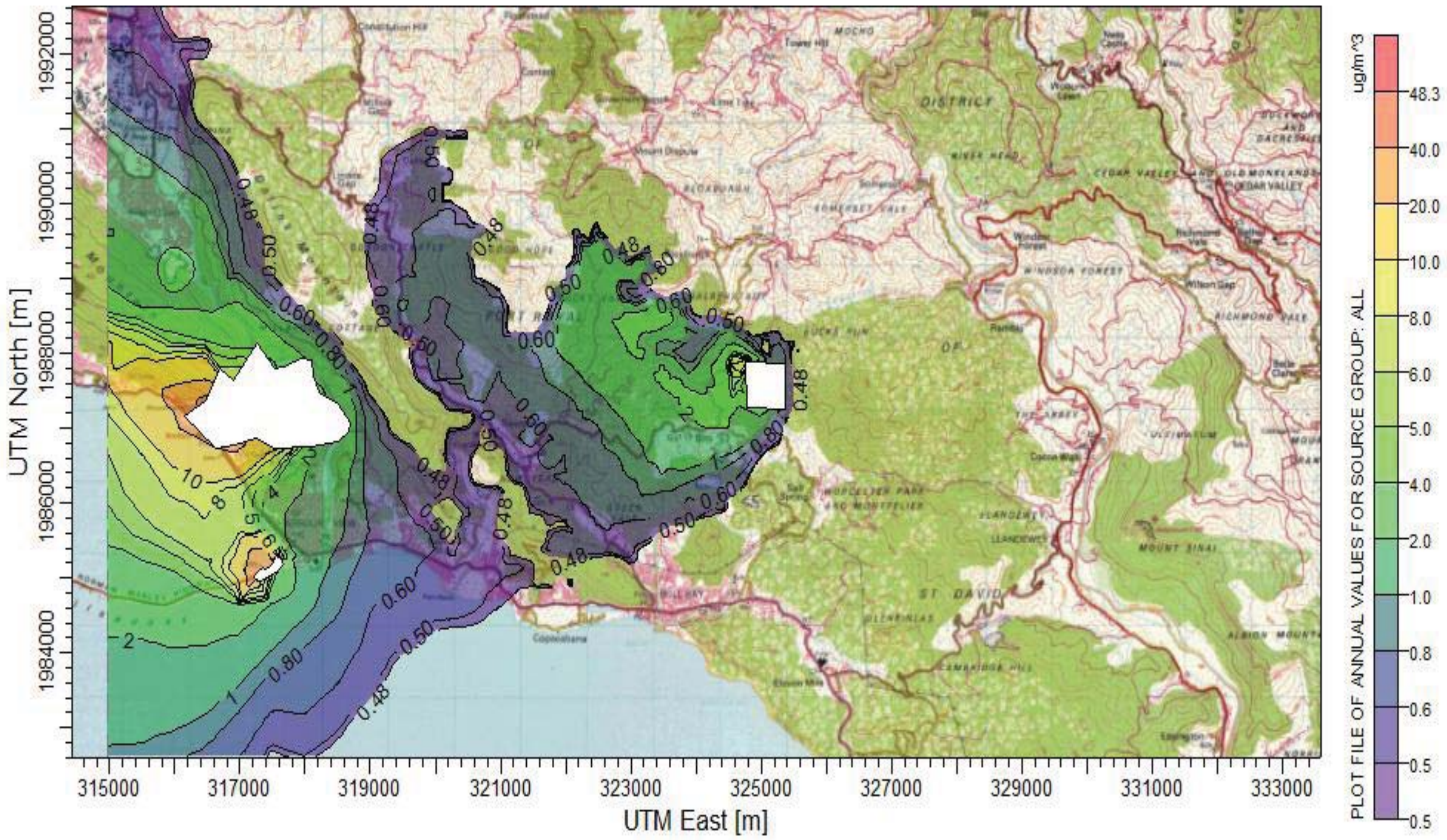


Figure 8.2 *Predicted cumulative annual TSP concentrations*

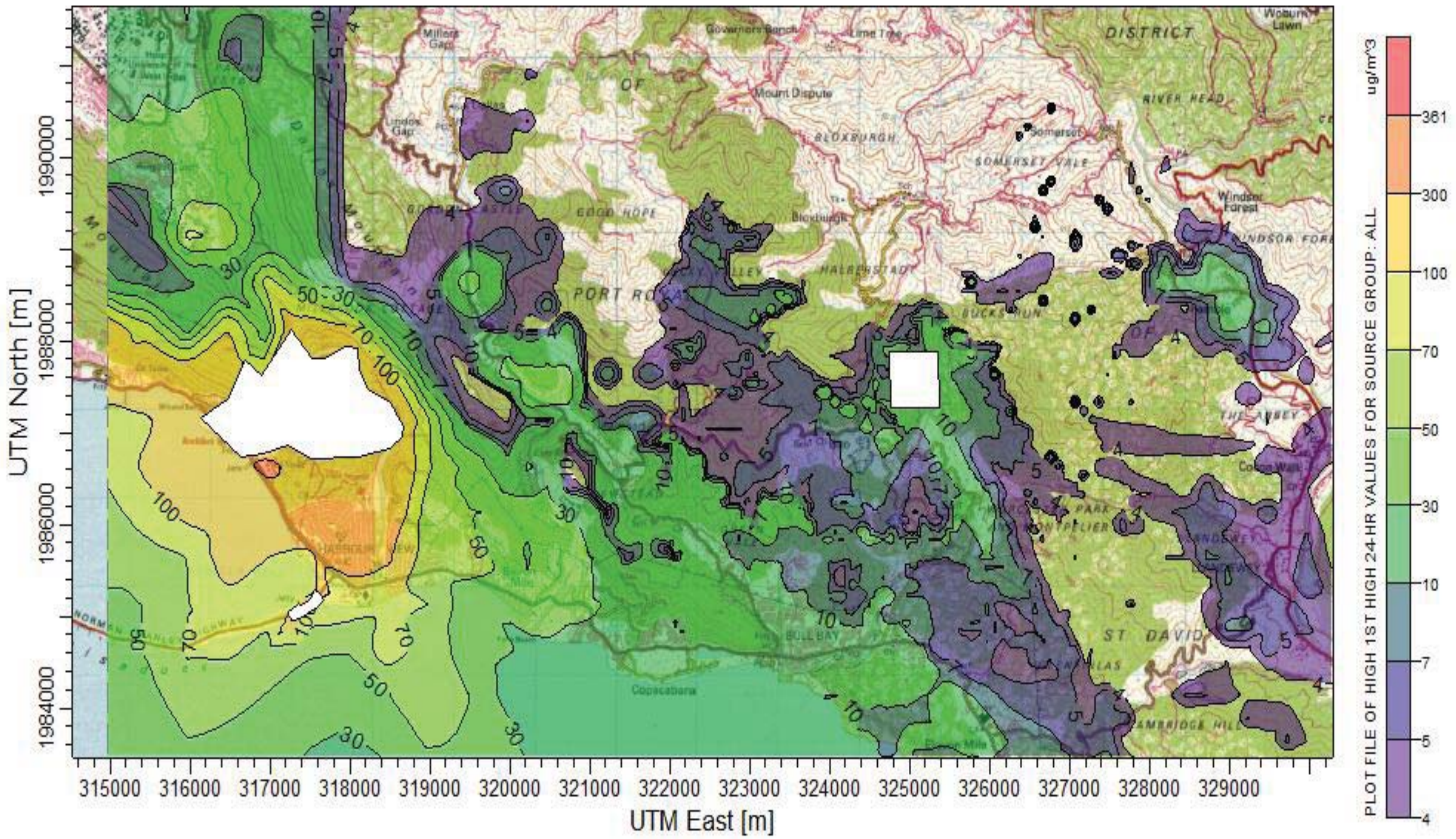


Figure 8.3 *Predicted cumulative 24-h PM_{10} concentrations*

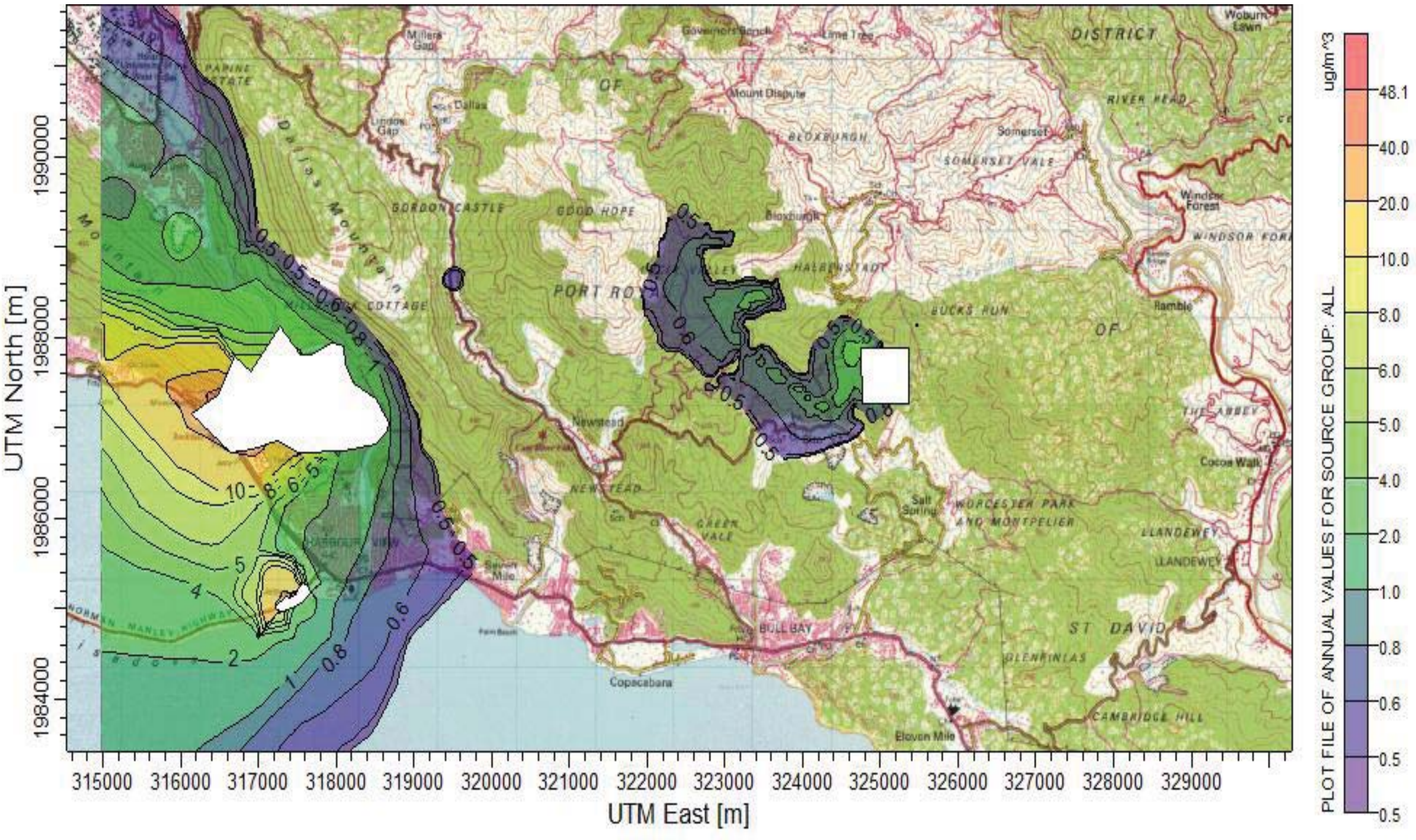


Figure 8.4 *Predicted cumulative annual PM_{10} concentrations*

8.2 Noise/Vibration Nuisance

The cumulative noise impact takes into account all the existing background noise sources. Existing mining industries (Bito gypsum quarry) are associated with various noise-generating activities, some of which are daily:

- removal of topsoil and overburden;
- excavation with machinery;
- drilling and blasting of rock;
- crushing and screening of aggregates;
- the transport of quarried material.

More importantly, blasting can contribute to vibrations, audible noise, flyrock and dust. However, the levels of vibration induced by the blasting are not significant enough to cause any damage to nearby structures. What is likely to happen is the vibration will be transmitted through the ground and pressure waves through the air may lead to buildings and/or individual experiencing these vibrations accompanied by audible noise.

Noise may cause nuisance, sleep disturbance and can also affect wildlife. There exist no noise-sensitive receptors such as schools, hospitals, nursing homes, churches, etc. in the immediate area to be affected by the operations of the proposed Halberstadt quarry site.

8.3 Rock Blasting

In addition to Bito gypsum quarry operations, blasting is expected to be concentrated mainly within the deposition boundary of the Halberstadt site. The main concerns are that of fragments of rocks which will be propelled into the air by explosions. These rocks create hazards if and when they are propelled into nearby settlements causing harm or even death. Fumes, both toxic and non-toxic, are released into the atmosphere as a result of using explosives for blasting. Settlements may be affected by dust and fumes within 100 metres. Deposited dust may give rise to complaints from locals as cars, windows or any surface expected to remain free from dust may have noticeable deposition. Another concern is vibrations caused by blasting that will affect structures within close proximity to the blasting location.

8.4 Aesthetics and Landscaping

The implementation of aggregate workings within a quarry can remove parts of an existing landscape, such as a hill, or can introduce intrusive features, such as quarry faces or overburden mounds.

At present the Gypsum quarries can be seen from the 11 miles Bull Bay area. The Halberstadt deposit however is situated behind the hill, away from the road so there will be no visual intrusion from the Bull Bay area. Persons living within the community nearby the quarries however, will be visually affected.

A development plan should be implemented that will indicate areas of high landscape quality and natural heritage Areas, where quarrying will not normally be permitted.

9.0 RECOMMENDED MITIGATION

9.1 Physical

9.1.1 Drainage

The following subsections outline the recommended mitigation and design considerations. Please also refer to the “Drainage Assessment Report for Halberstadt Mine, St. Thomas” (CEAC Solutions Co. Ltd., July 2013) for additional details.

9.1.1.1 Soil Loss

Several sub-catchments are expected to have relatively high debris flow volumes from soil loss. It is in the developers' best interest to consider relevant mitigation measures so as to minimize the possibilities of blockages in openings and thus flooding and damage to properties and the propose road. Suitable mitigation measures should be considered and put in place including:

i. Implementation of check dams which are small dams, temporary or permanent, constructed across a channel or drainage ditch (See Plate 9.1). They are constructed not only to capture the runoff sediment directly, but also to decrease the volume and discharge runoff sediment (sediment control). Although check dams made of concrete are the most popular, they can be built with logs, stone, or sandbags. They also lower the rate of debris flow during storm events.

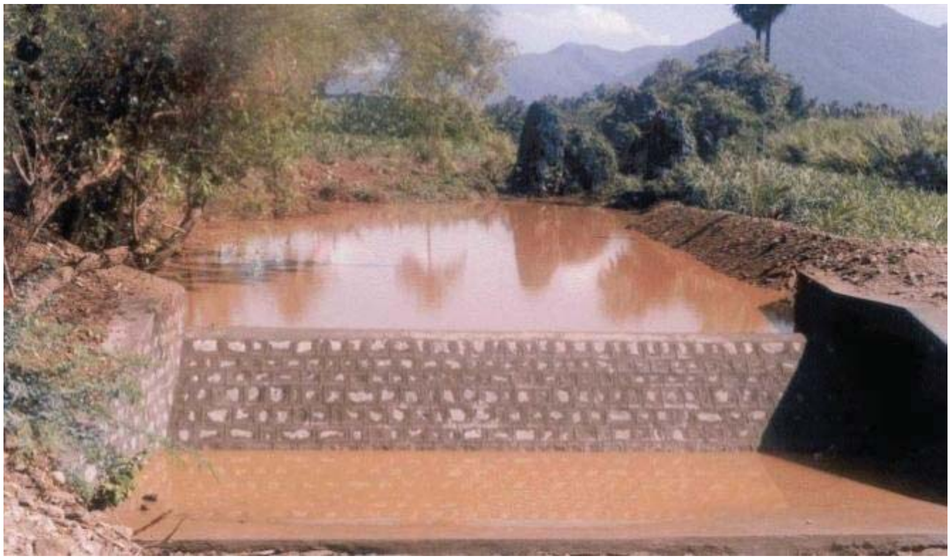


Plate 9.1 An example of a check dam being used

ii. The introduction of reinforcement elements such as metal soil nails (see Plate 9.2) or anchors to increase the shear strength of the rock and to reduce the stress release created subsequent to soil cutting. Gravity walls or concrete walls with counterforts may also be introduced.

Plate 9.2 Installation of metal soil nails at edge of slope

iii. Re-profiling the slope with the purpose of improving stability by either reducing the slope angle or cutting benches into the face of the soil (see Plate 10.3). There are three options: Balanced cut and fill, full bench cut or through cut.

Plate 9.3 Bench trail cut on face of steep slope

iv. Erecting gabion walls from the foot of the slope along its faces which act as a type of low gravity retaining structure (see Plate 10.4). These are generally wire frames filled with aggregates as seen below:

Plate 9. Gabion walls erected along face of steep slope

v. Constructing rockfall protection mesh systems, for example catch fences, rockfall drapery or rockfall netting, which are made from high-tensile steel wire (see Plate 10.5).

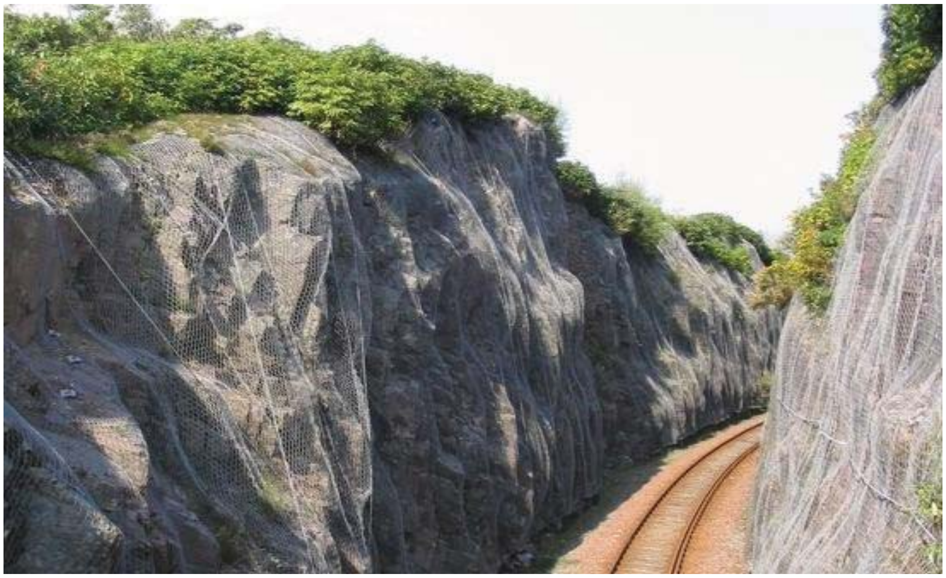


Plate 9.4 Rockfall netting used to protect equipment from falling rocks

vi. The implementation of soil erosion preventative measures, for instance, geomats, geogrids or brushwood mats, as water near the surface of the hillside may cause the erosion of surface material (see Plate 10.6).

Plate 9.5 Geogrids being placed on face of slope

9.1.1.2 Surface /Subsurface Water Pollution

Surface Runoff

Some or all of the following suggested mitigation measures may be appropriate, depending on the nature and scale of the proposed project:

i. Only clean uncontaminated water should be discharged, under the approved licence, to surface waters including clean dewatering from the quarry floor to minimise surface water run-off into the quarry workings ;
ii. The developer/proprietor should construct and commission proposed detention ponds/silt ponds prior to the commencement of extraction operations;
iii. All the run-off from roads and paved areas should pass through adequately sized and located oil/petrol interceptors before discharge to surface water drainage. *Refuelling should only take place on such paved areas with oil/petrol interceptors;*
iv. All above ground chemical (petroleum/oil) storage tanks should be adequately bunded to protect against oil spillage. Bunding should be impermeable and capable of retaining a volume equal to 110% of the capacity of the largest tank. Drainage from bunded areas should be collected and disposed of in a safe manner and to the satisfaction of the planning authority;
v. The developer should maintain on site an adequate supply of containment booms and suitable absorbent materials to contain and absorb any spillage;
vi. Washing ponds (used to separate the suspended solids during the aggregate washing process) should be carefully designed and operated to ensure that where practicable water is recycled and not discharged to watercourses.
vii. No surface water should be allowed to flow from the site onto the public road during the construction or operational phases of the development.
viii. The haul road is to be properly graded and drained to prevent run-off from cutting into banks of the road, avoiding erosion.

Groundwater Pollution

Some or all of the following suggested mitigation measures may be appropriate, depending on the nature and scale of the proposed project:

i. If excavating below the water table, a hydro-geological study should be conducted to determine the likely effect on groundwater flows in the area, particularly in relation to wells. Replacement wells or water supplies may have to be provided in the event of de-watering. Stream augmentation should be considered where there exists the possibility for reduction of base flow in streams.

ii. Sufficient sewage and storm water treatment should be provided on site; strict control of run-off from pits, quarries, spoil heaps, embankments and all other parts of sites, including access roads and wheel-wash facilities is required;

iii. Groundwater can be adversely affected by residues from explosives used in rock quarries. It is important that blast operatives ensure that all material is ignited; *Use of explosive slurries in karst terrain should be avoided.*

9.1.1.3 Proposed Drainage Design

Drains along Roads

Earth Swales

The surface runoff traversing the site from the north-west to south-east will be channelled through proposed earth swales with implemented check dams where possible. In addition, the drains located on the eastern boundary of the site will be bounded with compacted berms designed to be 0.3m above the estimated water level.

The drains were sized to convey the 50 year flows from the associated site catchment. Based on the location of the proposed drain and the associated contributing sub-catchment, the configuration of the drains varied. The drains were designed with a 5% slope as proposed by the client as the target grading of the site roads. However, if this target is not achieved the drains will be capable of conducting greater flows than designed due to the steep terrain of the site. It was determined that two (2) main configurations are capable of handling the peak flows.

The resulting drain sizes are outlined in Table 9.1 and shown in Figure 9.1 and Figure 9.2.

Table 9.1 Summary of main drains to be improved for conducting the 50 year flows through the development

Parameter	Values	Values	Units
Manning's Coefficient	0.035	0.035	
Side slope	1.5	1.5	
Width of channel (at top)	3.00	3.70	m
Flow Depth	0.60	0.80	m
Depth + freeboard	0.75	1.00	m
Width of channel (at base)	0.75	0.70	m
R	0.4	0.6	m
P	3.45	3.58	m
A	1.41	2.20	m^2
Flow	**4.94**	**10.15**	**m^3/sec**

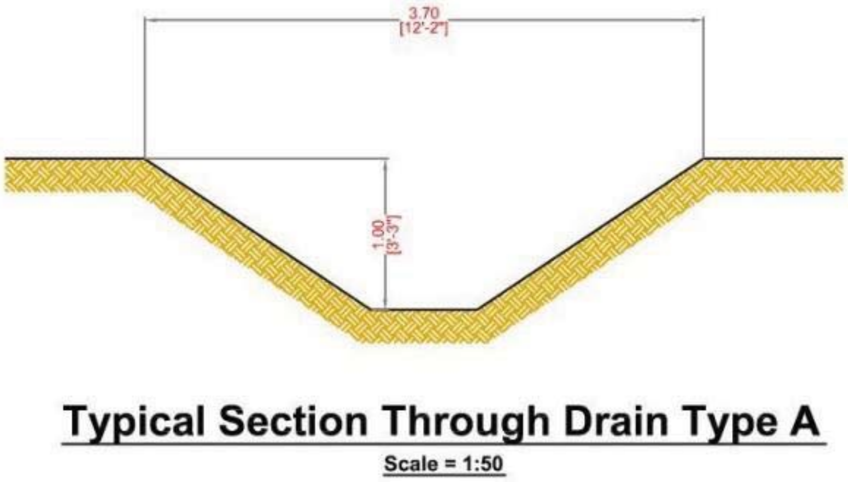


Figure 9.1 Typical cross-section through Type A drain

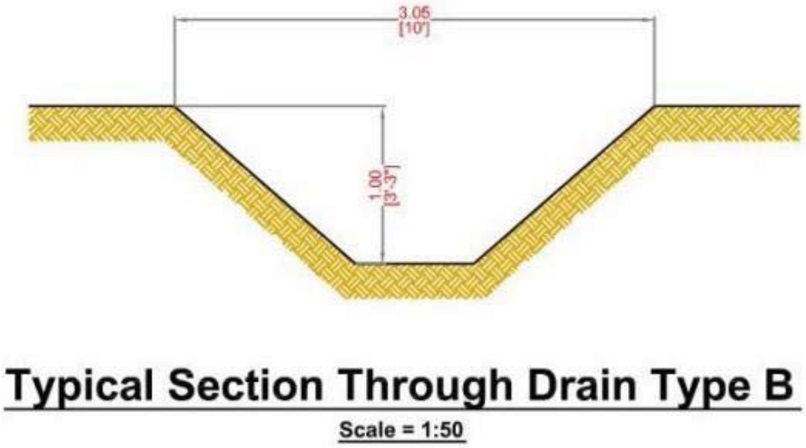


Figure 9.2 Typical cross-section through Type B drain

Culvert Crossings

With the proposed boundary storm drains along the site roads, several culvert crossings were identified which would be required in order to efficiently convey stormwater flows across the roads. The capacities of the culverts were analysed using the peak flows generated from a 50 year rainfall event. The box culverts are proposed to be constructed of concrete varying in two (2) main sizes: 2.2m wide by 1.5m high and 1.5m wide by 1.5m high (see Figure 9.3 and Figure 9.4).

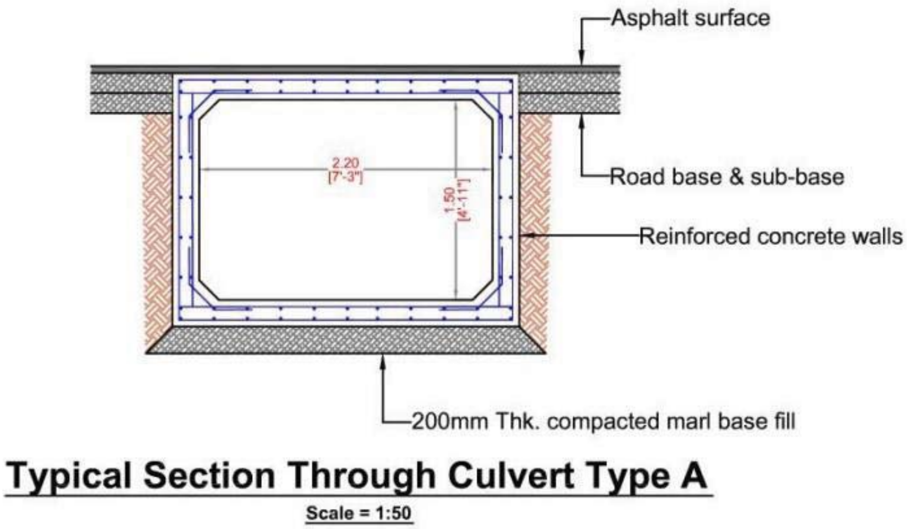


Figure 9.3 Typical cross-section through Type A culvert

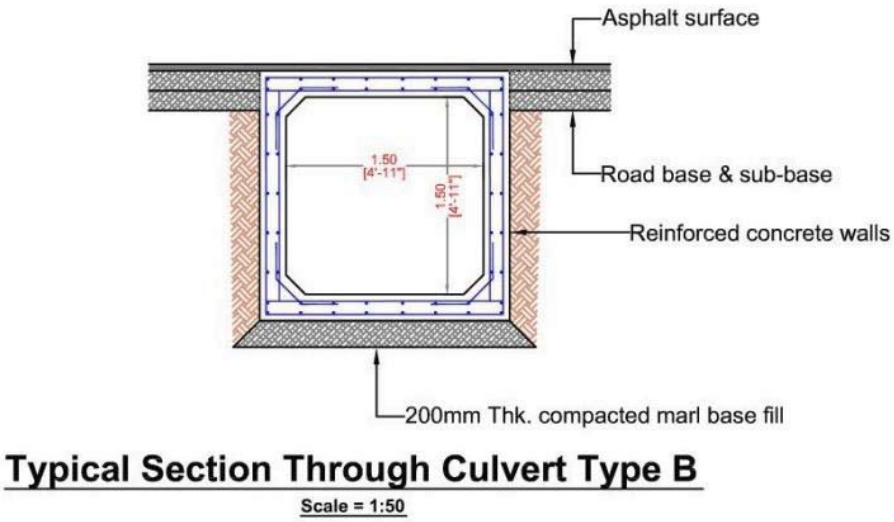


Figure 9.4 Typical cross-section through Type B culvert

Detention Pond

The flows generated from the site catchment will, where possible, pass through a detention basin prior to final discharge through the proposed culvert. There is a natural depression within the topography of the site where the space required to construct detention ponds is available. It was envisaged that the proposed pond should be capable of reducing up to the 25yr peak future flows without any significant construction.

It is further proposed that the boundaries to the east of the quarry boundary be bermed to prevent the untreated surface runoff from simply flowing down the mountain slopes and into the Bull Park River. The stormwater generated from the west of the quarry boundary will be directed to proposed drains along the roads where it will negotiate a series of check dams and routed through the detention basin.

On passing through the basin, the storm water will first traverse the proposed sediment traps which will aim to reduce the sediments being transported within the runoff. This ‘filtered’ stormwater will then flow over the weir, spread out in the detention basin and reduce the peak flow out of the basin as some of the volume flowing in will be stored and a negligible amount lost to evaporation.

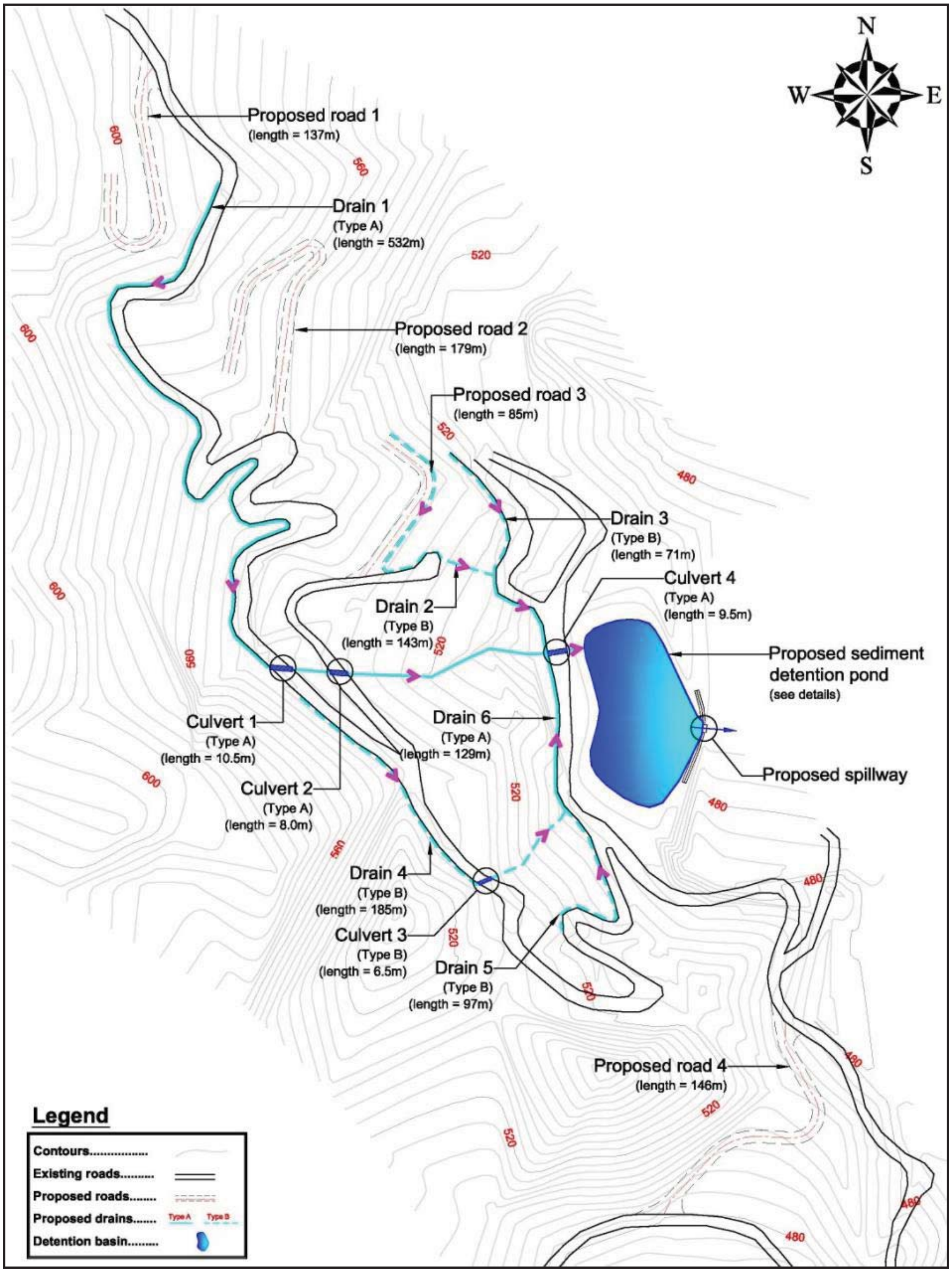


Figure 9.5 Proposed layout of drainage including earth swales, culvert crossings and detention pond

Peak Flows

The estimated peak flow from the catchment was reduced by approximately 42.4% for the 25 year storm after being routed through the detention basin. The estimated peak flows to the detention pond for various scenarios are shown in Table 6.8 and Table 6.9. The resulting inflow and outflow hydrographs are shown in Figure 9.6 below. In summary, the following was noted:

- For the catchment of the Halberstadt site, the 25yr post development *maximum* peak flow of 8.64 cubic meters per second is estimated by to be reduced to 6.07 cubic meters per second (see Figure 9.6);
- Approximately 42 percent of the runoff will be contained by the detention pond. The peak flows will be further attenuated, however, when passing through the network of drains and check dams, minimizing any downstream impacts that may arise from the reopening of the quarry.

Table 9.2 below summarizes the pond size and the relative impact on the peak runoff for the catchment.

Table 9.2 Resulting 50yr peak inflow from the catchment and outflow from proposed detention pond

Detention Pond (Routed)		
Parameter	**Value**	**Unit**
Required:		
Top surface area	0.5	Ha
Base surface area	0.45	Ha
	4	m
Output:		
Length of outlet Weir	3	m
Max water depth above Weir	1.34	m
Peak unrouted flow	8.64	m^3/s
Peak routed flow	6.07	m^3/s

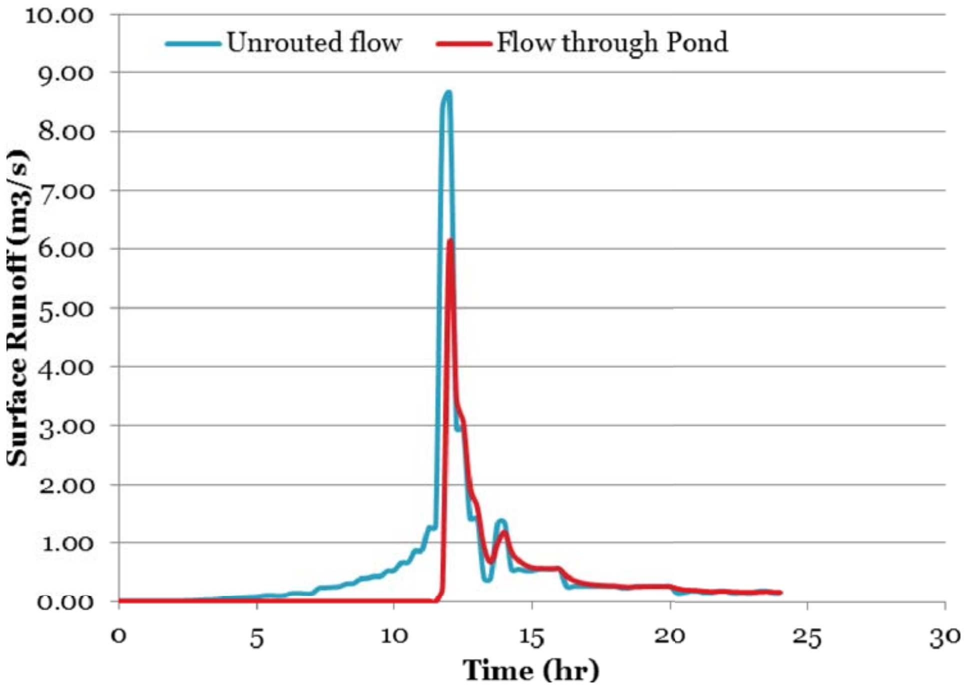


Figure 9.6 Hydrograph showing the resulting peak flows with the effect of the detention ponds

9.1.2 Transportation and Roads (Onsite/Offsite)

9.1.2.1 Congestion

The following precautions must be taken to ensure minimal disruption and potential danger to traffic:

i. Construction traffic entering of leaving the site will be scheduled for off peak hours to minimize additional congestion at the intersection and or disruptions in the regular traffic flow.
ii. Erection of signs ahead of the works warning motorists of the heavy/construction units entering the Bull Bay Main Road right of way.

9.1.2.2 Safety

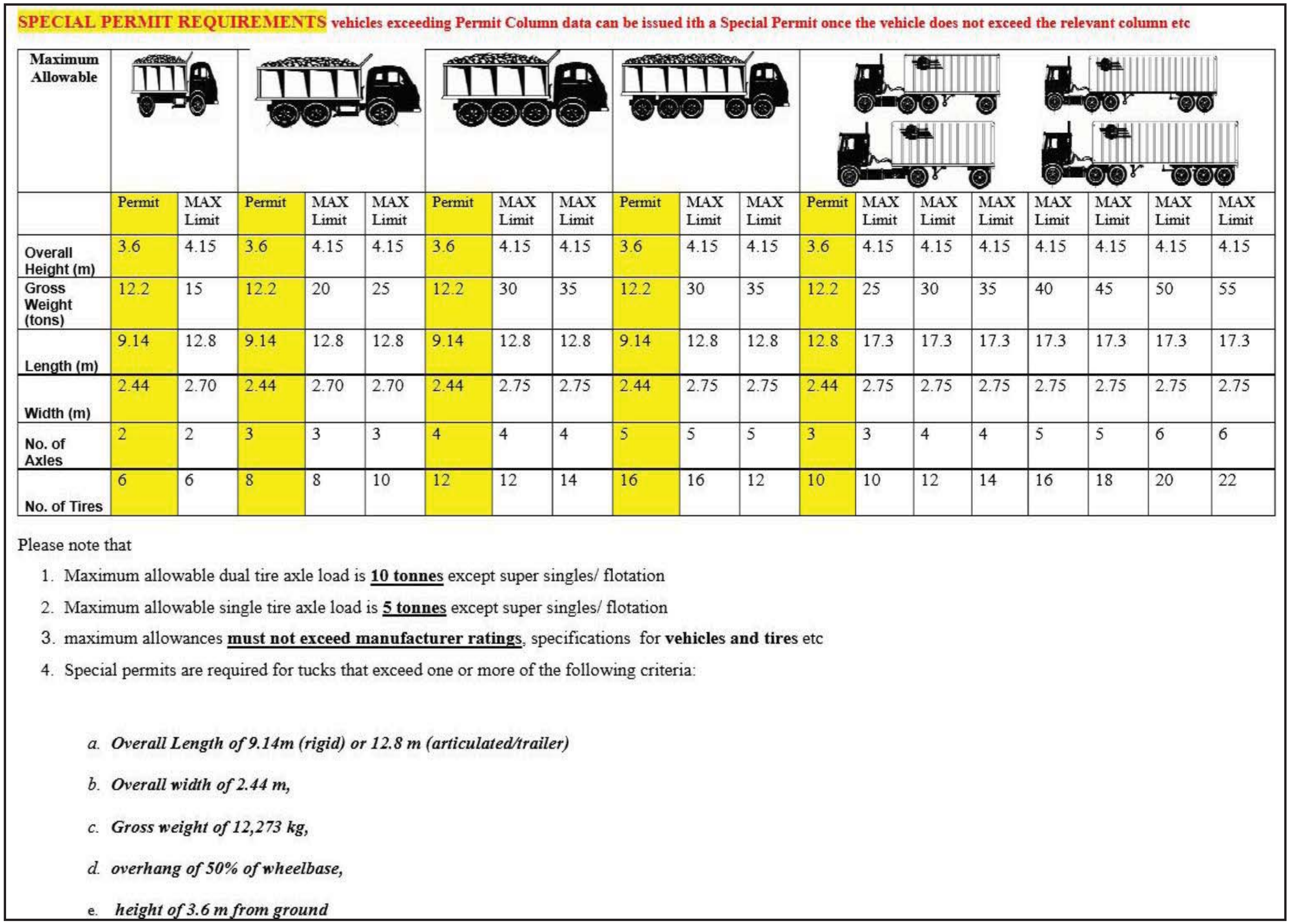
Safety of motorist is of great concern and the following steps should be taken to mitigate or reduce accidents on the roads leading to the site:

i. Appropriate traffic warning signs, informing road users of a construction site entrance ahead and instructing them to reduce speed, should be placed along the main road in the vicinity of the intersection of the Bull Bay main Road and the PC road for the duration of the construction and operational period.

ii. Flagmen should be utilized to minimize the likelihood of accidents when heavy units are entering the roadway.

The weight of the heavy vehicles traversing the roads to access and leave the site would be a contributor to the destruction of the roads, especially during the operational phase. It is therefore recommended that a scale be placed onsite to ensure the trucks leaving the site are within the appropriate weight limits as prescribed by the NWA. The National Works Agency of Jamaica (NWA) has a standard for loads per axel that all trucks exert on roads (See Figure 9.7 below).

It is further recommended that a maintenance plan be put in place to address the issue of the PC road degradation over the operational life of the quarry. This is needed because it is anticipated that even though the trucks may be within the weight limits, the PC roads in the unpaved areas especially will deteriorate with continued used by trucks from the quarry.



SPECIAL PERMIT REQUIREMENTS vehicles exceeding Permit Column data can be issued ith a Special Permit once the vehicle does not exceed the relevant column etc

Maximum Allowable																			
	Permit	MAX Limit	Permit	MAX Limit	MAX Limit	Permit	MAX Limit	MAX Limit	Permit	MAX Limit	MAX Limit	Permit	MAX Limit	MAX Limit	MAX Limit	MAX Limit	MAX Limit	MAX Limit	MAX Limit
Overall Height (m)	3.6	4.15	3.6	4.15	4.15	3.6	4.15	4.15	3.6	4.15	4.15	3.6	4.15	4.15	4.15	4.15	4.15	4.15	4.15
Gross Weight (tons)	12.2	15	12.2	20	25	12.2	30	35	12.2	30	35	12.2	25	30	35	40	45	50	55
Length (m)	9.14	12.8	9.14	12.8	12.8	9.14	12.8	12.8	9.14	12.8	12.8	12.8	17.3	17.3	17.3	17.3	17.3	17.3	17.3
Width (m)	2.44	2.70	2.44	2.70	2.70	2.44	2.75	2.75	2.44	2.75	2.75	2.44	2.75	2.75	2.75	2.75	2.75	2.75	2.75
No. of Axles	2	2	3	3	3	4	4	4	5	5	5	3	3	4	4	5	5	6	6
No. of Tires	6	6	8	8	10	12	12	14	16	16	12	10	10	12	14	16	18	20	22

Please note that

1. Maximum allowable dual tire axle load is **10 tonnes** except super singles/ flotation
2. Maximum allowable single tire axle load is **5 tonnes** except super singles/ flotation
3. maximum allowances **must not exceed manufacturer ratings**, specifications for **vehicles and tires** etc
4. Special permits are required for tucks that exceed one or more of the following criteria:

   a. ***Overall Length of 9.14m (rigid) or 12.8 m (articulated/trailer)***

   b. ***Overall width of 2.44 m,***

   c. ***Gross weight of 12,273 kg,***

   d. ***overhang of 50% of wheelbase,***

   e. ***height of 3.6 m from ground***

Figure 9.7 National Works Agency of Jamaica weight limit requirements for heavy vehicles

9.1.2.3 Road Construction and Maintenance Recommendations

General

Do not disturb roadway sections which do not need maintenance while repairing, blading, or grading those sections which do. When routine maintenance is being performed, limit the amount of disturbed areas to that which can be re-established to the desired final shape by the end of the work day. To minimize opportunity for degradation of the roadway, it is best not to blade, grade, or drag if rain or freezing temperatures are favourable within the 48 hour forecast. As much as possible, avoid non-essential or non-emergency work near streams or stream crossings during the “wet” months of the year. Save this work for drier seasons.

It is best to limit roadway blading to times when there is enough moisture content to allow for immediate re-compaction. Often, an optimum time for this is soon after a rain while the surface materials are still moist but not too wet. Blading with little moisture content in the soil is futile, and is often a causative factor in road surface degradation such as “washboarding” and other problems associated with loss of fines.

Blading and Dragging

Blading and dragging is a smoothing operation which pulls loose material from the side of the road or spreads wind-rowed aggregate to fill surface irregularities and restore the road crown. It is performed with the moldboard tilted forward with light down pressure on the motor grader blade. The angle of the moldboard is adjusted to between 30 and 45 degrees, and in most cases, the front wheels are tilted slightly 10 to 15 degrees toward the direction the aggregate should roll.

The following should be adhered to when blading:

i. Avoid blading during extended dry periods to minimize the loss of fine aggregates and minimize “washboarding”.
ii. Blading/dragging speed depends on the operator’s skill, type and condition of machine (grader), tire pressure, and road surface condition. Normally, three miles per hour in second gear is advised.
iii. Periodically blade the road surface against traffic flow to prevent aggregate from drifting onto ends of bridges, culverts, intersections, and railroad crossings. This is commonly referred to as “back dragging”.

iv. On hill crests, avoid cutting into the road surface, gradually adjusting the blade up as the front wheels pass over the crest and then down as the rear wheels
v. In valleys or swags, gradually adjust the blade down as the front wheels pass the lowest point and then adjust the blade up as the rear wheels follow. This will prevent loose, easily erodible materials from piling up where runoff and concentrated flows frequently occur, thus preventing loss of valuable road fill, and preventing massive sedimentation to local streams and waterways

Reconstructive Grading

Reconstructive grading consists of cutting through, redistributing, and re-compacting the road surface crust, and/or adding new road fill material to obtain the desired roadway shape and profile. This method is used when reshaping the roadway or when the correction of major surface defects such as deep ruts, soft spots, severe erosion, etc. is necessary. Breaking the crust with a scarifying rake may be required before moldboard work can be performed.

The following should be adhered to when grading:

i. Perform grading cutting operations with the outer edge of the moldboard at the road surface's edge.
ii. If the road ditch is not to be re-worked along with road grading operations, keep a minimum of one foot from the ditch line so that vegetation or rock stabilization is not disturbed. In this case, grading work must always bring the road surface back up to and slightly above the ditch line elevation to allow road surface runoff to flow into the ditch and not create a false ditch down the roadway.
iii. Lightly scarify the existing road surface before adding new material. This blends the soils and improves cohesion.
iv. Adding new material should be done by running the dump truck down the centre of the roadway and dumping as it travels. The new material should then be blended with the scarified old material using a grader, and compacted.
v. To reduce potential roadway degradation, the entire width of the of the roadway disturbed by grading should be compacted by the end of the day.
vi. Positive drainage to road ditches or other outlets must be established throughout the entire finished road surface.

Dust

Dust in the air is a loss of fine, binder aggregates from road surfaces. Loss of these fines leads to other types of road distresses such as loss of cohesion and compaction of the road fill material, and reduced capacity to maintain moisture in the road fill. These deficiencies also tend to feed on themselves, compounding the problems - especially the lack of moisture within the road fill. Mechanically adding water to the road surface for dust control a short-term solution. In some cases, dust can be reduced by applying chemical additives which draw moisture from the air to improve fine aggregate cohesion, however, this also can be an expensive solution and may be feasible only in the most severe cases

Ravelling

Ravelling is the loss of coarser aggregates. This is brought about when the coarser aggregates are worn away by traffic after fine, binder aggregates have been lost due to dust or erosion. Correct by grading or blading with the addition of fines or other binder to improve surface gradation and composition

Slipperiness

Slipperiness is caused when the road surface contains excessive fine aggregates in proportion to coarser aggregates, especially within the crust. Traffic wear can reduce coarse aggregates to finer aggregates, thus disproportioning the original road fill aggregate mix. During wet weather, the road surface becomes slippery and may become impassable. This problem can be corrected by mixing the surface fines with coarser aggregate by grading and/or blading the road surface and compacting back in place. Occasionally, coarser aggregate will need to be hauled in and added to the roadway.

Surface Deformations

Surface deformation problems are almost solely the end result of excessive moisture in the road fill and thus can be reduced with proper road surface and road ditch maintenance.

Rutting

Ruts are longitudinal depressions in the wheel paths caused by high moisture content in the subsurface soil or base, inadequate surface course thickness, and /or heavy traffic loads. Rutting can be corrected by adding suitable material, grading, crowning, and rolling the road surface. Do not simply fill ruts with stone or soil. Filing ruts with stone can lead to new ruts being generated beside the original ones and thus would be an expensive and temporary "fix" which can also interfere with grading. The surface must be re-mixed and properly bladed or graded in more severe cases. Areas of sustained and repeated rutting may require more severe measures. An elaborate drain system and/or geotextile fabric foundation with a crushed stone road fill may be used to correct severe rutting problems.

Corrugating/"Washboarding"

Corrugating/"washboarding" is a series of ridges and depressions across the road surface caused by the lack of surface cohesion. This lack of cohesion is a result of the loss of fines in the road surface which, in turn, is usually a result of very dry conditions within the road surface. These conditions are aggravated and enhanced by excessive vehicle speeds and high traffic volumes.

Where surface fines are segregated from coarser aggregates, blading with sufficient moisture content can repair the road surface. When the causative problem is of loss of fines, blading alone is not recommended. The problem will only recur shortly thereafter. The problem is best corrected by scarifying the road surface while damp, thereby re-mixing the road surface with a good percentage of fines, regrading, re-establishing the crown, and compacting the surface.

Depressions

Depressions are localized low areas one or more inches below the surrounding road surfaces caused by settlement, excessive moisture content, and improper drainage. These are larger areas not to be confused with potholes.

Depressions should be corrected by filling them with a well-graded aggregate, then grading the effected road surface, and compacting. Under drains or cross drains may be necessary to improve drainage and prevent recurrence.

Potholes

Potholes are small depressions or voids in the road surface one or more inches deep which are caused by excessive moisture content, poor drainage, poorly graded aggregate, or a combination of these factors. Potholes may be corrected by patching with well-graded materials and compacting, and/or spot grading. Large areas of potholed road surface indicate a poor road fill condition over an extended section of roadway, and thus may require the re-grading, re-crowning, and re-compacting of the affected roadway section to mix aggregates into a well-graded road fill and improve road surface drainage. Under drains may also be necessary in these areas to drain the sub-grade.

Softspots

Softspots are areas of the road surface and/or sub-grade made weak by poor drainage. These areas depress under vehicular weight and almost always develop one or more of the other types of surface deformations. These areas can be corrected by improving drainage conditions or replacing the soft spot with more drainable materials. Depending on the cost effectiveness and feasibility of each, the following methods may be used to correct soft spots:

i. Improving the drainage of the road fill and/or sub-grade with under drain. This method is outlet dependent.
ii. Improving the drainage of the road fill and/or sub-grade by grading road ditches low enough to remove water from beneath the problem area. This may involve piping to move water from one side of the road to the other. This method is outlet dependent.
iii. Patching the soft spot area with a suitable material such as well-graded stone or gravel.
iv. A combination of the above.

Storing and Stockpiling Soil Materials

Improper storing or stockpiling of soil material can increase the amount of sediment that enters streams and damage sensitive areas, particularly wetlands. Soil materials should not be placed in or along wetlands, drainage ditches, swales, streambanks, areas within 50 feet of (and drain into) a waterway, and against slopes that are more than 2 horizontal to 1 vertical. Always ensure the area down slope of the storage area has an adequate vegetated filter strip to trap sediments, or use a properly installed and maintained silt fence or other barrier. Seed or vegetate any fill or spoil disposal areas as soon as possible.

Plan erosion-safe storage and stockpiling areas ahead of time, especially in the winter and early spring when rainfall can be high and vegetative cover minimal. Level to gently sloping, grassed areas usually provide good storage sites. Hilltops, ridges, and inactive or active borrow pits also often provide good sites. These planned storage areas will help reduce sedimentation and will also provide the opportunity to utilize these materials later when needed for roadway repairs. This can reduce overall maintenance costs by saving fill material and making it conveniently and readily available

9.1.3 Air Dispersion and Quality

It should be noted that the calculation of the dust emissions from the unpaved haul roads assumed that the roads would be sprayed with water, and therefore the spraying of the unpaved haul roads with water is a recommended mitigation measure.

In addition:

i. Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased. In order to conserve on water, since the proposed operation does not use water, it is recommended that any excess water in detention ponds be used to wet the site.
ii. Minimize cleared areas to those that are needed to be used.
iii. Cover equipment when not in use and/or wet construction materials to prevent a dust nuisance.
iv. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.

9.1.4 Noise Pollution

i. Use equipment that has low noise emissions as stated by the manufacturers.
ii. Use equipment that is properly fitted with noise reduction devices such as mufflers.
iii. Operate noise-generating equipment during regular working hours (e.g. 7 am – 7 pm) to reduce the potential of creating a noise nuisance during the night.
iv. Construction workers operating equipment that generates noise should be equipped with noise protection. A guide is workers operating equipment generating noise of ≥ 80 dBA (decibels) continuously for 8 hours or more should use ear muffs. Workers experiencing prolonged noise levels 70 - 80 dBA should wear earplugs.

9.1.5 Vibration

All blasts must be so designed to minimize ground vibration. Prior warning and explanation should been given to residents in the area before blasting occurs.

9.1.6 Solid Waste Generation

i. Skips and bins should be strategically placed within the campsite area.
ii. The skips and bins at the campsite should be adequately designed and covered to prevent access by vermin and minimise odour.
iii. The skips and bins at both the campsite and construction site should be emptied regularly to prevent overfilling.
iv. Disposal of the contents of the skips and bins should be done at an approved disposal site.

9.1.7 Wastewater Generation and Disposal

i. Provide portable sanitary conveniences during construction for the workers for control of sewage waste. A ratio of approximately 25 workers per chemical toilet should be used.

9.2 Biological

9.2.1 Habitat destruction

i. Establish a site rehabilitation plan for the site.
ii. A buffer zone of minimal to no activity should be established surrounding the proposed area. The vegetation in this area may then become a natural seed-source to the mined-out lands after closure. If considered, seedlings may also be actively transplanted from this area as well.
iii. The staged and sequential clearing of vegetation over the life of the quarry should be contemplated.
iv. Monitoring of indirect impacts on threatened plant species surrounding the site should be considered.
v. All staff on site should be made aware of the mitigation plans to be implemented.

9.2.2 Habitat fragmentation

i. Limit the development of roadways to the existing road network.

ii. Consider the development of a conveyor-belt system for the transport of aggregate which would minimise the need for the construction of additional roads and minimise the impact of vegetation removal. It would also lead to a decrease in traffic through the area.
iii. Conveyor belts, if used, should be covered so as to minimise the spread of particulates over the plant community.

9.2.3 Accidental or intentional removal of important plant species

i. The removal of endemic species, especially in the areas surrounding the site, should be avoided.
ii. If removal is necessary, a nursery or buffer should be established for the maintenance and propagation of the endemic species and other naturally occurring plants. These plants may later be reintroduced into the area based on a rehabilitation plan.

9.2.4 Increased soil/substrate erosion

i. If possible, trees with trunks of DBH 20 cm and greater should be left intact.
ii. Remove trees only as necessary.
iii. A site preparation plan should be developed prior to project initiation.
iv. Leaving or planting strips of vegetation on steep slopes may help to prevent erosion.
v. A phased approach to mining activities is recommended.

9.2.5 Increased effects of airborne particulates or dust

i. It should be investigated if the mechanical crusher to be employed can accommodate a filter-system.
ii. It should also be considered that the crushed material be transported by conveyor to the plant or to key points and not by trucks. These measures should substantially reduce the dust emissions; however it is understood that some vehicular movement around the site will be necessary.
iii. Water (recycled if possible) should also be used for dust suppression where required.
iv. Vegetation and soil should be removed together (mixed) so that the plant matter helps to hold the soil. Alternatively, vegetation

can be stripped and stockpiled and then spread over the newly made stockpiles of soil.

v. Where practical, rehabilitation of the quarry should be progressive: proceeding after the closure of mined out sections.
vi. In terms of aesthetics, natural vegetation surrounding the quarry should be retained (such as in a buffer area) so as to help minimise dust emissions.
vii. Vegetation should only be cleared where it is absolutely necessary for operation.
viii. As the quarry expands, the time between clearing and quarrying should not be protracted.
ix. When trucking material it should be covered for the duration of the trip and when idle.

9.2.6 Storage of overburden and other waste

i. Storage of chemicals, oils, etc., should be avoided on site.
ii. If off-site storage is not feasible then a central area should be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of oils and chemicals into the sediment.
iii. Based on observations, the area currently designated for the storage of overburden seems to be more of a ledge rather than a basin/depression capable of storing material. As such, the planned overburden area needs to be modified so as to accommodate this material.
iv. Remove topsoil with vegetation in it (rather than cutting off the vegetation) so that the vegetation helps to hold and enrich the soil while it is in stockpiles.
v. Stockpile topsoil in conical heaps not exceeding 2m in height (to permit moisture and oxygen to penetrate the heaps), and in localities where it will not easily be eroded by surface water flow.
vi. Allow grass and indigenous shrubs to establish on the stockpiles naturally, but remove any alien invasive species.
vii. Remove and stockpile subsoil separately,
viii. Replace first the subsoil where appropriate, then the topsoil.
ix. As each section of the quarry is worked out, the stockpiled topsoil should be used to cover the terraces in order to allow the natural vegetation to re-establish.

9.2.7 Increased human and invasive species access

i. A buffer area should be established and maintained between the project area and the surrounding forest.
ii. Fencing of exposed points to human and ruminant entry may be considered as this would reduce their intrusion.
iii. The public education as well as education of staff regarding the location of buffer-boundaries and other mitigative strategies would be beneficial.
iv. No vegetation should be cleared for the establishment of lavatories.
v. Designated areas should be established for the collection and removal of solid waste and sewage.

9.2.8 Avifauna

It will be challenging to implement a full scale mitigation plan for the avifauna, since they are highly mobile. However, listed below are measures that can reduce the negative impact of the proposed quarry on the avifauna in the area:

i. All the vegetation in the area should not be removed or cleared at the same time for the Quarry project. Instead, vegetation removal should be undertaken in phases, in order that some of the bird’s habitat will remain, allowing birds more time to find a new habitat. This may be viewed as a form of transition to a new habitat.
ii. Clearing of the vegetation should not be carried out in the peak breeding season. Nesting activity in general usually follows rainy periods. The birds in Jamaica usually begin to nest as early as December; however the peak of the local breading season is from April to June. It is recommended that the major clearing of vegetation be done before the breeding season or after the peak of the local breeding season.

9.3 Aesthetics

Due to the topography of the area, the proposed Halberstadt deposit is situated behind a hill, away from view of the coastal main road. Therefore, the proposed quarry is not expected to have a negative visual impact being viewed from the Bull Bay area. Persons living within the community nearby the quarries however will be visually affected.

9.4 Rehabilitation Plan Considerations - Ground Control Management Plan

It is recommended that the implemented and planned rehabilitation activities (as outlined in section 5.4.7) be included in a Ground Control Management Plan (GCMP), which will be made available (submitted) to the regulators.

A GCMP is a document in which the processes used to manage the mining environment are defined especially in regards to all aspects that affect the stability of the slopes. A ground control management plan is an important tool for the safe, efficient and economical operation of the quarry. It is at the same time a communication tool, as well as an auditing tool for management and regulators to address issues that may come up during the lifetime of the operation in an informed manner. The main objectives of the GCMP are the prevention of

- loss of life or injury to persons working or visiting the mine;
- loss of worker income, loss of worker confidence, loss of corporate credibility, increased legal liability;
- disruption of operations, loss of ore, loss of equipment, increased stripping, cost of clean-up, loss of markets , and
- collapse of nearby infrastructure/facilities into the open pit, for example, mine waste dumps, tailings storage facilities etc., and interference with natural drainage.

The GCMP covers the life of the quarry operation, from the beginning of the operation of the mine, to the final closure and rehabilitation of the quarry. Through the life of the quarry the GCMP will define and report on, including but not limited to:

- excavation geometry
- ground reinforcement and support
- excavation methods
- ongoing data collection procedures and monitoring strategies
- monitoring of ground movements
- mapping of geological structure
- groundwater monitoring
- recording general ground performance
- emergency action procedures
- production
- rehabilitation

The GCMP should be reviewed annually, or at any time changes in the quarry design are to be implemented to address safety or performance issues.

10.0 IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

The following alternatives have been identified and are discussed in further detail below:

- Alternative 1 - The "No-Action" Alternative
- Alternative 2 - The Halberstadt Quarry as Proposed
- Alternative 3 - The Halberstadt Quarry with use of Conveyor Belt
- Alternative 4 - Re-opening of the Other Gypsum Quarries

10.1 Alternative 1 - The "No-Action" Alternative

The following positive impacts are anticipated:

- Destruction of natural habitats will be avoided from the vegetation clearance and excavation processes required during site preparation and operations.

The following negative impacts are anticipated:

- Inability to meet market demand for Portland cement and Blended Cement due to depleted gypsums reserves from the other four quarries in the area.
- Loss of potential employment opportunities.

10.2 Alternative 2 - The Halberstadt Quarry as Proposed

The following positive impacts are anticipated:

- Ability to meet market demand (national and regional) for Portland cement and Blended Cement for the next 33-50 years.
- Potential employment opportunities.

The following negative impacts are possible:

- Destruction of natural habitats from the vegetation clearance and excavation processes required during site preparation and operations.

- Possible contamination of groundwater and noise/dust nuisances on communities.

10.3 Alternative 3 - The Halberstadt Quarry with use of Conveyor Belt

An option exists for the quarry to be developed as proposed, however with the use of a conveyor belt to transport the material to Benoa, from which trucks will then take the material to the CCCL. Table 10.1 outlines the costs associated with this option (Alternative 3), versus the cost of using trucking only to transport the material to CCCL as per the proposed development (Alternative 2).

Table 10.1 Transportation cost for one million tonnes of gypsum to CCCL

Alternative 3 – The Halberstadt Quarry with use of Conveyor Belt **Conveyor construction cost (USD)**	*Alternative 2 - The Halberstadt Quarry as Proposed* **Trucking cost (inclusive of road wetting) (USD)**
$23,827,751.20	**$5,263,157.89**

In addition to the impacts previously listed for the development as proposed (section **Error! Reference source not found.**), the ollowing positive impacts are anticipated:

- Reduced dust emissions from conveyor belt system (versus trucking)

On the other hand, the following negative impacts are anticipated with the construction of a conveyor belt and service roads for the conveyor system:

- Continuous noise pollution from the conveyor belt system.
- Additional vegetation removal for the conveyor route and for service roads

10.4 Alternative 4 - Re-opening of the Other Gypsum Quarries

The re-opening of the other gypsum quarries (Brooks, Upper and Cave quarries) is not a viable option because all mineable ore has been depleted).

Resulting from a comparison of potential negative and positive impacts outlined above, as well as cost considerations, the preferred alternative is the Halberstadt quarry as proposed within this EIS document (Alternative 2).

11.0 RESIDUAL IMPACTS

Sections 7.0 (Identification and Assessment of Potential Direct and Indirect Impacts) and 9.0 (Recommended Mitigation) described the potential impacts that would occur as a result of different phases of the project and how the proposed mitigation measures would contribute to minimising or eliminating the impacts. Not all impacts can be fully mitigated and therefore residual impacts will be experienced by the environmental and social receptors affected by the project.

11.1 Site Preparation and Construction

11.1.1 Noise and Vibration

The proposed project has the potential to be a noise nuisance during both the construction and the operation phases. Even with the proper mitigative steps, short-term impacts of varying duration such as blasting which is a high-noise activity will be a nuisance to nearby residential communities.

11.1.2 Air Quality

Fugitive dust has the potential to affect the health of the resident population and the surrounding vegetation. Both types of impacts will be of moderate intensity but of relatively short duration.

11.1.3 Traffic

Site preparation may introduce traffic delays thereby increasing the travel time. Negative impacts on traffic are expected during the site preparation stage.

11.1.4 Heritage and Cultural

The proposed project area has very dense vegetation cover. When this vegetation is removed from the proposed site, there is a high probability of finding prehistoric and historic cultural material. However, there is the possibility that they may be destroyed by heavy machinery and equipment during the site clearance process.

11.2 Operation

11.2.1 Socio-Economic

11.2.1.1 Unmet Employment Expectations

Because of the high unemployment rate in the area and in the island in general, residents in directly affected communities who are unsuccessful in their job application are likely to become frustrated when they do not gain employment on the proposed project. This could create resentment and possibly hostility towards those who are successful in getting jobs, and even towards Caribbean Cement Co. Ltd/Jamaica Gypsum and Quarries.

11.2.1.2 Accidents involving community members

The possibility exists that accidents involving community members will occur at some stage during site preparation/construction or operation. This could be traffic-related, blasting-related or other accidents. A residual impact is created in terms of diminishing the standard of living for a person, negatively impacting his or her household.

11.3 Closure

Mining is an intrinsically destructive process where there are a number of environmental impacts that remain after a project site has been mined such as erosion, siltation of watercourses and permanent visual effects ("scarring"). Although land can rarely be returned to its former state, efforts should be made to address potential residual impacts during the closure process.

As discussed previously in section 5.4.7, Jamaica Gypsum will implement a progressive rehabilitation plan for the Halberstadt quarry. The full rehabilitation plan for Halberstadt quarry may be seen in Appendix 7.

11.3.1 Aesthetics

There are various mitigation measures that can be employed, across a range of timescales, to mitigate the potential impacts of the proposed Halberstadt site on the landscape and visual amenity. It is determined that the quarry operations will have a short to medium term impact on the landscape and visual amenity. However, the short and medium term mitigation measures are considered below to reduce the impacts on landscape and visual amenity. The long term mitigation measures will include restoring the landscape to enhance character and visual amenity.

11.3.2 Siltation

With exposed hillslopes materials, the effects of sediment transport become more apparent. Following the closure of the quarry, if landscape restorative processes are not implemented, the Bull Park River may experience increased siltation generated by surface runoff. Furthermore, the implementation of sedimentation basins will prove essential but not 100% effective.

Historically, rehabilitation was typically limited to the removal of equipment following the termination of activities. This proved unacceptable from a community and environmental standpoint. Some measures to employ during closure to assist with this are:

- Operations are ended efficiently and cost effectively – all infrastructures and equipment should be removed from site;
- All proposed extractive development proposals must be accompanied by a detailed restoration plan;
- The site is rehabilitated and returned to a safe and stable state – Native species of trees and shrubs should be planted to create food reserves for wildlife; tree, hedgerow and under-storey planting enhances visual amenity;
- The final land use conforms to the concept of sustainable development.

12.0 ENVIRONMENTAL MANAGEMENT OF THE PROJECT

An Environmental Management System (EMS) is an important tool which can be used to assist operations managers in meeting current and future environmental requirements and challenges. It can be used to measure a company's operations against environmental performance indicators, thereby helping the company to reach its environmental targets. A good management system will integrate environmental management into a company's daily operations, long-term planning and other quality assurance systems.

It is therefore recommended that several parameters be monitored before during and after the project implementation to record any negative construction impacts and to propose corrective or mitigation measures. The suggested parameters include but not limited to the following:

1) Water quality to include but not be limited to:
    a. pH
    b. electrical conductivity
    c. turbidity
    d. BOD
    e. COD
    f. Total Suspended solids (TSS)
    g. Grease and Oils
    h. Faecal Coliform
    i. Nitrates and Phosphates
2) Noise
3) Dust
4) Traffic
5) Solid Waste Generation and Disposal
6) Sewage Generation and Disposal
7) Equipment Maintenance

12.1 Phased Recommendations

12.1.1 Site Clearance and Preparation Phase

- Daily inspections to ensure that site clearance and preparation activities are not being conducted outside of regular working hours (e.g. 7 am – 7 pm). In addition, a one off noise survey should be

undertaken to determine workers exposure and construction equipment noise emission.
CARIB CEMENT's project engineer / site supervisor should monitor the work hours. NEPA should conduct spot checks to ensure that the hours are being followed.

- Daily monitoring to ensure that the activity is not creating a dust nuisance. CARIB CEMENT's project engineer / construction site supervisor should monitor the site clearance. Particulate measurements should be taken especially during the excavation activity and compared with the baseline data outlined in this report to ensure that residents or workers are not being exposed to excessive dust. NEPA should conduct spot checks to ensure that this stipulation is followed.
- Background readings should be taken of all water quality parameters prior to site clearance. Readings should be conducted monthly.
- Undertake daily inspections of trucks carrying solid waste generated from site clearance activities to ensure that they are not over laden as this will damage the public thoroughfare and onsite lead to soil compaction.
  Person(s) appointed by Carib Cement may perform this exercise.
- Daily monitoring of vehicle refuelling and repair should be undertaken to ensure that these exercises are carried out on hardstands. This is to reduce the potential of soil contamination from spills. Spot checks should be conducted by NEPA.
  Person(s) appointed by Carib Cement may perform this exercise.
- Traffic should be monitored during preconstruction at each location for one week to assess alternate routes.

12.1.2 Construction Phase

- Daily inspection of site clearance activities to ensure that they are following the proposed plan and to ensure that site drainage system are not impacting on any waterways. Check and balance can be provided by NEPA.
  Person(s) appointed by NWA may perform this exercise.
- Undertake monthly water quality monitoring or a frequency agreed to with NEPA to ensure that the construction works are not negatively impacting on water quality.
  Any organization with the capability to conduct monitoring of the listed parameters should be used to perform this exercise. It is

recommended that a report should be given to NEPA at the end of each monitoring exercise.

- Daily inspections to ensure that construction activities are not being conducted outside of regular working hours (e.g. 7 am – 7 pm). In addition to noise environmental noise monitoring noise survey should be undertaken to determine workers exposure and construction equipment noise emission. Noise monitoring to be conducted monthly at the site and settlements near to site.

  Carib Cement's project engineer / site supervisor should monitor the construction work hours. NEPA should conduct spot checks to ensure that the hours are being followed.
- Daily monitoring to ensure that fugitive dust from cleared areas, access roads and raw materials are not being entrained in the wind and creating a dust nuisance. Particulate measurements should be conducted monthly.

  Carib Cement's project engineer / site supervisor should monitor the construction work hours. NEPA should conduct spot checks to ensure that this stipulation is being followed. In addition, any Citizens Association within the area can be used to provide additional surveillance.
- Conduct daily inspections to ensure that flagmen where necessary are in place and that adequate signs are posted along the roadways where heavy equipment interact with existing roads. This is to ensure that traffic have adequate warnings and direction.
- Undertake daily assessment of the quantity of solid waste generated and keep records of its ultimate disposal. Additionally, solid waste generation and disposal of the campsite should also be monitored.
- Weekly assessment to determine that there are adequate numbers of portable toilets and that they are in proper working order. This will ensure that sewage disposal will be adequately treated.
- Daily monitoring of vehicle refuelling and repair should be undertaken to ensure that these exercises are carried out on hardstands. This is to reduce the potential of soil contamination from spills. Spot checks should be conducted by NEPA.
- Traffic should be monitored to ensure approved traffic management plans at critical areas are being followed. NEPA and Carib Cement should perform spot checks to ensure compliance. Monitoring should be conducted daily to ensure major disruption

to the public transport is avoided. Reports should be made to Carib Cement on a fortnightly basis.

- Where possible, construction crews should be sourced from within the study area. This will ensure that the local community will benefit from the investment.

12.1.3 Operational Phase

- Annual checks on the stream flows and the river channel to ensure that there are no impediments.
  This should be done by a qualified person. Carib Cement/WRA or their appointed person should conduct these inspections.
- During operation noise, dust and water quality monitoring should be conducted quarterly.

12.2 Reporting Requirements

12.2.1 Noise Assessment

12.2.1.1 Ambient

This report shall include the following data:

i. Dates, times and places of test.
ii. Test Method used.
iii. Copies of instrument calibration certificates.
iv. Noise level measurements in decibels measured on the A scale (Leq), Lmin and Lmax and wind speed and direction.
v. Noise levels measured in low, mid and high frequency bands (dBL)
vi. A defined map of each location with distance clearly outlined in metric
vii. Evaluation of data, discussions and statement giving a professional opinion of the noise impact of the quarry.

The report shall be submitted to the Client or his designate within two weeks after completion of testing.

The Client shall distribute the report within four (4) weeks of testing being completed to NEPA.

In the event that emissions do not meet the required criteria, investigations shall be carried out and corrective actions were necessary taken and a re-test shall be scheduled at the earliest possible time and a new report submitted.

Reports will be maintained on file for a minimum of three years.

12.2.2 Air Emissions

It is recommended that a PM_{10} monitor be installed downwind of the proposed facility, possibly at the location of the highest predicted maximum PM_{10} concentration. The purpose of the monitor would be to measure PM_{10} concentration throughout the life of the quarry facility in order to track the effectiveness of the watering control for the unpaved haul roads.

The report will summarize the results of ambient air quality monitoring. This report will provide information relative to SO_2, NO_x, $PM_{2.5}$ and PM_{10} concentrations in the project area.

i. Dates, times and places of test.
ii. Test Methods used.
iii. Copies of instrument calibration certificates.
iv. A defined map of each sampling location with distance clearly outlined in metric
v. Evaluation of data, discussions and statement giving a professional opinion of the impact of the quarry.

The report shall be submitted to Client or his designate within four weeks after completion of testing.

The Developer shall distribute the report within four (4) weeks of testing being completed to NEPA.

In the event that emissions do not meet the required criteria, investigations shall be carried out and corrective actions were necessary taken and a re-test shall be scheduled at the earliest possible time and a new report submitted.

Reports will be maintained on file at the plant for a minimum of three years.

12.2.3 Water Quality

A report shall be prepared by the Contacted party. It shall include the following data:

i. Dates, times and places of test.
ii. Weather condition.

iii. A defined map of each location with distance clearly outlined in metric.
iv. Test Method used.
v. Parameters measured
vi. Results
vii. Conclusions

The report will be submitted to the Client or his designate within two weeks of the monitoring being completed.

The Client shall distribute the report within four (4) weeks of testing being completed to NEPA.

In the event that the water quality does not meet the required criteria, investigations shall be carried out and corrective actions were necessary taken and a re-test shall be scheduled at the earliest possible time and a new report submitted.

If three (3) to six (6) results demonstrate that the site or parts of the site have stabilised, the sampling frequency and sampling locations may be reviewed and reduced or discontinued as per approved monitoring plan.

Reports will be maintained on file at the plant for a minimum of three years.

13.0 REFERENCES

Adams, C. D. 1972. *Flowering plants of Jamaica*. University of the West Indies, Mona, Jamaica.

Asprey, G. F. & R. G. Robbins. 1953. The Vegetation of Jamaica. *Ecological monographs*. 23:4, pp. 359-412.

Auer, A.H., 1978. *Correlation of Land Use and Cover with Meteorological Anomalies*. Journal of Applied Meteorology, **17**:636-643

Cardno HRP. 2013. Gold Coast Quarry: Final EIS Executive Summary. *Boral Resources (Qld) Pty Limited*.

Colin Christian & Associates (CCA). 2008. Proposed Cement Manufacturing Plant and Quarry: Sargberg (Otavi/Tsumeb) Environmental Impact Assessment and Management Plan. Ohorongo Mining (Pty) Ltd.

CL Environmental. 2005. Final Draft Report, Environmental Impact Assessment of the Proposed Yallahs Bridge Reconstruction in Yallahs, St. Thomas.

CPG Australia Pty Ltd. (2012). Quarry Hills PSP Integrated Water Management Strategy. South Melbourne: CPG Australia Pty Ltd.

Darwish, T. M., R. Stehouer, D. Miller, J. Sloan, I. Jomaa, A. Shaban, C. Khter & M., Hamzé. 2008. Assessment of abandoned quarries for revegitation and water harvesting in Lebanon, East Mediterranean. *Proc. of National Meeting of the American Society of Mining and Reclamation*. June 14-19.

Davis, Claude. November 2006. *Natural Resources Conservation Authority (NRCA) Ambient Air Quality Guideline Document*

Delport, D. (2013). The Issue of Borrow Pits Being Used in The Aggregate and Sand Industry. Retrieved 07 07, 2013, from Aggregate & Sand Producers Association of Southern Africa: http://www.aspasa.co.za/Envir/ASPASA%20ISSUE%20OF%20BORROW%20PITS.pdf

Department of Natural Resources and Environment (NRE). (2001). Sedimentation of rivers and streams. Victoria, Australia: Flora and Fauna Statewide Programs, Parks Flora and Fauna Division.

Department of the Environment, Heritage and Local Government. (2004). Quarries and Ancillary Activities, Guidelines for Planning Authorities. Department of the Environment, Heritage and Local Government.

Department of Minerals and Energy (1999) Geotechnical Considerations in Open Pit Mines, Guideline

EKMEKÇI, M. (1993). IMPACT OF QUARRIES ON KARST GROUNDWATER SYSTEMS. Ankara, Turkey: International Research and Application Center for Karst Water Resources, Hacettepe University,.

EnviroPlanners Ltd. (2008). Environmental Impact Assessment (EIA) of the Proposed Limestone Mining Project at Rose Hall in Clarendon. Kingston, Jamaica: EnviroPlanners Ltd.

Environmental Solutions Limited 2005 Environmental Impact Assessment, Caribbean Cement Company Expansion and Modernisation Programme.

Geological Survey Department. *Jamaica Metric Grid Map for Kingston*

Google Earth Maps. 2013.

Grossman, D. H., S. Iremonger & D. M. Muchoney. 1991. *Jamaica: a rapid ecological assessment*. Arlington, Virginia: The Nature Conservancy.

Hodgetts, R. (2012). LANDSCAPE AND VISUAL IMPACT ASSESSMENT, Stonepits Quarry, Benefield. Greatworth, Banbury: Vista Landscape Studio Ltd.

Jamaica Gypsum & Quarries Limited. March 2013. *Proposed Mining Approach for Halberstadt Deposit*

Lakes Environmental Software. 1996-2012. *User's Guide for ISC-AERMOD View*.

Lakes Environmental Software. 2002-2012. *WebGIS*.

Lameed, G. A. & A. E. Ayodele. 2010. Effect of quarrying activity on biodiversity: Case study of Ogbere site, Ogun State Nigeria. African Journal of Environmental Science and Technology Vol. 4(11), pp. 740-750

Langer, W. H. 2001. Potential environmental impacts of quarrying stone in karst: a literature review. USGS Open-File Report OF–01–0484.

Mid-America Regional Council. (2013). Keep Sediment Out of Our Waters. Retrieved 07 08, 2013, from Mid-America Regional Council: http://www.marc.org/environment/water/sediment.htm

Mines and Geology Division, Kingston (July 2003) Jamaica Impact of Gypsum Mining Operations on Flooding in Bull, St. Andrew: September 27-30, 2002 Flood Rains

National Pollutant Inventory. December 2001. "Emission Estimation Technique Manual for Mining Version 2.3". Environment Australia, pp. 41.

National Pollutant Inventory. 1998. References for AP-42 equations for Wind Erosion (1998, Fourth Edition).

O'Hara, M. and Bryce, R. (1983) A Geotechnical Classification of Jamaican Rocks. Bulletin No. 10, Kingston, Jamaica

Ohio State University. December 2004. *Gypsum for Agricultural Use in Ohio-Sources and Quality of Available Products*, Ohio State University Extension Fact Sheet, ANR-20-05

Parker, T. 2003. *Manual of dendrology: Jamaica*. GOJ: Forestry Department, Ministry of Agriculture.

Primack, R. B. 2006. Essentials of conservation biology. 4th Ed. Sunderland, MA: Sinauer Ass.

Proposed Residential Development for Morant farms Estates St. Thomas. 2002. http://www.nepa.gov.jm/eias/morantfarms/morantfarms_eia.pdf Accessed 2/8/2013

Smith, T. M. & R. L. Smith. 2006. Elements of ecology. 6th Ed. San Francisco, CA: Pearson Education Inc.

Swaziland National Trust Commission. (2013). Environmental Impact Assessment and Comprehensive Mitigation Plan. Retrieved 07 07, 2013, from Swaziland Greenstone Quarry: http://www.sntc.org.sz/discuss/mitigation.html

Thompson, A., & Howarth, C. (2007). REDUCING THE ENVIRONMENTAL EFFECT OF AGGREGATE QUARRYING ON THE WATER ENVIRONMENT. Mineral Industry Research Organisation.

United States Environmental Protection Agency. (2012, 08 08). SPCC Requirements and Pollution Prevention Practices for Mines and Quarries. Retrieved 07 07, 2013, from United States Environmental Protection Agency: http://www.epa.gov/region6/6sf/sfsites/oil/mines.htm

U.S. Environmental Protection Agency, 1998. *Revised Draft User's Guide for the AERMOD Meteorological Preprocessor (AERMET)*. U. S. Environmental Protection Agency, Research Triangle Park, NC.

U. S. Environmental Protection Agency, 2006. *Addendum User's Guide for the AERMOD Meteorological Preprocessor (AERMET).* EPA-454/B-03-002. Office of Air Quality Planning and Standards, Research Triangle Park, NC

United States Environmental Protection Agency. November 2006. *Emission Factor Documentation for AP-42: Unpaved Roads*. Office of Air Quality Planning and Standards, Office of Air and Radiation, U.S. Environmental Protection Agency, Research Triangle, North Carolina.

United States Environmental Protection Agency. November 2006. *Emission Factor Documentation for AP-42: Aggregate Handling and Storage Piles*. Office of Air Quality Planning and Standards, Office of Air and Radiation, U.S. Environmental Protection Agency, Research Triangle, North Carolina.

Webber et al., 2003. Changes in water quality and plankton of Kingston Harbour, Jamaica, after 20 years of continued eutrophication. Bulletin of Marine Science, 73(2): 361-378

14.0 APPENDICES

Appendix 1 – Terms of Reference

1.0 Introduction

The Introduction should give a background; explain the need for, and the context of the project.

2.0 Project Brief

The Project Brief should give a summary of the project activities, including site location maps and project timelines.

3.0 Project Description

This section should provide:

A comprehensive description of the proposed project should be provided. It should clearly demarcate the exact location of the proposed project and should clearly identify the areas which will be used for quarrying and those which will be used for mineral processing. If there are areas to be preserved in their natural state or if a buffer is to be established then these should also be clearly identified.

The description should detail the elements of the development/project, highlighting the activities which will be involved in all the major aspects of the development/project. Therefore activities which will be involved in the construction, operation and decommissioning phases should be addressed. These may include but are not limited to the following:

- Construction: exploration drilling and trenching; location of stockpiles, access, plant and accommodation during initial development phase, duration, timing and working hours of the initial phase.
- Operation: quarrying rate, quarrying method, processing methods, plant and machinery, duration and phasing, nature and quantity of material to be extracted, stability of quarry faces, frequency of blasting and predicted vibration levels, dust generation and control (air quality), noise generation and control, fuel and other chemical storage, power supply, disposal of excess topsoil, waste rock, boulders and unmarketable products, transportation (internal and external), safety (worker), ongoing/phased remediation/revegetation, fencing and security.

- Decommissioning: long term quarry face stability, long term pollution potential and control (water), removal of administrative buildings, plant and machinery, strategies for site rehabilitation, closure plans for any waste treatment facilities associated with the development, monitoring and management and land use options after closure.

If there is potential room for growth or expansion with respect to the area, output or further processing then this should be discussed. Associated or ancillary developments should also be discussed. These may include machinery maintenance, haulage enterprises and downstream processing.

The description should involve the use of maps, site plans, aerial photographs and other graphic aids and images, as appropriate and include information on location, general layout and size, as well as pre-construction, construction, operation and decommissioning plans. For projects to be done on a phased basis, all phases must be clearly defined and the relevant time schedules provided and phased maps, diagrams and appropriate visual aids included.

4.0 Description of the Environment

This task involves the generation of baseline data which is used to describe the study area as follows:

i. Physical environment
ii. Biological environment
iii. Socio-economic and cultural constraints.

The methodologies employed to obtain baseline and other data should be clearly detailed in the EIS.

Baseline data should include:

Physical

A detailed description of the existing geology and hydrology. Special emphasis should be placed on storm water run-off, drainage patterns, including projected discharge points for surface water runoff and actual quarry surface drainage, effect on groundwater and availability of potable water. Any slope stability issues and natural hazard issues that could arise should be thoroughly explored. Every effort should also be made to identify any existing karst topographic features including sinkholes, caverns and their hydrologic connectivity.

Water quality of any existing wells, rivers, ponds, streams or coastal waters in the vicinity of mining activities. Quality Indicators should include but not necessarily be limited to nitrates, phosphates, faecal coliform, and suspended solids.

Climatic conditions and air quality in the area of influence, including particulate emissions from stationary or mobile sources, NOx, SOx, wind speed and direction, precipitation, relative humidity and ambient temperatures, (a review of the Natural Resources Conservation Authority Air Quality Regulations and the implications of the regulations on the proposed project should be conducted and ascertained)

Noise levels of undeveloped site and the ambient noise in the area of influence.

Obvious sources of pollution existing and extent of contamination.

Availability of solid waste management facilities.

The site forms part of the BITO quarry zone hence the extent of that zone should also be shown

Biological

Present a detailed description of the flora and fauna (terrestrial, aquatic and avifauna) of the area, with special emphasis on rare, endemic, protected or endangered species. Migratory species should also be considered. There may be the need to incorporate micro-organisms and the existence of micro-habitats to obtain an accurate baseline assessment. Species dependence, niche specificity, community structure, population dynamics, carrying capacity, species richness and evenness (a measure of diversity) ought to be evaluated.

Socio-economic & Cultural

Present and projected population; present and proposed land use; planned development activities, issues relating to squatting and relocation, community structure, employment, distribution of income, goods and services, recreation, public health and safety; cultural peculiarities, aspirations and attitudes should be explored. The historical importance of the area should also be examined. While this analysis is being conducted, it is expected that an assessment of public perception of the proposed project be conducted. This assessment may vary with community structure and may take multiple forms such as public meetings or questionnaires.

5.0 Policy, Legislation & Regulatory Consideration

This section should provide details of the pertinent regulations, policies and standards governing environmental quality, safety and health, cultural significant finds, protection of endangered species and land use control. The examination of the legislation should include at a minimum the Natural Resources Conservation Authority Act,

6.0 Identification and Assessment/Analysis of Potential Impacts

The likely impacts of the proposed project on the described environment, including direct, indirect and cumulative impacts should be identified. The major concerns surrounding environmental and public health issues should be noted and their relative importance to the design of the project and the intended activities indicated. The potential impacts may be subdivided into Physical Impacts, Biological Impacts and Socio-economic and Cultural Impacts. These may include but are not limited to the following:

- Physical Impacts - These may include the effect on soil and geology (loss of topsoil and potential erosion, change in drainage patterns, flooding risks, changes to underground water flows), air (generation of dust from processing, drilling, transportation, material storage and handling, fly rock from surface workings); water (possible contamination of resources from improper waste disposal); the landscape (loss of character of the area, impact of excavation); material assets (effects of vibration on surface structures, damage to roads during transportation)
- Biological Impacts – These will address the effects on flora and fauna, such as the loss of habitats, niches and species.
- Socio-economic and Cultural Impacts – These may include health and safety of the potential workers as well as the residents of the surrounding environs, loss of amenity and aesthetic impact of the development.

The EIS should seek to distinguish between significant positive and negative impacts, direct and indirect, long term and immediate impacts. Identify avoidable as well as irreversible impacts. Characterize the extent and quality of the available data, explaining significant information deficiencies and any uncertainties associated with the predictions of impacts. A major environmental issue is determined after examining the impact (positive and negative) on the environment and having the negative impact significantly outweigh the positive. It is also determined by the number and magnitude of mitigation strategies which need to be employed to reduce the risk(s) introduced to the environment. Project activities and impacts should be represented in matrix form with separate matrices for pre and post mitigation scenarios.

7.0 Mitigation

The EIS should seek to provide mitigation measures to address, as far as possible, any adverse impacts due to proposed usage of the site and utilising of existing environmental attributes for optimum development. The mitigation measures should endeavour to avoid, reduce and remedy the potential impacts and where possible maximize potential positive effects.

8.0 Environmental Management and Monitoring

Design a plan to monitor implementation of mitigatory or compensatory measures and project impacts during construction and operation. An Environmental Management Plan for the long term operations of the site should also be prepared.

An outline monitoring programme should be included in the EIS, and a detailed version submitted to NEPA. This is usually a condition of the granted Environmental Permit and must be submitted for approval prior to the commencement of the development. At the minimum the monitoring programme and report should include:

- Introduction outlining the need for a monitoring programme and the relevant specific provisions of the permit license(s) granted.
- The activity being monitored and the parameters chosen to effectively carry out the exercise.
- The methodology to be employed and the frequency of monitoring.
- The sites being monitored. These may in instances, be pre-determined by the local authority and should incorporate a control site where no impact from the development is expected.
- Frequency of reporting to NEPA
- Raw data collected. Tables and graphs are to be used where appropriate

- Discussion of results with respect to the development in progress, highlighting any parameter(s) which exceeds the expected standard(s).
- Recommendations
- Appendices of data and photographs if necessary.

9.0 Public Participation/Consultation

A public presentation of the EIS findings will be required to discuss, inform and solicit the comments of the public on the proposed project This public presentation should be:

Conducted at an appropriate location agreed to by the National Environment and Planning Agency (NEPA)

Held in accordance with the NEPA's Guidelines for Conducting Public Presentations available on the Agency's website (www.nepa.gov.jm)

10.0 Identification of Alternatives

Alternatives to the proposed project including the no-action alternative should be examined. This examination of alternatives should incorporate the use history of the overall area in which the site is located and previous uses of the site itself.

All findings must be presented in the EIS report and must reflect the headings which have been outlined in the body of the ToRs. References should also be provided. Ten hard copies and an electronic copy of the report will be required for submission. The report should include an appendix with items such as maps, site plans, the study team, photographs, and other relevant information.

In addition to the approved TORs outlined above, the following email correspondence on July 04, 2013 (Aisha Bedasse/Carlton Campbell) reads:

Re: Application for a Permit under Section 9 of the Natural Resources Conservation Authority (NRCA) Act, 1991, in respect of Mining of Gypsum and Anhydrite at Haberstadt Quarry, St. Andrew

Please note that additional comments have been received and as such, the following additional information is also required for inclusion in the final TORs:

- There should be an indication of the possible sites selected for the storage of overburden and the methods by which such sites are to be chosen
- The potential for flooding of settlements further down slope shall be investigated and the associated mitigation measures such as cleaning of river channels and maintenance of storm water drainage culverts should be incorporated.
- The impact that the mining activities may have on slope stability and the possible generation of landslides should be examined. Associated slope protection measures should be explored and provided. It is recommended that benching be explored as a method of mining.
- The TOR should also provide a restoration plan which speaks specifically to the re-vegetation of those areas which will be mined

Appendix 2 – Study Team

- Carlton Campbell, M. Phil., CIEC (Noise, Air and Socio-economics)
- Matthew Lee, M.Sc. (Noise, Air, Climate and Vibration)
- Stephen Haughton, Air Quality Consultants (Air Dispersion)
- CEAC Solutions Ltd.: Christopher Burgess M.Sc. Eng., PE, Carlnenus Johnson, Kristoffer Freeman, Marc Henry (Drainage Assessment)
- Kristoffer Lue, BSc. (Water Quality)
- Rachel D'Silva, BSc. (Water Quality)
- Environmental Management Consultants Caribbean Ltd. (emc2): Marc Rammelaere and Dr. Ravidya Burowes (Geology)
- Dr Eric Garraway (Fauna)
- Dr Catherine Murphy (Entomology)
- Damion Whyte (Avifauna)
- Dr Philip Rose (Flora)
- Karen McIntyre (Socioeconomics and GIS)
- Tamia Harker, BSc. (Legislation)
- Glen Patrick (Field Technician)
- Errol Harrison (Field Technician)

Appendix 3 – NEPA Guidelines for Public Participation

NATURAL RESOURCES CONSERVATION AUTHORITY

GUIDELINES FOR CONDUCTING PUBLIC PRESENTATIONS

1997-01-08

Section 1: General Guidelines

1.1 Introduction

There are usually two forms of public involvement in the environmental impact assessment (EIA) process. The first is direct involvement of the affected public or community in public consultations during EIA study. These consultations allow the developer to provide information to the public about the project and to determine what issues the public wishes to see addressed. The extent and results of these consultations are included in the documented EIA report.

The second level of involvement takes place after the EIA report and addendum, if any, have been prepared after the applicant has provided the information needed for adequate review by NRCA and the public.

Public involvement in the review process is in keeping with Principle 7 of the United Nations Environment Programme (UNEP) decision published as Goals and Principles of Environmental Impact Assessment [Decision 14/25 of the Governing Council of UNEP, of 17, June, 1987]

1.2 Purpose

These guidelines are prepared for the use of the developer/project proponent, the consultants who did the EIA study and prepared the EIA report and the public.

Section 2: Specific Guidelines for Public Presentations/Meeting

2.1 Requirements

When a decision is taken by the Authority that a pubic presentation is required, the developer and consultant will be notified by the NRCA. [See Appendix 1] On receipt of the notification arrangements must be made for the public presentation in consultation with the NRCA in respect of date, time, venue and participants.

2.2 Public Notification

The developer/consultants must in addition to specific invitation letters, put a notice in the press advertising the event. Specific notice to relevant local NGOs should be made by the developer/consultants. The notice should indicate where the EIA report is available. A typical notice is in Appendix 2.

2. 3 Responsibility of Developer/Consultant Team

The consultant is responsible for distribution of copes of the EIA report to ensure that they are available to the public in good time for the meeting. A summary of the project components and the findings of the EIA in non-technical language should be prepared for distribution also in good time for the meeting. Three (3) to four (4) weeks in advance of the meeting is recommended. Copies should be placed in the Local Parish Library and the Parish Council office as well as at the nearest NRCA Regional Coordinator's office and other locations in the community.

The consultant is also responsible for making the arrangements to document the proceedings of the meeting. A permanent record of the meeting is required and one can consider tape recording from which a written record can be made.

2.4 Conduct of the Meeting

With respect to the conduct of the meeting, the NRCA will advice on the selection of a Chairman and will make arrangements to document the concerns of the audience for its own records. The Chairman should be "neutral", that is, not have a direct interest in the project. NRCA staff may on occasion be responsible to chair the meeting. The role and responsibilities of the chairmen are in Appendix 4.

The technical presentation by the proponent and the consulting team should be simple, concise and comprehensive. The main findings of the EIA with respect to impacts identified and analysed should be presented both adverse and beneficial.

The mitigation measures and costs associated with these measures should be presented. The presentation should inform the public on how they will get access to monitoring results during construction and operational phases of the project (if it is approved) bearing in mind that the public and NGO groups are expected to be involved in post-approval monitoring. Graphic and pictorial documentation should support the technical presentation.

Presenters are advised to keep the technical presentation simple and within a time limit of 20-30 minutes depending on the complexity of the project and to allow up to 30-60 minutes for questions.

Please note that the public will be given a period of thirty (30) days after the meeting to send in written comments.

A typical agenda for a meeting is given in Appendix 3

APPENDIX 1

Date

Name of Organization Submitting EIA

Address of the Organization

Attention: Responsible Party

Dear

Subject: Notification of Requirement of Public Presentation/Meeting

The Natural Resources Conservation Authority (NRCA) has determined that a public meeting is required to adequately assess the potential environmental impacts associated with the following proposed activity:

____

____

____

NRCA guidelines for conducting public meetings are attached. As noted in the guidelines, a Notification of Public Meeting must be issued by you once the date, time, venue and programme has been established in consultation with the NRCA. Please note that further processing of your application will halt until the public meeting be carried out by the developer and consulting team and that the public will be allowed a period of thirty (30) days after the meeting to send in written comments.

Questions regarding the public presentation process should be directed to:

____

____

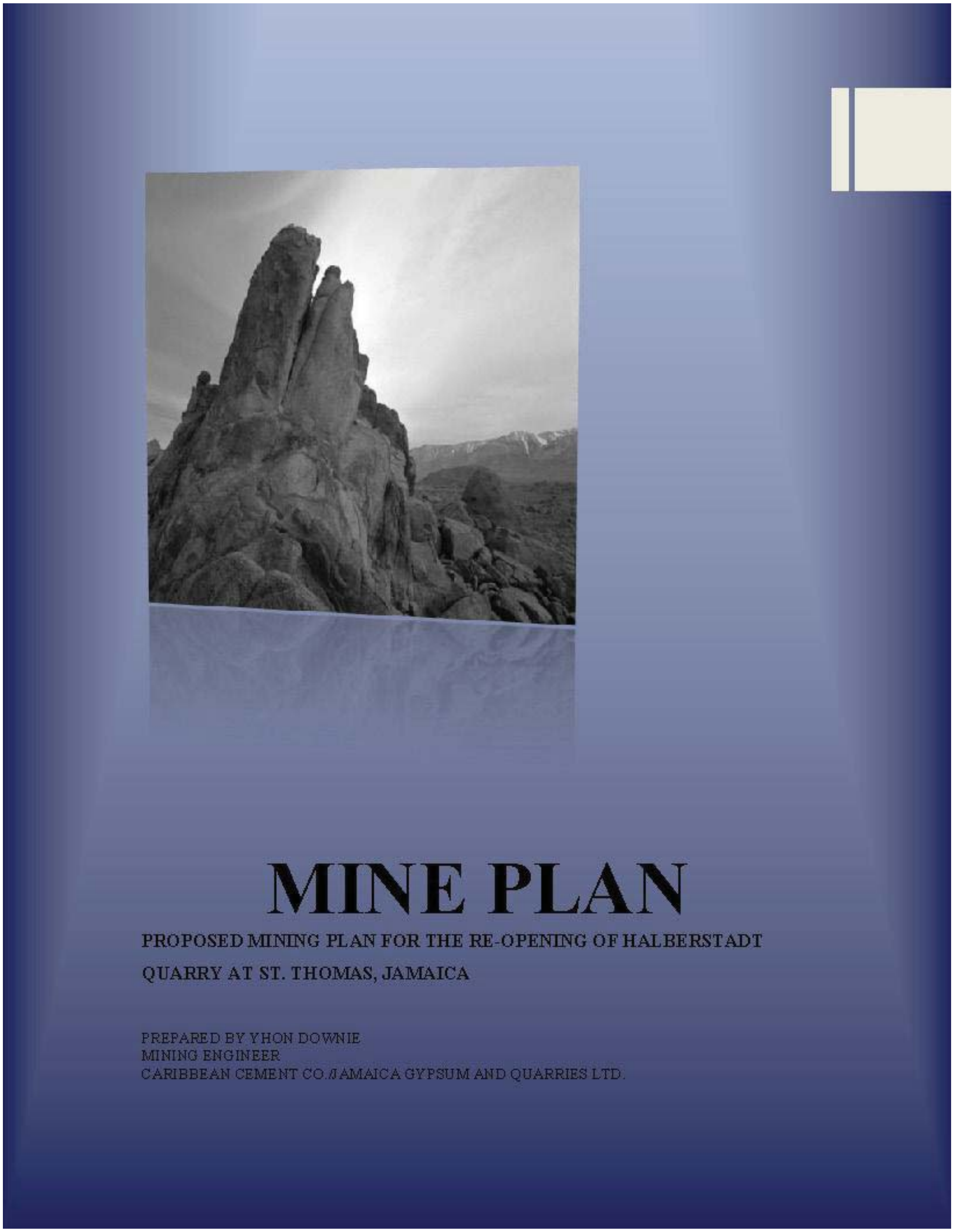
Signature___________________________

Name______________________________
Title_______________________________

Date_______________________________

cc: other government agencies

Appendix 4 – Proposed Mining Plan for the Re-Opening of Halberstadt Quarry at St. Thomas, Jamaica



MINE PLAN

PROPOSED MINING PLAN FOR THE RE-OPENING OF HALBERSTADT
QUARRY AT ST. THOMAS, JAMAICA

PREPARED BY YHON DOWNIE
MINING ENGINEER
CARIBBEAN CEMENT CO./JAMAICA GYPSUM AND QUARRIES LTD.

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

TABLE OF CONTENTS

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

Executive Summary

The quarrying operation of Jamaica Gypsum and Quarries (JGQ) a subsidiary of Caribbean Cement Company is located 15 kilometres east of Kingston, Jamaica. The company is engaged in the mining of pozzolan, gypsum and anhydrite. Gypsum in this paper is referred to as +60 % gypsum content and anhydrite –60% content. The only economical reserve of Gypsum remaining is contained in the Halberstadt Deposit. A recent exploration drilling program at Halberstadt puts the reserves at approximately 5 million metric tons.

At TCL Group's current consumption rate (Approx. 100k tons), mine life at Halberstadt will be 50 years. The reserves quoted in the plan are mainly proven from borehole data and geological field mapping.

With these existing quarries nearing the end of mine life, it is incumbent on Jamaica Gypsum and Quarries, in order for its survival, to develop the Halberstadt deposit for production

1.0 Introduction

1.1 Objectives

- To evaluate the material within the Halberstadt deposit in order to determine the quality, quantity, distribution and mineable reserves.
- To assess the potential impact of the operation on the environment.
- To prepare a mine plan, based on geomorphology, economics and statutory conditions.

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

1.2 *Background*

Mining in the present quarries has been extremely difficult in recent times as diminishing reserves and high stripping costs have placed the company under severe financial stress. The remaining gypsum in Bito and Upper quarries is overlain by overburden which is twice the thickness of the ore reserve. With these challenges coupled with issues affecting the Bull Bay area caused by the mining operation at JGQ, the company has sought to determine with respect to Halberstadt i) the quantities of gypsum/anhydrite the company has in its possession; ii) the quality of this material; and iii) what must be done to reduce or mitigate the environmental impacts in a safe manner. The Halberstadt quarry has been inactive for over 40 years and is fully re-vegetated, Therefore a mine plan is being prepared to guide the process of reopening the quarry.

The company is involved in the mining of gypsum and anhydrite, both of which are shipped to countries such as Colombia, Venezuela, Trinidad and Barbados. A smaller amount is used locally by Caribbean Cement Company Ltd. in the final stage of cement processing.

Gypsum, $CaSO_4H_2O$ (hydrous calcium sulphate) is a soft mineral that can be scratched by the fingernail and has a density of 2.2. Gypsum is used primarily in the manufacturing of building materials such as sheet rock, laths, and tiles. It is also used in the paper and paint industry as filler, in cement manufacture, and as a fertilizer in agriculture.

Anhydrite, $CaSO_4$ is the anhydrous form of calcium sulphate and is harder and denser with density of 2.7. It is an important industrial raw material in cement, sulphuric acid and fertilizers.

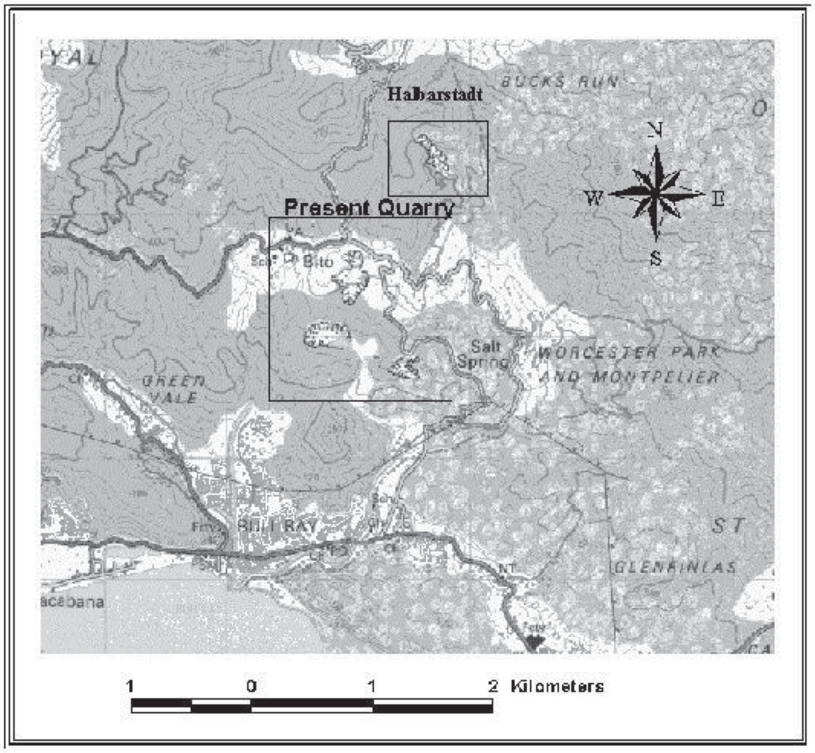
1.3 *Location and Topography*

The Halberstadt deposit is located approximately 2km NE of the Bito Quarry, on faulted mountains which display small and steep watersheds overlooking the valley of Bull Park River (Fig 1.). The general topography is hilly country along the crest of the mountain (steepening).

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

The Bull Bay area is shown to be an alluvial fan that is prone to domination by debris flow processes that transport large volumes of coarse and fine sediments and organic debris. The region is largely vegetated and steep, thus facilitating swift runoff.
Rainfall data averages between 1000-1400mm annually (Meteorological Department, 2010) in this region.

Fig 1: Location Map of Halberstadt in relation to present quarries shown on a 1:50,000 scale.



JAMAICA GYPSUM & QUARRIES LTD (JGQ)

2.0 Geology

2.1 Geological Setting

The area is located on the south-eastern tip of the fault bounded Wagwater Belt and comprises mainly tertiary volcanics, plutonics, alluvial submarine-deltaic sediments, limestones and gypsum/anhydrite. The quarries (Brooks, Bito and Upper Quarry) represent the largest of sulphate deposit within the Wagwater Trough.

2.2 Geology of the Area

In the mining area gypsum is overlain by the Newcastle Volcanics and underlain by the Halberstadt Volcanics. These lithologies are observed in the cores recovered from the exploration drilling program. Figure 2 shows the surface geology of the Halbersatdt region.

2.3 Lithology

The area consists of three main types of rock types. These are described below.

Halberstadt Volcanics

This is the oldest rock type that occurs in the area, and it forms a basement of the spilitised basalt lavas and associated breccias and volcaniclastics. The Halberstadt Volcanics are highly fractured, jointed, and calcite veins are common throughout. It generally weathers to a rich brown colour, producing a granular look soil.

Sulphate

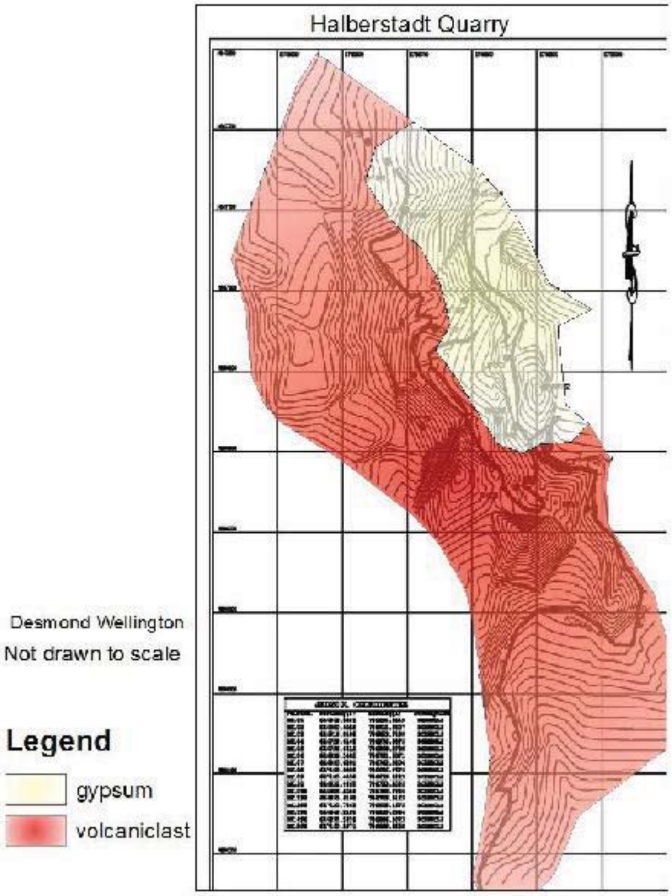
Sulphate occurs as both gypsum and anhydrite where anhydrite forms the core of the deposits and the gypsum is found in the outer, more exposed surfaces. The gypsum/anhydrite sequence is easily identified in the field with different colours ranging from transparent/translucent (selinite) to white, brown, red, light grey and dark grey (alabaster) and fibrous variety (Satin spar). The darker grey gypsum is generally interbedded with black bands of organic matter.

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

Newcastle Volcanics

The Newcastle Volcanics occupy the highest stratigraphic position in the region. This volcanics occur as lavas and breccias, and they are highly jointed and brecciated. The colour varies depending on the level of weathering. The heavily weathered rocks are dark brown to purplish brown, while the fresh samples are light to dark grey in appearance.

Fig 2: Surface Geology of the Halberstadt Deposit



Source: Economic Value of Mineral Deposits at Halberstadt by summer intern.

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

2.4 Structure

The dominating structures in the area are the small faults and numerous joints observed in the gypsum outcrops. No major tectonic features are present in the area.

3.0 Reserves Calculation

3.1 Assumptions/Basis upon which calculations made:

- Elevation data and contours were constructed by photogrammetric interpretation of aerial photographs
- based on the deposit/region analysis of existing topographic maps (CCL-HALB 1:2000 May 2012 cartographic series by GEO GRAPHICS and 1:50000 metric topographic map Jamaica series)
- Calculated tonnage was generated using the depth of boreholes from the surface, length and width of the approximated limits of the deposit on the existing topographic map.
- Weight calculations are based on in-situ bulk density of 2.33 for gypsum, and 2.9 for anhydrite. The estimate for reserves of Halberstadt Deposit is based on the assumption that the geology of the region is heterogeneous.
- The cross-sectional method was also used in calculating the reserves.

Reserves are calculated as **proven** reserves and **inferred** reserves.

-**Proven**- Gypsum/anhydrite that extends from the surface to any depth reached by bore holes and area of influence based on polygons drawn around the drill hole(s) 7.3 m. Calculations also based on quarry face, are also referred to as proven. All benches are closely sampled and measured, and geology is well known by its size, shape and mineral content. The quality of each bench is monitored in the JGQ lab.

-**Inferred**- Gypsum/Anhydrite material with geological evidence (faults, folds, lithology). Based on the continuity of the gypsum/anhydrite, there is no reason to question the validity of such assumption.

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

3.2 Reserves Discussion

A map of the quarry is attached as Appendix I that shows the layout of the boreholes used to generate this reserves estimate.

NHL Engineering carried out a geological survey (Appendix 111), to determine the reserve capacity of the Gypsum deposit at the Halberstadt Quarry. The completed field work showed the following soil types;

1) The Clays, sands and Gravels
Depth Range: Variable, typical 0-15m

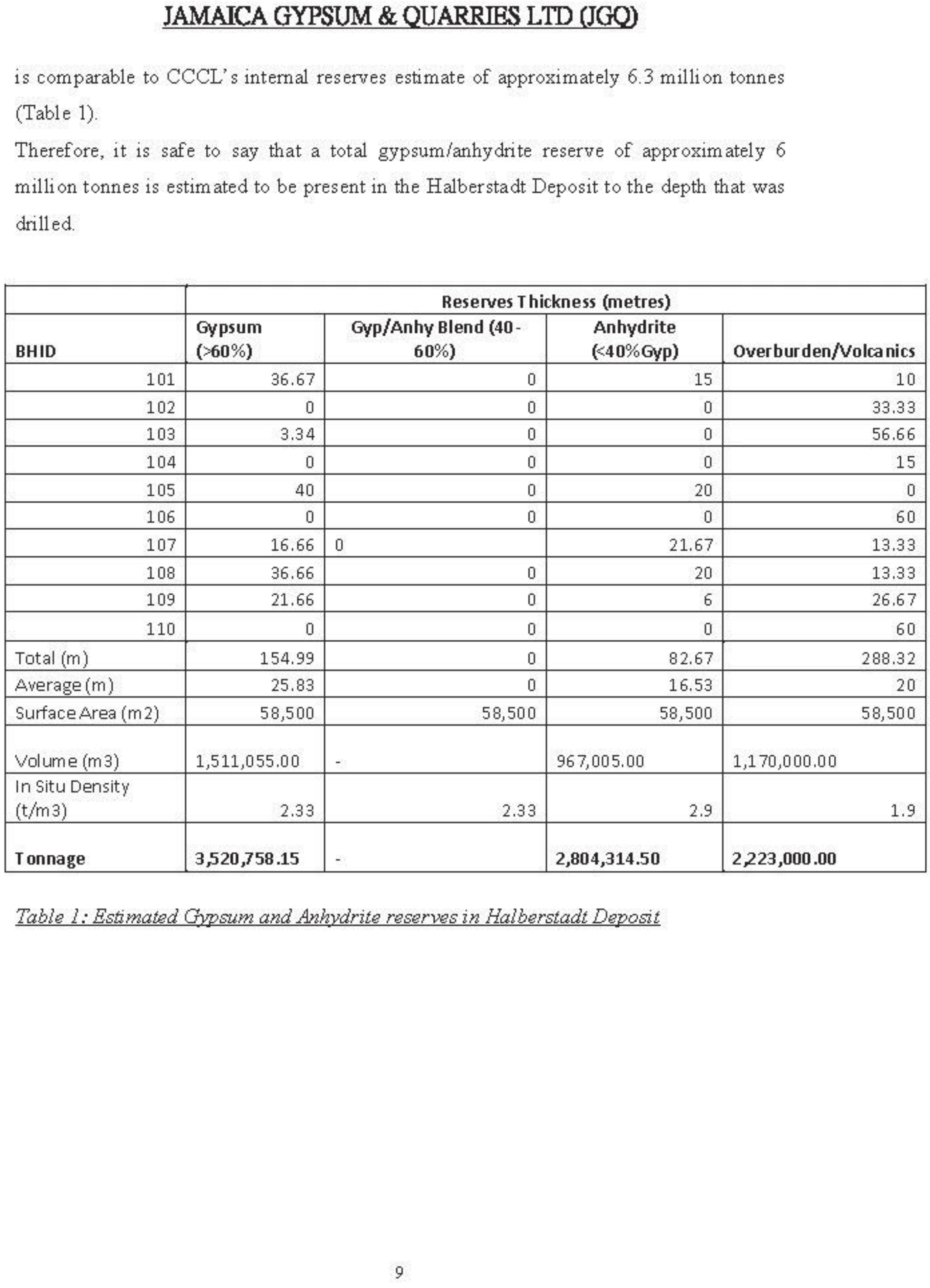
2) The Clayey Shales, Sandstones
Depth Range: Variable

3) The Gypsum/Anhydrite Formation
Depth Range: Variable, typically 15-60m

The core samples were tested at the JBI labs and the results indicated the average percentage of gypsum was approximately 50%, with a high of 90%. In general minimal gypsum was identified in boreholes 102, 104, 106 and 110. The other locations all showed gypsum between the depth ranges of 10.7 to 45m with the significant concentration (peak depth range) between the 13.7 to 37m depth range. Boreholes 103 and 105 had gypsum from the 1.5m depth range.

The reserve was obtained by a simplified representative cross sectional area of the deposit. The cross sectional area varies between 5625 and 6300m2. The presumptive profile indicates an effective depth of length of the deposit of about 460m (including slope and dip of strata). A conservative volumetric estimate of the deposit was 2,587,500m3.

Based on the laboratory results, the average content of the gypsum is approximately 52%. The volumetric reserve estimate of gypsum is therefore 1,350,804m3. Applying the in-situ densities of gypsum and anhydrite (2.33 t/m3 and 2.9 t/m3 respectively), gives a reserve estimate of 3,147,373 tonnes of gypsum and 3,586,418 tonnes of anhydrite. This



JAMAICA GYPSUM & QUARRIES LTD (JGQ)

is comparable to CCCL's internal reserves estimate of approximately 6.3 million tonnes (Table 1).

Therefore, it is safe to say that a total gypsum/anhydrite reserve of approximately 6 million tonnes is estimated to be present in the Halberstadt Deposit to the depth that was drilled.

	Reserves Thickness (metres)			
BHID	**Gypsum (>60%)**	**Gyp/Anhy Blend (40-60%)**	**Anhydrite (<40%Gyp)**	**Overburden/Volcanics**
101	36.67	0	15	10
102	0	0	0	33.33
103	3.34	0	0	56.66
104	0	0	0	15
105	40	0	20	0
106	0	0	0	60
107	16.66	0	21.67	13.33
108	36.66	0	20	13.33
109	21.66	0	6	26.67
110	0	0	0	60
Total (m)	154.99	0	82.67	288.32
Average (m)	25.83	0	16.53	20
Surface Area (m2)	58,500	58,500	58,500	58,500
Volume (m3)	1,511,055.00	-	967,005.00	1,170,000.00
In Situ Density (t/m3)	2.33	2.33	2.9	1.9
Tonnage	**3,520,758.15**	-	**2,804,314.50**	**2,223,000.00**

Table 1: Estimated Gypsum and Anhydrite reserves in Halberstadt Deposit

9

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

4.0 Pit Design

4.1 Slope

All slopes will be vertical to facilitate blasting. Bench heights average 8m (26 ft) with a bench width of 20m (66ft) and length no exceeding 100m (328 ft).

4.2 Haul Roads

The current access road to Halberstadt was prepared to facilitate exploration drilling and as such is not adequately designed to accommodate haulage. Table 2 shows the various roadways that require immediate repairs and modification prior to commencement of mining at Halberstadt.

Roadways	Type	Length	Required Work
Salts Spring	Access to Mine	Approx. 2km	Complete restoration including retaining walls and culverts
From Benoa to Halberstadt	Access to Mine	Approx. 2km	Needs to be widened to accommodate the passage of 2 trucks side by side. A section is to be re-aligned as a result of a major landslide recently.
In Pit Roads	Haul Roads	Approx. 3.5km	To be developed

Table 2: Road networks connecting Halberstadt to the surrounding communities

Access roads, as best as possible, will be designed at a 5% gradient for haul roads.
The Salt Spring Parochial road is not shown on the map presented in this document; however, this road will be reopened to facilitate the transporting of material from the quarry to storage, as the current route through the Bito deposit is not feasible.

Roads will be minimum 15m wide with maximum slope of 1:7. The minimum width of the road is designed to be at least three times the width of the widest vehicle use in the quarry. Daily wetting of roads to suppress dust and periodic grading is done to provide safe and good quality roads.
Only authorised personnel are allowed to use the road.

Over the life of the mine, the quarry profile will undergo numerous changes and so the road will have to be redesigned to meet the requirements of proper mining practices. All efforts to maintain visibility in the quarry will be taken; hence, bends will be made horizontal or super-elevated.

4.3 Pit cross section

Pit resembles a step like profile in section. Each step is one bench and the height of each bench will be 26ft (8m). The width of the bench will be a minimum of twice the height to allow for safe operating of loading equipment and haul trucks. Two cross sectional drawings of the deposit are shown in Appendix II. The borehole survey indicated that the higher elevations of the mine also have significant overburden while in the lower elevations the gypsum/anhydrite rises to the surface.
The budgeted production from halberstadt for 2013 is approximately 100k tonnes. Based on the reserves, it is proposed that an annual extraction of 100-150k tonnes be targeted to extend the life of the quarry and the supply to the parent company CCCL. This will allow for supplying CCCL annual demand as well as approximately 50-100k tonnes of sales to other group companies and/or third parties. At these levels of production and based on the “proven” reserves, the life of the quarry will be 33-50 years.

4.4 Bench Elevations

Cut off elevation will be at 460 m above sea level based on the depth of Gypsum/Anhydrite reserves as shown in the boreholes. This allows for the creation of four benches. Reserves to this elevation are proven in the in the Halberstadt deposit. Below this elevation, geological composition is unknown. Benches will be defined from top elevation.

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

4.5 Site Facilities

A site office will be erected at Halberstadt. This office will house quarters for the mining engineer, production supervisor, changing rooms, bathrooms, lunch room/waiting area and JGQ's field Laboratory.

5.0 Mining and Production

5.1 Stripping and Development

Due to financial constraints, stripping and development this year will be concentrated in the lower section of the deposit to facilitate the production of 100k tonnes of Gypsum for the TCL Group.

5.2 Test Hole Drilling

Test holes will be drilled at a spacing of 30m around BH 103 and BH 105, following stripping to determine the grade distribution of the gypsum on those benches. This information will then be used to determine where to mine first, based on the gypsum demand for the TCL group.

5.3 Drilling and Blasting

Material will be extracted by the process of drilling (Plate 2) and blasting, as is the case now with the present operating quarries. Depending on the demand for product, blasting will be done at a maximum of 2 times weekly (Mon – Fri) between 8am to 4pm. No blasting will be done outside of these time periods.

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

Plate 2. Production holes being drilled for blasting using the Ingersoll Rand drill

5.4 Mining Schedule

The mine schedule therefore will be for the benches containing BH 103 and BH 105 to be mined this year down to a depth of 12m each. This is due to the current state of access to these boreholes (see appendix 1 for Borehole layout). This will be sufficient to supply the TCL Group gypsum demand for 2013. Table 3 and 4 below shows the extraction quantities for 2013 and five (5) year Production projection from Halberstadt.

	AUG	SEP	OCT	NOV	DEC	Total
2013 JGQ Production	27,360	30,240	21,600	12,160	12,160	103,520

Table 3: Projected production from Halberstadt in 2013

	2013	2014	2015	2016	2017
Gypsum Production	103,520	250,000	250,000	250,000	250,000

Table 4: Halberstadt Quarry 5 year Production Projection

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

5.5 Mining Method

The mining method to be employed is open-pit mining, by benching. Benches will be minimum 12m in height and 6m in width.

Equipment	Quantity	Capacity (M/T)
365BL II Excavator	1	10
980H	2	12 each
D11 Dozer	1	-
140H Grader	1	-
Mobile Crusher	1	500-800TPH
Dumper Trucks	15	25-35

Table 5: Mining Equipment Requirement

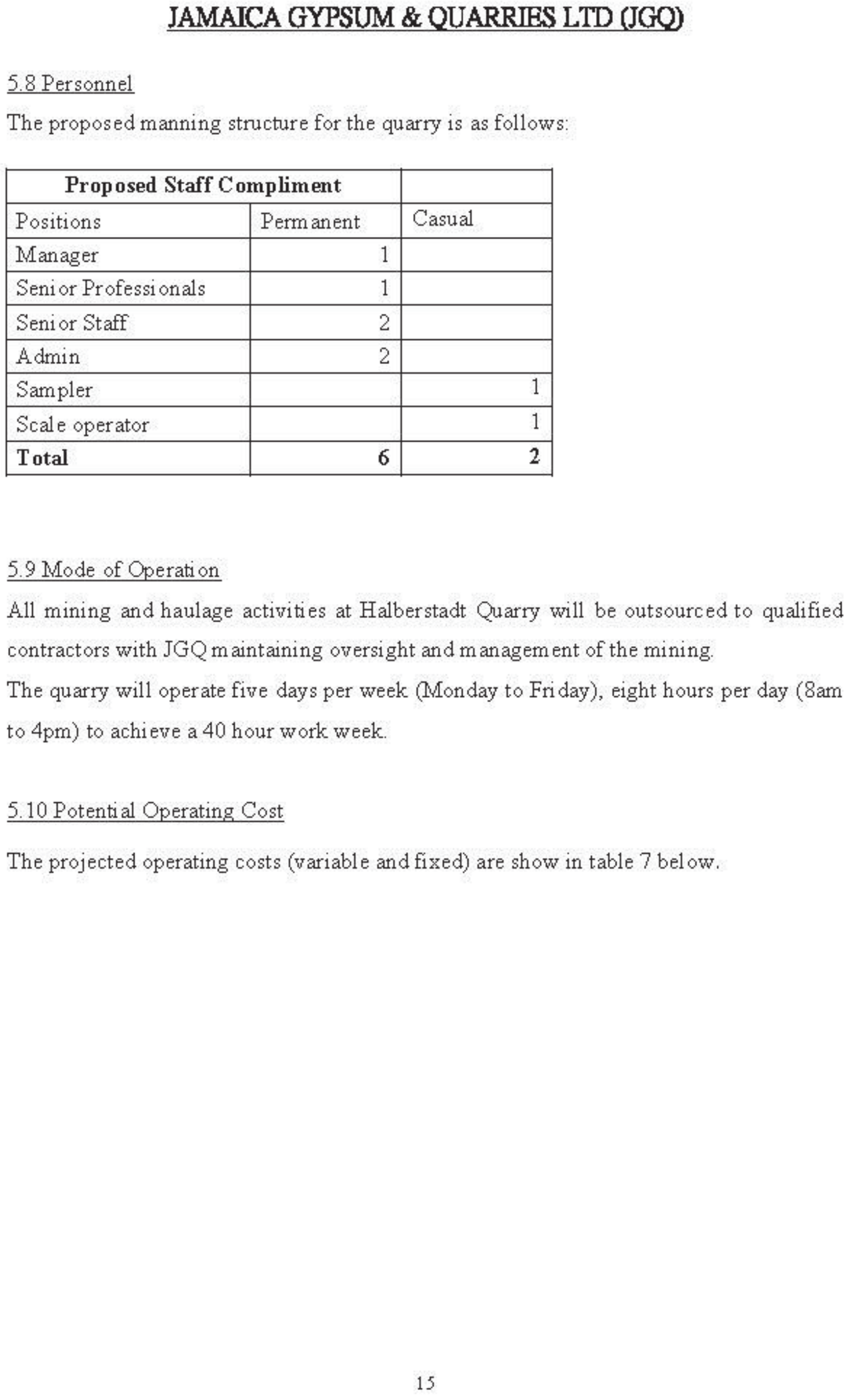
5.6 Crushing and screening

Crushing and screening will be done using a mobile crusher and screen at the bench face. A track mounted, fully mobile crusher and screen is the preferred units of choice for the mine site crushing. The rated capacity of this crusher will be 500-800tph (see picture 1).

Picture 1: Mobile Crusher

5.7 Stockpiling and Haulage

Stockpiling and loading of crushed product will be done by a 980 front end loader. Dumpers (20-35t) will collect finished product from the quarry and transport for storage and use to JGQ Port and CCCL plant respectively.



JAMAICA GYPSUM & QUARRIES LTD (JGQ)

5.8 Personnel

The proposed manning structure for the quarry is as follows:

Proposed Staff Compliment		
Positions	Permanent	Casual
Manager	1	
Senior Professionals	1	
Senior Staff	2	
Admin	2	
Sampler		1
Scale operator		1
Total	**6**	**2**

5.9 Mode of Operation

All mining and haulage activities at Halberstadt Quarry will be outsourced to qualified contractors with JGQ maintaining oversight and management of the mining.

The quarry will operate five days per week (Monday to Friday), eight hours per day (8am to 4pm) to achieve a 40 hour work week.

5.10 Potential Operating Cost

The projected operating costs (variable and fixed) are show in table 7 below.

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

Variable Cost				**Cost to Import**	
Activity	$	J$/t	US$/t		US$/t
Stripping/Development	$ 16,516,800.00	$ 165.17	$ 1.84	CIF	$ 44.00
Equipment Operational	$ 102,251,880.00	$ 1,022.52	$ 11.36	Equipment Operational	$ -
Drilling and blasting	$ 10,956,556.80	$ 109.57	$ 1.22	Drilling and blasting	$ -
Rehabilitation	$ 15,316,800.00	$ 153.17	$ 1.70	Rehabilitation	$ 1.70
Haulage to Port	$ 42,733,056.00	$ 427.33	$ 4.75	Haulage to Port	$ -
Environment	$ 20,840,000.00	$ 208.40	$ 2.32	Environment	$ 2.32
R&M	$ 9,737,820.00	$ 97.38	$ 1.08	R&M	$ 1.08
Stockpiling at Port	$ 6,424,000.00	$ 64.24	$ 0.71	Stockpiling at Port	$ 0.36
Selling Expense	$ 33,204,003.30	$ 332.04	$ 3.69	Selling Expense	$ -
Total	**$ 257,980,916.10**	**$ 2,579.81**	**$ 28.66**	**Total**	**$ 49.46**
Fixed Cost				**Fixed Cost**	
Activity	$	J$/t	US$/t	Activity	
Salaries	$ 12,402,500.67	124.03	1.38	Salaries	0.69
Insurance	$ 12,144,871.29	121.45	1.35	Insurance	1.35
Depreciation	$ 13,200,000.00	132.00	1.47	Depreciation	-
Admin	$ 10,436,575.00	104.37	1.16	Admin	1.16
Selling Expense	$ 32,760,000.00	327.60	3.64	Selling Expense	3.64
Management Fees	$ 18,000,000.00	180.00	2.00	Management Fees	-
Security	$ 22,800,000.00	228.00	2.53	Security	1.27
Total	**$ 98,943,946.96**	**$ 989.44**	**$ 10.99**	**Total**	**8.10**
Total CPT (var. and fix.)		**$ 3,569.25**	**$ 39.66**	**Total CPT (var. and fix.)**	**$ 57.56**

Table 7: Projected operating cost for Halberstadt Quarry producing 100k tonnes of Product in 2013 and cost to import Gypsum.

It is projected that the variable cost for mining 100k tonnes of product at Halberstadt in 2013 will be US$28.66/t while the fixed cost will be U$10.99/t, giving a total cost of **US$39.66/t** . This compares to total projected cost of **US$57.56/t** to import Gypsum.

6.0 Environment Impacts & Safety

6.1 Introduction

Quarrying at the JGQ quarries over the years since 1949 has affected the surrounding environment. Over the years the company has assisted in cleaning the river channel of excessive siltation of which the mining operation is a contributor. In 2002 the company embarked on a new initiative to produce a more comprehensive solution to the environmental issues. These issues are: air pollution, noise pollution, ground vibration, water pollution, impact on vegetation, visual intrusion and landslide risk etc. With all of this in mind the company is examining the possibility of implementing an Environmental Management System (EMS). An Environmental Management System is a management tool that enables an organisation to address the impacts of its products, services and processes on the environment.

Several mitigation measures will be implemented prior to commencement of mining operations at Halberstadt. Mitigation measures refer to those measures that may be applied in an effort to reduce, minimize or eliminate potential negative impacts on the environment or public health.

The following environmental impacts are commonly associated with quarries.

6.2 Air Pollution

Dust emanating from the quarry is a potential hazard and can be detrimental to community and the workers as a whole.

Air pollution results from the dust emanating from the quarries and the crusher. The dust can cause damage to property (equipment and buildings) and can result in respiratory ailments and other related illnesses.

Dust Mitigation

The water truck is used to sprinkle the quarry haul roads and material at the stockpile. A sprinkling water system (mist of water blown by air) is affixed to the main crusher to cut down on dust, created by the crushing operation. A dust monitoring system is to be set up to check the concentration of dust in the atmosphere. A tree planting exercise to re-vegetate the fines dump and surrounding areas is also planned.

6.3 Noise Pollution

Most quarrying activity will generate noise. Noise in the quarry emanate from many different operations, such as blasting, ripping and pushing operations, as well as from equipment such as drill rigs, compressors, loaders and trucks.

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

Noise Mitigation

Planting of trees will help to reduce the noise. All employees are given the appropriate personal protective equipment (PPE). The company will engage in buying equipment that generates less noise. Also haul roads will be appropriately designed so as to reduce noise; measures include reducing the gradient of all haul roads to avoid the use of low gear, which results in high, excessive and unnecessary revving of engine.

6.4 Ground Vibration

Ground vibration is common in this quarry operation given that we are mining relative hard-rock deposits and blasting will be our primary extraction method. The large earth moving equipment and haul trucks will also add to the level of ground vibration emanating from this quarry.

Mitigation

All blast is so designed to minimize ground vibration. Also the cycle time does not allow any truck to be racing another.

6.5 Water Pollution

Run-off from the quarry is a problem and as a result has adverse impacts on the communities on the flood plain of the Bull Park River.

Mitigation

The haul road is to be properly graded and drained to prevent run-off from cutting into banks of the road, avoiding erosion. The company will be constructing silt traps, to trap silt material from the fines dump (waste dump). A 6ft diameter culvert will be installed to drain water away from the fines dump.

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

6.6 Impact on Vegetation

The Halberstadt quarry has been dormant for some time and this has allowed for the natural re-vegetation of the area. The impact on the vegetation will be limited to within the quarry boundary and the access roads.

Plate 1. Present state of Halberstadt after 40 years of natural re-vegetation

The plants currently flowering in the Halberstadt area are pioneering species with the most notable one being the Acacia plant. A comprehensive botanical study will be conducted prior to the clearing of vegetation at the site. This study will identify the type of vegetation present at the site. This information will be extremely important in the rehabilitation process as we will know the type of vegetation best suited for area.

Trees will be planted in areas where mining has affected the vegetation.

6.7 Visual Intrusion

At present the Gypsum quarries can be seen from the 11 miles Bull Bay area. Planting of trees and building of dirt berms are to be carried out to reduce the impact. The Halbarstad deposit however is situated behind the hill, away from the road so there will be no visual intrusion from the Bull Bay area.

6.8 Landslide & Flooding Risk

The eastern flank of the deposit is drained by the Bull Park River so extreme care will be given to the prevention of silt accumulating in the channel. The steep sided slopes mean that in times of heavy rainfall, the possibility of landslides is high. All areas influenced by the mining operation will be either benched or geotechnically engineered to prevent downslope movement of material.

6.9 Impact on Human Settlement

There is a small community known as Benoa of approximately 20 residents located approximately 1km from the deposit. This community however, is right beside the access road and will be affected by the noise from the blasting and from trucks transporting the product from the quarry. They will also be affecting from ground vibrations emanating from earth moving equipment and blasting. The possibility of relocating these residents will also be explored by the company as a means to mitigate the impact of our mining operations on the residents.

7.0 Rehabilitation Programme

Rehabilitation will commence before the first blade of material is removed from the site. A complete biological assessment of the area will be conducted prior to the commencement of developing access roads to the area. This assessment will be used to guide the process of re-vegetation of mined out areas. Progressive rehabilitation will be aggressively pursued during the operation of this quarry. Topsoil removed during development will be stored in designated locations so that pits can be backfilled as soon as a mine section is exhausted. While the mine is active, systematic grading and levelling will be conducted as required to rehabilitate areas to prevent the formation of steep cliffs and depressions. Artificial drainages will be conducted to channel excess runoff in the mines to the natural waterway to the east of the deposit. Rehabilitation will be conducted in stages during the life of the mine.

8.0 Conclusion

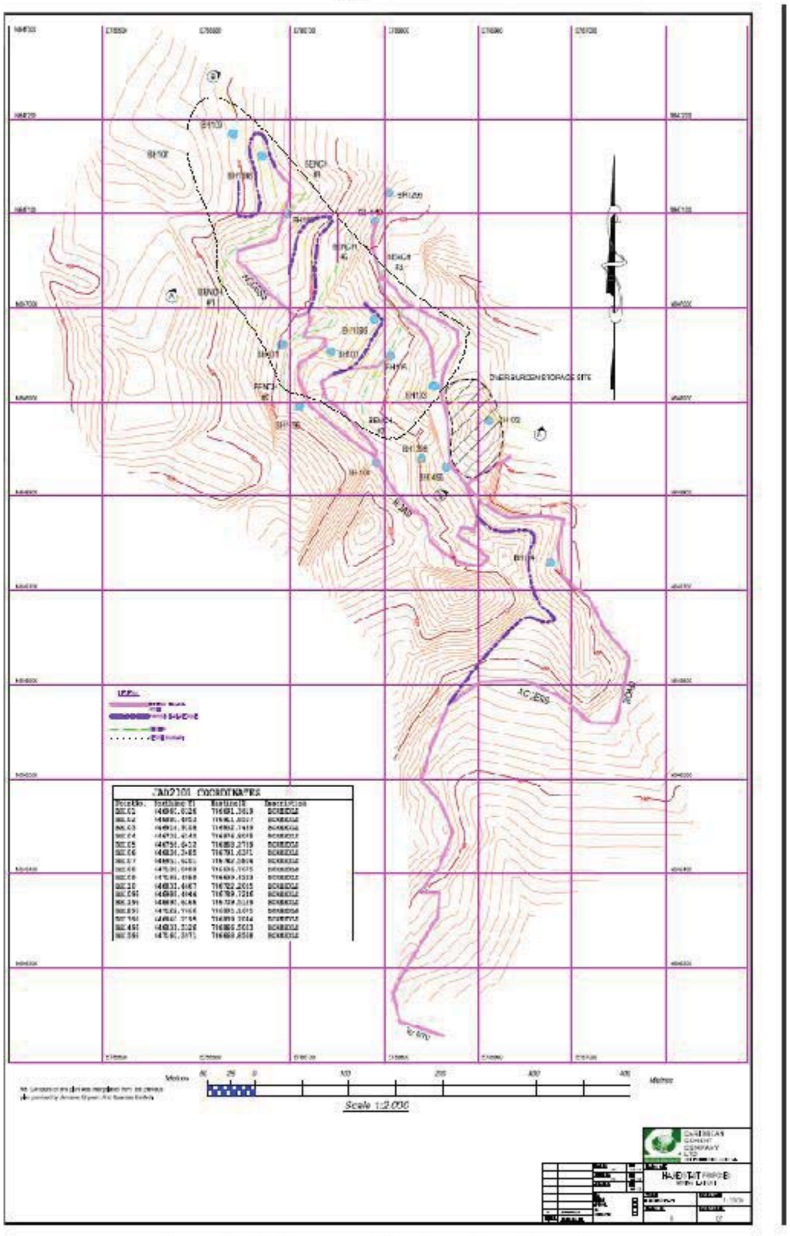
The reserves presented here are proven based on data collected from the recently concluded exploration drilling exercise. This exploration project was designed to test the accuracy of the data from previous drilling programs. All the boreholes that returned significant gypsum/anhydrite cores were terminated prior to reaching the base of the deposit. Therefore, we cannot determine the actual thickness of the sulphate unit. Additional exploration will have to be done during mining, to determine the true reserves quantity within the area.

Before any mining can occur at Halbesrtadt, a feasibility study has to be commissioned to determine the most economical way of getting the product to the customer.

The quarrying operation which has, in the past, resulted in a number of hazards will be carefully monitored by adopting proper planning and quarrying techniques, along with implementing effective mitigation strategies as outlined above. The company will operate in compliance with the Quarry Act (1983) and Mining (Safety and Health) Regulation (1977).

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

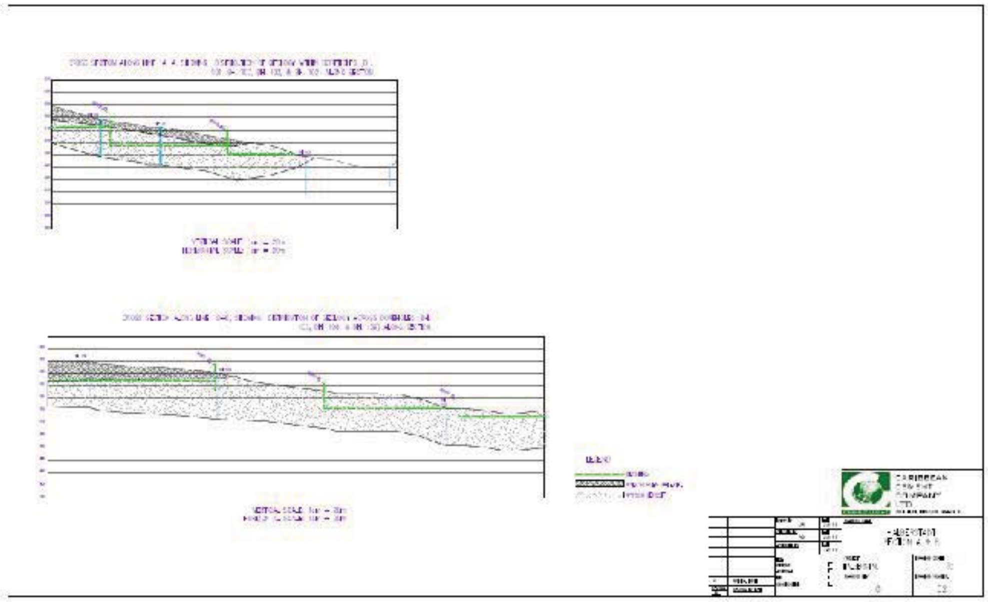
Appendix 1



Appendix 1: Proposed haul roads and benches

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

Appendix 11



Appendix 11: cross sectional view of Benches 1 and 2 on which mining will begin in 2013

JAMAICA GYPSUM & QUARRIES LTD (JGQ)

Appendix 111

Geotechnical Report conducted by NHL Engineering Limited

Appendix 5 – Jamaica Gypsum and Quarries Limited Proposed Quarry Emission Estimates

Jamaica Gypsum & Quarries Limited Proposed Quarry Emission Estimates

Emission Estimates for Haul Roads, Loading, and Unloading Operations

Emission Factor Summary	Source ID#	PM_{10}				PM			
		PM_{10} EF	lb/yr	Tpy	g/s	PM EF	lb/yr	Tpy	g/s
Road Emissions (Loaded)	RL	3.25 lb/VMT	2,762	1.25	0.04	11.44 lb/VMT	9,713	4.41	0.14
Road Emissions (Empty)	RE	1.85 lb/VMT	1,572	0.71	0.02	6.51 lb/VMT	5,527	2.51	0.08
Loading Emissions at Mine	LM	3.571E-02 lb/ton	4,976.1	2.26	0.07	7.550E-02 lb/ton	10,521.0	4.77	0.15
Unloading Emissions at Storage Pile	USP	3.571E-02 lb/ton	4,976.1	2.26	0.07	7.550E-02 lb/ton	10,521.0	4.77	0.15
Total			14,286	6	0.2		36,282	16	0.5

Emission Factor Equation and Data for Road Emissions, November 2006 AP-42

$E\ (lb/VMT) = k * (s/12)^{a} * (w/3)^{b}$

Where:

s = silt content, % (may be measured by % that passes through 200 mesh screen)

w = Weight of transport truck, loaded or unloaded, tons

k=1.5, a=0.9, b=and 0.45 are constants from EPA AP-42 Table 13.2.2-2 for PM_{10} emissions

k=4.9, a=0.7, and b=0.45 are constants from EPA AP-42 Table 13.2.2-2 for PM_{30} emissions

Unpaved Road Emission Factors were calculated based on Equation (1a) in EPA section 13.2.2 relating to Unpaved Roads
The constants for the equation above are from Table 13.2.2-2 relating to PM emissions.

Emission Factor Equation and Data for Loading/Unloading Emissions, November 2006 AP-42

$E\ (lb/ton) = k * (0.0032) * (u/5)^{1.3} * (m/2)^{1.4}$

Where:

u = mean windspeed, miles per hour

m = material moisture content, %

k=0.35 is the particle sized multiplier for particles < 10um

k=0.74 is the particle sized multiplier for particles < 30um

Loading emission factors were calculated based on Equation (1) in EPA section 13.2.4 relating to Aggregate Handling and Storage Piles. The Particle Size Multipliers are based on 10 and 30 micron diameters.

Project Data

Mass of gypsum Loaded/Unloaded =	126,400	tonne/yr (505.6 tonne/day * 50 wks/yr * 5 days/wk)
	139,356	tons/yr
Days of Operation per Year =	250	days/year
Typical Gypsum Moisture Content =	0.38	% (from Ohio State University Extension Fact Sheet, ANR-20-05)
Particle Size Multiplier (10 microns) =	0.35	(EPA page 13.2.4-4)
Particle Size Multiplier (30 microns) =	0.74	(EPA page 13.2.4-4)
Mean Wind Speed =	12.0	miles per hour - 5.36 m/s from 2011 MM5 Data for NMIA Incinerator
Approximate Silt Content of road bed =	8.3	%
Number of Days with measurable Rainfall =	43	# (using 2011 MM5 data for NMIA)
Hours of Operation per day =	8	

Unpaved Road Emission Caclulation Data

Unpaved Road Silt Loading =	8.3	% (mean value for Stone Quarrying and Processing - EPA Table 13.2.2-1)
Control Efficiency (roads are sprayed with water) =	90	% (from EPA Figure 13.2.2-2, M = 4.25)
Transport Truck Speed =	20	miles per hour
Transport Truck Distance Traveled =	0.113	miles/trip
Number of Transport Truck Trips =	600	one-way trip/day (15 trucks, round trip = 2 trips, 20 round trips/day)
Loaded Vehicle Miles Traveled =	8,494	miles/year
Empty Vehicle Miles Traveled =	8,494	miles/year
Average Weight of UnLoaded Truck =	10.0	tons (truck weight only--assumed)
Average Weight of Loaded Truck =	35.0	tons (truck weight and aggregate)

Other Calculations

Tpy = (lb/y) * (ton/2000 lb) * (tonne/1.102311 ton)
g/s = Tpy * (y/365d) * (d/24h) * (h/3600s) *(1E6g/tonne)

Emission Estimates for Quarry Storage Piles

Emission Factor Equation and Data

E = 1.9 * (s/1.5) * 365 * (365-p)/235 * (f / 15)

Where:
E = emissions, kg/ha/yr
s = silt content, % (may be measured by % that passes through 200 mesh screen)
p = number of days with > 0.25mm rainfall
f = % time that the wind is greater than 5.4 m/s

Source: (1) National Pollutant Inventory, "Emission Estimation Technique Manual for Mining Version 2.3". December 2001, Environment Australia, pp. 41.
(2)NPI references AP-42 equations for Wind Erosion (1998, Fourth Edition)

Storage Pile and Atmospheric Data

Storage Pile Description	Source ID#	Height (m)	Length (m)	Width (m)	Area (m2)	Area (ha)
Gypsum Storage Pile	GSP	20	90	55.00	4,950	0.50

4	= s, approximate Silt Content (%) of the Gypsum
43	= p, number of days with > 0.25mm rainfall
188	= number of days with an average windspeed > 5.4 m/s
51.51	= f, % of time the windspeed is > 5.4 m/s

Emissions Estimate

Storage Pile Description	Source ID#	PM/PM10 EF (kg/ha/yr)	PM/PM10 Emissions (kg/yr)	PM/PM10 Emissions (Tpy)	PM/PM10 Emissions (g/s)
Gypsum Storage Pile	GSP	8,701	4,307	4.3	0.27

Emissions lb/hr = (Tonne/year) * (2000lb/ton) / (hours disturbance/year)
Hours Disturbance/year = 8,760 hours/yr * % Windspeed is > 5.4 m/s

Emission Estimates for Crushing Operations

Emission factors obtained from USEPA AP42 Table 11.19.2-2

Emissions Estimate

PM EF (lb/ton)	PM10 EF (lb/ton)	PM Emissions (Tpy)	PM Emissions (g/s)	PM10 Emissions (Tpy)	PM10 Emissions (g/s)
0.0054	0.0024	0.3413	0.0108	0.1517	0.0048

Emissions Tpy = (lb/ton) * throughput (ton/year) * (ton/2000lb) * (tonne/1.102311ton)

Appendix 6 – Borehole Record (NHL Engineering Ltd.)

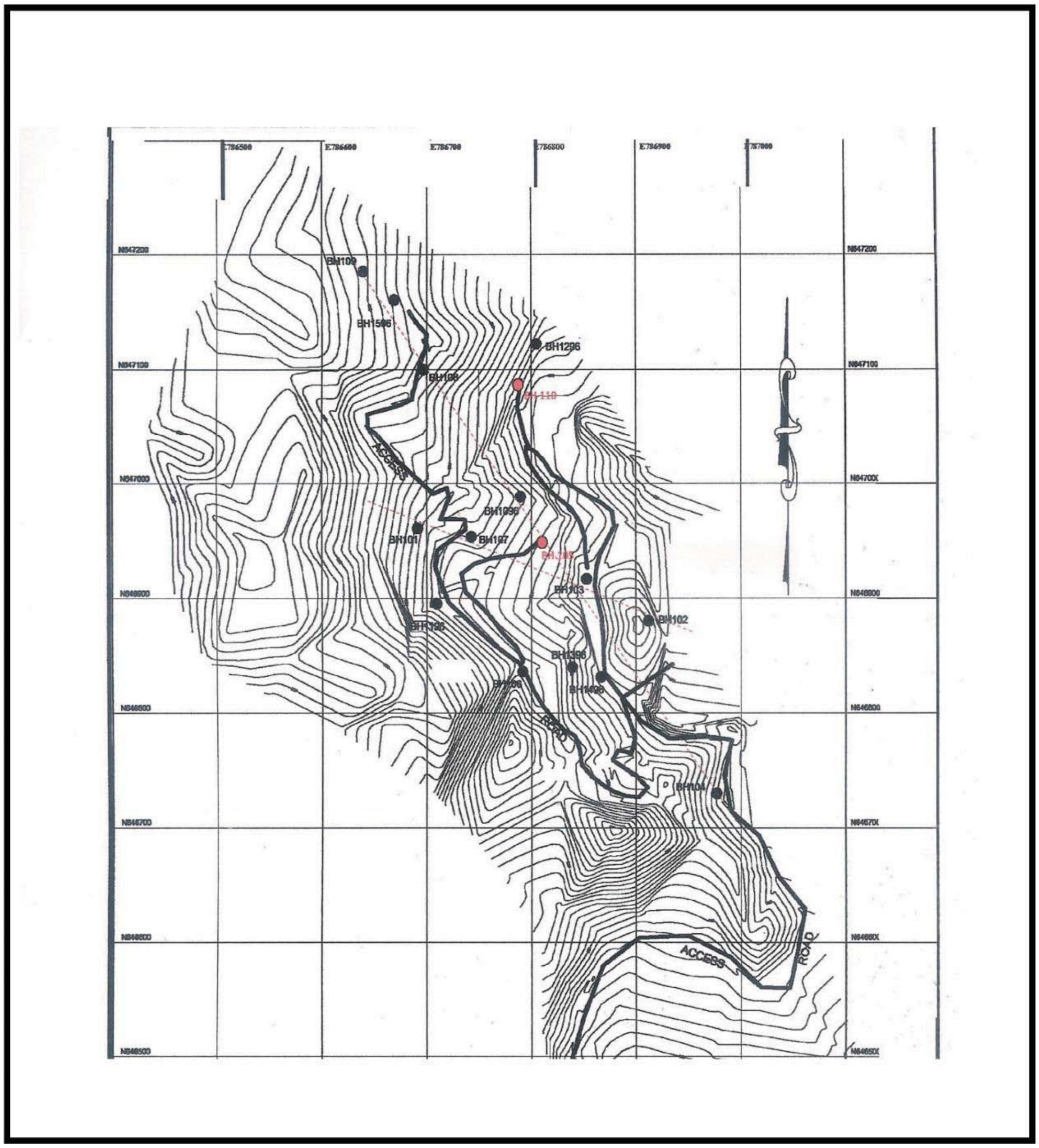
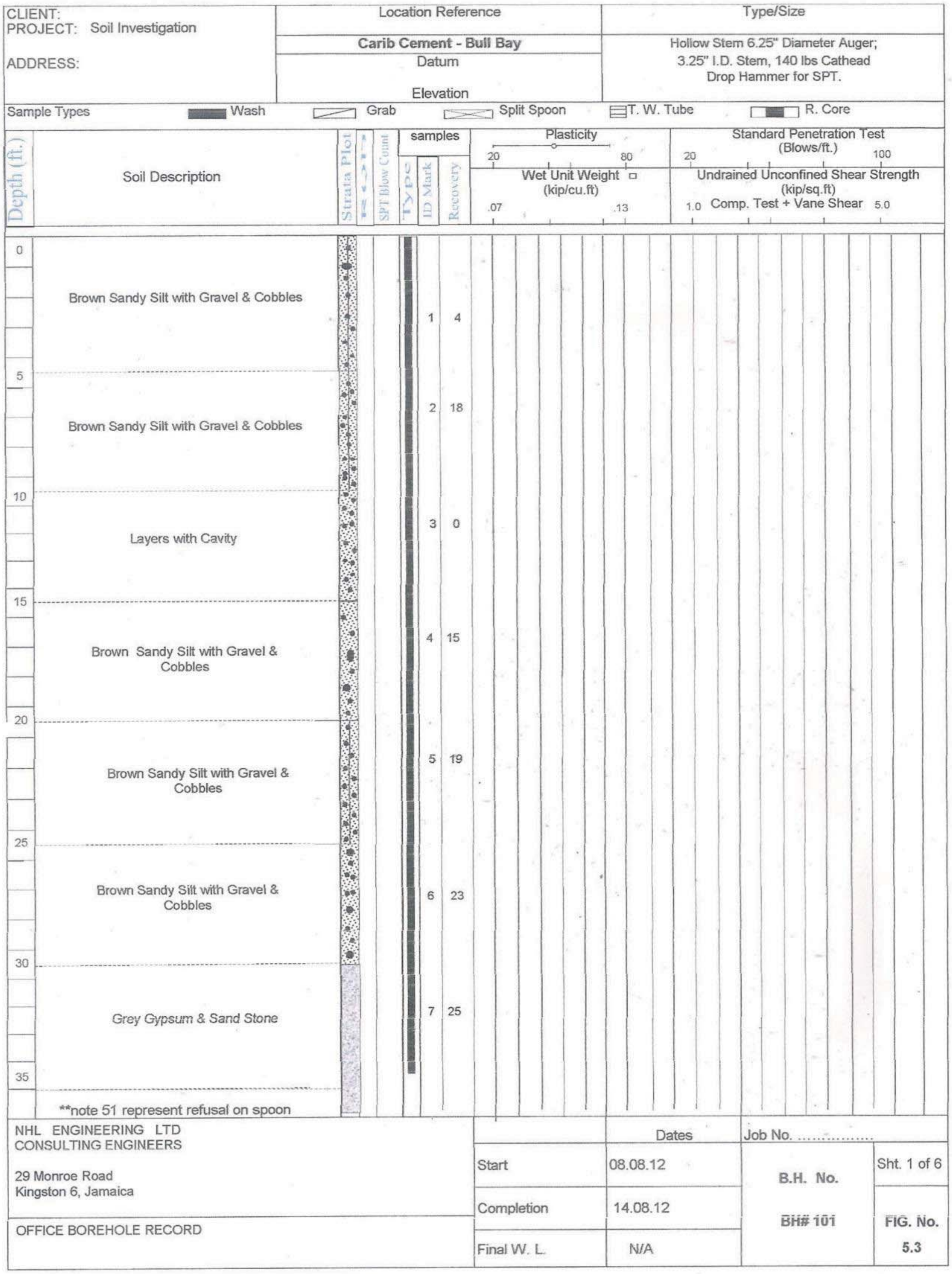


FIG. 5.2 TEST LOCATION PLAN – GYPSUM RESERVE ESTIMATION HALDERSTADT QUARRY



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ▬ Wash, ▭ Grab, ⊠ Split Spoon, ⊟ T. W. Tube, ▬ R. Core

Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	Type	ID Mark	Recovery	Plasticity 20 – 80 Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 100 Undrained Unconfined Shear Strength (kip/sq.ft) 1.0 Comp. Test + Vane Shear 5.0
0	Brown Sandy Silt with Gravel & Cobbles				1	4		
5	Brown Sandy Silt with Gravel & Cobbles				2	18		
10	Layers with Cavity				3	0		
15	Brown Sandy Silt with Gravel & Cobbles				4	15		
20	Brown Sandy Silt with Gravel & Cobbles				5	19		
25	Brown Sandy Silt with Gravel & Cobbles				6	23		
30	Grey Gypsum & Sand Stone				7	25		
35								

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

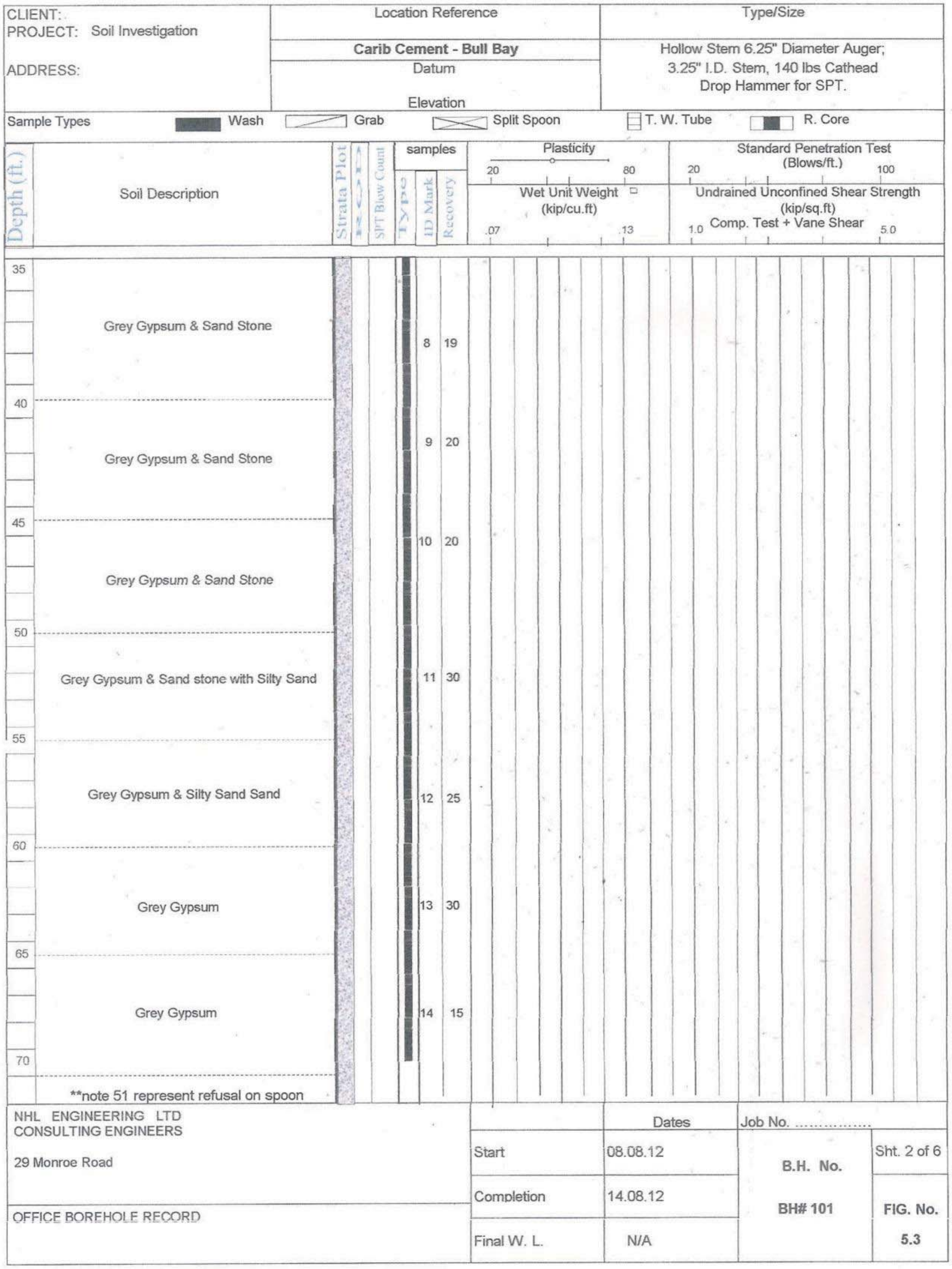
	Dates
Start	08.08.12
Completion	14.08.12
Final W. L.	N/A

Job No. ……………

B.H. No.
BH# 101

Sht. 1 of 6

FIG. No.
5.3



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▬ Wash ▭ Grab ▭ Split Spoon ▭ T. W. Tube ▭ R. Core

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	Type	ID Mark	Recovery
35	Grey Gypsum & Sand Stone				8	19
40	Grey Gypsum & Sand Stone				9	20
45	Grey Gypsum & Sand Stone				10	20
50	Grey Gypsum & Sand stone with Silty Sand				11	30
55	Grey Gypsum & Silty Sand Sand				12	25
60	Grey Gypsum				13	30
65	Grey Gypsum				14	15
70						

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road

OFFICE BOREHOLE RECORD

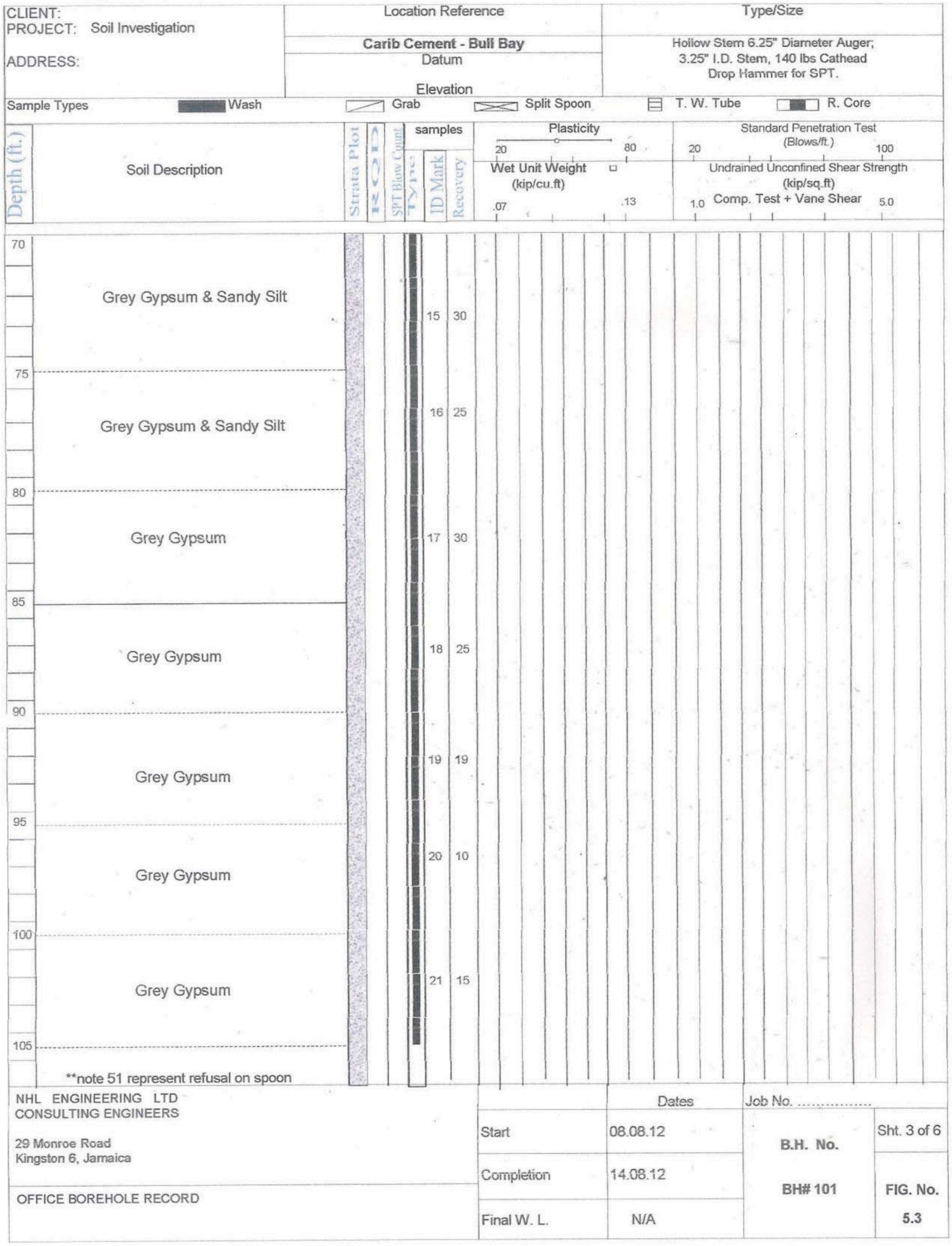
	Dates
Start	08.08.12
Completion	14.08.12
Final W. L.	N/A

Job No. ....

B.H. No.
BH# 101

Sht. 2 of 6

FIG. No.
5.3



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ▬ Wash ▱ Grab ⊠ Split Spoon ⊟ T. W. Tube ▭ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
70	Grey Gypsum & Sandy Silt					15	30
75	Grey Gypsum & Sandy Silt					16	25
80	Grey Gypsum					17	30
85	Grey Gypsum					18	25
90	Grey Gypsum					19	19
95	Grey Gypsum					20	10
100	Grey Gypsum					21	15
105							

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	08.08.12
Completion	14.08.12
Final W. L.	N/A

Job No. ....
B.H. No. BH# 101
Sht. 3 of 6
FIG. No. 5.3

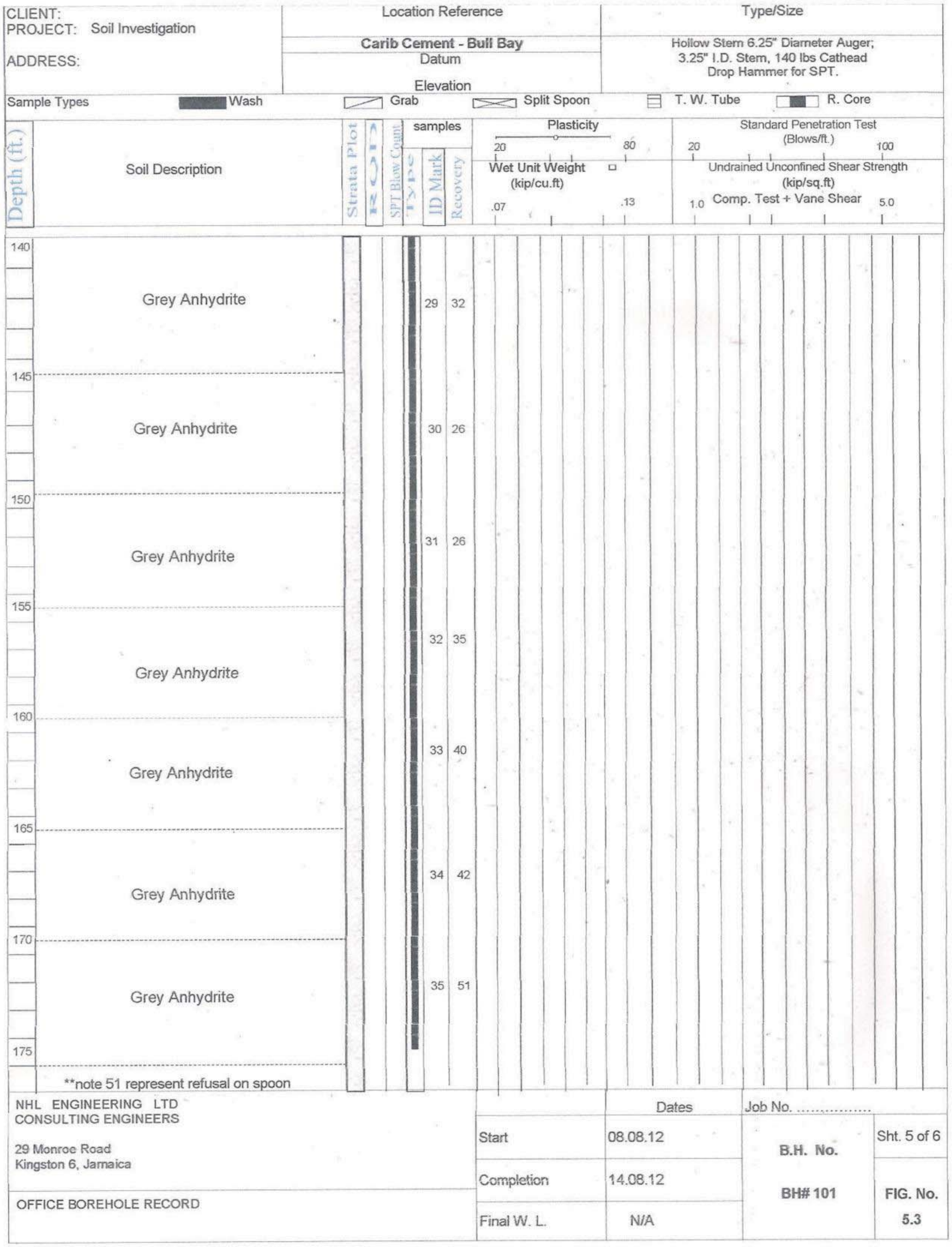
CLIENT: PROJECT: Soil Investigation ADDRESS:	Location Reference **Carib Cement - Bull Bay** Datum Elevation	Type/Size Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types ▬ Wash ◸ Grab ⊠ Split Spoon ⊟ T. W. Tube ▣ R. Core

Depth (ft.)	Soil Description	Strata Plot	R Q D	SPT Blow Count	Type	ID Mark	Recovery	Plasticity 20 – 80 Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 100 Undrained Unconfined Shear Strength (kip/sq.ft) 1.0 – 5.0 Comp. Test + Vane Shear
105	Grey Gypsum					22	22		
110	Grey Gypsum					23	25		
115	Grey Gypsum					24	30		
120	Grey Gypsum					25	25		
125	Grey Gypsum					26	30		
130	Grey Gypsum					27	28		
135	Grey Gypsum					28	26		
140									

**note 51 represent refusal on spoon

NHL ENGINEERING LTD CONSULTING ENGINEERS 29 Monroe Road Kingston 6, Jamaica		Dates	Job No.	
	Start	08.08.12	B.H. No.	Sht. 4 of 6
	Completion	14.08.12	BH# 101	FIG. No.
OFFICE BOREHOLE RECORD	Final W. L.	N/A		5.3



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types ▬ Wash ▱ Grab ⊠ Split Spoon ☐ T. W. Tube ▬ R. Core

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
140	Grey Anhydrite					29	32
145	Grey Anhydrite					30	26
150	Grey Anhydrite					31	26
155	Grey Anhydrite					32	35
160	Grey Anhydrite					33	40
165	Grey Anhydrite					34	42
170	Grey Anhydrite					35	51
175							

**note 51 represent refusal on spoon

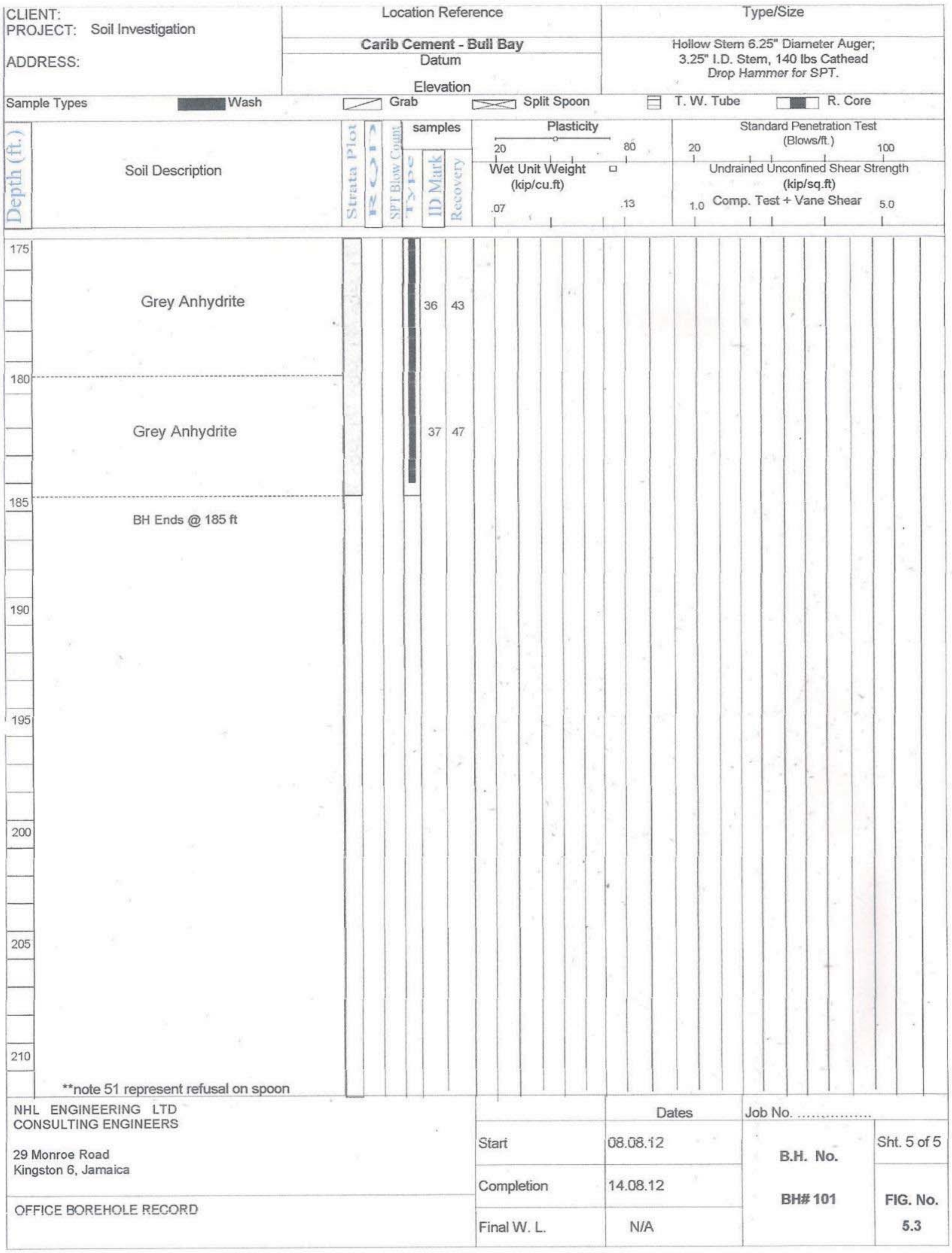
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	08.08.12
Completion	14.08.12
Final W. L.	N/A

Job No. ....
B.H. No. **BH# 101**
Sht. 5 of 6
FIG. No. 5.3



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▇ Wash ◿ Grab ☒ Split Spoon ▤ T. W. Tube ▇ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples		
					Type	ID Mark	Recovery
175	Grey Anhydrite					36	43
180	Grey Anhydrite					37	47
185	BH Ends @ 185 ft						
190							
195							
200							
205							
210							

Plasticity: 20 – 80
Wet Unit Weight (kip/cu.ft): .07 – .13
Standard Penetration Test (Blows/ft.): 20 – 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear: 1.0 – 5.0

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

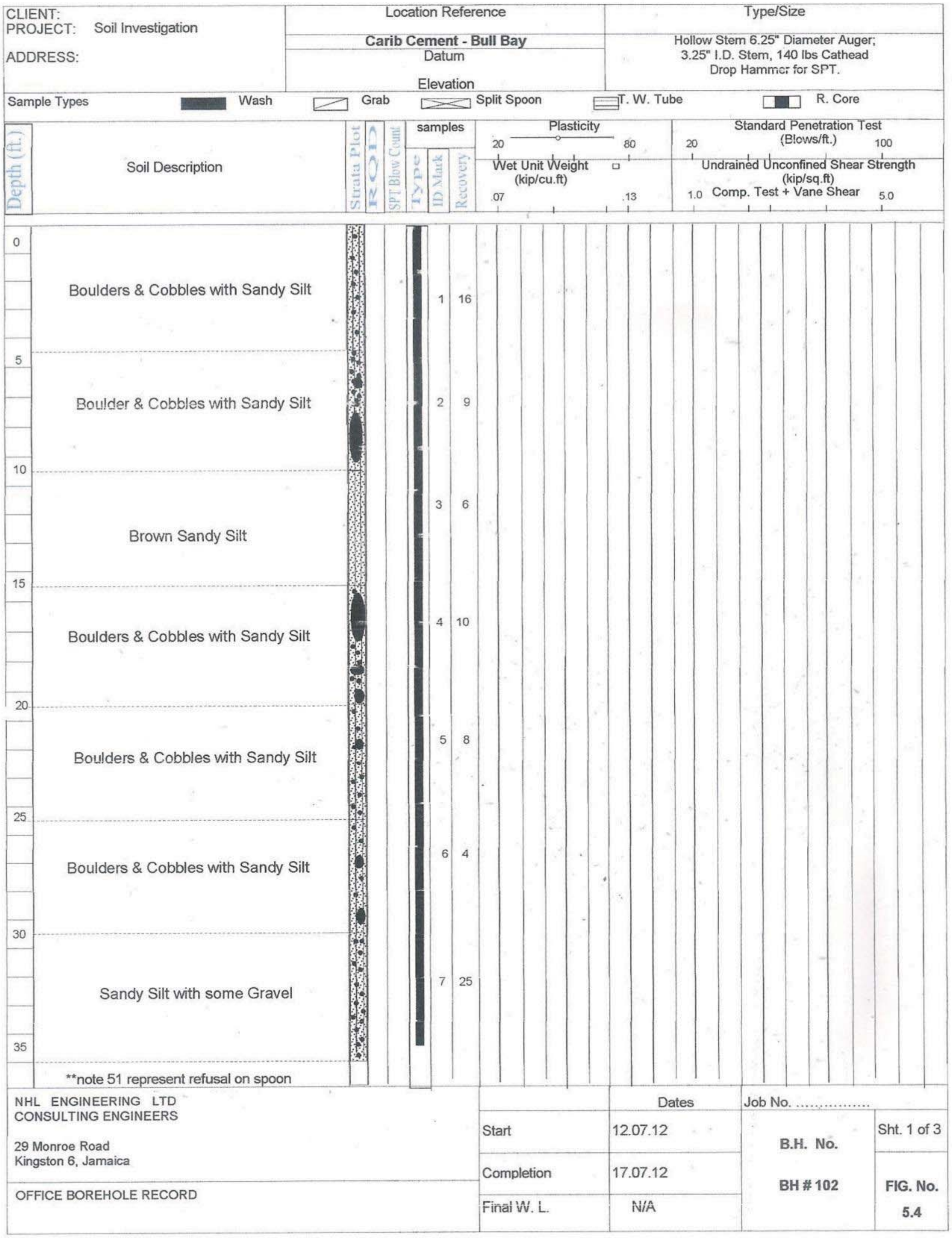
	Dates
Start	08.08.12
Completion	14.08.12
Final W. L.	N/A

Job No. ....

B.H. No. **BH# 101**

Sht. 5 of 5

FIG. No. 5.3



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference: **Carib Cement - Bull Bay**
Datum
Elevation

Type/Size: Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types: ■ Wash ▭ Grab ⊠ Split Spoon ☰ T. W. Tube ◧ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples: Type	ID Mark	Recovery	Plasticity 20 – 80 Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 100 Undrained Unconfined Shear Strength (kip/sq.ft) 1.0 Comp. Test + Vane Shear 5.0
0	Boulders & Cobbles with Sandy Silt					1	16		
5	Boulder & Cobbles with Sandy Silt					2	9		
10	Brown Sandy Silt					3	6		
15	Boulders & Cobbles with Sandy Silt					4	10		
20	Boulders & Cobbles with Sandy Silt					5	8		
25	Boulders & Cobbles with Sandy Silt					6	4		
30	Sandy Silt with some Gravel					7	25		
35									

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

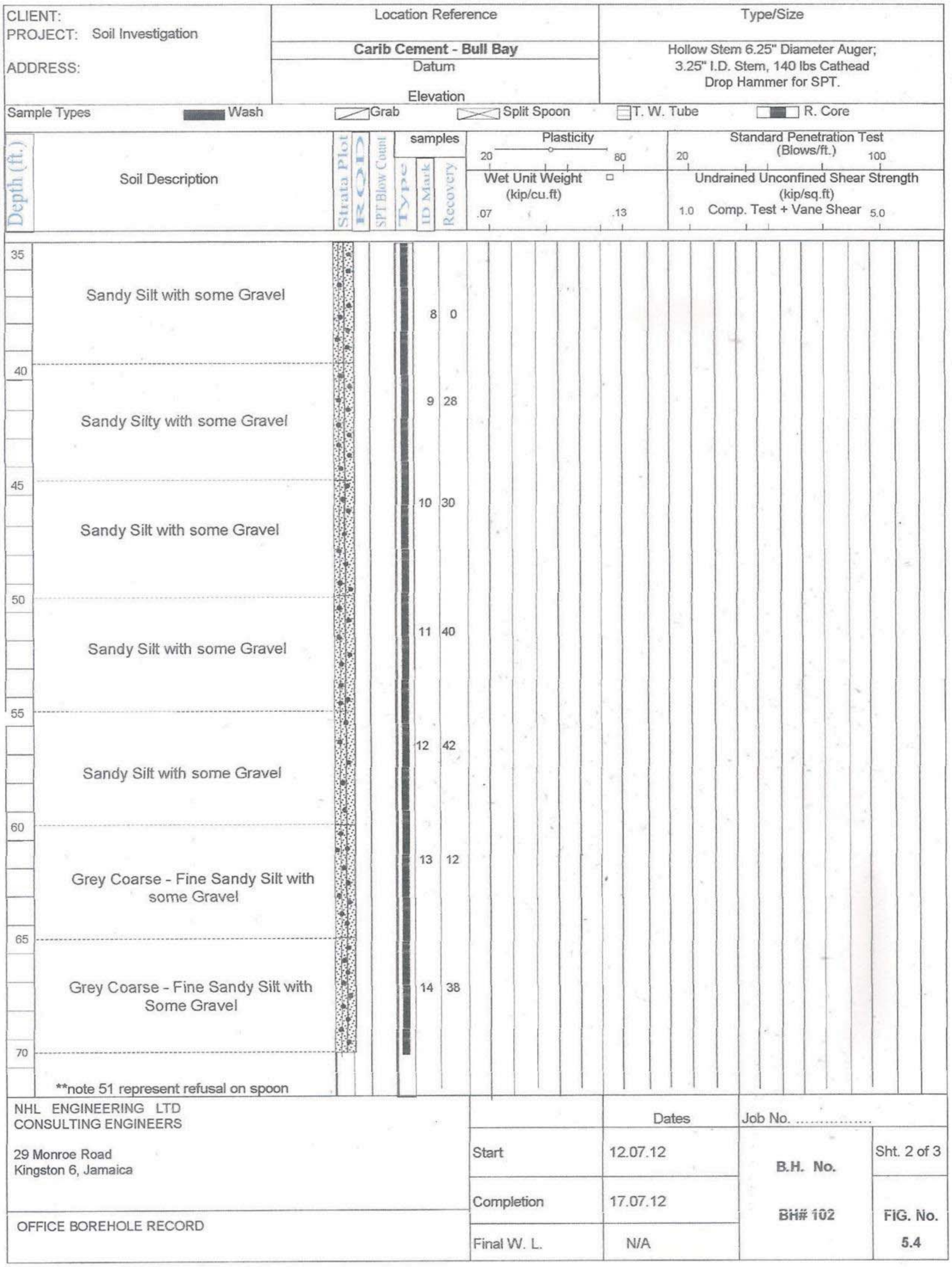
	Dates
Start	12.07.12
Completion	17.07.12
Final W. L.	N/A

Job No. ....

B.H. No. BH # 102

Sht. 1 of 3

FIG. No. 5.4



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▬ Wash ▱ Grab ▱ Split Spoon ☐ T. W. Tube ▬ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
35	Sandy Silt with some Gravel					8	0
40	Sandy Silty with some Gravel					9	28
45	Sandy Silt with some Gravel					10	30
50	Sandy Silt with some Gravel					11	40
55	Sandy Silt with some Gravel					12	42
60	Grey Coarse - Fine Sandy Silt with some Gravel					13	12
65	Grey Coarse - Fine Sandy Silt with Some Gravel					14	38
70							

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft) 1.0 Comp. Test + Vane Shear 5.0

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

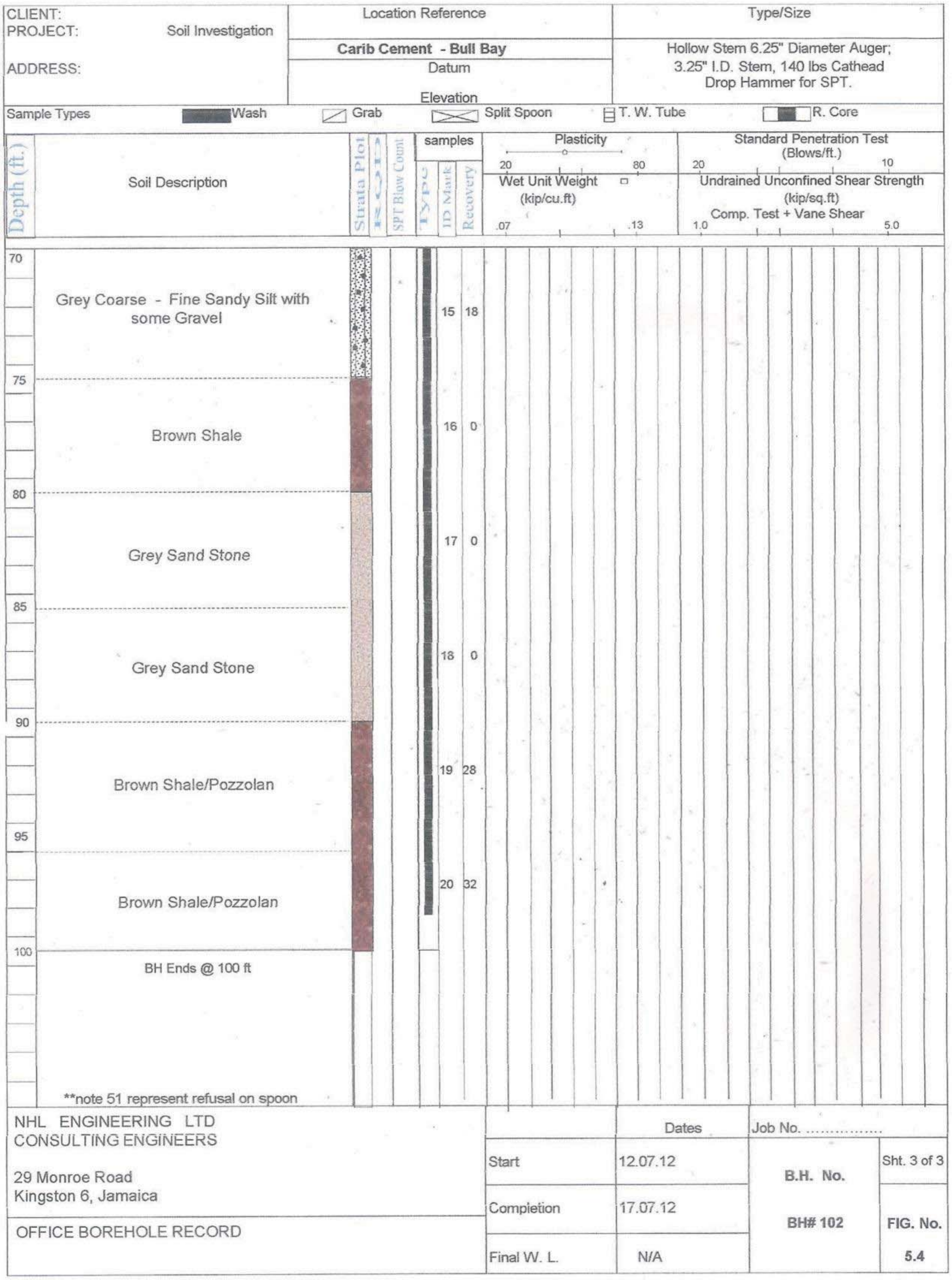
	Dates
Start	12.07.12
Completion	17.07.12
Final W. L.	N/A

Job No. ....

B.H. No.
BH# 102

Sht. 2 of 3

FIG. No.
5.4



CLIENT: PROJECT: Soil Investigation ADDRESS:	Location Reference **Carib Cement - Bull Bay** Datum Elevation		Type/Size Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types ▬ Wash ◺ Grab ⊠ Split Spoon ⊟ T. W. Tube ▭ R. Core

Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	Type	ID Mark	Recovery	Plasticity 20 – 80 Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 10 Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0
70	Grey Coarse - Fine Sandy Silt with some Gravel				15	18		
75	Brown Shale				16	0		
80	Grey Sand Stone				17	0		
85	Grey Sand Stone				18	0		
90	Brown Shale/Pozzolan				19	28		
95	Brown Shale/Pozzolan				20	32		
100	BH Ends @ 100 ft							

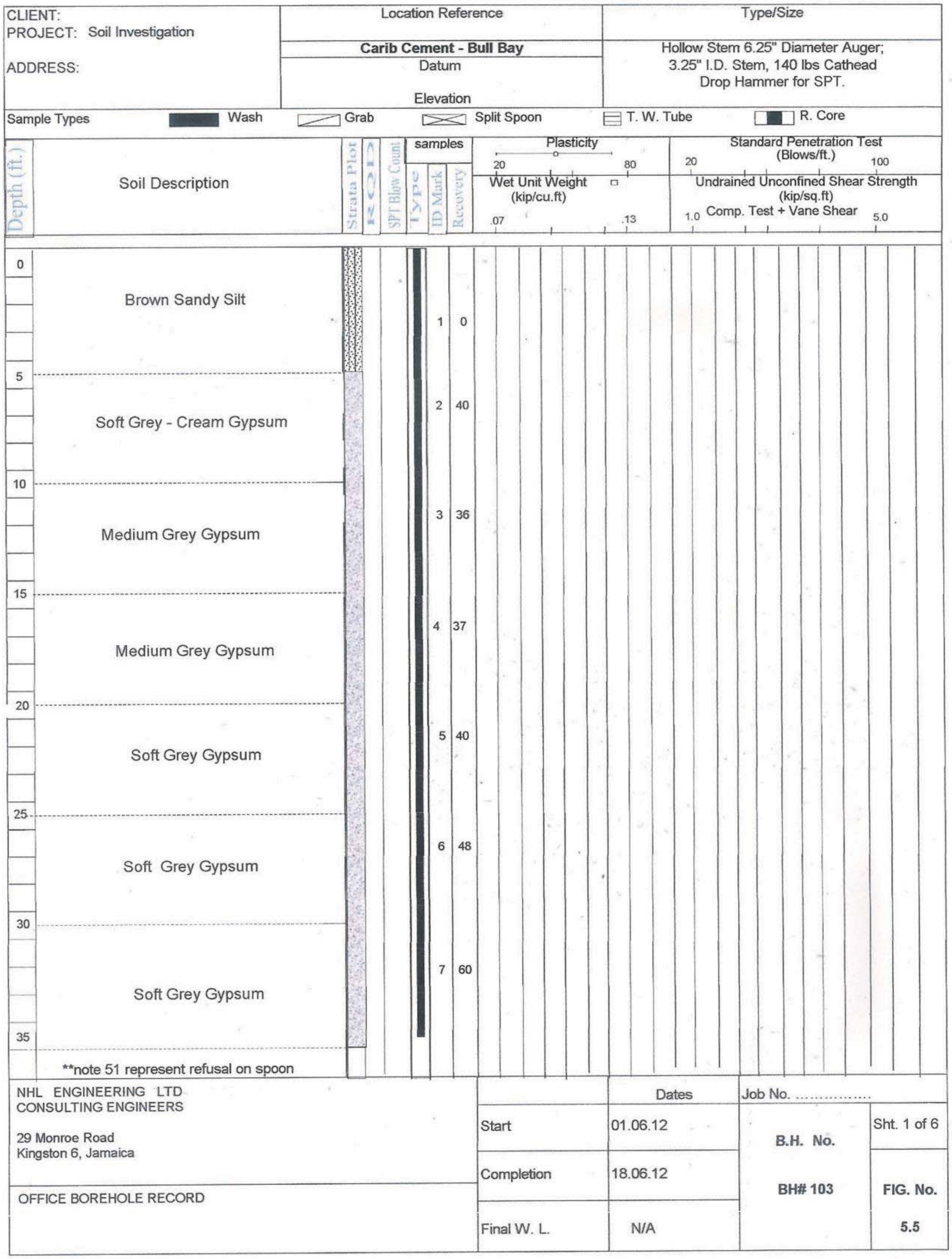
**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates	Job No.	
Start	12.07.12	B.H. No.	Sht. 3 of 3
Completion	17.07.12	BH# 102	FIG. No.
Final W. L.	N/A		5.4



CLIENT: PROJECT: Soil Investigation ADDRESS:	Location Reference **Carib Cement - Bull Bay** Datum Elevation	Type/Size Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types ■ Wash ▨ Grab ⊠ Split Spoon ⊟ T. W. Tube ◧ R. Core

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples		
					Type	ID Mark	Recovery
0	Brown Sandy Silt					1	0
5	Soft Grey - Cream Gypsum					2	40
10	Medium Grey Gypsum					3	36
15	Medium Grey Gypsum					4	37
20	Soft Grey Gypsum					5	40
25	Soft Grey Gypsum					6	48
30	Soft Grey Gypsum					7	60
35							

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates	Job No.	
Start	01.06.12	B.H. No.	Sht. 1 of 6
Completion	18.06.12	BH# 103	FIG. No.
Final W. L.	N/A		5.5

CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ▬ Wash ▱ Grab ☒ Split Spoon ☰ T. W. Tube ▭ R. Core

Plasticity 20 80 | Wet Unit Weight (kip/cu.ft) .07 .13 | Standard Penetration Test (Blows/ft.) 20 100 | Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	Strata Plot	R.Q.D.	SPT Blow Count	Type	ID Mark	Recovery
35	Soft Grey Gypsum					8	0
40	Soft Grey Gypsum					9	48
45	Soft Grey Gypsum					10	48
50	Soft Grey Gypsum					11	40
55	Grey Gypsum					12	56
60	Grey Gypsum					13	40
65	Grey Gypsum					14	40
70							

**note 51 represent refusal on spoon

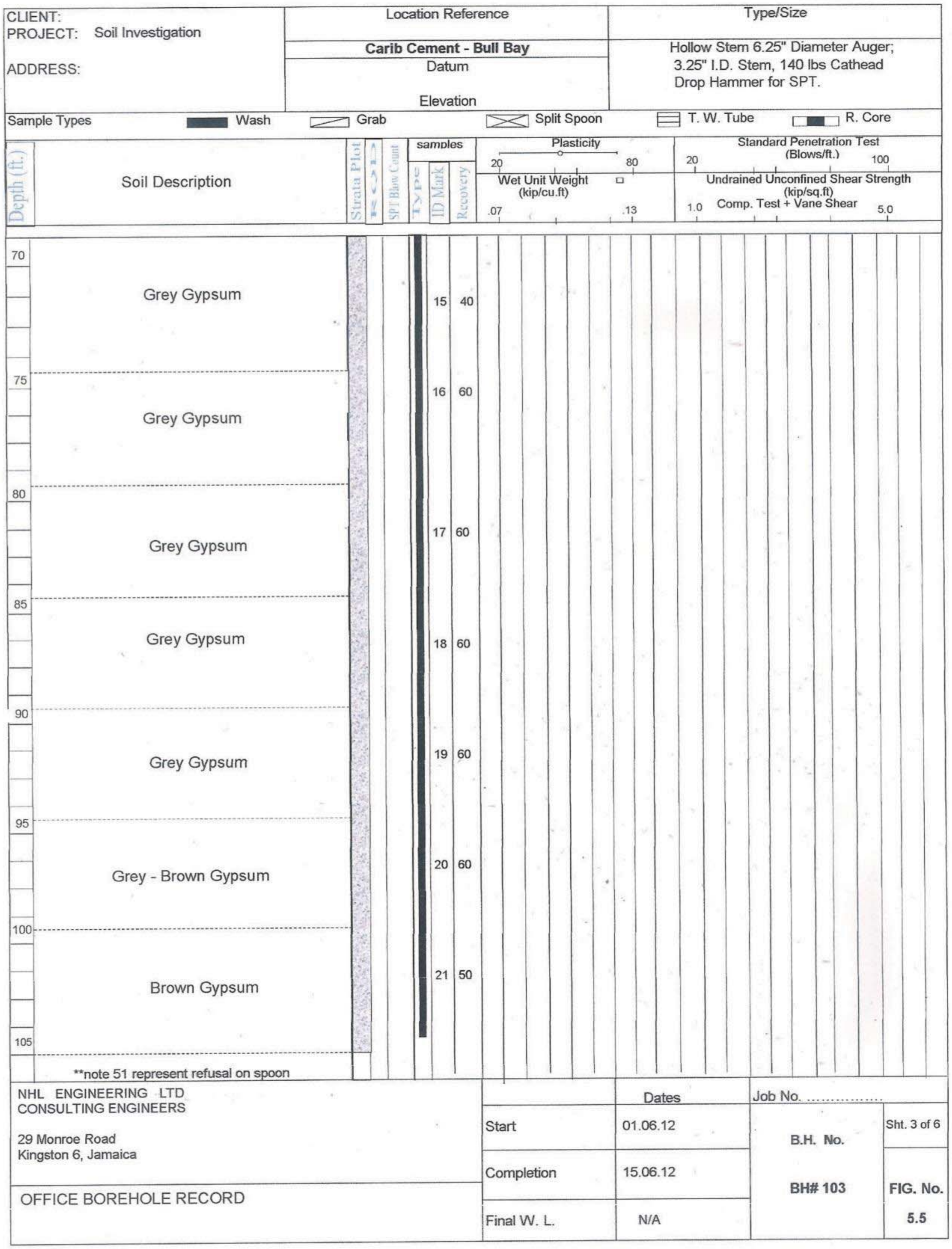
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	01.06.12
Completion	15.06.12
Final W. L.	N/A

Job No. ....
B.H. No.
BH# 103
Sht. 2 of 6
FIG. No.
5.5



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types ▬ Wash ▱ Grab ☒ Split Spoon ☰ T. W. Tube ▭ R. Core

Plasticity 20 – 80
Wet Unit Weight (kip/cu.ft) .07 – .13
Standard Penetration Test (Blows/ft.) 20 – 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0

Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	Type	ID Mark	Recovery
70	Grey Gypsum				15	40
75	Grey Gypsum				16	60
80	Grey Gypsum				17	60
85	Grey Gypsum				18	60
90	Grey Gypsum				19	60
95	Grey - Brown Gypsum				20	60
100	Brown Gypsum				21	50
105						

**note 51 represent refusal on spoon

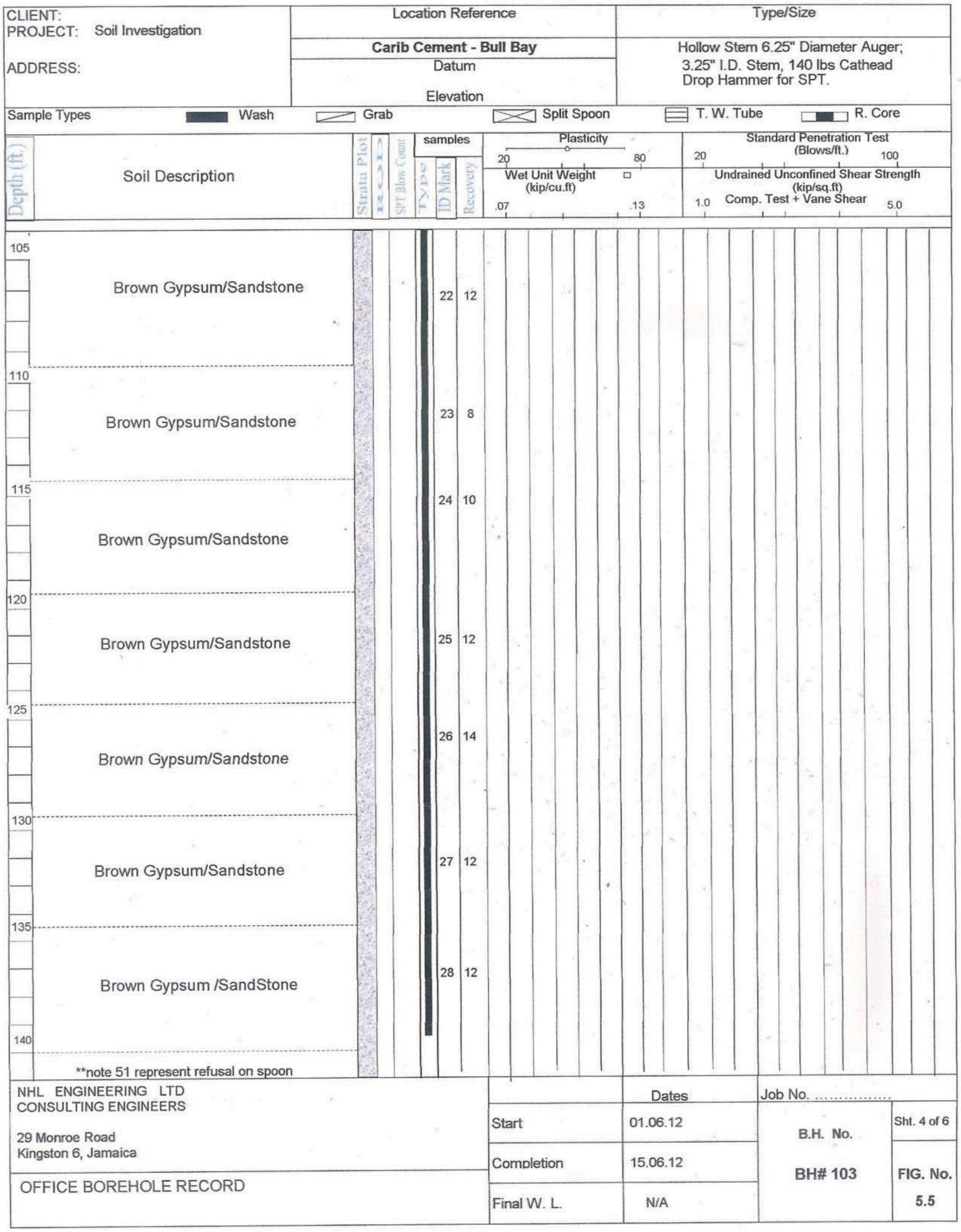
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	01.06.12
Completion	15.06.12
Final W. L.	N/A

Job No. ....
Sht. 3 of 6
B.H. No. **BH# 103**
FIG. No. **5.5**



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: Wash | Grab | Split Spoon | T. W. Tube | R. Core

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
105	Brown Gypsum/Sandstone					22	12
110	Brown Gypsum/Sandstone					23	8
115	Brown Gypsum/Sandstone					24	10
120	Brown Gypsum/Sandstone					25	12
125	Brown Gypsum/Sandstone					26	14
130	Brown Gypsum/Sandstone					27	12
135	Brown Gypsum /SandStone					28	12
140							

**note 51 represent refusal on spoon

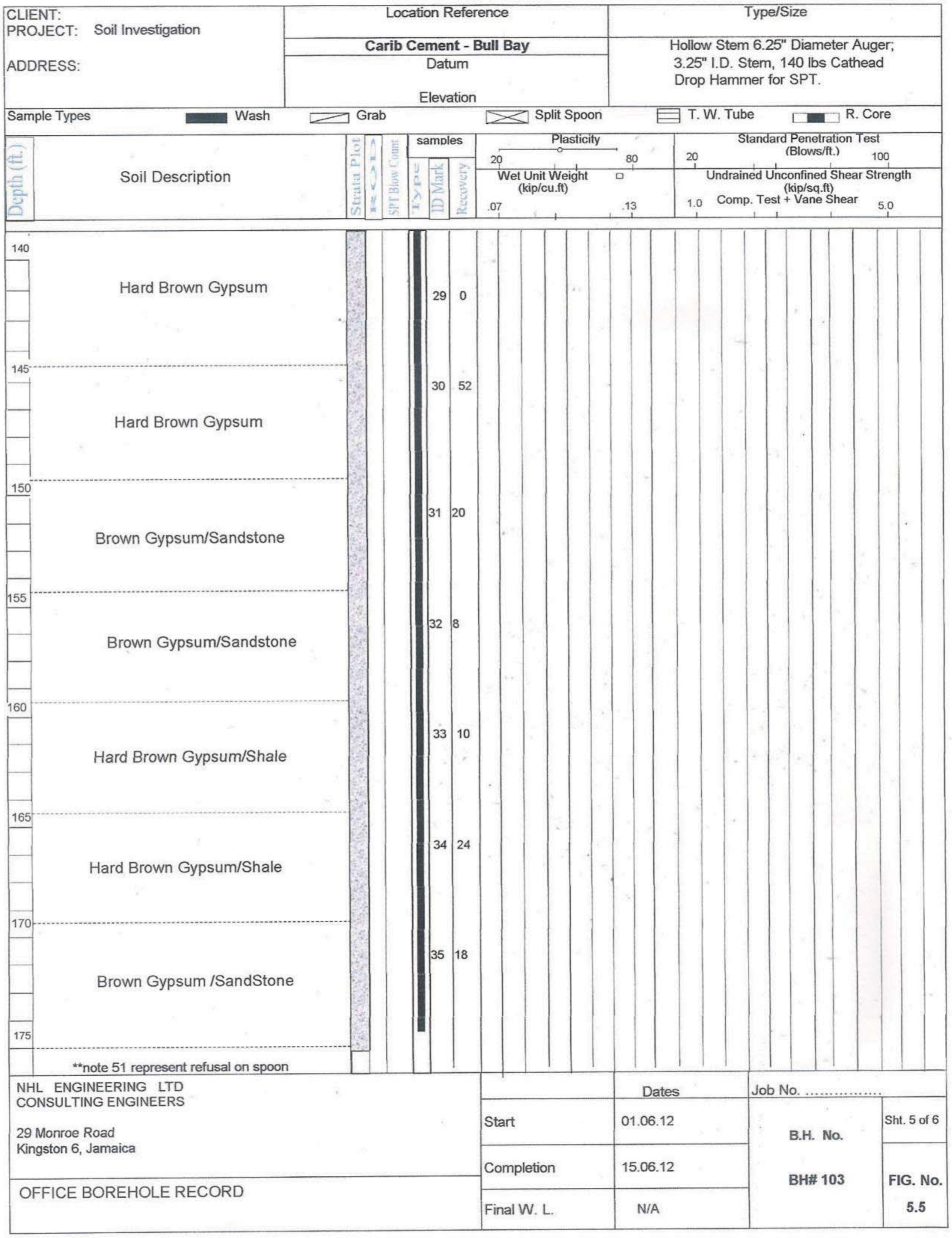
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	01.06.12
Completion	15.06.12
Final W. L.	N/A

Job No. ....
B.H. No. BH# 103
Sht. 4 of 6
FIG. No. 5.5



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▬ Wash ▱ Grab ☒ Split Spoon ▤ T. W. Tube ▭ R. Core

Plasticity 20 – 80
Wet Unit Weight (kip/cu.ft) .07 – .13
Standard Penetration Test (Blows/ft.) 20 – 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0

Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	Type	ID Mark	Recovery
140	Hard Brown Gypsum				29	0
145	Hard Brown Gypsum				30	52
150	Brown Gypsum/Sandstone				31	20
155	Brown Gypsum/Sandstone				32	8
160	Hard Brown Gypsum/Shale				33	10
165	Hard Brown Gypsum/Shale				34	24
170	Brown Gypsum /SandStone				35	18
175						

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	01.06.12
Completion	15.06.12
Final W. L.	N/A

Job No. ....
Sht. 5 of 6
B.H. No.
BH# 103
FIG. No.
5.5

CLIENT: PROJECT: Soil Investigation ADDRESS:	Location Reference **Carib Cement - Bull Bay** Datum Elevation	Type/Size Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types ■ Wash ▭ Grab ☒ Split Spoon ▤ T. W. Tube ▭■▭ R. Core

Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	samples Type	samples ID Mark	samples Recovery	Plasticity 20 – 80 Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 100 Undrained Unconfined Shear Strength (kip/sq.ft) 1.0 Comp. Test + Vane Shear 5.0
175	Brown Gypsum/Sandstone	▨		■	36	16		
180	Hard Brown Gypsum/Shale	▨		■	37	36		
185	BH Ends @ 185 ft							
190								
195								
200								

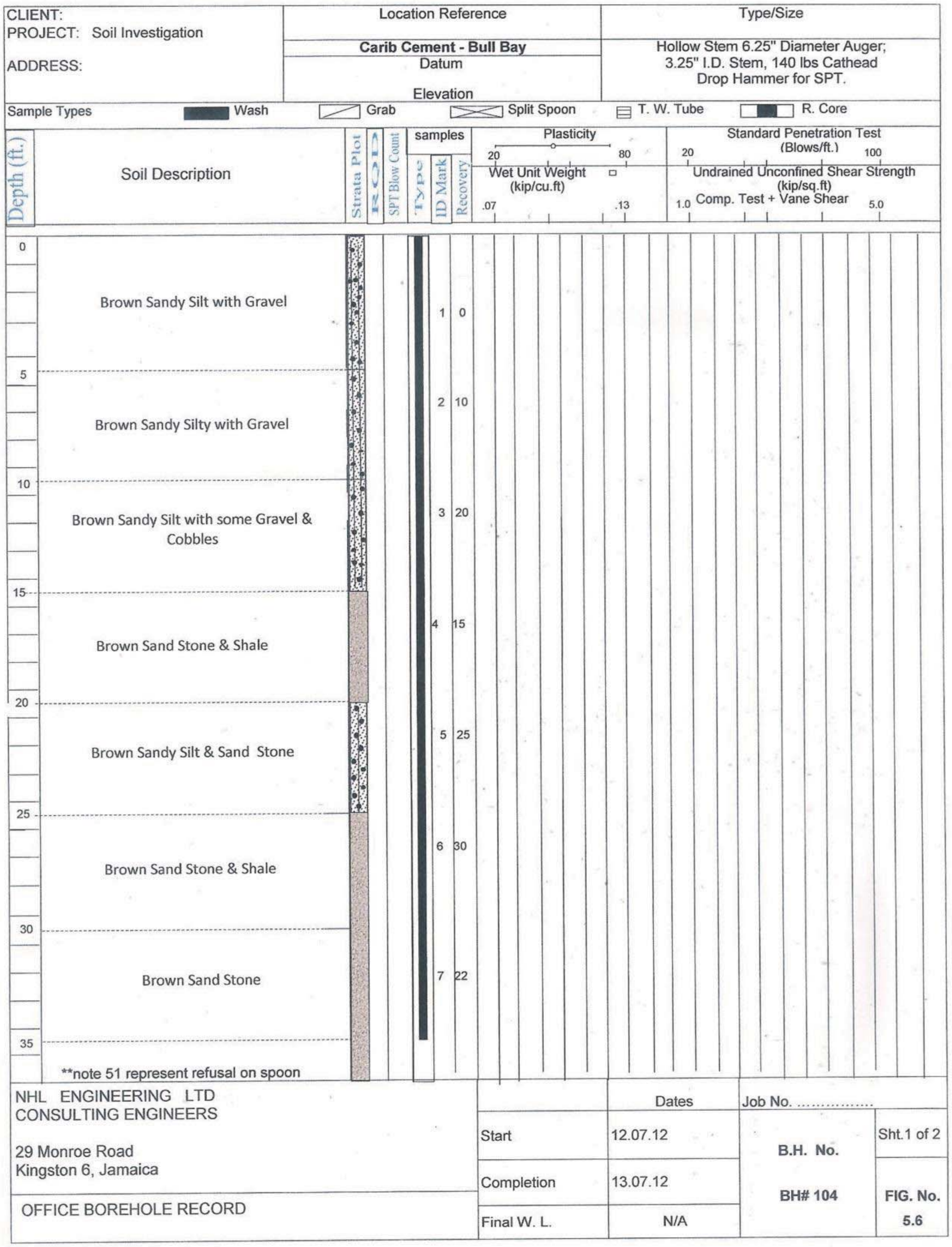
**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates	Job No.	
Start	01.06.12	B.H. No.	Sht. 6 of 6
Completion	15.06.12	BH# 103	FIG. No.
Final W. L.	N/A		5.5



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types: ▬ Wash · Grab · Split Spoon · T. W. Tube · R. Core

Plasticity 20 – 80 · Wet Unit Weight (kip/cu.ft) .07 – .13
Standard Penetration Test (Blows/ft.) 20 – 100 · Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0

Depth (ft.)	Soil Description	ID Mark	Recovery
0	Brown Sandy Silt with Gravel	1	0
5	Brown Sandy Silty with Gravel	2	10
10	Brown Sandy Silt with some Gravel & Cobbles	3	20
15	Brown Sand Stone & Shale	4	15
20	Brown Sandy Silt & Sand Stone	5	25
25	Brown Sand Stone & Shale	6	30
30	Brown Sand Stone	7	22
35			

**note 51 represent refusal on spoon

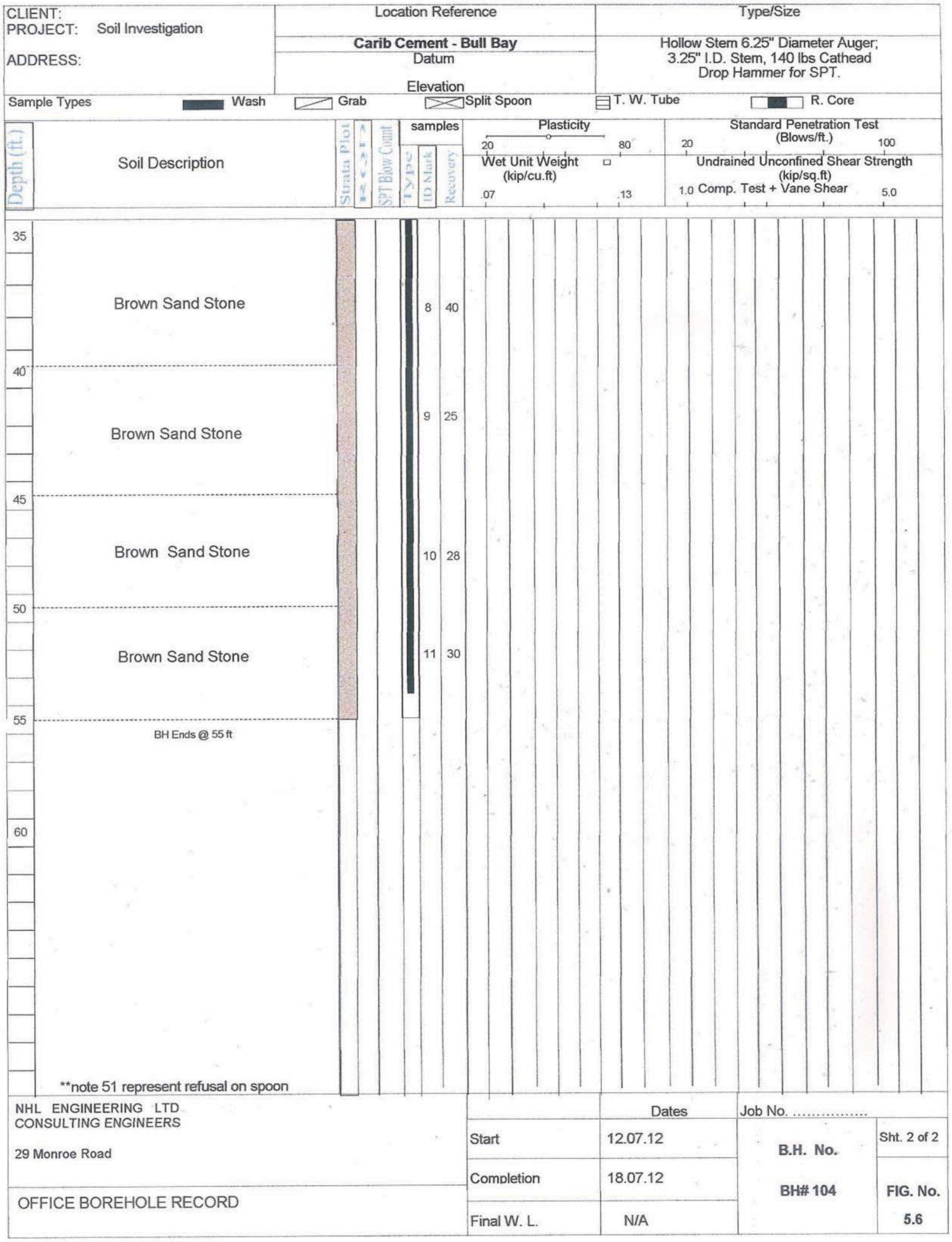
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	12.07.12
Completion	13.07.12
Final W. L.	N/A

Job No. ....
Sht.1 of 2
B.H. No. BH# 104
FIG. No. 5.6



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ▬ Wash ▱ Grab ☒ Split Spoon ▤ T. W. Tube ▭ R. Core

Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	Type	ID Mark	Recovery	Plasticity 20 – 80 Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 100 Undrained Unconfined Shear Strength (kip/sq.ft) 1.0 Comp. Test + Vane Shear 5.0
35	Brown Sand Stone				8	40		
40	Brown Sand Stone				9	25		
45	Brown Sand Stone				10	28		
50	Brown Sand Stone				11	30		
55	BH Ends @ 55 ft							
60								

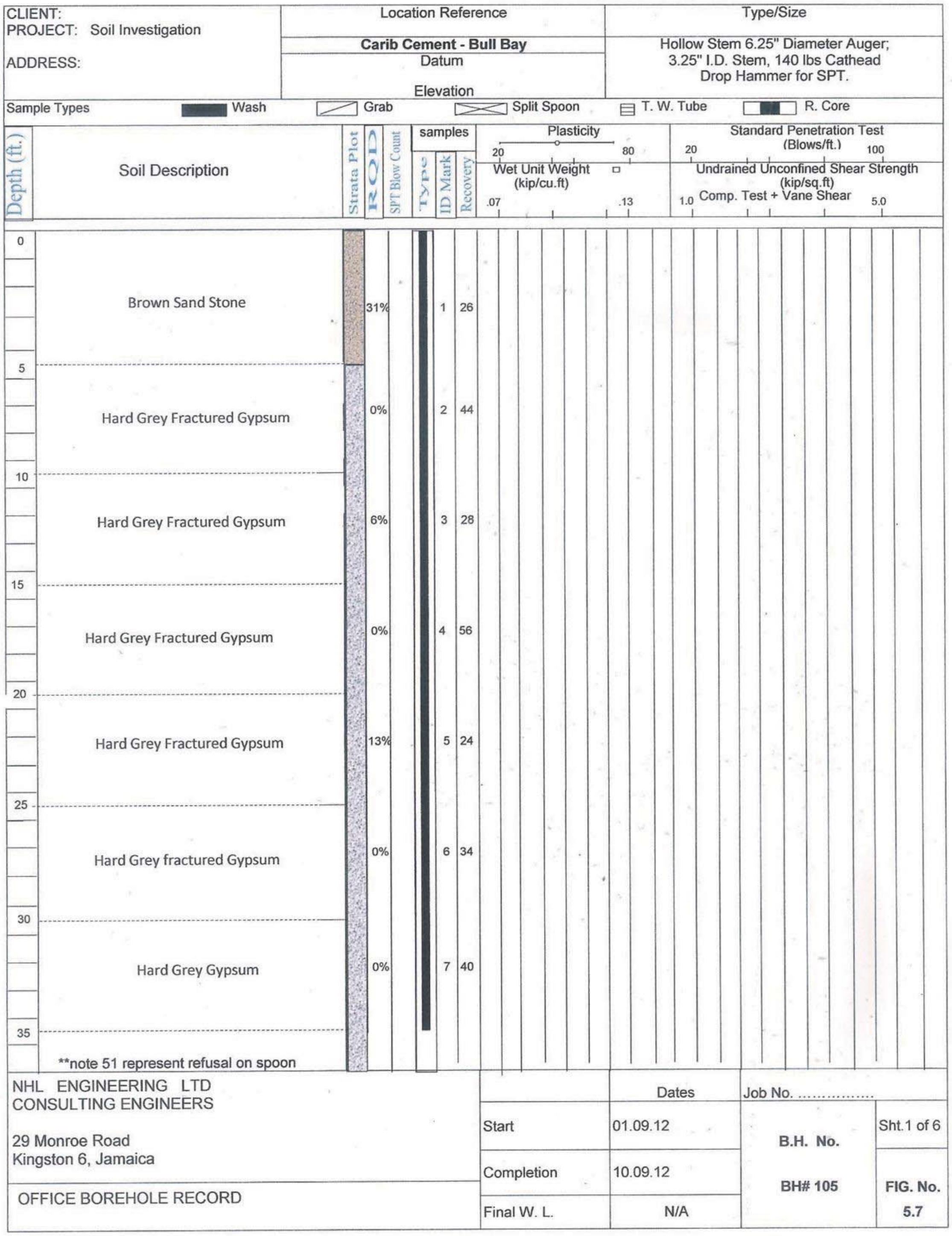
**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS
29 Monroe Road

OFFICE BOREHOLE RECORD

	Dates
Start	12.07.12
Completion	18.07.12
Final W. L.	N/A

Job No. ....
B.H. No. **BH# 104**
Sht. 2 of 2
FIG. No. 5.6



CLIENT: PROJECT: Soil Investigation ADDRESS:	Location Reference **Carib Cement - Bull Bay** Datum Elevation	Type/Size Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types ■ Wash ▭ Grab ⊠ Split Spoon ⊟ T. W. Tube ▣ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples Type	samples ID Mark	samples Recovery	Plasticity 20 80 Wet Unit Weight (kip/cu.ft) .07 .13	Standard Penetration Test (Blows/ft.) 20 100 Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0
0	Brown Sand Stone		31%		■	1	26		
5	Hard Grey Fractured Gypsum		0%		■	2	44		
10	Hard Grey Fractured Gypsum		6%		■	3	28		
15	Hard Grey Fractured Gypsum		0%		■	4	56		
20	Hard Grey Fractured Gypsum		13%		■	5	24		
25	Hard Grey fractured Gypsum		0%		■	6	34		
30	Hard Grey Gypsum		0%		■	7	40		
35									

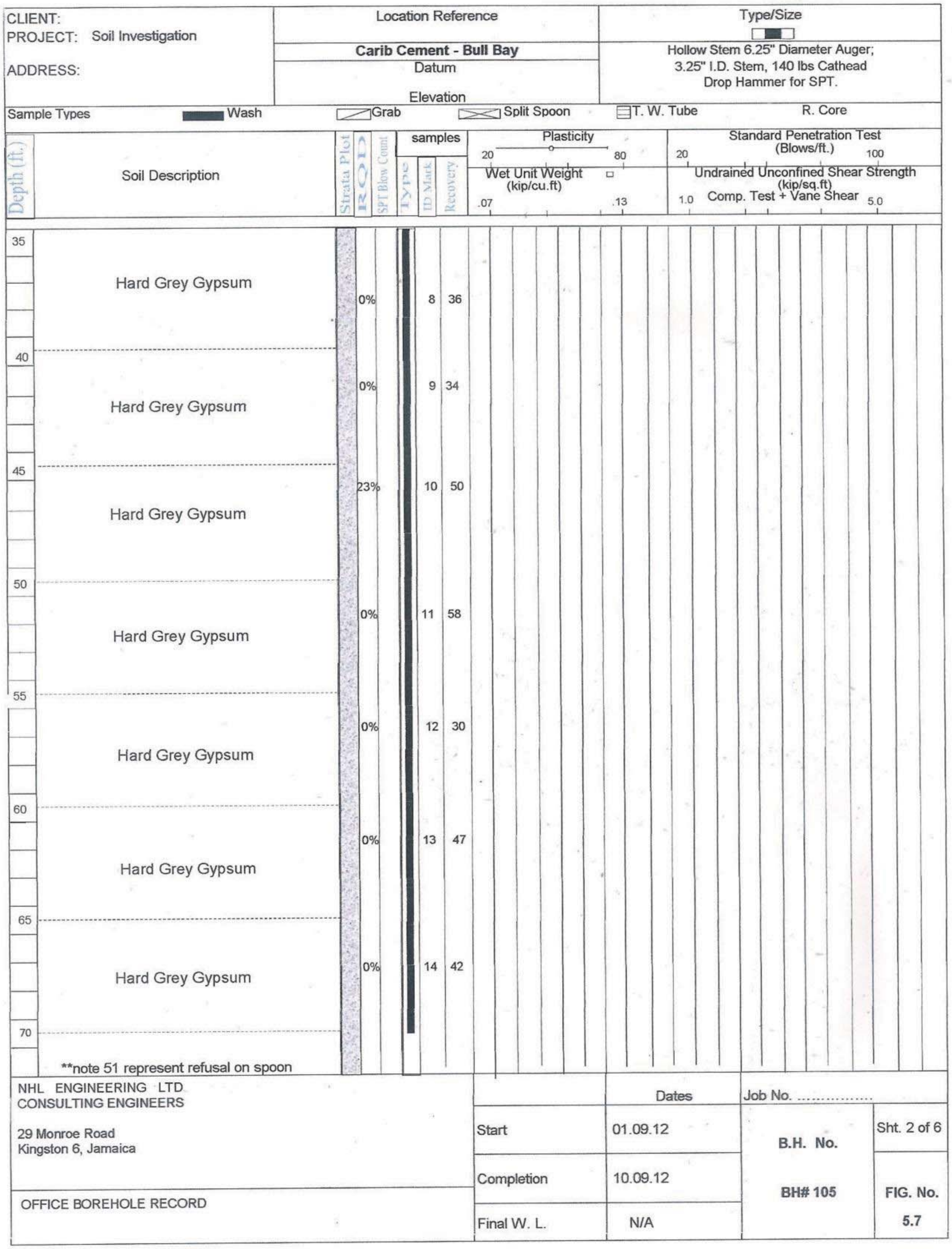
**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates	Job No.	
Start	01.09.12	**B.H. No.**	Sht.1 of 6
Completion	10.09.12	**BH# 105**	**FIG. No.**
Final W. L.	N/A		**5.7**



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▬ Wash ▭ Grab ⊠ Split Spoon ⊟ T. W. Tube R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples Type	samples ID Mark	samples Recovery	Plasticity 20 – 80 Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 100 Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0
35	Hard Grey Gypsum		0%			8	36		
40	Hard Grey Gypsum		0%			9	34		
45	Hard Grey Gypsum		23%			10	50		
50	Hard Grey Gypsum		0%			11	58		
55	Hard Grey Gypsum		0%			12	30		
60	Hard Grey Gypsum		0%			13	47		
65	Hard Grey Gypsum		0%			14	42		
70									

**note 51 represent refusal on spoon

NHL ENGINEERING LTD.
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates	Job No.	
Start	01.09.12	B.H. No.	Sht. 2 of 6
Completion	10.09.12	BH# 105	FIG. No.
Final W. L.	N/A		5.7

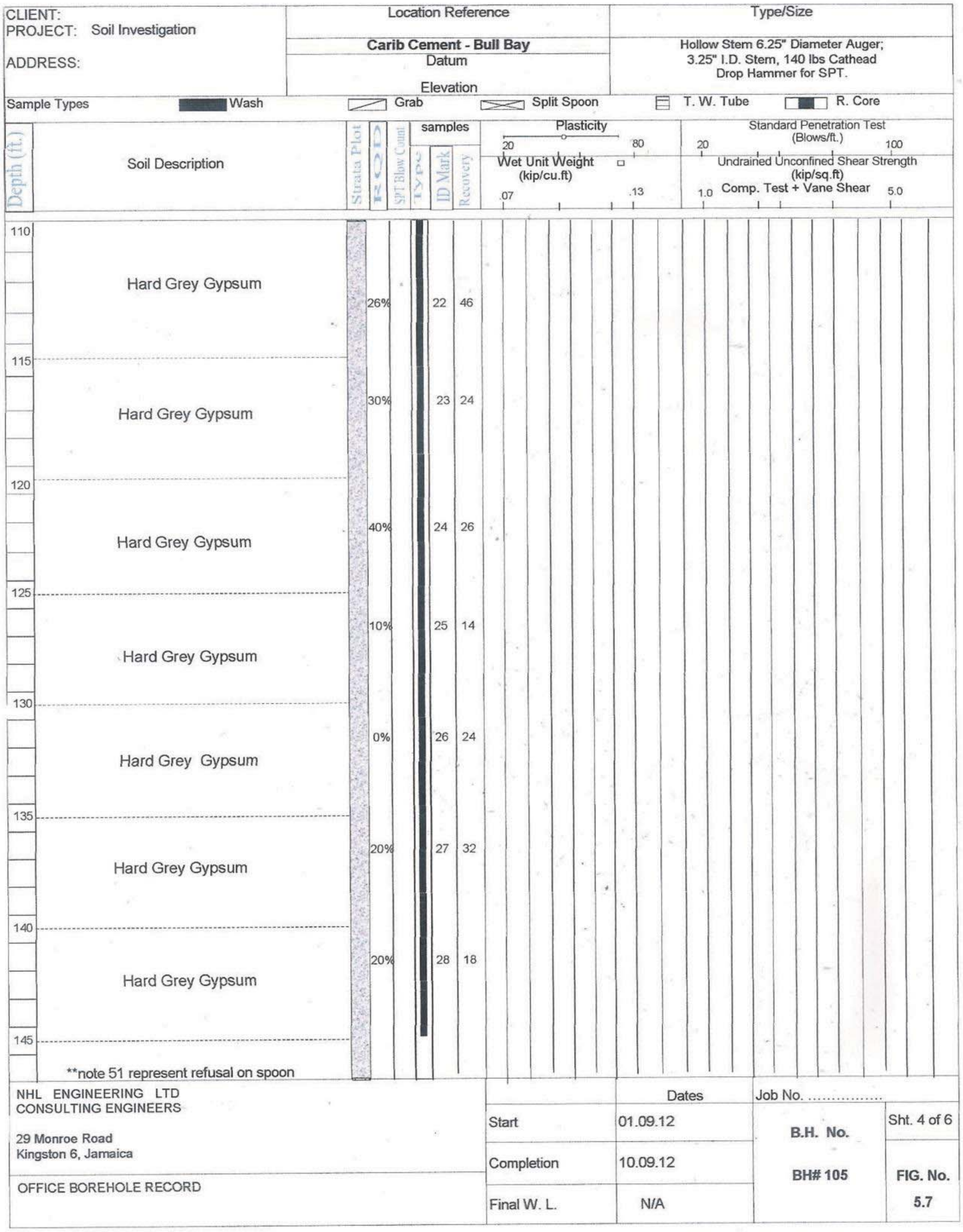
CLIENT: PROJECT: Soil Investigation ADDRESS:	Location Reference **Carib Cement - Bull Bay** Datum Elevation	Type/Size Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types ■ Wash ▨ Grab ⊠ Split Spoon ⊟ T. W. Tube ◨ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples Type	ID Mark	Recovery	Plasticity 20 – 80 Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 10 Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0
70	Hard Grey Gypsum		0%			15	60		
75	Hard Grey Gypsum		35%			16	30		
80	Hard Grey Gypsum		18%			17	30		
85	Hard Grey Gypsum		23%			18	30		
90	Hard Grey Gypsum		46%			19	30		
95	Hard Grey Gypsum		40%			20	28		
100	Hard Grey Gypsum		20%			21	30		
105									

**note 51 represent refusal on spoon

NHL ENGINEERING LTD CONSULTING ENGINEERS 29 Monroe Road Kingston 6, Jamaica		Dates	Job No.	
	Start	01.09.12	B.H. No.	Sht. 3 of 6
	Completion	10.09.12	BH# 105	FIG. No.
OFFICE BOREHOLE RECORD	Final W. L.	N/A		5.7



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▬ Wash ▱ Grab ⊠ Split Spoon ▤ T. W. Tube ■ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
110	Hard Grey Gypsum		26%			22	46
115	Hard Grey Gypsum		30%			23	24
120	Hard Grey Gypsum		40%			24	26
125	Hard Grey Gypsum		10%			25	14
130	Hard Grey Gypsum		0%			26	24
135	Hard Grey Gypsum		20%			27	32
140	Hard Grey Gypsum		20%			28	18
145							

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

**note 51 represent refusal on spoon

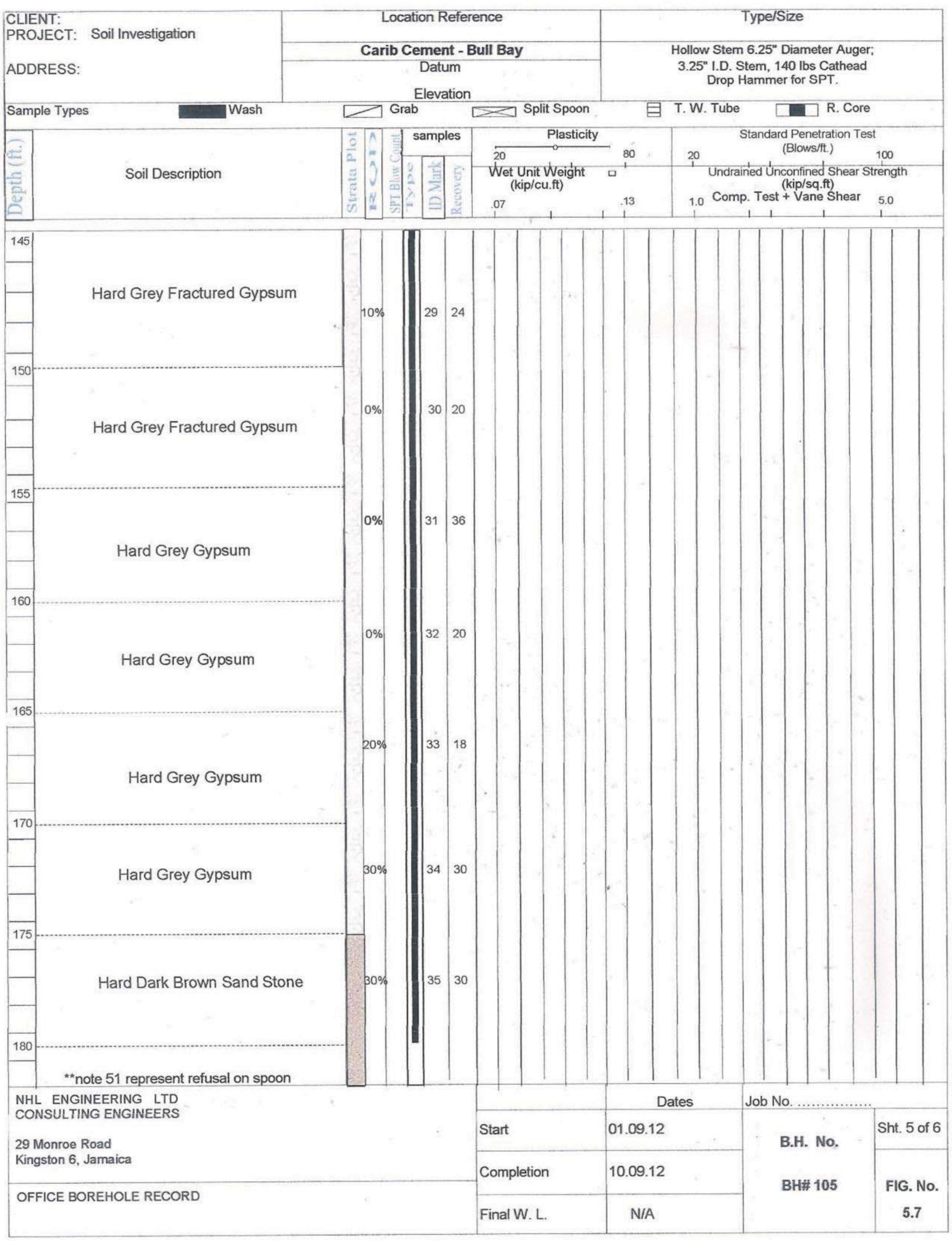
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	01.09.12
Completion	10.09.12
Final W. L.	N/A

Job No. ....
B.H. No.
BH# 105
Sht. 4 of 6
FIG. No.
5.7



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ■ Wash · ▱ Grab · ☒ Split Spoon · ⊟ T. W. Tube · ■ R. Core

Plasticity 20 — 80
Wet Unit Weight (kip/cu.ft) .07 — .13
Standard Penetration Test (Blows/ft.) 20 — 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 — 5.0

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
145	Hard Grey Fractured Gypsum		10%			29	24
150	Hard Grey Fractured Gypsum		0%			30	20
155	Hard Grey Gypsum		0%			31	36
160	Hard Grey Gypsum		0%			32	20
165	Hard Grey Gypsum		20%			33	18
170	Hard Grey Gypsum		30%			34	30
175	Hard Dark Brown Sand Stone		30%			35	30
180							

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

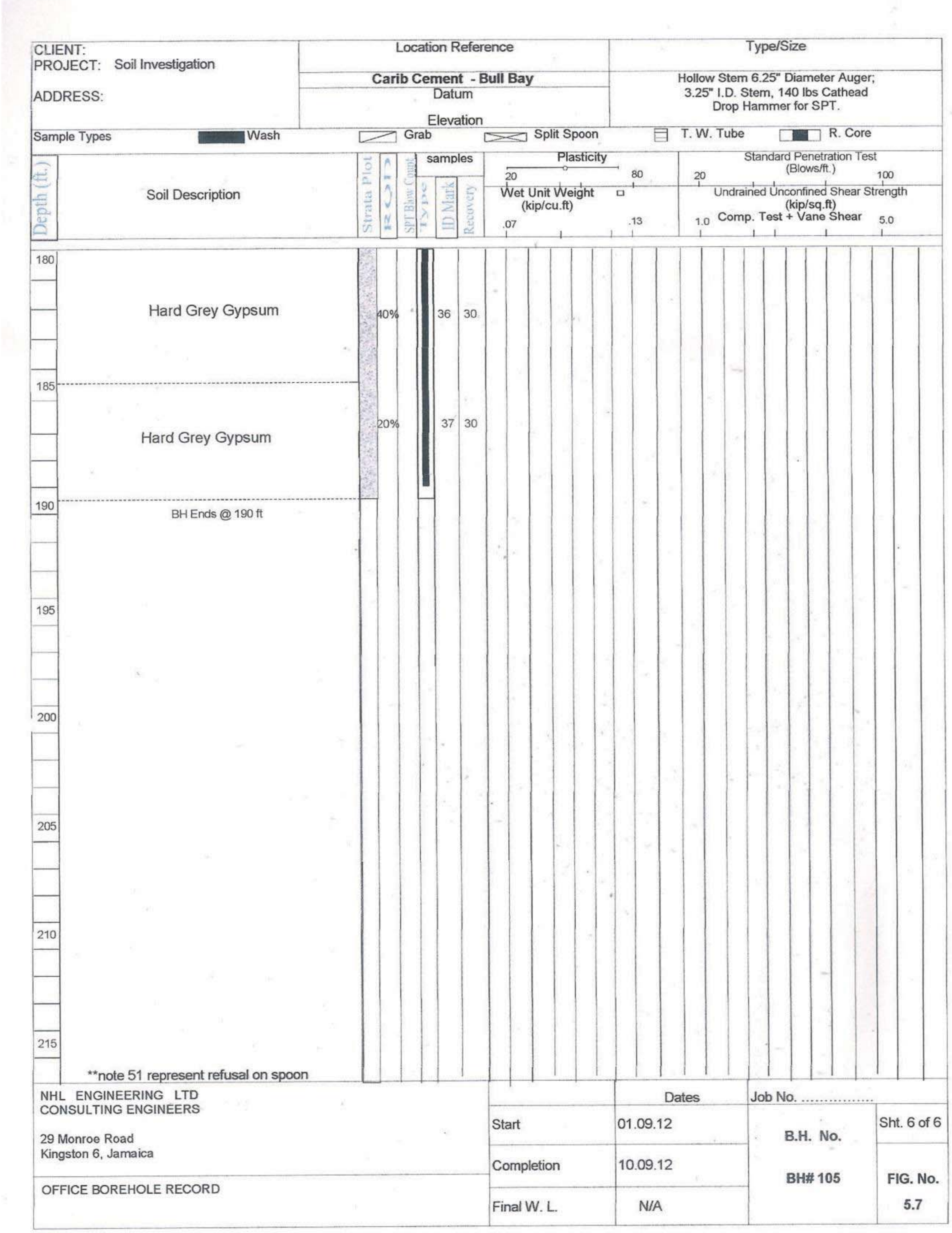
	Dates
Start	01.09.12
Completion	10.09.12
Final W. L.	N/A

Job No. ....

B.H. No.
BH# 105

Sht. 5 of 6

FIG. No.
5.7



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▇ Wash ⧄ Grab ⋈ Split Spoon ☐ T. W. Tube ▣ R. Core

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft)
Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
180	Hard Grey Gypsum		40%			36	30
185	Hard Grey Gypsum		20%			37	30
190	BH Ends @ 190 ft						
195							
200							
205							
210							
215							

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	01.09.12
Completion	10.09.12
Final W. L.	N/A

Job No. ....

B.H. No.
BH# 105

Sht. 6 of 6

FIG. No.
5.7

CLIENT: PROJECT: Soil Investigation ADDRESS:	Location Reference **Carib Cement - Bull Bay** Datum Elevation	Type/Size Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types ▬ Wash ▭ Grab ☒ Split Spoon ▤ T. W. Tube ▭ R. Core

Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	samples Type	samples ID Mark	samples Recovery	Plasticity 20 – 80 Wet Unit Weight ▫ (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 100 Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0
0	Brown Sandy Silt with Gravel & Cobbles			▬	1	0		
5	Brown Sandy Silt with Gravel & Cobbles			▬	2	0		
10	Brown Sandy Silt with Gravel & Cobbles			▬	3	0		
15	Brown Sandy Silt with Gravel & Cobbles			▬	4	0		
20	Brown Sandy Silt with Gravel & Cobbles			▬	5	0		
25	Brown Sandy Silt with Gravel & Cobbles			▬	6	0		
30	Brown Sandy Silt with Gravel & Cobbles			▬	7	0		
35								

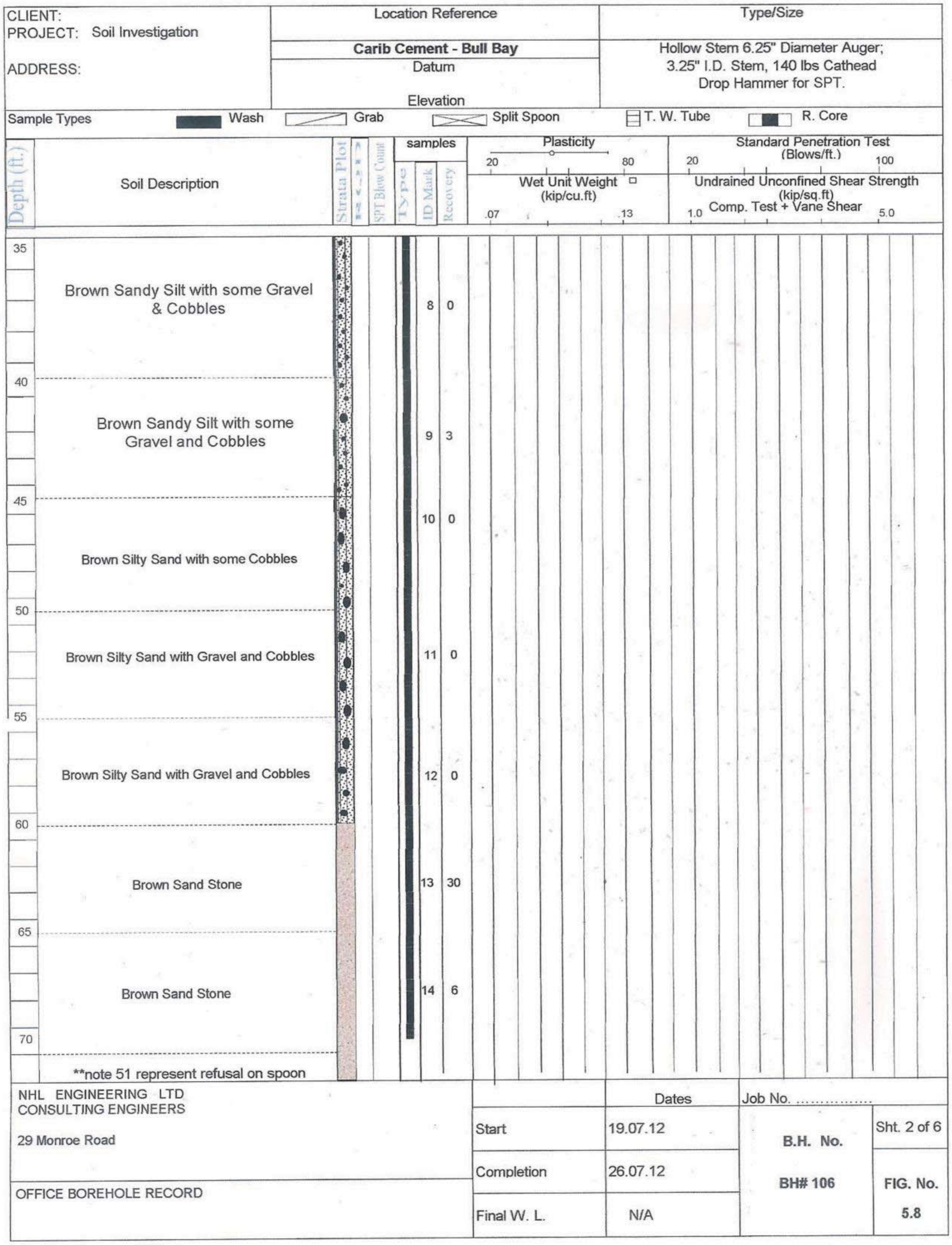
**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates	Job No.	
Start	19.07.12	**B.H. No.**	Sht. 1 of 6
Completion	26.07.12	**BH# 106**	**FIG. No.**
Final W. L.	N/A		**5.8**



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ▬ Wash ▭ Grab ⊠ Split Spoon ⊟ T. W. Tube ▣ R. Core

Plasticity: 20 – 80
Wet Unit Weight (kip/cu.ft): .07 – .13
Standard Penetration Test (Blows/ft.): 20 – 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear: 1.0 – 5.0

Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	Type	ID Mark	Recovery
35	Brown Sandy Silt with some Gravel & Cobbles				8	0
40	Brown Sandy Silt with some Gravel and Cobbles				9	3
45	Brown Silty Sand with some Cobbles				10	0
50	Brown Silty Sand with Gravel and Cobbles				11	0
55	Brown Silty Sand with Gravel and Cobbles				12	0
60	Brown Sand Stone				13	30
65	Brown Sand Stone				14	6
70						

**note 51 represent refusal on spoon

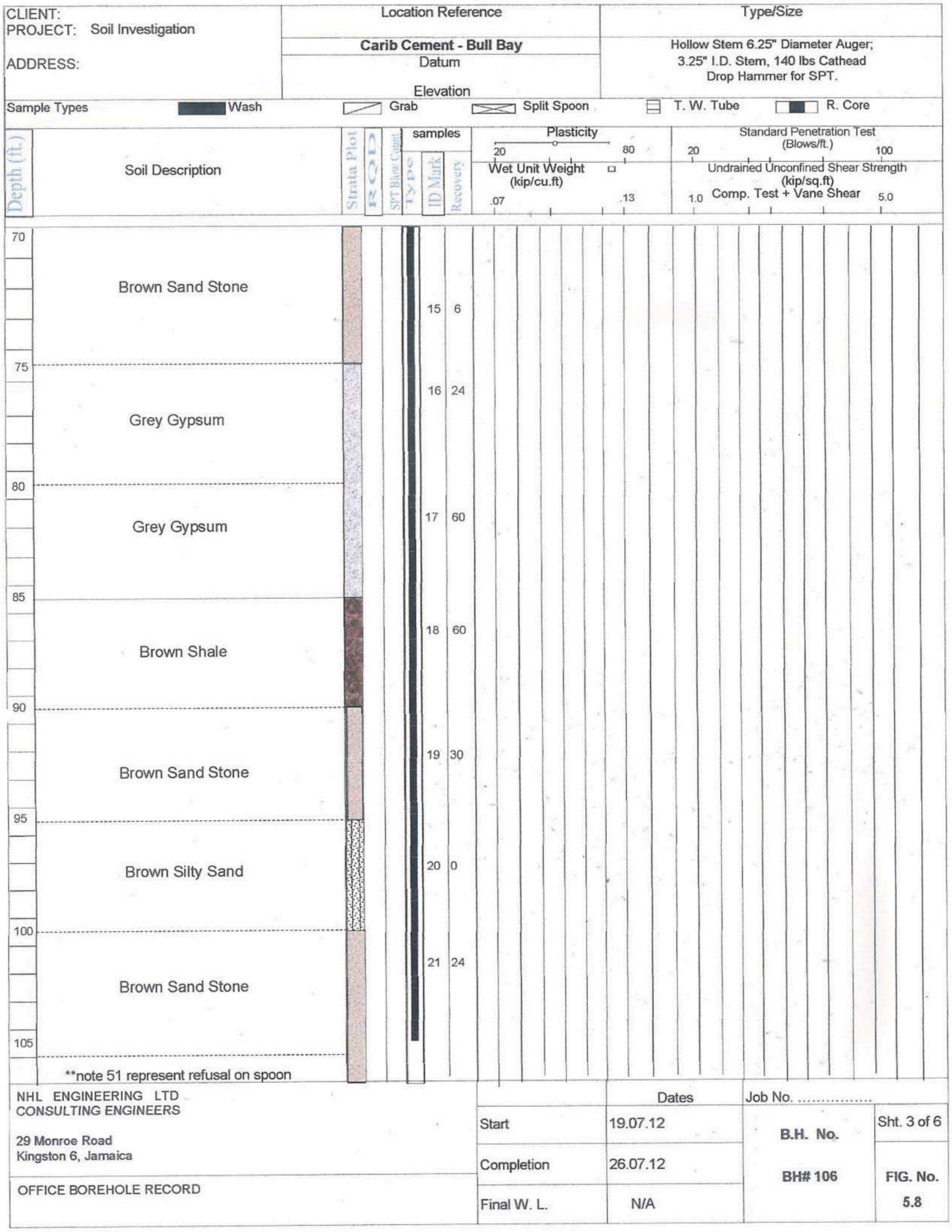
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road

OFFICE BOREHOLE RECORD

	Dates
Start	19.07.12
Completion	26.07.12
Final W. L.	N/A

Job No. ....
B.H. No. **BH# 106**
Sht. 2 of 6
FIG. No. **5.8**



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▬ Wash ▱ Grab ⊠ Split Spoon ⊟ T. W. Tube ◧ R. Core

Plasticity 20 80 · Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100 · Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	Strata Plot	R Q D	SPT Blow Count	Type	ID Mark	Recovery
70	Brown Sand Stone					15	6
75	Grey Gypsum					16	24
80	Grey Gypsum					17	60
85	Brown Shale					18	60
90	Brown Sand Stone					19	30
95	Brown Silty Sand					20	0
100	Brown Sand Stone					21	24
105							

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	19.07.12
Completion	26.07.12
Final W. L.	N/A

Job No. ....
B.H. No. **BH# 106**
Sht. 3 of 6
FIG. No. 5.8

CLIENT: PROJECT: Soil Investigation ADDRESS:	Location Reference **Carib Cement - Bull Bay** Datum Elevation	Type/Size Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types: Wash, Grab, Split Spoon, T. W. Tube, R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery	Plasticity 20 – 80 / Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 100 / Undrained Unconfined Shear Strength (kip/sq.ft) 1.0 Comp. Test + Vane Shear 5.0
105 – 110	Brown Shale					22	12		
110 – 115	Brown Shale with some Silty Sand					23	15		
115 – 120	Brown Silty Sand with some Shale					24	26		
120 – 125	Brown Shale					25	26		
125 – 130	Brown Sandy Silty with Cobbles					26	23		
130 – 135	Brown Sand Stone					27	20		
135 – 140	Brown Sand Stone					28	24		

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

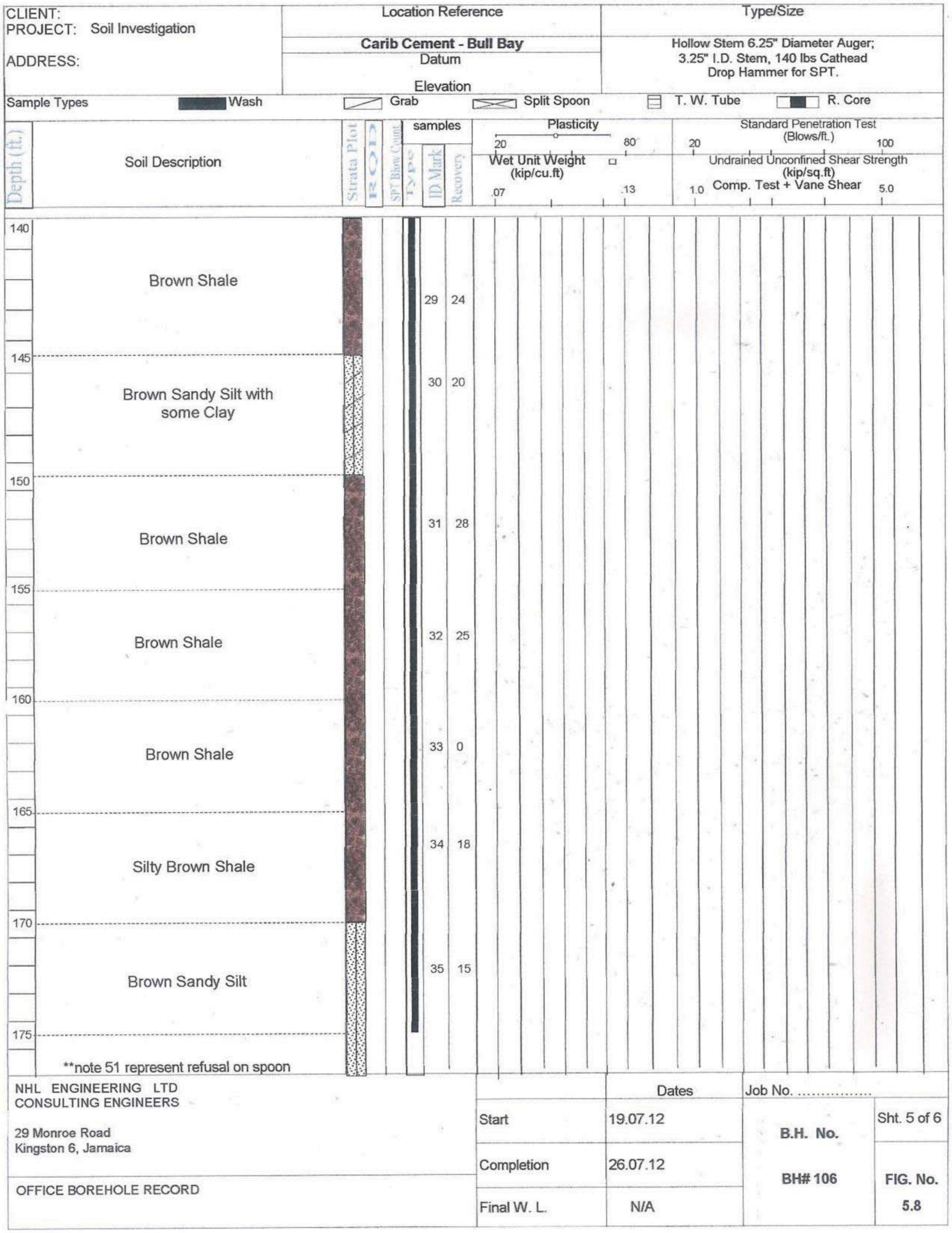
	Dates
Start	19.07.12
Completion	26.07.12
Final W. L.	N/A

Job No. ....

B.H. No.
BH# 106

Sht. 4 of 6

FIG. No.
5.8



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▬ Wash ⧄ Grab ⊠ Split Spoon ⊟ T. W. Tube ◨ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery	Plasticity 20 – 80 Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 100 Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0
140	Brown Shale					29	24		
145	Brown Sandy Silt with some Clay					30	20		
150	Brown Shale					31	28		
155	Brown Shale					32	25		
160	Brown Shale					33	0		
165	Silty Brown Shale					34	18		
170	Brown Sandy Silt					35	15		
175									

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

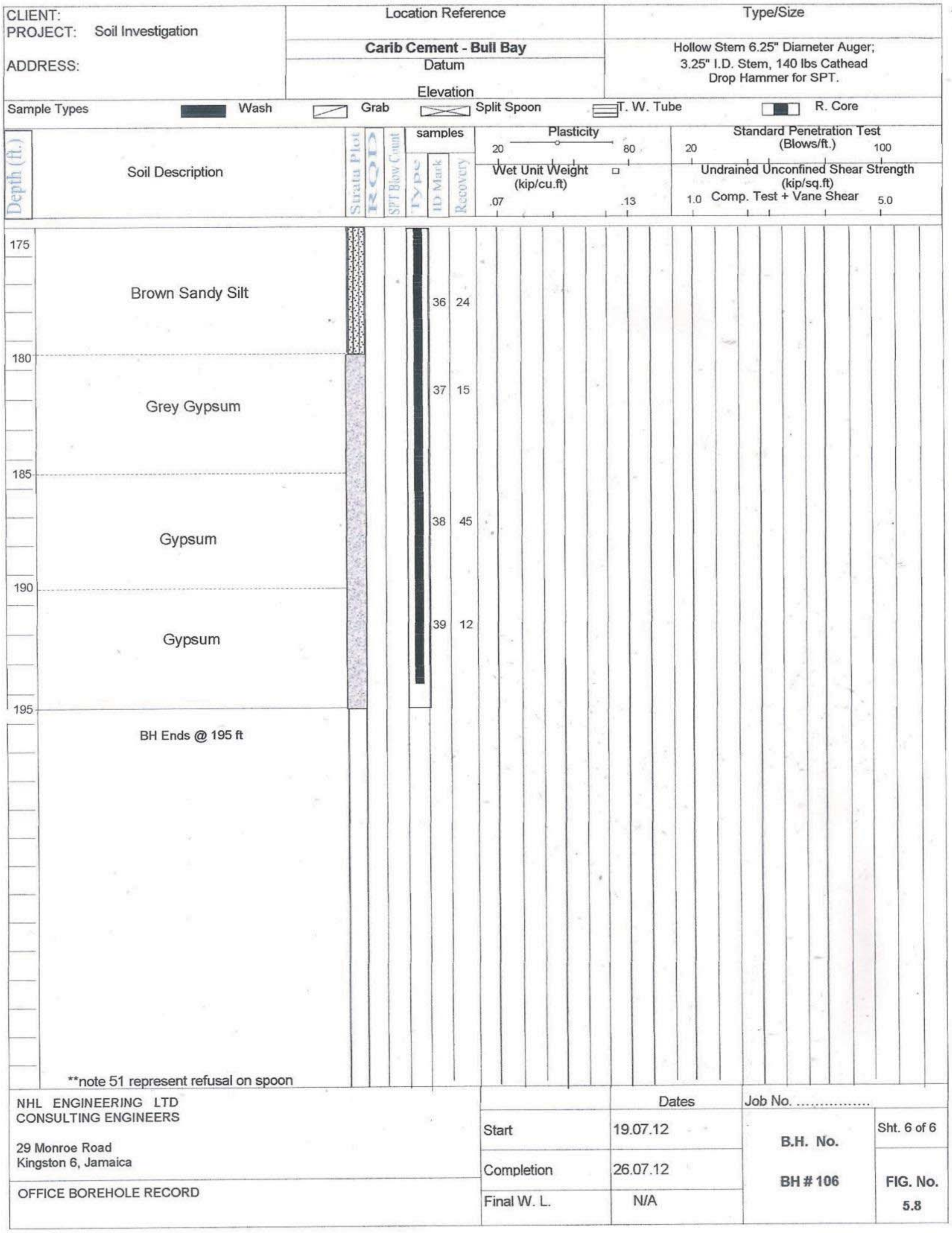
	Dates
Start	19.07.12
Completion	26.07.12
Final W. L.	N/A

Job No. ....

B.H. No.
BH# 106

Sht. 5 of 6

FIG. No.
5.8



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ▬ Wash; Grab; Split Spoon; T. W. Tube; R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
175	Brown Sandy Silt				▬	36	24
180	Grey Gypsum				▬	37	15
185	Gypsum				▬	38	45
190	Gypsum				▬	39	12
195	BH Ends @ 195 ft						

Plasticity: 20 – 80
Wet Unit Weight (kip/cu.ft): .07 – .13
Standard Penetration Test (Blows/ft.): 20 – 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear: 1.0 – 5.0

**note 51 represent refusal on spoon

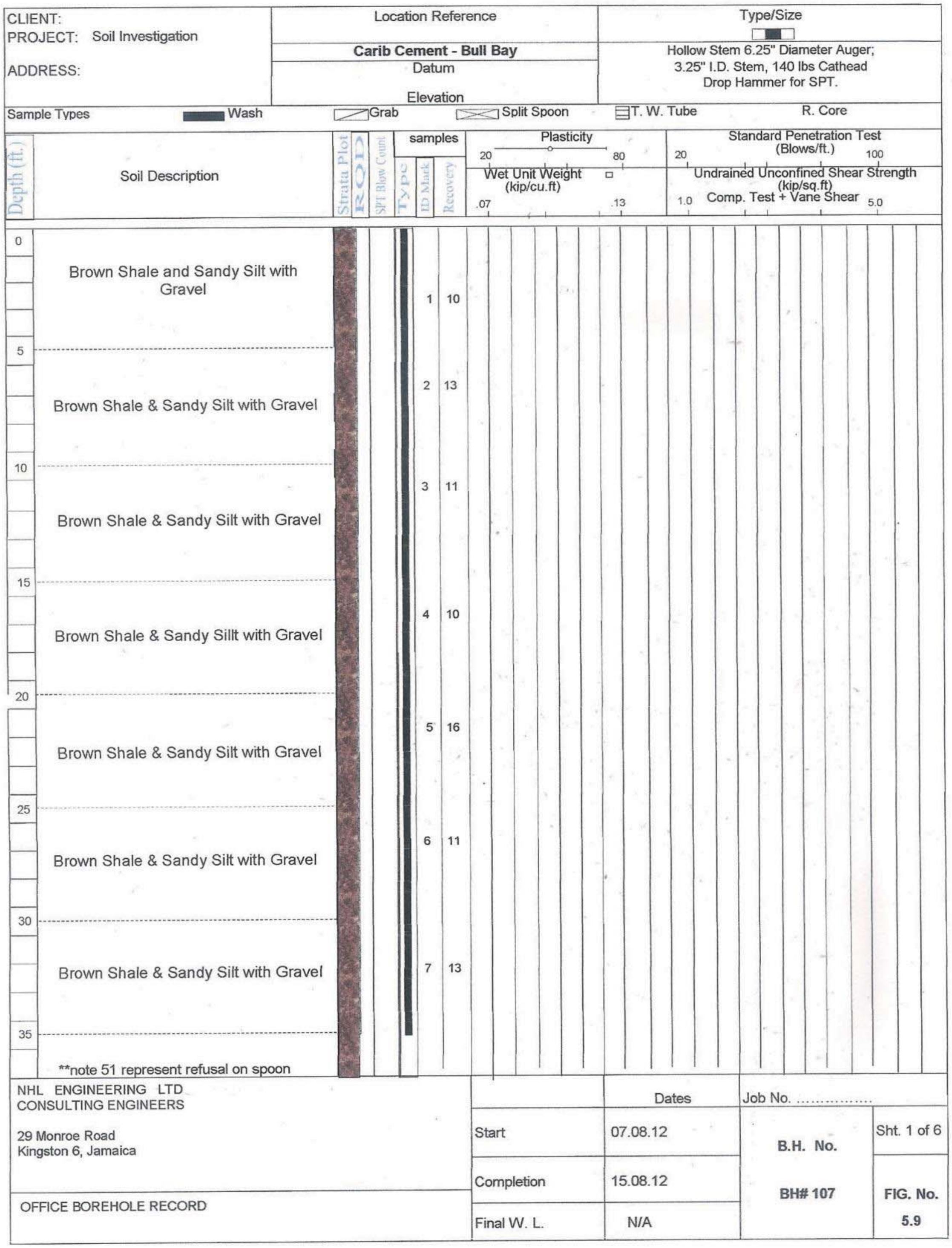
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	19.07.12
Completion	26.07.12
Final W. L.	N/A

Job No. ....
B.H. No. BH # 106
Sht. 6 of 6
FIG. No. 5.8



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ■ Wash ▨ Grab ▨ Split Spoon ☐ T. W. Tube R. Core

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
0	Brown Shale and Sandy Silt with Gravel					1	10
5	Brown Shale & Sandy Silt with Gravel					2	13
10	Brown Shale & Sandy Silt with Gravel					3	11
15	Brown Shale & Sandy Sillt with Gravel					4	10
20	Brown Shale & Sandy Silt with Gravel					5	16
25	Brown Shale & Sandy Silt with Gravel					6	11
30	Brown Shale & Sandy Silt with Gravel					7	13
35							

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

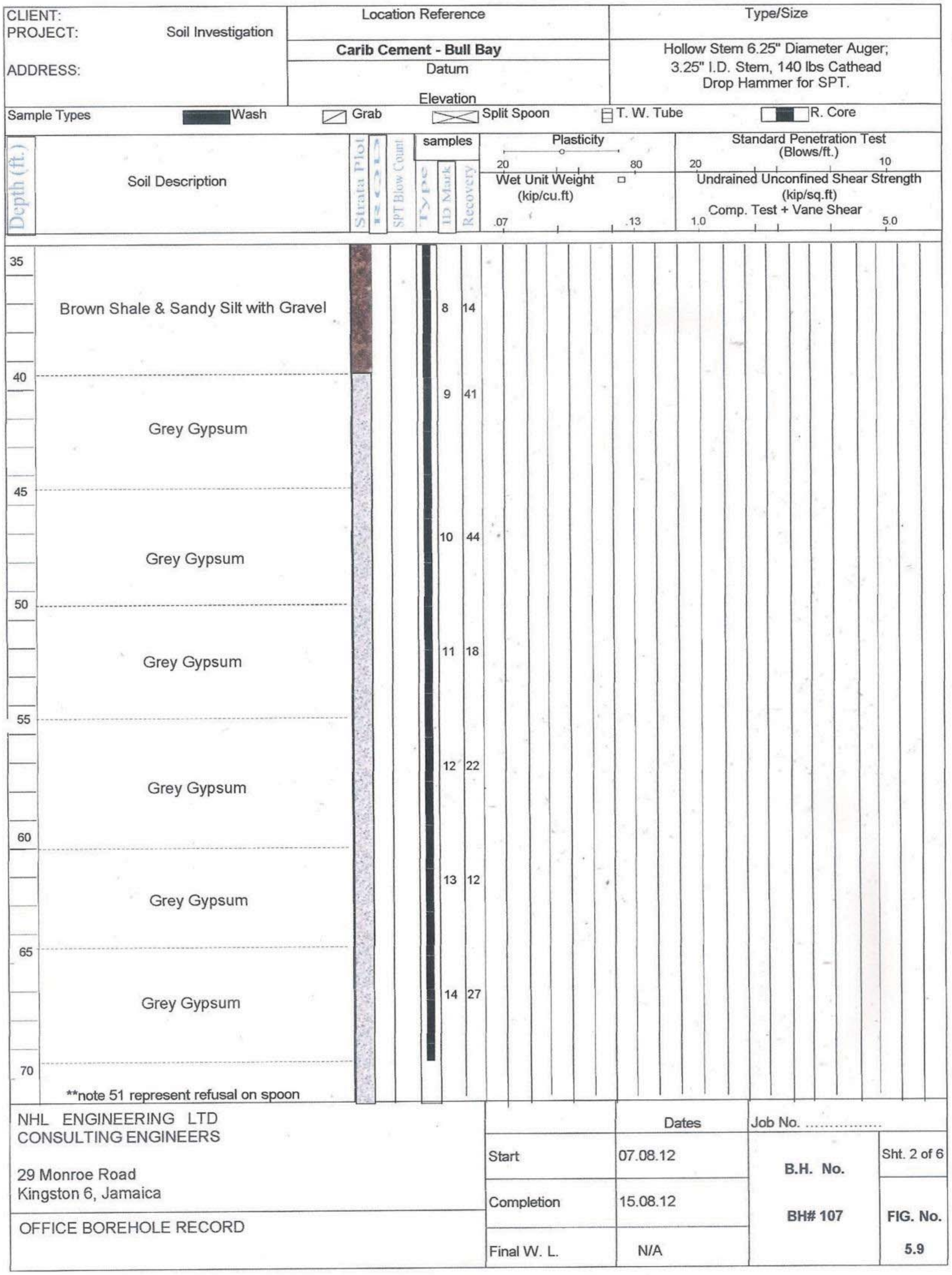
	Dates
Start	07.08.12
Completion	15.08.12
Final W. L.	N/A

Job No. ....

B.H. No.
BH# 107

Sht. 1 of 6

FIG. No.
5.9



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ■ Wash ▨ Grab ⊠ Split Spoon ⊟ T. W. Tube ■ R. Core

Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	Type	ID Mark	Recovery
35	Brown Shale & Sandy Silt with Gravel				8	14
40	Grey Gypsum				9	41
45	Grey Gypsum				10	44
50	Grey Gypsum				11	18
55	Grey Gypsum				12	22
60	Grey Gypsum				13	12
65	Grey Gypsum				14	27
70						

samples

Plasticity 20 80

Wet Unit Weight (kip/cu.ft) .07 .13

Standard Penetration Test (Blows/ft.) 20 10

Undrained Unconfined Shear Strength (kip/sq.ft)
Comp. Test + Vane Shear 1.0 5.0

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	07.08.12
Completion	15.08.12
Final W. L.	N/A

Job No. ....

Sht. 2 of 6

B.H. No.
BH# 107

FIG. No.
5.9

CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▬ Wash ▱ Grab ⊠ Split Spoon ▤ T. W. Tube ■ R. Core

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
70	Grey Gypsum				■	15	30
75	Grey Gypsum				■	16	30
80	Grey Gypsum				■	17	30
85	Grey Gypsum				■	18	30
90	Gypsum with Sand Silt and Shales				■	19	30
95	Gypsum with Sand Stone				■	20	35
100	Grey - Cream Gypsum				■	21	44
105							

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	07.08.12
Completion	15.08.12
Final W. L.	N/A

Job No. ....

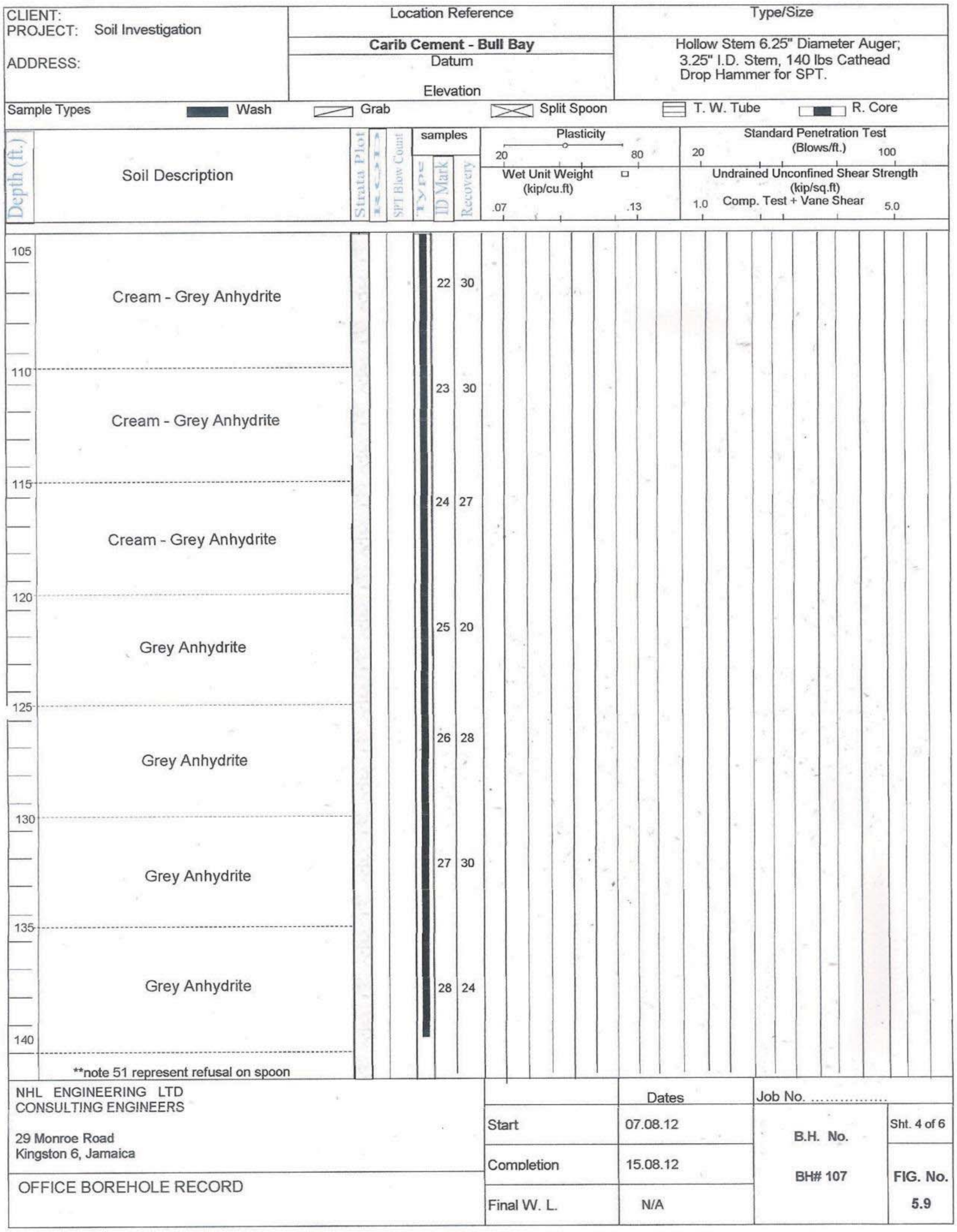
B.H. No.

BH# 107

Sht. 3 of 6

FIG. No.

5.9



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types ▬ Wash ▱ Grab ☒ Split Spoon ▤ T. W. Tube ▭ R. Core

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	ID Mark	Recovery
105	Cream - Grey Anhydrite	22	30
110	Cream - Grey Anhydrite	23	30
115	Cream - Grey Anhydrite	24	27
120	Grey Anhydrite	25	20
125	Grey Anhydrite	26	28
130	Grey Anhydrite	27	30
135	Grey Anhydrite	28	24
140			

**note 51 represent refusal on spoon

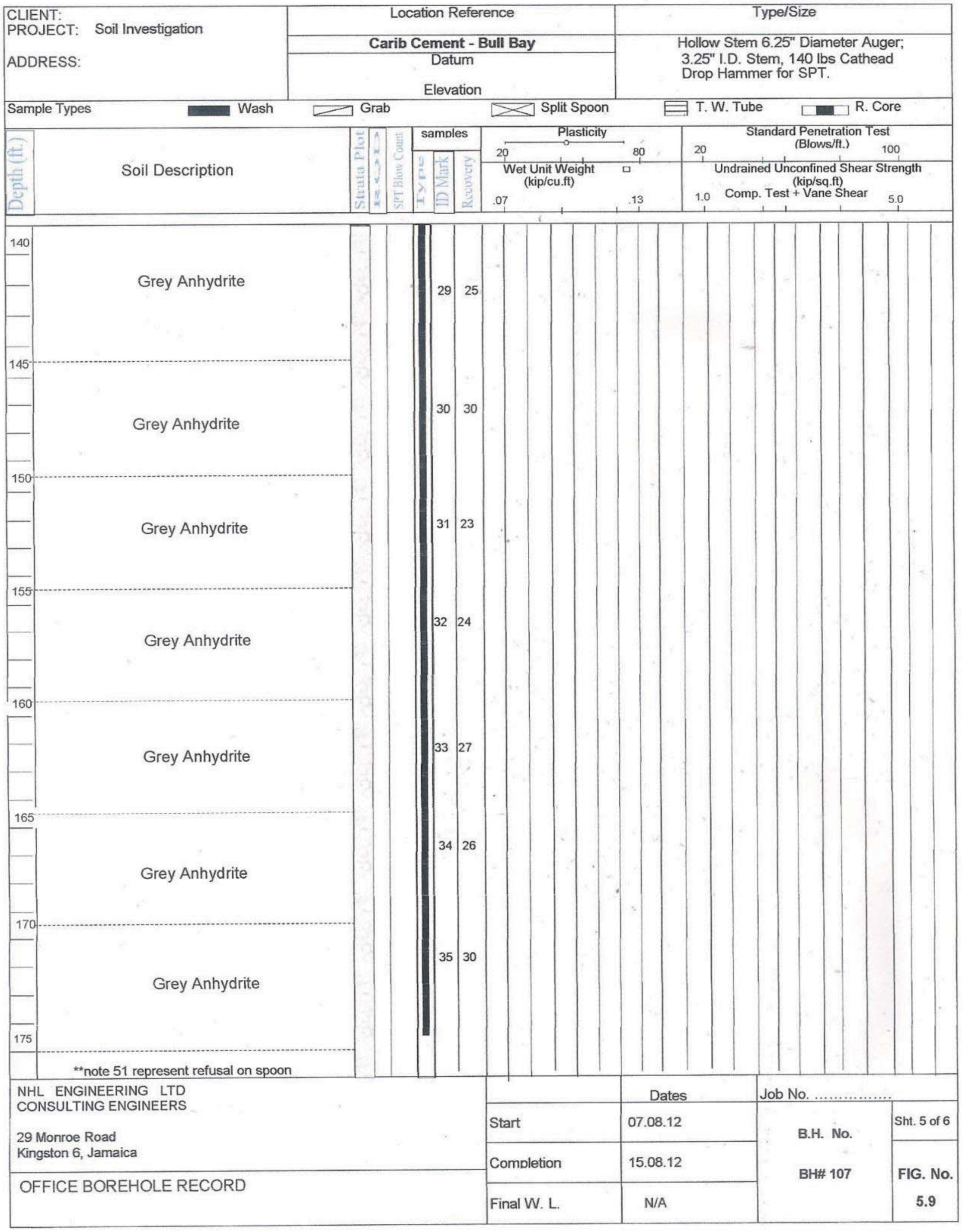
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	07.08.12
Completion	15.08.12
Final W. L.	N/A

Job No. ....
B.H. No. BH# 107
Sht. 4 of 6
FIG. No. 5.9



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▬ Wash ▱ Grab ☒ Split Spoon ☰ T. W. Tube ▬ R. Core

Plasticity 20 80 — Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100 — Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	samples Type	samples ID Mark	samples Recovery
140	Grey Anhydrite				29	25
145	Grey Anhydrite				30	30
150	Grey Anhydrite				31	23
155	Grey Anhydrite				32	24
160	Grey Anhydrite				33	27
165	Grey Anhydrite				34	26
170	Grey Anhydrite				35	30
175						

**note 51 represent refusal on spoon

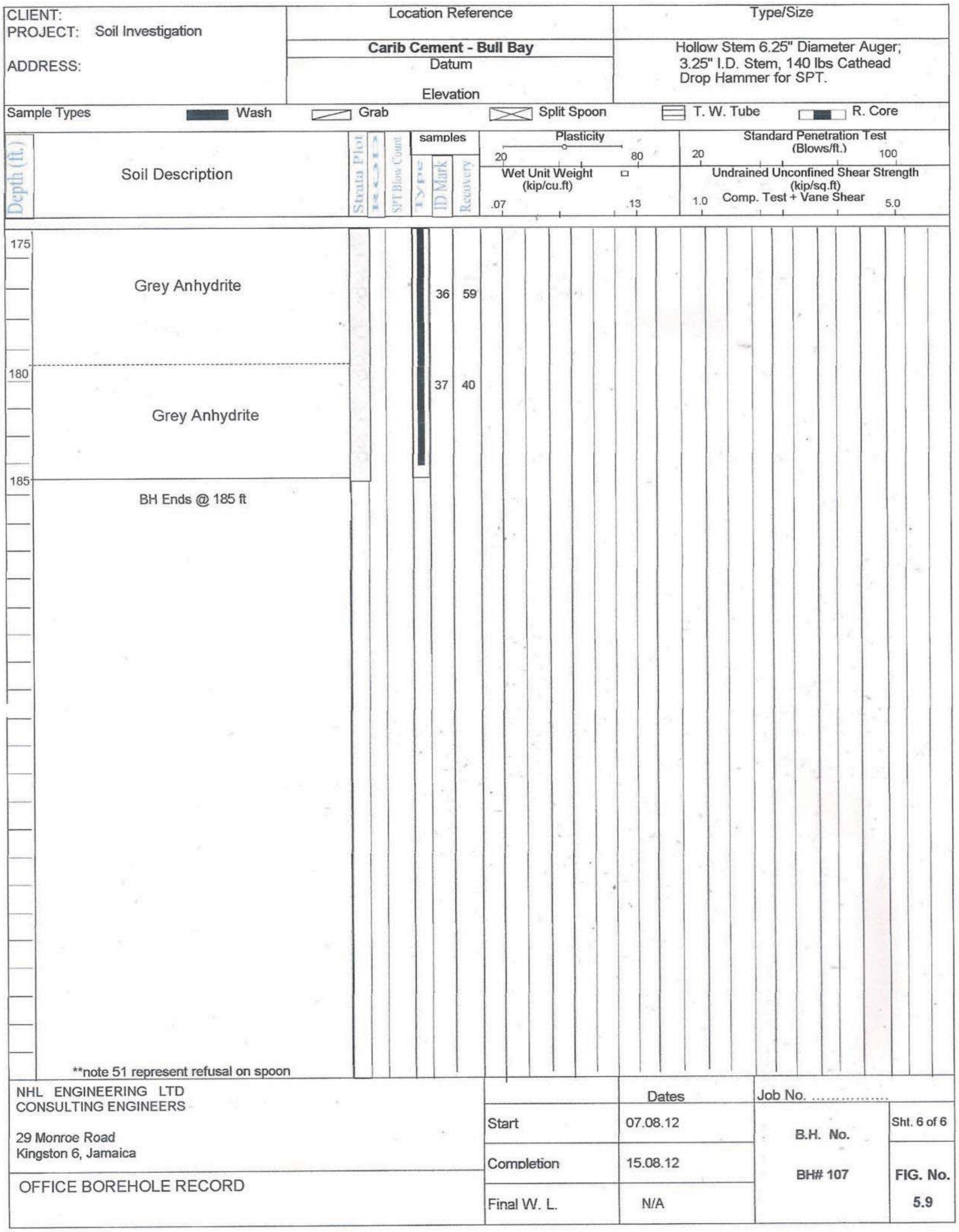
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	07.08.12
Completion	15.08.12
Final W. L.	N/A

Job No. ....
B.H. No. BH# 107
Sht. 5 of 6
FIG. No. 5.9



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference	Type/Size
Carib Cement - Bull Bay	Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.
Datum Elevation	

Sample Types ▬ Wash ▱ Grab ☒ Split Spoon ☰ T. W. Tube ▭ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples Type	samples ID Mark	samples Recovery	Plasticity 20 – 80 / Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 100 / Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0
175	Grey Anhydrite				▬	36	59		
180	Grey Anhydrite				▬	37	40		
185	BH Ends @ 185 ft								

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates	Job No.	
Start	07.08.12	B.H. No.	Sht. 6 of 6
Completion	15.08.12	BH# 107	FIG. No.
Final W. L.	N/A		5.9

CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▬ Wash ▱ Grab ☒ Split Spoon ☰ T. W. Tube ▭ R. Core

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	Type	ID Mark	Recovery
0	Brown Sandy Silt with Gravel			▬	1	0
5	Brown Sandy Silt with Gravel			▬	2	0
10	Brown Sandy Silt with Gravel			▬	3	0
15	Brown Sandy Silt with Gravel			▬	4	0
20	Brown Silt Formation			▬	5	10
25	Brown Silt Formation			▬	6	8
30	Brown Silt Formation with Gravel			▬	7	11
35						

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates	Job No.	
Start	15.08.12	B.H. No.	Sht. 1 of 6
Completion	21.08.12	BH# 108	FIG. No.
Final W. L.	N/A		5.10

CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference: **Carib Cement - Bull Bay**
Datum
Elevation

Type/Size: Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types: Wash ▬ Grab ▭ Split Spoon ☒ T. W. Tube ☰ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery	Plasticity 20 – 80 / Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 100 / Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0
35	Grey Gypsum					8	30		
40	Grey Gypsum					9	28		
45	Grey Gypsum					10	35		
50	Grey Gypsum					11	20		
55	Grey Gypsum					12	36		
60	Grey Gypsum					13	22		
65	Grey Gypsum					14	29		
70									

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

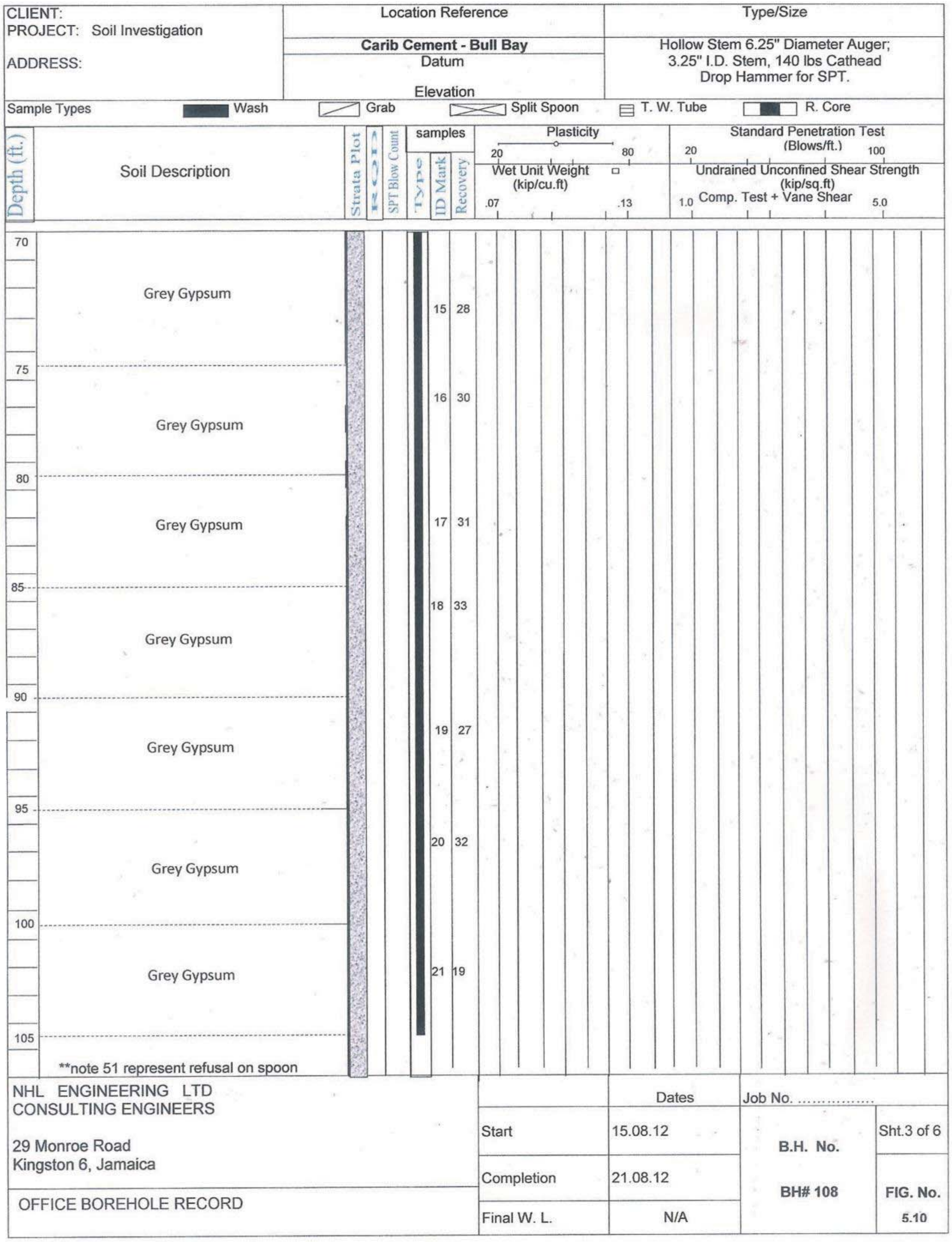
	Dates
Start	15.08.12
Completion	21.08.12
Final W. L.	N/A

Job No. ....

B.H. No. BH# 108

Sht. 2 of 6

FIG. No. 5.10



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference	Type/Size
Carib Cement - Bull Bay Datum Elevation	Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types: ▬ Wash ▱ Grab ⊠ Split Spoon ⊟ T. W. Tube ▭ R. Core

Depth (ft.)	Soil Description	Strata Plot	R Q D	SPT Blow Count	Type	ID Mark	Recovery
70–75	Grey Gypsum					15	28
75–80	Grey Gypsum					16	30
80–85	Grey Gypsum					17	31
85–90	Grey Gypsum					18	33
90–95	Grey Gypsum					19	27
95–100	Grey Gypsum					20	32
100–105	Grey Gypsum					21	19

Plasticity 20 – 80; Wet Unit Weight (kip/cu.ft) .07 – .13
Standard Penetration Test (Blows/ft.) 20 – 100
Undrained Unconfined Shear Strength (kip/sq.ft) 1.0 – 5.0; Comp. Test + Vane Shear

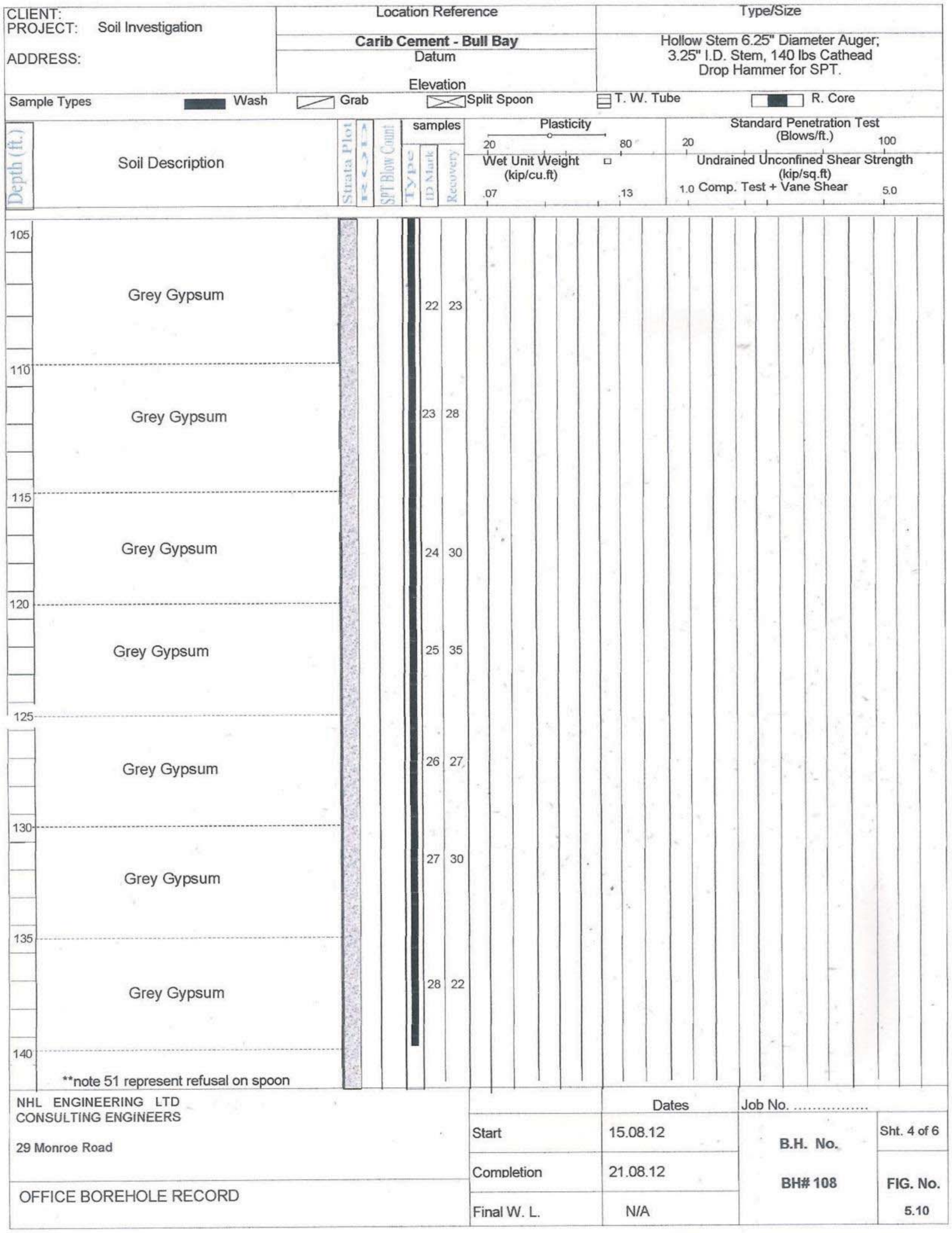
**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates	Job No.	
Start	15.08.12	B.H. No.	Sht.3 of 6
Completion	21.08.12	BH# 108	FIG. No.
Final W. L.	N/A		5.10



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ▬ Wash ▱ Grab ☒ Split Spoon ⊟ T. W. Tube ▭ R. Core

Depth (ft.)	Soil Description	Strata Plot	W.L.	SPT Blow Count	samples: Type	ID Mark	Recovery	Plasticity 20 80 Wet Unit Weight (kip/cu.ft) .07 .13	Standard Penetration Test (Blows/ft.) 20 100 Undrained Unconfined Shear Strength (kip/sq.ft) 1.0 Comp. Test + Vane Shear 5.0
105	Grey Gypsum					22	23		
110	Grey Gypsum					23	28		
115	Grey Gypsum					24	30		
120	Grey Gypsum					25	35		
125	Grey Gypsum					26	27		
130	Grey Gypsum					27	30		
135	Grey Gypsum					28	22		
140									

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road

OFFICE BOREHOLE RECORD

	Dates
Start	15.08.12
Completion	21.08.12
Final W. L.	N/A

Job No. ....

B.H. No.
BH# 108

Sht. 4 of 6

FIG. No.
5.10

CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ▬ Wash ▱ Grab ⊠ Split Spoon ⊟ T. W. Tube ▣ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples Type	samples ID Mark	samples Recovery	Plasticity 20 – 80 / Wet Unit Weight (kip/cu.ft) .07 – .13	Standard Penetration Test (Blows/ft.) 20 – 100 / Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0
140	Grey Gypsum					29	25		
145	Grey Gypsum					30	35		
150	Grey Gypsum					31	38		
155	Grey Gypsum					32	40		
160	Grey Gypsum					33	25		
165	Grey Gypsum					34	30		
170	Grey Gypsum					35	22		
175									

**note 51 represent refusal on spoon

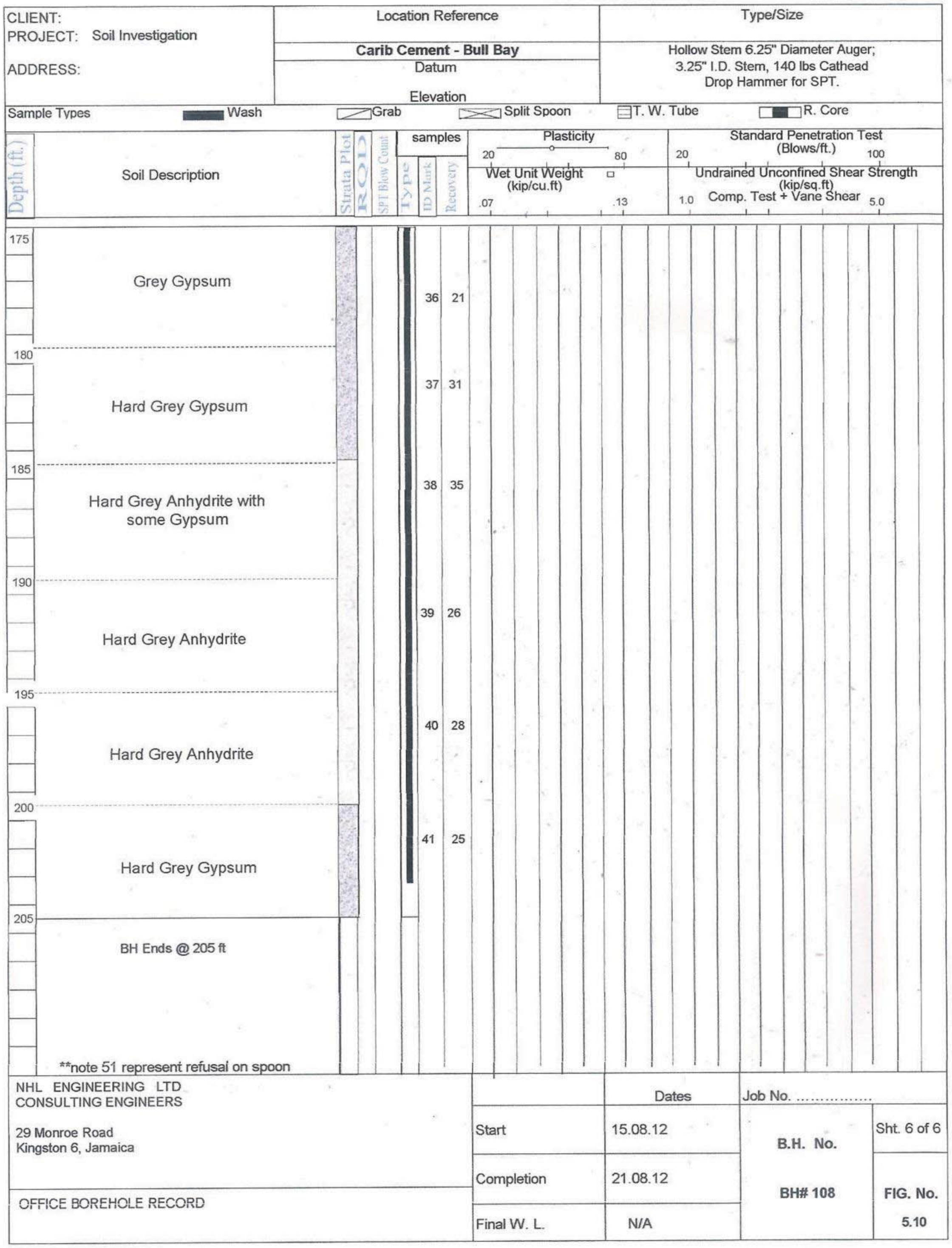
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	15.08.12
Completion	21.08.12
Final W. L.	N/A

Job No. ....
B.H. No. BH# 108
Sht.5 of 6
FIG. No. 5.10



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: Wash, Grab, Split Spoon, T. W. Tube, R. Core

Plasticity 20 – 80
Wet Unit Weight (kip/cu.ft) .07 – .13
Standard Penetration Test (Blows/ft.) 20 – 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
175	Grey Gypsum					36	21
180	Hard Grey Gypsum					37	31
185	Hard Grey Anhydrite with some Gypsum					38	35
190	Hard Grey Anhydrite					39	26
195	Hard Grey Anhydrite					40	28
200	Hard Grey Gypsum					41	25
205	BH Ends @ 205 ft						

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	15.08.12
Completion	21.08.12
Final W. L.	N/A

Job No. ....
B.H. No. BH# 108
Sht. 6 of 6
FIG. No. 5.10

CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ■ Wash ▱ Grab ⊠ Split Spoon ⊟ T. W. Tube ◫ R. Core

Plasticity 20 – 80; Wet Unit Weight (kip/cu.ft) .07 – .13; Standard Penetration Test (Blows/ft.) 20 – 10; Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0

Depth (ft.)	Soil Description	Samples ID Mark	Recovery
0	Brown Sandy Silt with Gravel	1	0
5	Brown Sandy Silt with Gravel	2	0
10	Brown Sandy Silt with Gravel	3	0
15	Brown Sandy Silt and Boulders	4	3
20	Brown Sandy Silt and Boulders	5	0
25	Brown Sandy Silt and Boulders	3	0
30	Sandy Silt and Gravel	7	0
35			

**note 51 represent refusal on spoon

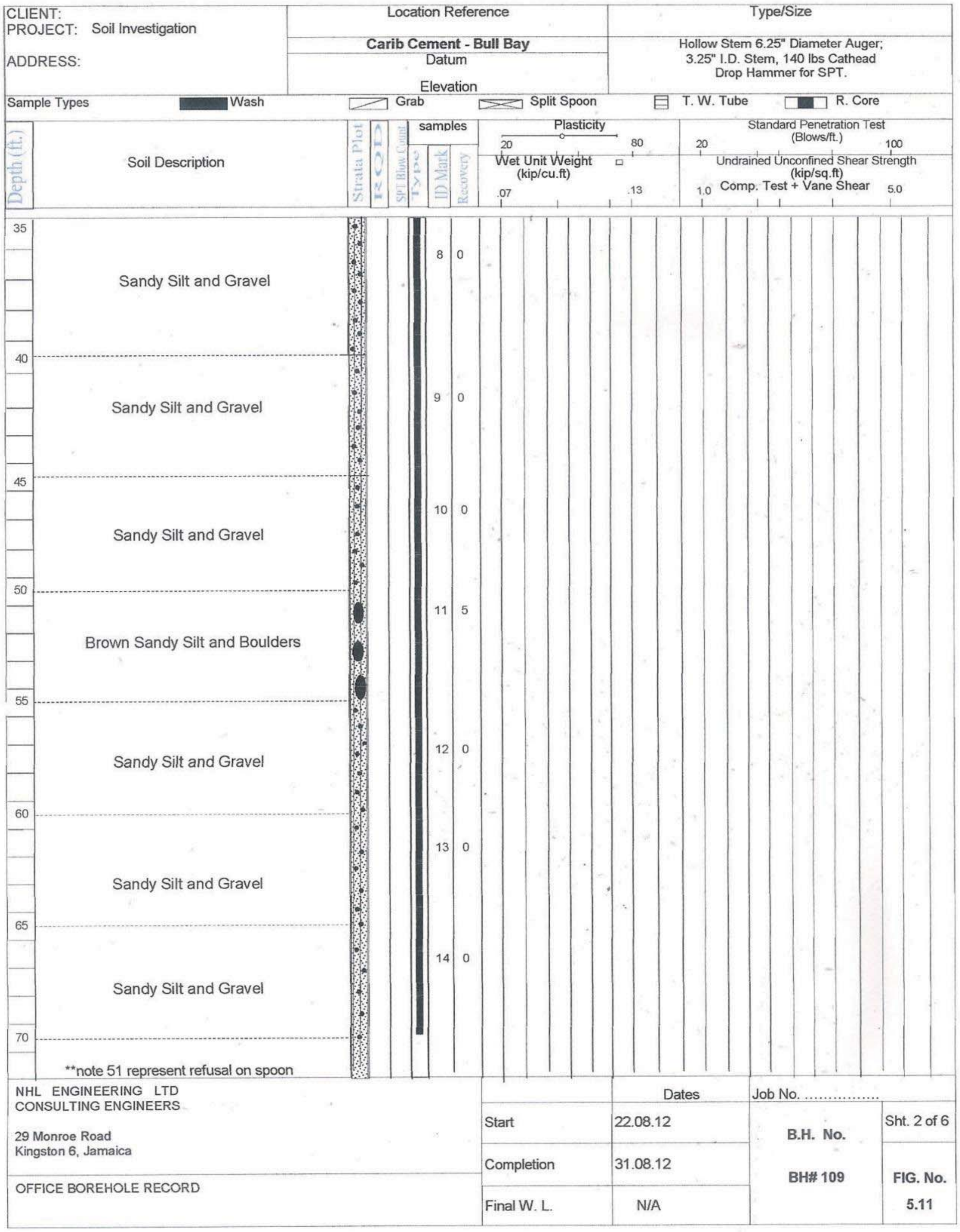
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	22.08.12
Completion	31.08.12
Final W. L.	N/A

Job No. ....
B.H. No. BH# 109
Sht. 1 of 6
FIG. No. 5.11



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▇ Wash ▱ Grab ⋈ Split Spoon ⊟ T. W. Tube ▭ R. Core

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
35	Sandy Silt and Gravel					8	0
40	Sandy Silt and Gravel					9	0
45	Sandy Silt and Gravel					10	0
50	Brown Sandy Silt and Boulders					11	5
55	Sandy Silt and Gravel					12	0
60	Sandy Silt and Gravel					13	0
65	Sandy Silt and Gravel					14	0
70							

**note 51 represent refusal on spoon

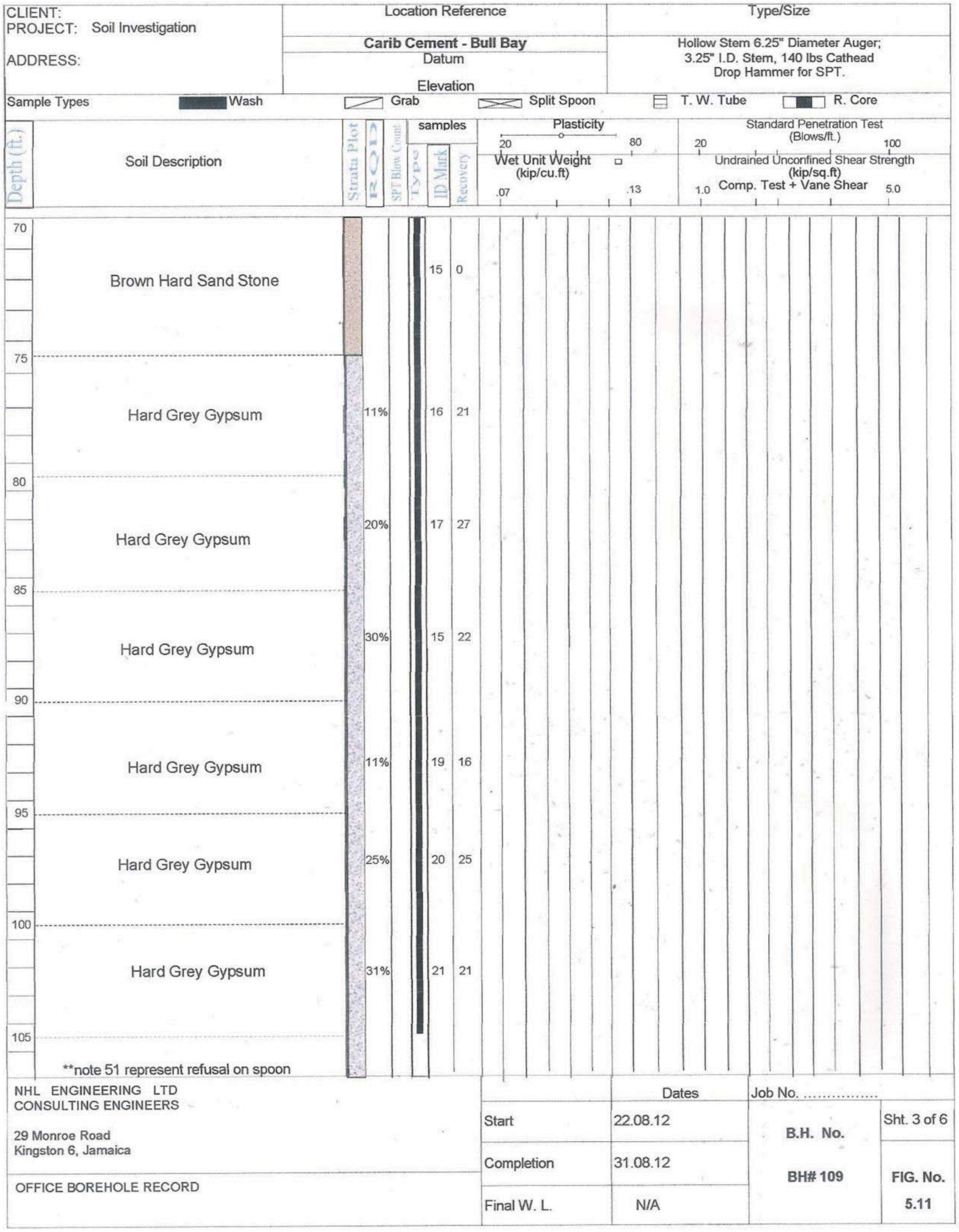
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	22.08.12
Completion	31.08.12
Final W. L.	N/A

Job No. ....
B.H. No.
BH# 109
Sht. 2 of 6
FIG. No.
5.11



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference: **Carib Cement - Bull Bay**
Datum
Elevation

Type/Size: Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types: ▆ Wash; Grab; Split Spoon; T. W. Tube; R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
70	Brown Hard Sand Stone					15	0
75	Hard Grey Gypsum		11%			16	21
80	Hard Grey Gypsum		20%			17	27
85	Hard Grey Gypsum		30%			15	22
90	Hard Grey Gypsum		11%			19	16
95	Hard Grey Gypsum		25%			20	25
100	Hard Grey Gypsum		31%			21	21
105							

Plasticity 20 – 80; Wet Unit Weight (kip/cu.ft) .07 – .13
Standard Penetration Test (Blows/ft.) 20 – 100; Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 – 5.0

**note 51 represent refusal on spoon

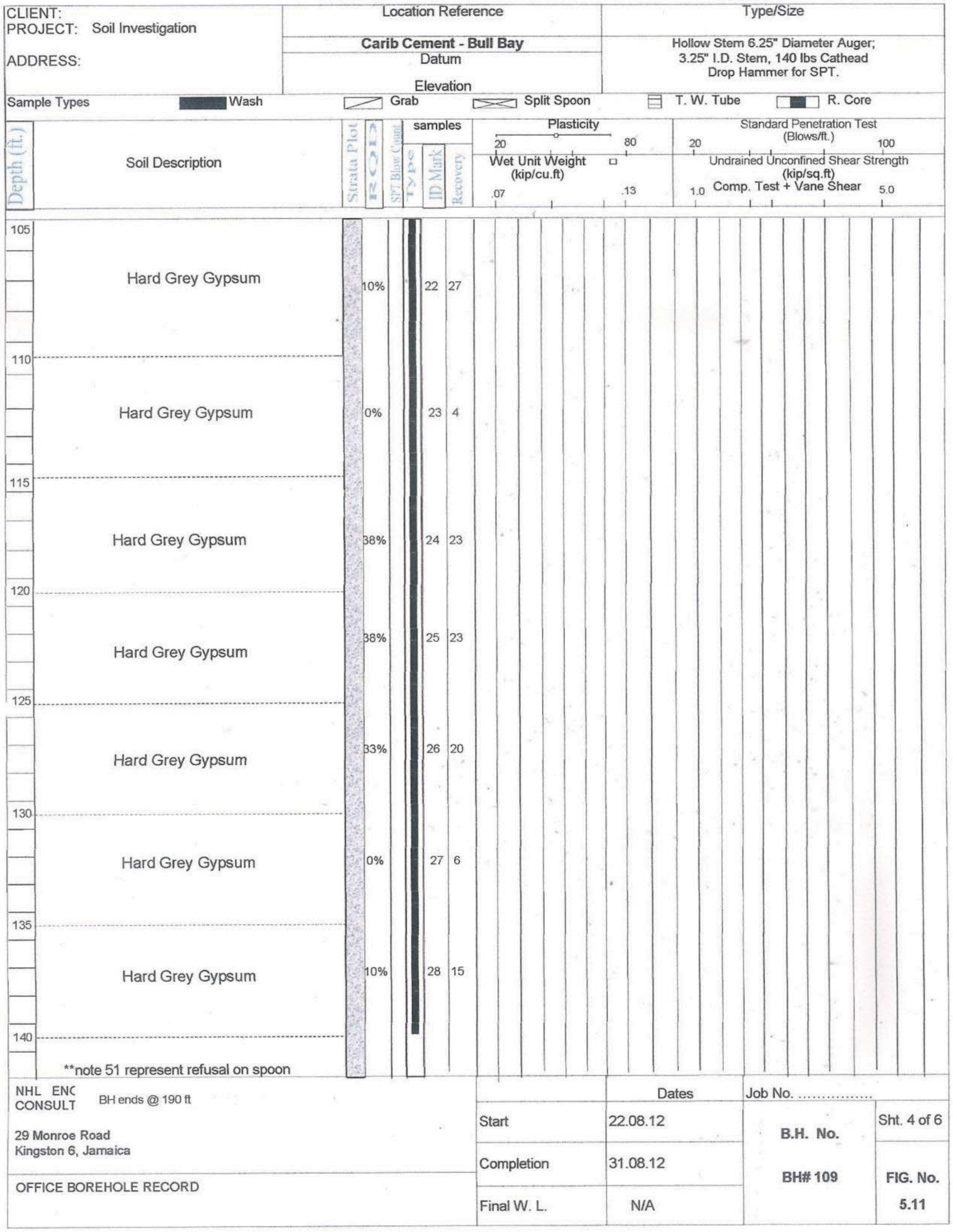
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	22.08.12
Completion	31.08.12
Final W. L.	N/A

Job No. ....
B.H. No. BH# 109
Sht. 3 of 6
FIG. No. 5.11



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ▬ Wash ⧄ Grab ⊠ Split Spoon ⊟ T. W. Tube ▬ R. Core

Plasticity 20 80 — Wet Unit Weight (kip/cu.ft) .07 .13

Standard Penetration Test (Blows/ft.) 20 100 — Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0

Depth (ft.)	Soil Description	RQD	SPT Blow Count	Type	ID Mark	Recovery
105	Hard Grey Gypsum	10%			22	27
110	Hard Grey Gypsum	0%			23	4
115	Hard Grey Gypsum	38%			24	23
120	Hard Grey Gypsum	38%			25	23
125	Hard Grey Gypsum	33%			26	20
130	Hard Grey Gypsum	0%			27	6
135	Hard Grey Gypsum	10%			28	15
140						

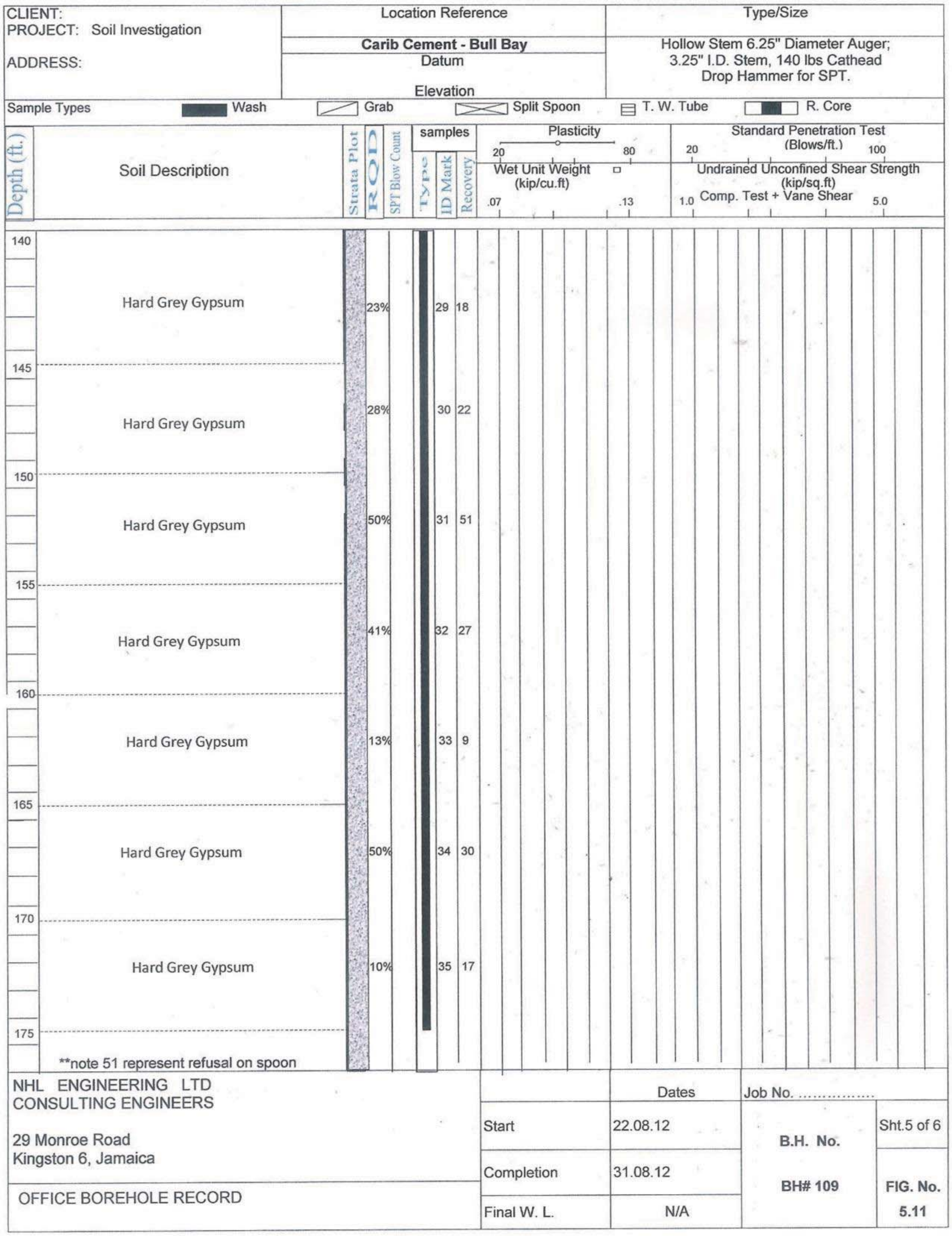
**note 51 represent refusal on spoon

NHL ENC
CONSULT
BH ends @ 190 ft

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates	Job No.	
Start	22.08.12	**B.H. No.**	Sht. 4 of 6
Completion	31.08.12	**BH# 109**	**FIG. No.**
Final W. L.	N/A		**5.11**



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ▬ Wash ▱ Grab ⊠ Split Spoon ⊟ T. W. Tube ▭ R. Core

Plasticity: 20 – 80; Wet Unit Weight (kip/cu.ft) .07 – .13
Standard Penetration Test (Blows/ft.) 20 – 100; Undrained Unconfined Shear Strength (kip/sq.ft) 1.0 – 5.0, Comp. Test + Vane Shear

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples Type	ID Mark	Recovery
140	Hard Grey Gypsum		23%			29	18
145	Hard Grey Gypsum		28%			30	22
150	Hard Grey Gypsum		50%			31	51
155	Hard Grey Gypsum		41%			32	27
160	Hard Grey Gypsum		13%			33	9
165	Hard Grey Gypsum		50%			34	30
170	Hard Grey Gypsum		10%			35	17
175							

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

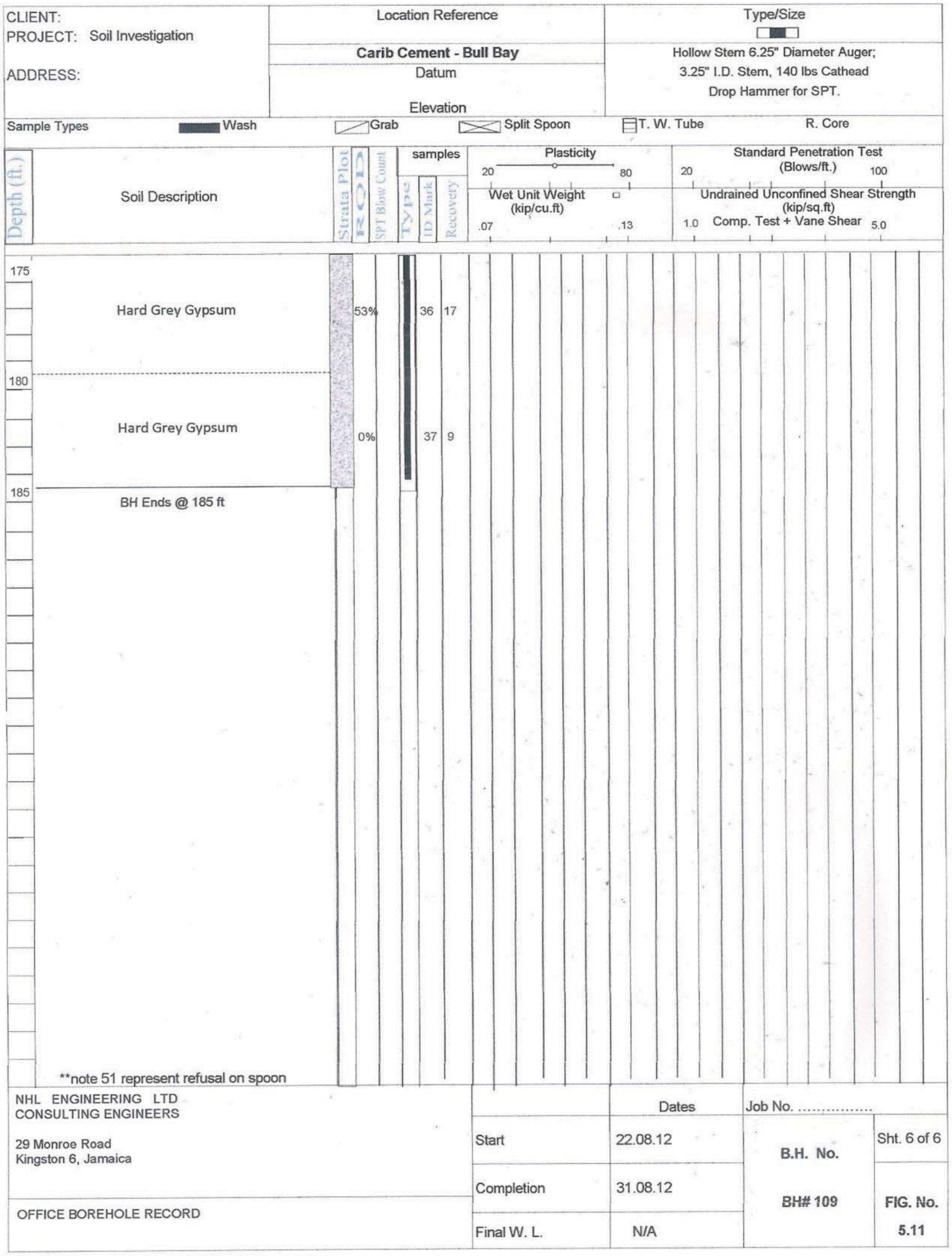
	Dates
Start	22.08.12
Completion	31.08.12
Final W. L.	N/A

Job No. ....

B.H. No. **BH# 109**

Sht.5 of 6

FIG. No. **5.11**



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ▬ Wash; ▱ Grab; ⊠ Split Spoon; ☐ T. W. Tube; R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples Type	ID Mark	Recovery	Plasticity 20–80 / Wet Unit Weight (kip/cu.ft) .07–.13	Standard Penetration Test (Blows/ft.) 20–100 / Undrained Unconfined Shear Strength (kip/sq.ft) 1.0 Comp. Test + Vane Shear 5.0
175	Hard Grey Gypsum		53%			36	17		
180	Hard Grey Gypsum		0%			37	9		
185	BH Ends @ 185 ft								

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates	Job No.	
Start	22.08.12	B.H. No.	Sht. 6 of 6
Completion	31.08.12	BH# 109	FIG. No.
Final W. L.	N/A		5.11

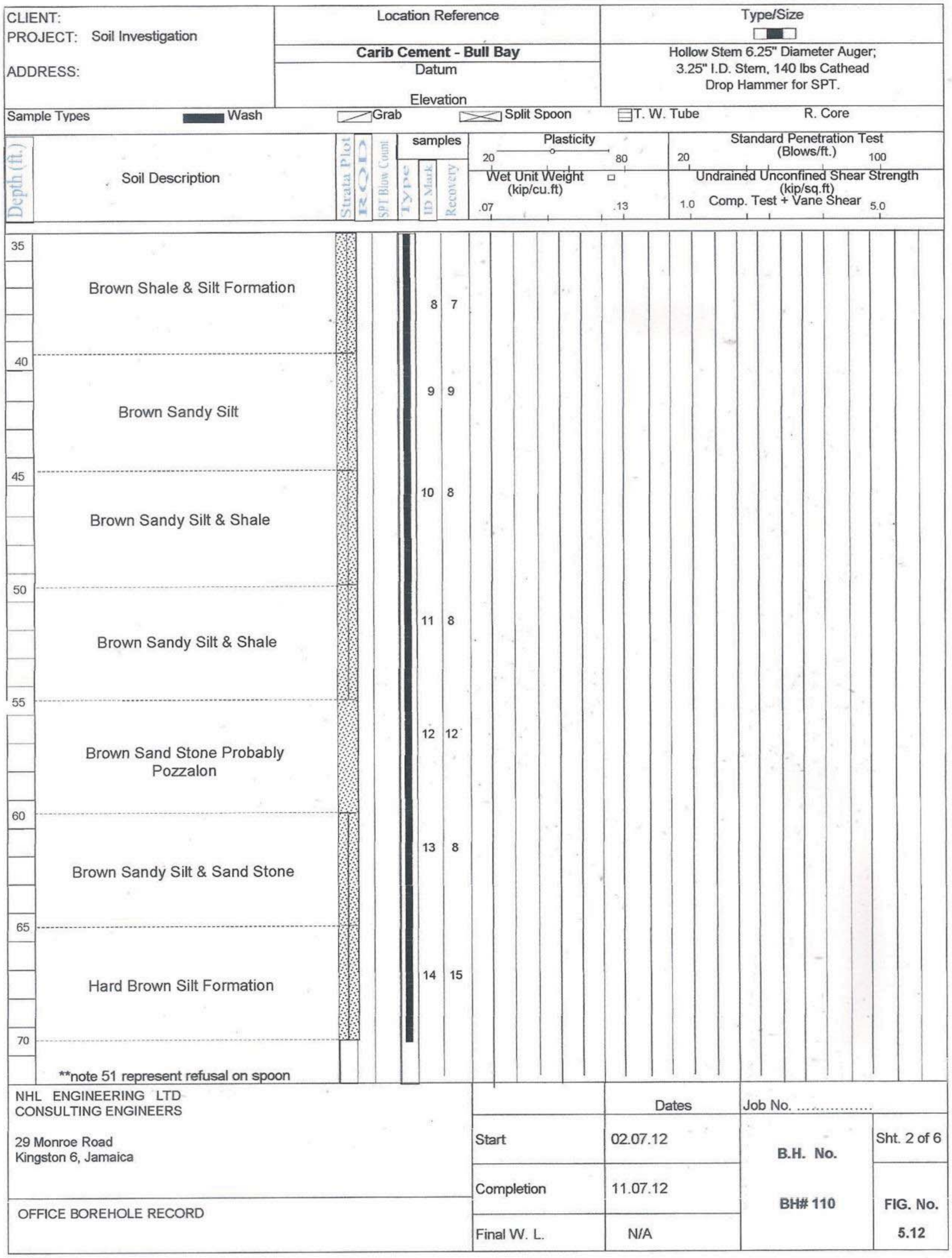
]

CLIENT: PROJECT: Soil Investigation ADDRESS:	Location Reference **Carib Cement - Bull Bay** Datum Elevation	Type/Size Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types ■ Wash ▭ Grab ⊠ Split Spoon ▤ T. W. Tube ▮ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples Type	ID Mark	Recovery	Plasticity 20 80 Wet Unit Weight (kip/cu.ft) .07 .13	Standard Penetration Test (Blows/ft.) 20 100 Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0
0	Brown Sandy Silt					1	12		
5	Brown Sandy Silt					2	7		
10	Brown Sandy Silt					3	14		
15	Brown Shale & Silty Sand					4	7		
20	Brown Silty Sand					5	0		
25	Brown Silty Sand - Sandy Silt with some Gravel					6	0		
30	Brown Silty Sand - Sandy Silt with some Gravel/Cobbles					7	0		
35	**note 51 represent refusal on spoon								

NHL ENGINEERING LTD CONSULTING ENGINEERS 29 Monroe Road Kingston 6, Jamaica		Dates	Job No.	
	Start	02.07.12	B.H. No.	Sht.1 of 6
	Completion	11.07.12	BH# 110	FIG. No.
OFFICE BOREHOLE RECORD	Final W. L.	N/A		5.12



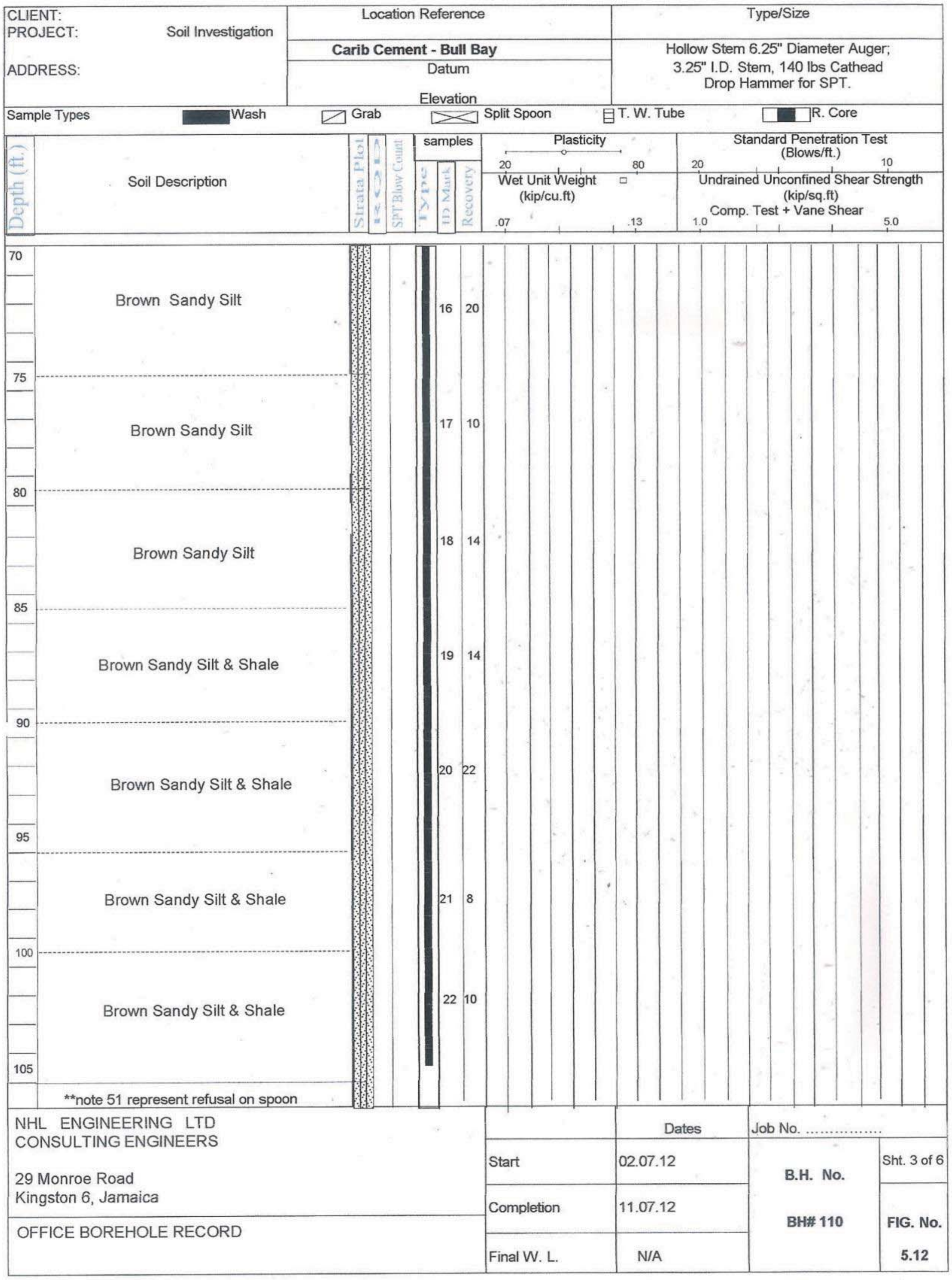
CLIENT: PROJECT: Soil Investigation ADDRESS:	Location Reference **Carib Cement - Bull Bay** Datum Elevation	Type/Size Hollow Stem 6.25" Diameter Auger; 3.25" I.D. Stem, 140 lbs Cathead Drop Hammer for SPT.

Sample Types ▬ Wash ▱ Grab ⊠ Split Spoon ☐ T. W. Tube R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples Type	samples ID Mark	samples Recovery	Plasticity 20 — 80 Wet Unit Weight (kip/cu.ft) .07 — .13	Standard Penetration Test (Blows/ft.) 20 — 100 Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 — 5.0
35	Brown Shale & Silt Formation					8	7		
40	Brown Sandy Silt					9	9		
45	Brown Sandy Silt & Shale					10	8		
50	Brown Sandy Silt & Shale					11	8		
55	Brown Sand Stone Probably Pozzalon					12	12		
60	Brown Sandy Silt & Sand Stone					13	8		
65	Hard Brown Silt Formation					14	15		
70									

**note 51 represent refusal on spoon

NHL ENGINEERING LTD CONSULTING ENGINEERS 29 Monroe Road Kingston 6, Jamaica		Dates	Job No.	
	Start	02.07.12	B.H. No.	Sht. 2 of 6
	Completion	11.07.12	BH# 110	FIG. No.
OFFICE BOREHOLE RECORD	Final W. L.	N/A		5.12



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: Wash, Grab, Split Spoon, T. W. Tube, R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	samples Type	samples ID Mark	samples Recovery	Plasticity 20–80 / Wet Unit Weight (kip/cu.ft) .07–.13	Standard Penetration Test (Blows/ft.) 20–10 / Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0–5.0
70	Brown Sandy Silt					16	20		
75	Brown Sandy Silt					17	10		
80	Brown Sandy Silt					18	14		
85	Brown Sandy Silt & Shale					19	14		
90	Brown Sandy Silt & Shale					20	22		
95	Brown Sandy Silt & Shale					21	8		
100	Brown Sandy Silt & Shale					22	10		
105									

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

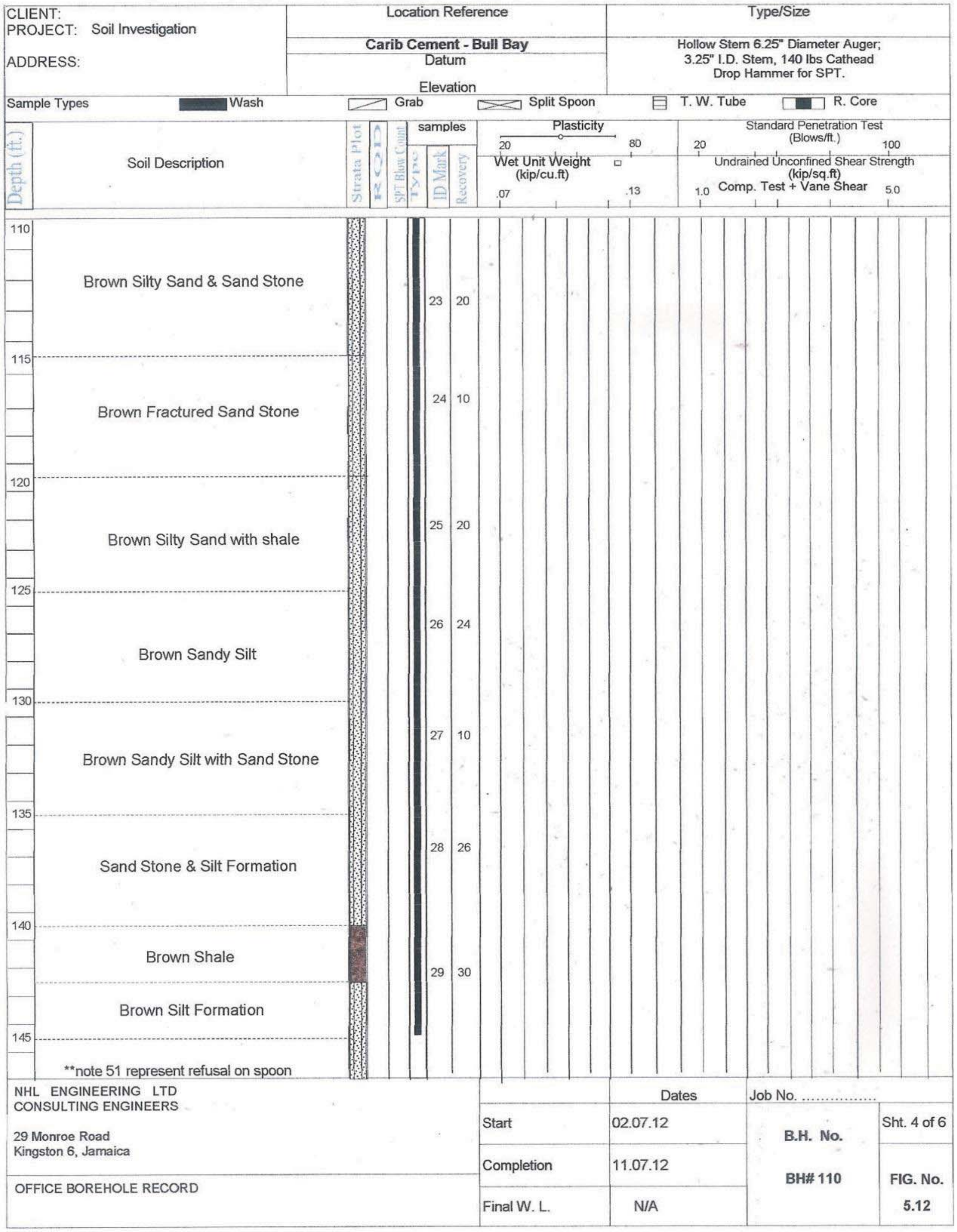
	Dates
Start	02.07.12
Completion	11.07.12
Final W. L.	N/A

Job No. ....

B.H. No. **BH# 110**

Sht. 3 of 6

FIG. No. **5.12**



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: ▬ Wash ▭ Grab ☒ Split Spoon ⊟ T. W. Tube ▣ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery	Plasticity 20 80 / Wet Unit Weight (kip/cu.ft) .07 .13	Standard Penetration Test (Blows/ft.) 20 100 / Undrained Unconfined Shear Strength (kip/sq.ft) Comp. Test + Vane Shear 1.0 5.0
110	Brown Silty Sand & Sand Stone					23	20		
115	Brown Fractured Sand Stone					24	10		
120	Brown Silty Sand with shale					25	20		
125	Brown Sandy Silt					26	24		
130	Brown Sandy Silt with Sand Stone					27	10		
135	Sand Stone & Silt Formation					28	26		
140	Brown Shale					29	30		
	Brown Silt Formation								
145									

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

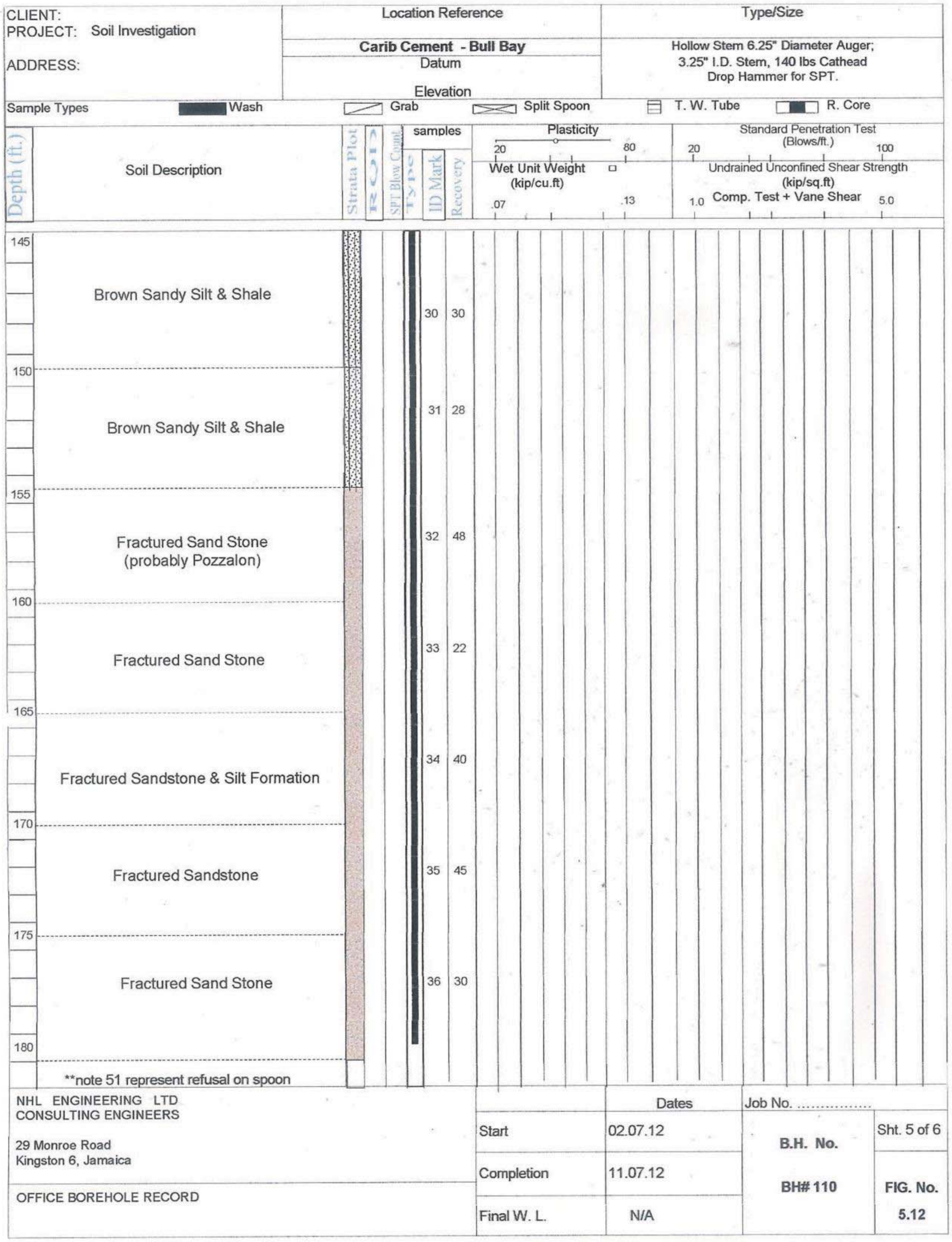
	Dates
Start	02.07.12
Completion	11.07.12
Final W. L.	N/A

Job No. ....

B.H. No. **BH# 110**

Sht. 4 of 6

FIG. No. 5.12



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull Bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types ■ Wash ▱ Grab ⊠ Split Spoon ⊟ T. W. Tube ■ R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	samples ID Mark	Recovery
145	Brown Sandy Silt & Shale					30	30
150	Brown Sandy Silt & Shale					31	28
155	Fractured Sand Stone (probably Pozzalon)					32	48
160	Fractured Sand Stone					33	22
165	Fractured Sandstone & Silt Formation					34	40
170	Fractured Sandstone					35	45
175	Fractured Sand Stone					36	30
180							

**note 51 represent refusal on spoon

Plasticity 20 80
Wet Unit Weight (kip/cu.ft) .07 .13
Standard Penetration Test (Blows/ft.) 20 100
Undrained Unconfined Shear Strength (kip/sq.ft)
Comp. Test + Vane Shear 1.0 5.0

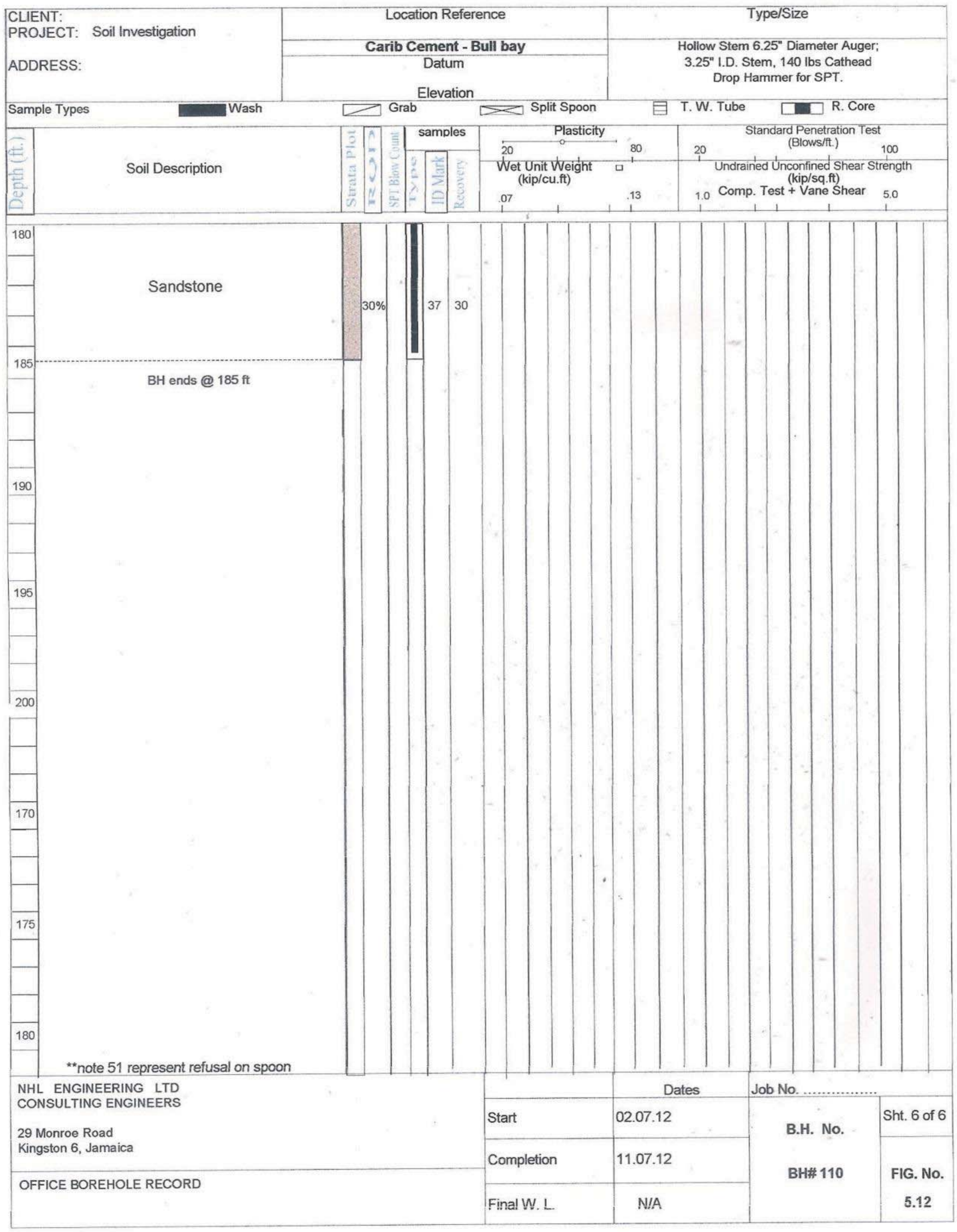
NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	02.07.12
Completion	11.07.12
Final W. L.	N/A

Job No. ....
B.H. No. **BH# 110**
Sht. 5 of 6
FIG. No. **5.12**



CLIENT:
PROJECT: Soil Investigation
ADDRESS:

Location Reference
Carib Cement - Bull bay
Datum
Elevation

Type/Size
Hollow Stem 6.25" Diameter Auger;
3.25" I.D. Stem, 140 lbs Cathead
Drop Hammer for SPT.

Sample Types: Wash; Grab; Split Spoon; T. W. Tube; R. Core

Depth (ft.)	Soil Description	Strata Plot	RQD	SPT Blow Count	Type	ID Mark	Recovery
180	Sandstone		30%			37	30
185	BH ends @ 185 ft						
190							
195							
200							
170							
175							
180							

Plasticity: 20 – 80
Wet Unit Weight (kip/cu.ft): .07 – .13
Standard Penetration Test (Blows/ft.): 20 – 100
Undrained Unconfined Shear Strength (kip/sq.ft): 1.0 – 5.0
Comp. Test + Vane Shear

**note 51 represent refusal on spoon

NHL ENGINEERING LTD
CONSULTING ENGINEERS

29 Monroe Road
Kingston 6, Jamaica

OFFICE BOREHOLE RECORD

	Dates
Start	02.07.12
Completion	11.07.12
Final W. L.	N/A

Job No. ....

B.H. No. **BH# 110**

Sht. 6 of 6

FIG. No. **5.12**

Appendix 7 – Rehabilitation Plan for Halberstadt Quarry

Rehabilitation of The Halberstad Quarry

This document seeks to demonstrate an effective plan for systematic rehabilitation of mined out lands to an aesthetically pleasing landscape, with similar or greater value than prior to quarrying activities, promoting the integrity of TCL group of companies as good corporate citizens. It will demonstrate the restoration and reshaping of the quarry. The affected areas should be rehabilitated in a manner so that its value is similar to or greater than it was before disturbance, producing a safe, environmentally stable landscape compatible with adjoining lands.

Introduction

Jamaica Gypsum and Quarries Ltd (JGQ) quarries are located north of Bull Bay. The Halberstadt Quarry, in which mining operations were halted, will soon be reopened to mining activities. Therefore it is essential that a rehabilitation plan is presented executed and monitored in stages to effectively result in safety, aesthetical and environmental satisfaction in safeguarding legacies of the TCL group of companies and it's subsidiaries, as good corporate citizens. Rehabilitation will commence before the first blade of material is removed from the site. A complete biological assessment of the area will be conducted prior to the commencement of developing access roads to the area. This assessment will be used to guide the process of re-vegetation of mined out areas. Progressive rehabilitation will be aggressively pursued during the operation of this quarry. Topsoil removed during development will be stored in designated locations so that pits can be backfilled as soon as a mine section is exhausted. While the mine is active, systematic grading and levelling will be conducted as required to rehabilitate areas to prevent the formation of steep cliffs and depressions. Artificial drainages will be conducted to channel excess runoff in the mines to the natural waterway to the east of the deposit. Rehabilitation will be conducted in stages during the life of the mine.

Geological Setting, implications and constraints

The Jamaica gypsum quarry and premises lies within the Wagwater basin which is a fault bounded area containing lower tertiary sedimentary and volcanic rocks. It is thought that the area formed through the extension of the Jamaican landmass separating Jamaica in two (2) blocks. A rift basin was formed which was then flooded by the sea. Pillow basalts (magma) flowed out along the extensional weaknesses within the flooded basin. Sediments from the slopes of the rift settled within the basin sometimes creating turbidite activities. Limestone was formed from the organisms living within the flooded basin. The orogeny (terrain) of the area is produced from reversed tectonics; where extensional faulting is reversed resulting in compression, which produce the mountainous terrain now experienced. Figures 1.1.1 and 1.1.2 show models indicating the formation of the Wagwater basin

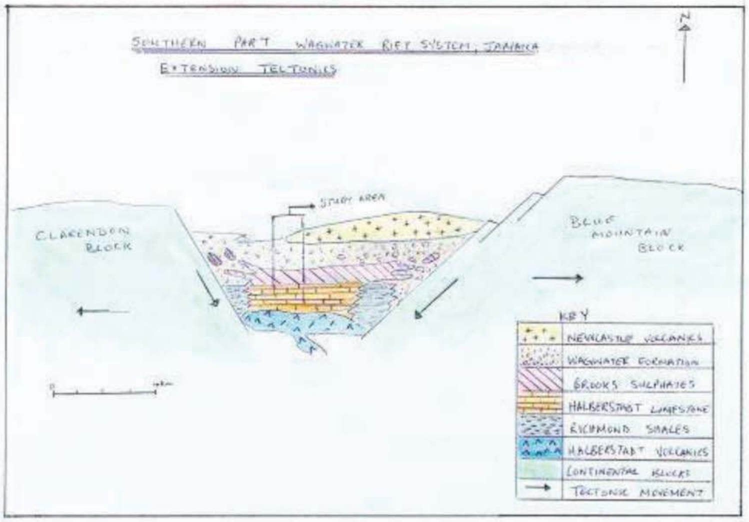


Figure1.1. 1 Rift

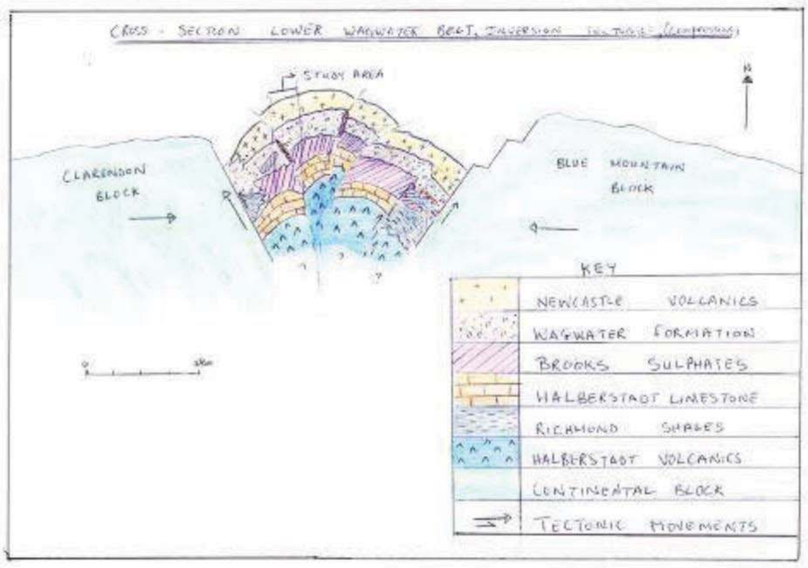


Figure 1.1.2 Compression system

1.2 Structure

The structure of the region is very complex with mini faults and folds visible in the bare outcrops, chevron and other features which may indicate a bigger more complex fold up-thrust system are observed. Bedding of rocks seems to be dipping in varying directions and this indicates the structural complexities of the area. These complexities contribute to the instability of the region as it relates to landslides. With continued plate movement in the Caribbean region structures must be carefully engineered and slopes most be carefully stabilized to protect human dwellings from massive failures.

1.3: Lithology

The area consists of six main lithologies these can be seen in table one. The youngest rock type lies to the top of the table.

Lithology	**Description**
Newcastle Volcanics	Keratophyric lavas and breccias with moderate to extensive jointing and brecciation
Wagwater conglomerates and sandstones	Normally graded purple-red weathering rocks sometimes containing sulphate flakes
Sulphate	Gypsum and anhydrite are common to these outcrops, various structures and occurrences famous amalgamated (chicken wire), selenite, satin spar and alabaster are the varieties of gypsum found
Richmond facies	Fissile dark grey to black shales and sandstones with calcite veining
Halberstadt Limestone	Extensively recrystallized, light grey to black impure (sometimes micritic) limestone, with branching structures and coralline imprints
Halberstadt Volcanics	Splitized basalt lavas with vesicules and pillow structures (shale material)

Table 1.3.1: Lithology of study area

Figure 2.1.1:Brooks quarry at end of mine

Figure2.1.2: Brooks quarry 2008

2.5: Halberstadt Quarry

The Halberstadt quarry has been inactive for over forty years. This has allowed extensive natural re-vegetation. However, this quarry will be reopened and as such plans must be made for its rehabilitation that will guide mining operations.

Figure 2.5.1: Forty years natural un-aided re-vegetation at Halberstadt Quarry (will be undone when mining resumes)

Landslide assessment

The term landslide includes gravitationally induced mass movement of slope materials through the mechanisms of sliding, falls, and flows. From a structural standpoint a very significant percentage of the slopes in the quarries studied are subject to failure simply by having a slope angle of greater than 42 degrees. If the slope consists of unconsolidated or porous material it will be more likely to fail than consolidated non porous slope. In addition the orientation of some rocks on a slope makes it more likely to fail for example the limestone cliffs in Bito and brooks are dipping in favour of failure. The factor of safety (FS) can be calculated on each slope. FS should be greater than one for a slope to be considered stable. Fs greater than one can be achieved by reducing the driving forces and increasing the resisting forces.

FS=∑Resisting forces/ ∑ Driving forces

Rehabilitation plan

In order to execute a productive and effective rehabilitation a simplified, systematic approach must be taken. We therefore, have taken initiative to group action plan into Four (4) stages.

Stages for rehabilitation plan

Stage (I) -stage before and during initial stages of mining

Stage (II) - stage during and near end of mine

Stage (III) - stage at end of mine for quarry in question

Stage (IV) - stage of total rehabilitation for entire area

Stage (I)

Currently the Halberstadt Quarry is at this stage. This is a very important stage which allows the mining operations to be focused on the end product of mining and how it will fit in with rehabilitation. Top soil can be successfully removed and stored for reapplication at the end of the mine as this will save the company the expensive costs of creating and maturing the soil so it can foster diverse flora and fauna. This stage allows the mine plan to incorporate reclamation and rehabilitation in its plans, which will make the execution of rehabilitation easier and more cost effective. At this stage a specific schedule is not necessary but activities should be incorporated in daily activities. Overburden piles or waste materials (tailings) should be tactfully stored where it can be accessed and not covered by regolith. Water management treatment must also be considered at this stage, alternative artificial drainage should be created or planned to reduce the effect of water affecting the operations and also to present minimal damage to the environmental systems.

Stage (II)

This stage is also a cost effective stage, rather than doing the work in huge burdensome and budget breaking chunks, the cost will be offset by everyday operations. Areas already mined will be backfilled and graded in a systematic way. This will allow pioneering or introduced species of vegetation to colonize and contribute to the development and stabilization of the soil in areas already worked. If the site has major cliff barricades and fences will be installed for human and animal safety. All overburden and waste piles will be in the process or are totally utilized. The water management again must be taken into consideration. If possible natural drainage systems could be restored otherwise artificially engineered aesthetically pleasing alternatives are to be implemented. All buildings, equipment and infrastructure must be taken into consideration, whether they should be demolished, sold or transformed to other productive uses. This also provides the perfect opportunity to cover any landfills and waste disposal sites.

Stage (III)

Here the final stages of backfilling and grading should take place. Permanent Vegetation (trees) will be planted and aesthetically pleasing landscaping can begin. Permanent fencing and barriers are to be installed in areas in which they are needed.

Stage (IV)

This stage is where the final rehabilitation is executed on the entire area. For example if the area is to be separated into plots for sale or creation of a large scale farm, or the development of a recreational park. This stage can only be completed when all mining operations cease.

Biological Engineering

This involves the proposal of systematic installation planting of primarily vetiveria zizanioides (Adams 1972) (Jamaican Cush Cush or Maat grass) among other native vegetation to stabilize the soils and eliminate visual intrusion. Vetiver (as it is commonly called globally) has long been used to stabilize slope along with its many other applications in perfume and craft industries. The roots of this plant can extend to in excess of three (3) meters (five feet), (figure 4. 2.1). Mean tensile strength of the roots of the vetiver roots can be as much as 75 Mpa which is the equivalent strength as 1/6 to that of mild steel employed in the construction industry.

The vetiver plant is very effective for slope stabilization if planted closely relative to the slopes profile. A good hedge will reduce rain water run off by 70 % and sediment by up to 90 %. It also acts as a terrace collecting and leveling out soil upslope (essentially making the slope less steep). With its wide ranging tolerance of adverse climatic, toxic and soil conditions the Vetiver hedge system offers a simple and low cost alternative to constructed soil erosion and sediment control measures. The results of its implementation will also be easy on the eye. The Vetiver system offers a unique means of rehabilitation of these highly erodible lands and great potential for reclamation work in mining and other industrial waste and contaminated lands.

Figure 4.2.1: Extensive vertical roots of the vetiver

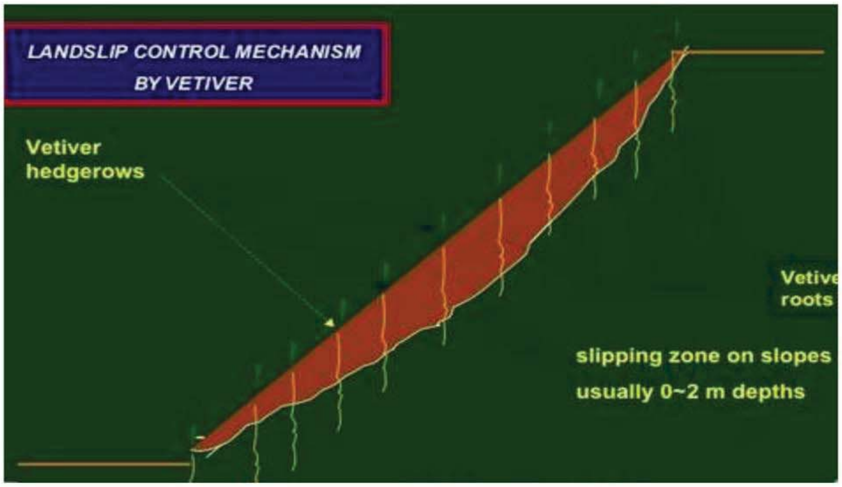


Figure 4.2.2: Demonstrate the engineering capacity of these plants operating as piles (resisting forces) holding the soil in place to prevent slipping

11

Figure 4.2.3 Slope rehabilitated

Figure 4.2.4California highway

Figure 4.2.5 Jamaica Flour Mills

Rehabilitation activities

The table below lists some of the activities to be employed in the initial rehabilitation programme.

REHABILITATION ACTIVITIES
Backfilling
Leveling/grading
Biological engineering
Road Maintenance
Mine River Diversions
Fencing
Demolishing of Buildings
Use Tires as Berms
Monitoring

Rehabilitation Action Plan

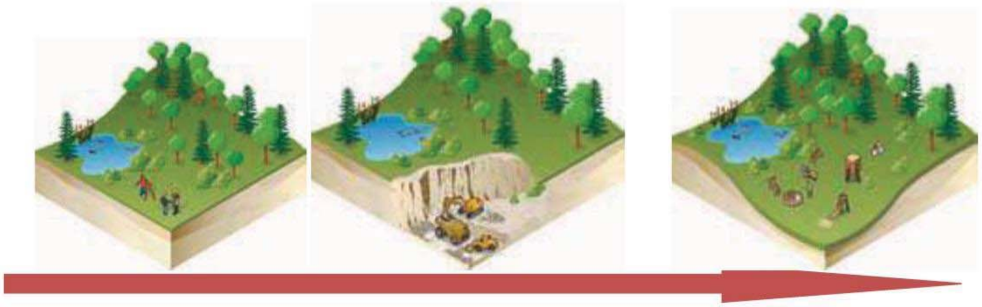


Figure 5.1: schematic diagram of successful quarry rehabilitation

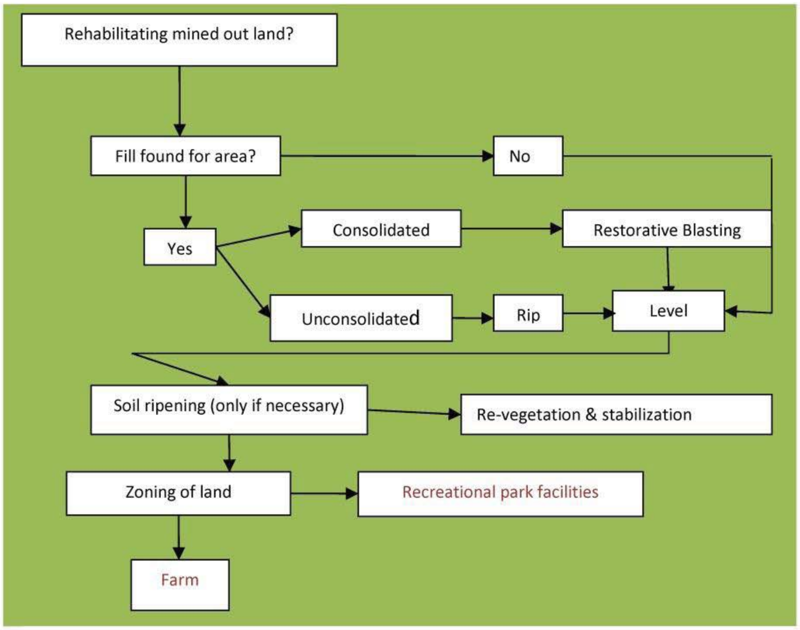


Figure 5.2: flow chart showing actions necessary in execution of rehabilitation plan

Systematic grading and leveling of areas that needs to be rehabilitated. For example if there is a steep cliff, a ramp should be created so instead of a geometric pit a more natural depression is created. In addition where cliffs are too high, restoration blasting could be employed to get fill material, and this will also eliminate the hazards associated with steep cliffs for example rock fall and topples.

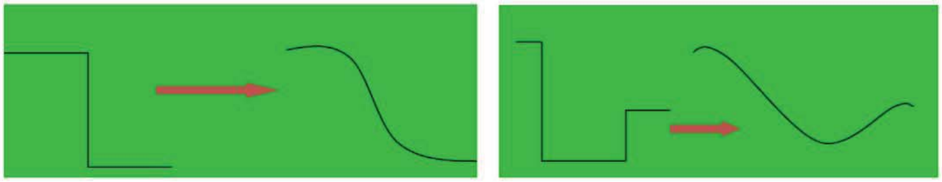


Figure 5.3: demonstration of effective grading and landscaping

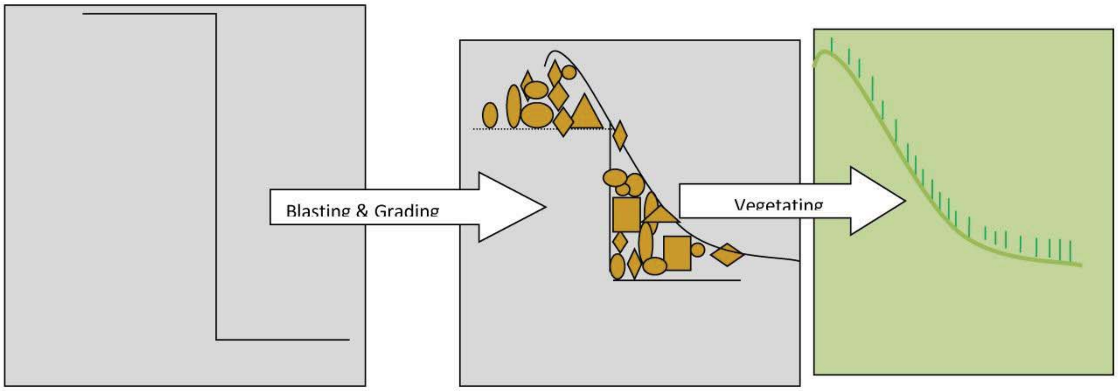
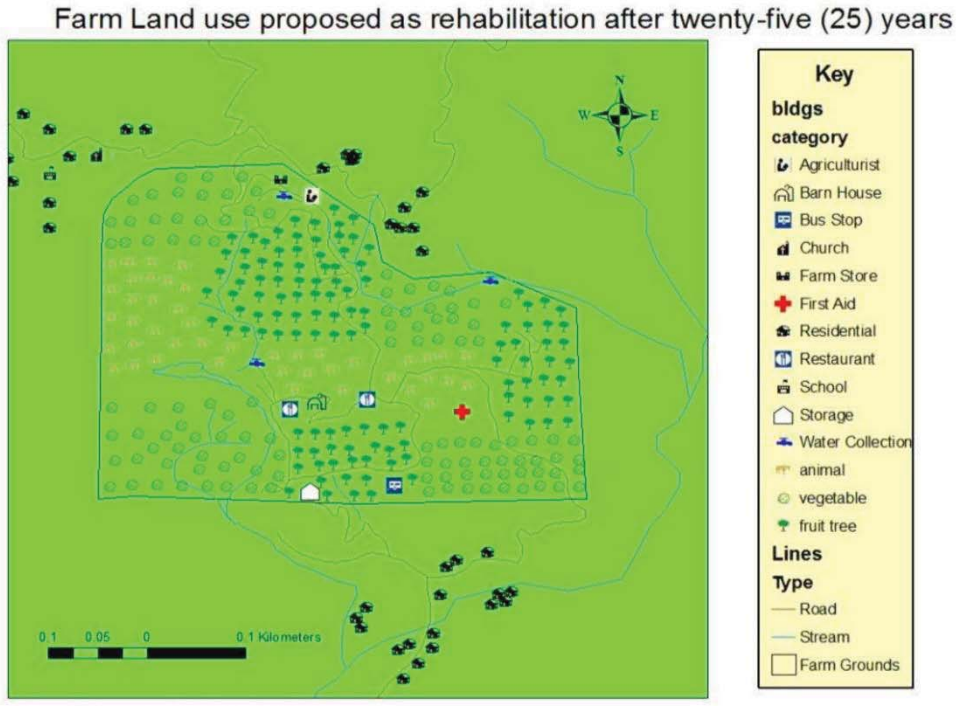


Figure 5.4: demonstration of restorative blasting employed in rehabilitation

Long-term Rehabilitation

After the end of all mining and decommissioning of mines a long-term rehabilitation plan can be employed to promote the corporate integrity of TCL group of companies. The option proposed is farm land use, this will provide income earning activities for the population which depends on the quarry industry.



Taneisha Edwards C/o JGQL & CCCL 2008 jad69

Figure 5.1.1: map showing simple farm as long term rehabilitation

The farm will take into consideration the type of vegetation that is conducive to the dry highly elevated area. Some vegetables are known to thrive in this condition such as thymes, scallion, and beetroots among others. In addition in the past the area was known for its mangoes. The mango tradition could be revived investing in mango orchards. In addition to that animals such as cows and goats could develop even further along with other animals such as the poultry industry. Special use could be made of the water courses that run through the area, for irrigation. Technical assistance could also be provided from an in house or on call agriculturist or RADA representative.

Chapter 6: Conclusion

The land will be restored by grading and leveling. After which it will be vegetated. The rehabilitation plan will systematically be executed according to the stages of quarry and in five year periods for twenty-five years. Biological engineering will be employed to stabilize the slopes, eliminate visual intrusion and eventually overall rehabilitation of the quarries. Fences will be installed to ensure human safety. Other activities, techniques and technology will be employed to execute this rehabilitation plan.

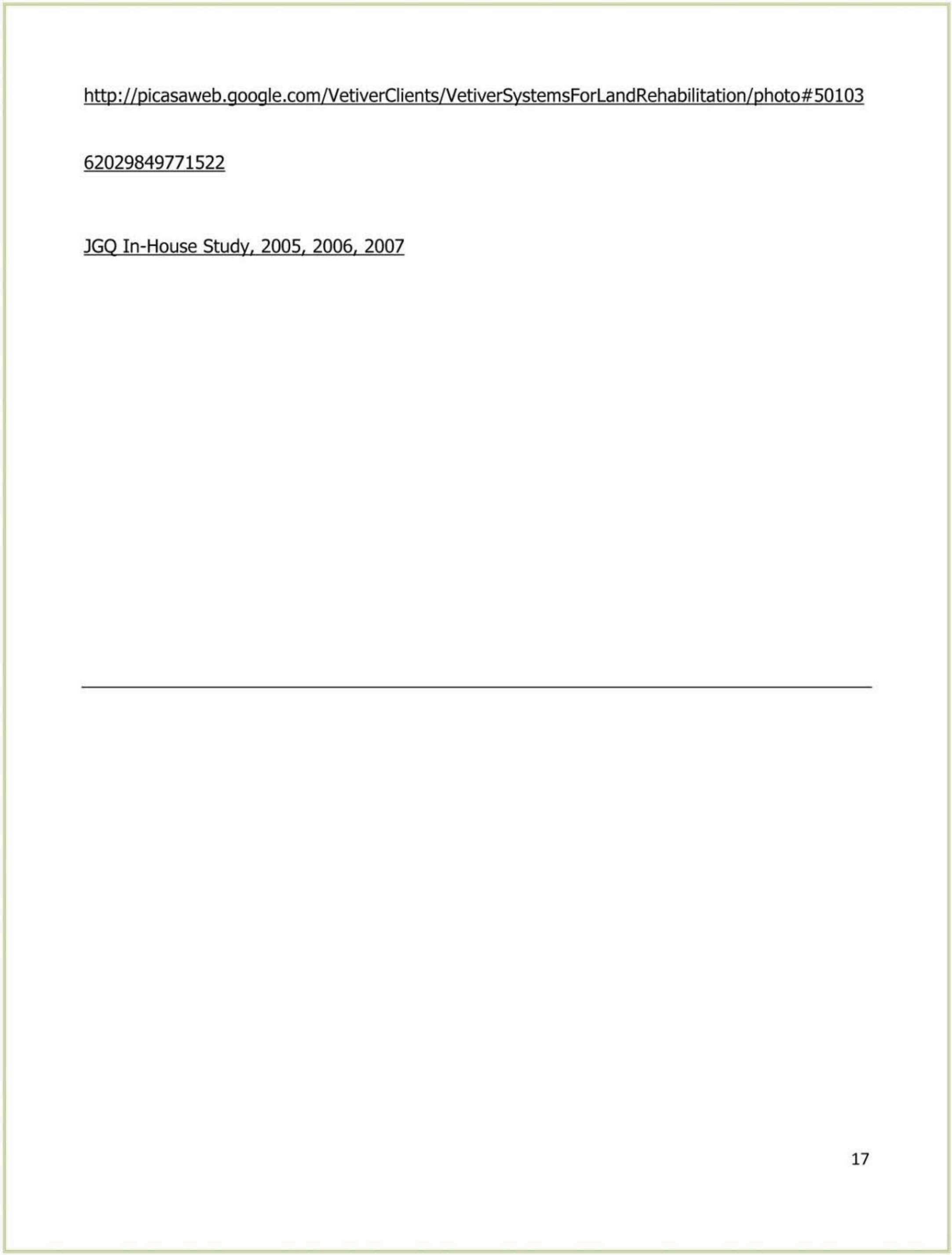
At quarry decommissioning further rehabilitation can be executed to replace the income based niche that quarrying operation in this area has filled.

References

Adams, C. D, 1972. "Flowering Plants of Jamaica" University Press, University of the west Indies, Robert MacLehose &Company University Press Glascow

Allen L. & Neita M. 1987, "Geology of the north Bull Bay sulphate occurrence zone". *Geologic Society Jamaica*, special issue 1987, pp. 282-295

http://www.vetiver.com/AUS_Hedges15.htm



http://picasaweb.google.com/VetiverClients/VetiverSystemsForLandRehabilitation/photo#50103

62029849771522

JGQ In-House Study, 2005, 2006, 2007

Appendix 8 – Calibration Certification (Hydrolab DS-5)

HACH®
Hydromet

Certificate of Instrument Performance

Agency Name: **CL Environmental**

Certification for Job# 1136954

Part/Model Number: **DS5**	Serial Number: **100100048757**

RECEIVED CONDITION:
(One must be checked)
☒ Within Tolerance
☐ Within Tolerance but Limited *(*see service report)*
☐ Out of Tolerance *(*see service report)*

RETURNED CONDITION:
(One must be checked)
☒ Within Tolerance
☐ Within Tolerance but Limited *(*see service report)*

Test Equipment Used, (ID#): N.I.S.T. - traceable glass thermometer (H-B Thermometer, Serial ***2Z9208)***
and a Cole-Parmer "*PolyStat*" Constant Temperature Circulator

Environmental Conditions:

Actual Temperature:	***10.00***	°C	Instrument Reading: 10.03	°C	Error +***03***	°C
	20.00	°C	20.01	°C	+***0.01***	°C
	30.00	°C	29.97	°C	-***0.03***	°C

Hach Company does hereby certify that the above listed equipment meets or exceeds all Manufacturers' Service Specifications (unless limited conditions apply). Test equipment used for performance verification are calibrated using standards traceable to the National Institute of Standards and Technology (NIST). Where such standards do not exist, the basis for calibration is documented. The proper operation of the above instrument was established at the time of certificate issuance. To insure continued performance, user must adhere to all requirements listed in the instrument manual.

Certified by: J K Burton
Title: Instrument Service Technician

Certification Date: 3-14-13

5600 Lindbergh Drive ● Loveland, CO 80538
(800) 227-4224 / FAX (970) 461-3924

Doc# 19773-01
Rev. 3

Appendix 9 – Noise Calibration Certification (Quest QC-10)

3M
3M Occupational Health and
Environmental Safety Division

Quest Technologies
1060 Corporate Center Drive
Oconomowoc, WI 53066-4828
www.questtechnologies.com
262 567 9157 800 245 0779
262 567 4047 Fax

QUEST TECHNOLOGIES
now part of 3M

Page 1 of 2

Certificate of Calibration

Certificate No: 1097581QII050083

Submitted By: C.L. ENVIRONMENTAL CO., LTD.
22 FORT GEORGE HEIGHTS
KINGSTON, 8

Serial Number: QII050083
Customer ID:
Model: QC-10 CALIBRATOR

Date Received: 7/17/2012
Date Issued: 7/20/2012
Valid Until: 7/20/2013

Test Conditions:
Temperature: 18°C to 29°C
Humidity: 20% to 80%
Barometric Pressure: 890 mbar to 1050 mbar

Model Conditions:
As Found: IN TOLERANCE
As Left: IN TOLERANCE

SubAssemblies:
Description:
Serial Number:

Calibration Procedure: 56V981

Reference Standard(s):

I.D. Number	Device	Last Calibration	Date Calibration Due
ET0000556	B&K ENSEMBLE	12/7/2010	12/7/2012
T00230	FLUKE 45 MULTIMETER	2/2/2012	2/2/2014

Measurement Uncertainty:
+/- 1.1% ACOUSTIC (0.1DB) +/- 1.4% VAC +/- 0.012% HZ
Estimated at 95% Confidence Level (k=2)

Calibrated By: Robert Workentine 7/20/2012
ROBERT WORKENTINE **Service Technician**

Reviewed/Approved By: 7/20/2012
Technical Manager/Deputy

This report certifies that all calibration equipment used in the test is traceable to NIST or other NMI, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of Quest Technologies.

098-393 Rev. B

An ISO 9001 Registered Company
ISO 17025 Accredited Calibration Laboratory

A2LA ACCREDITED
Calibration Laboratory
CERT#1326.01

Appendix 10 – Listing of plant species encountered during floral survey

Botanical Name	**Vernacular**	**Growth Form**	**DAFOR**
Adiantum sp.	Maiden Fern	**Herbs**	R-O
Agave sp.†			O-F
Alternanthera ficoidea	Crab Withe		F-A
Amaranthus sp.	Wild Calalloo		R-O
Andrographis paniculata	Rice Bitters		O
Argemone mexicana	Mexican Poppy		F
Bidens pilosa	Spanish Needle		O
Catharanthus roseus	Periwinkle		A
Commelina diffusa	Water Grass		O
Commelina sp.			O
Corchorus siliquosus	Slippery Bur		O-R
Crotolaria pallida			F
*Croton humilis var. adenophyllus**	Pepper Rod		R
Dactyloctenium aegyptium			R
Desmodium canum			R
Eleusine indica	Yard Grass		O
Emelia javanica	Cupid's Shaving Brush		O
Heliotropium angiospermum	Dog's Tail		F
Kallstroemia maxima	Police Macca		R
Launaea intybacea	Wild Lettuce		O
Leonotis nepetifolia	Christmas Candlestick		F-A
Macroptilium lathyroides			R
Malvastrum coromandelianum			O
Panicum maximum	Guinea Grass		A
Phytolacca rivinoides	Jocato		O
Pluchea carolinensis	Wild Tobacco		A
Portulaca oleracea	Pussley		O
Priva lappulacea	Clamy Bur		O-R
Rhynchelytrum repens	Natal Grass		O
Rivina humilis	Bloodberry		O
Ruellia tuberosa	Duppy Gun		R
Setaria setosa			F
Solanum americanum	Black Nightshade		R

Botanical Name	**Vernacular**	**Growth Form**	**DAFOR**
Sporobolus jacuemontii			F
Stachytarpheta jamaicensis	Vervine		O
Talinum paniculatum			R
Tridax procumbens			R
Verbesina pinnatifida			F
Wissadula amplissima			O
Pisonea aculeata	Cockspur	**Lianas**	F-A
Unknown Bryophyte		**Mosses**	R
Antigonon leptopus	Coralita	**Scramblers, Runners, Climbers and Epiphytes**	O
Aristolochia sp.			R
Borreria laevis	Button Weed		R
Calisia repens			O
Cissampelos pareira	Velvet Leaf		F
Cissus sicyoides	Snake Withe		F-A
Commicarpus scandens	Rat Ears		O
Cucurbita pepo	Pumpkin		R
Cuscuta americana	Love Vine/Bush		R
*Hyolocereus triangularis**	God Okra		F
Melothria gudalupensis			O
Mikania micrantha	Guaco		F
Morinda charantia	Wild Cerasee		F
Passiflora edulis	Passion Fruit		R
Passiflora perfoliata			R
Passiflora suberosa			R
Pithecoctenium echinatum	Monkey Comb		O
Tillandsia recurvata	Old Man's Beard		R
Tournefortia sp.			F
Tournefortia volubilis	Chigger Nut		F
Trichostigma octandrum	Basket With		O-R
Urechites lutea	Nightshade		O
Lantana camara	White Sage	**Shrubby Herbs**	F-A
Lasiacis divaricata	Bamboo Grass		O
Plumbago scandens	Wild Plumbago		R-O
Sida acuta	Broomweed		F-A
Sida sp.			O

Botanical Name	**Vernacular**	**Growth Form**	**DAFOR**
Sida sp. 2			O
Sida spinosa			F
Urena lobata	Ballard Bush		O
Waltheria indica	Raichie		A
Bambusa vulgaris‡	Common Bamboo	**Shrubs**	O
Capparis flexuosa	Bottle-Cod Root		O
Capsicum baccatum	Bird Pepper		R
Casearia guianensis	Wild Coffee		R
Cestrum diurnum	Wild Jasmine		O
Chromolaena odorata	Christmas Bush		A
Cordia brownei	Black Sage		R
Cordia globosa var. humilis	Wild Sage		R
Croton linearis	Rosemary		R
Euphorbia nudiflora			R
Melochia nodiflora			F
*Notoptera hirsuta**			R-O
Piper amalago†			R-O
Pithecelobium unguis-cati	Privet		R
Ricinus communis	Castor Oil Plant		A
Solanum torvum	Susumber		F
Tabernaemontana divaricata	Coffee Rose		R
Tecoma stans			F
Tournefortia hirsutissima	Cold Withe		O
Acacia farnesiana	Cassie Flower	**Trees**	F-A
Acacia villosa	Yellow Tamarind		R
Brya ebenus	West Indian Ebony		O
Bursera simaruba	Red Birch		O
Calliandra sp.			R
Cassia emarginata	Yellow Candle Wood		O
Catalpa longissima	French Oak		R
Cecropia peltata	Trunpet Tree		R
Ceiba pentandra	Silk Cotton Tree		R-O
Cocoloba sp.			R
Comocladia pinnatifolia	Maiden Plum		F
Cordia collococca	Clammy Cherry		O

Botanical Name	**Vernacular**	**Growth Form**	**DAFOR**
Cordia gerascanthus	Spanish Elm		O-F
Crescentia cujete	Calabash		O
Erythroxylum areolatum	Coca Shrub		F
Eugenia maleolens			F
Fagara martinicensis	Prickly Yellow		O
Guazuma ulmifolia	Bastard Cedar		F-A
Leucaena leucocephala	Lead Tree		O-F
Leucaena sp.			R
Malpighia sp.			R
Mangifera indica‡	Mango		O
Metopium brownei	Burn Wood		F
Muntinga calabura	Jamaican Cherry		R
Peltophorum pterocarpum‡			O
Piscidia piscipula	Dogwood		F
Psidium guajava	Guava		R
Samanea saman‡	Guango		O
Simarouba glauca	Bitter Damson		F
Trichilia hirta	Wild Mahogany		F
*Trichilia reticulata**			R-O

Appendix 11 – Community Questionnaire

PROPOSED QUARRYING AND MINERAL PROCESSING AT HALBERSTADT QUARRY, ST. ANDREW, JAMAICA COMMUNITY QUESTIONNAIRE

DATE:____________________

Jamaica Gypsum and Quarries Limited, a subsidiary of the Caribbean Cement Company operates a gypsum quarry in the Bito District located in Bull Bay St. Andrew. The Bito Gypsum Quarry is now depleted of mineable ore and reclamation activities are scheduled. The Cement Company uses gypsum in the manufacturing of cement. The Halberstadt Quarry which is now revegetated has been dormant for 40 years, but recent drilling information indicated that there are reserves of gypsum/anhydrite at the quarry (approx. 5 million tonnes) which could supply the quarry with the gypsum needed. The current consumption rate of the Trinidad Cement Limited is approx. 100k tonnes, and it is anticipated that mine life at Halberstadt will be 50 years. With existing quarries nearing the end of mine life, it is incumbent on Jamaica Gypsum and Quarries to develop the Halberstadt deposit for production in an effort to survive.

COHORT DESCRIPTION

1. What is the name of this/your community? ___________________________

2. (i) Male (ii) Female

3. Age group (i) 18- 25 yrs (ii) 26-33 yrs (iii) 34-41 yrs (iv) 42 – 50 yrs (v) 51 – 60 yrs (vi) older than 60 yrs

4. Are you the head of your household (i) yes (ii) no

5. What is your employment status? (i) employed (ii) unemployed (iii) retired

6. If employed, are you (i) self employed or do you (ii) have an employer

7. If employed what do you do? ______________________________________
(i) Casual labour (ii) semi-skilled (iii) skilled (iv) artisan (v) professional

8. Including yourself, how many people live in your household? (i) # of adults ____ (ii) # of children under 18 yrs ____

9. How long have you lived in your community? (i) <2 yrs (ii) 3-5 yrs (iii)5- 10 yrs (iv)10-15 yrs (v) > 15 yrs

EMPLOYMENT & INCOME

10. Including yourself how many people in your household are employed? ____________________________

11. What is the main employment status of household head? (If the interviewee is not the head of the household). (i) employed (ii) unemployed (iii) retired

12. If employed what does the head of household do? ______________________________________
(i) Casual labour (ii) semi-skilled (iii) skilled (iv) artisan (v) professional

**** Use Table to answer questions below**

1. Below $500	6. $3001 - $4000
2. $ 501 - $1000	7. $4001 - $5000
3. $1001 - $1500	8. $5001 - $6000
4. $1501 - $2000	9. $6001 - $7000
5. $2001 - $3000	10.Over $7000

13. What is the average weekly income of the household head? ______________________

14. What is your average weekly income? ______________________________

15. What is the average weekly income of the household? (All sources) _________________

16. Do you depend on the proposed location for business? (i) yes (ii) no
    a. If yes what do you depend on it for?
    ____

EDUCATION

17. What is the highest level of education completed? (Which was the last school you attended) (i)None (ii) Primary/All Age (iii) Some High School (iv) High School (v) College (vi) University (vii) HEART/Vocational training institute

18. Is there anyone in your household attending school at this time? (i) yes (ii) no
    a. If yes how many persons ? ________________________
    b. What is/are the names of the school(s) ____

Name of School	How many persons attend	Approximate travel distance

PERCEPTION

19. Have you ever heard of a company called the Jamaica Gypsum and Quarries Limited?
    (i) yes; (ii) no
    a. If yes what have you heard and how did you hear? ____
    ____

20. Have you ever heard of a company called the Caribbean Cement Company?
    (i) yes; (ii) no
    a. If yes what have you heard and how did you hear? ____
    ____

21. Did you know that the Jamaica Gypsum and Quarries Limited is proposing to reopen the Halberstadt Quarry to mine gypsum? (i) yes; (ii) no
    a. If yes how were you made aware? ____
    ____
    b. What have you heard ____
    ____

22. Do you have any concerns about the project as proposed? (i) yes; (ii) no
    a. If yes what are they? ____
    ____

23. Do you think that the reopening of the quarry will affect your life? (i) yes; (ii) no
    If yes, (i) positively or (ii) negatively

a. If positive how so? ____

b. If negative how so?____

HOUSING, HEALTH AND SOCIAL SERVICES

24. Do you _______ the house you live in? (i) Own (ii) Lease (iii) Rent (iv) Government Own (v) Squat (vi) Family own (vii)Other, specify ____________

25. Do you ________ the land on which your house is located?
(i) Own (ii) Lease (iii) Squat on (iv)Family Owned (v)Government Owned (vi)Other, specify ______________

26. What type of construction material is your residence made from?
   a. **Walls:** (i) Concrete and blocks (ii) Wood/Board (iii) Metal sheeting (zinc) (iv) Other specify________
   b. **Roof:** (i) Metal sheeting (zinc) (ii)Concrete (iii)Wood (iv) Shingle (v) Other specify________

27. How many of the following rooms does your residence have? (i) Bedrooms _______ (ii) Bathrooms ________

28. What type of toilet facility do you have?
(i) Water Closet (private) (ii) Water Close (shared) (iii) Pit Latrine (ivi) None (v)Other, specify ____________

29. What does your household use for lighting?
(i) Electricity (ii) Kerosene oil (iii)Gas (iv)Other, specify ___________

30. What type of fuel does the household use most for cooking?
(i) Gas (ii) Electricity (iii)Wood (iv)Coal (v)Other, specify _____________

31. What is the main source of domestic water supply for the household?
(i) Public piped water into dwelling (ii) Private Tank (iii) Community Tank (iv) Government Water Trucks (free) (v)Public Standpipe (vi). Private Water Trucks (paid) (vii) Spring or River (viii) Other, specify________

32. Do you have any problems with domestic/household water supply (i) yes (ii) no
   a. If yes what is the problem? (i) no water at all (ii) no pipes run to the area (iii) irregular water supply (iv) low water pressure
   b. If yes how do you cope with the problem (i) collect rain water (ii) buy water (iii) collect water from a spring/river (iv) water truck supplies water (v) community standpipe (vi) other _______________________
   c. How do you store water (i) drums (ii) underground tank (iii) aboveground tank (iv) other ________________

33. Do you have access to a residential telephone? (i) yes (ii) no
   a. If no do you have a mobile/cell phone? (i) yes (ii) no
   b. If no do you know of anyone having a residential telephone nearby? (i) yes (ii) no

34. What is the main method of garbage disposal for your household?
(i) Public Garbage Truck (ii) Private Collection (iii) Burn (iv) Bury (v) Dump (iv) Other specify ________
   a. If public garbage truck, how often do trucks pick up garbage? (i) once per week (ii) twice per week (iii) every 2 weeks (iv) 1 time per month (v) Other, specify __________________
   b. If dump, where? (i) river/ sea (ii) gully (iii) in own yard (iv) municipal site (v) other

35. In the event of illness, where do you obtain health care? (i). Public Clinic/ Health Centre (ii) Public Hospital (iii) Private Doctor (iv) Private Hospital
   a. Where (name of town/hospital/clinic)?

36. Do you suffer from any of the following conditions? (i). Asthma (ii). Sinusitis (iii) coughing (iv) congestion/bronchial problems (v) chest pains (vi) bouts of diarrhoea

37. Where do you usually shop (food, clothing etc)? (i) Supermarket (ii). Market (iii). supermarket & market (iv) Community Shop (v) Wholesale Shop

38. Are there any recreational centres/spaces in your community? (i). Yes (ii) No
(i) Is yes please give name and type ______________________________

39. What does the average person do for fun within the community? (i) Street dance/parties (ii) Youth Clubs (iii) Sports Clubs/bars (iv) Service clubs/Charity for e.g. Lions Club (v) Church groups/activities (vi) Other, specify________________

NATURAL HAZARDS & SOCIAL AMENITIES

40. Are there problems with frequent flooding? (i) Yes (ii) No
    a. If yes how frequently (i) each time it rains (ii) only times of heavy rains (iii) during hurricanes (iv) other
    b. How frequently does flooding occur? (i) once weekly (ii) once monthly (iii) once in three months (iv) once in six months (v) once in a year (vi) less than once in a year

41. Which areas typically flood? ____

How high does the water level rise? (i) less than 1 foot (ii) 1-5 ft (iii) more than 5 ft

42.

43. Do you have frequent fires in the area? (i) yes (ii) no
    a. If yes how frequently (i) once weekly (ii) once monthly (iii) once in three months (iv) once in six months (v) once in a year (vi) less than once in a year

44. Is there a problem with dust in your community? (i) yes (ii) no
    a. If yes, what is the problem? ____
    ____

45. Is there a problem with noise in your community? (i) yes (ii) no
    a. If yes, what is the problem? ____
____

46. Do you know of any site or area near the Halberstadt Quarry considered to be (i) a protected area (ii) historic area (ii) or other area of national, historic or environmental importance
If yes please give us as much detail as you can on this area ____
____

47. Is there anything in particular about your area that you would like to tell us?
____

Signature of Interviewer: ....

Thank You for your time.

Drainage Assessment Report

For

Halberstadt Mine, St. Thomas

Prepared for:

CARIB CEMENT

Prepared by:

CEAC
solutions
CIVIL ENVIRONMENTAL & COASTAL
engineers & planners

July 2013

Table of Contents

	Submission to Client			
Prepared by:	KF			
Reviewed by:	CJ			
Approved by:	CB			
Date:	17/07/2013			
Comments:	Prepared for submission to client			

Prepared by:
CEAC Solutions Co. Ltd.

1 Introduction

1.1 Background

Jamaica Gypsum intends to reopen the quarry in Halberstadt, St. Thomas. The Jamaica Gypsum Quarry (JGQ) seeks to open the Halberstadt quarry that has been inactive for over 40 years and is currently fully re-vegetated. Therefore a mine plan is being prepared to guide the process of reopening the quarry. The mining plan will however have to be supplemented with information to support the Environmental Impact Assessment (EIA). This includes:

1. Hydrology of the area/catchments;
2. Drainage measures;
3. Climate resilience to cope with potentially more extreme rainfall;
4. Mitigation measures to control sediments.

A mining plan was prepared and an EIA conducted. The proposed works will generate significant runoff and this can have a detrimental effect on the receiving water bodies. The downstream community at Bull Bay is known to flood and has inadequate river bed control works. It is recommended that the due consideration be given to both limit sediment delivery and to ensure that the post-development flood flows are less than the pre-development. The objective of this report is to conduct a hydraulic analysis, to recommend drainage and sediment control infrastructure improvements. The specific objectives include:

- Specify the type of drainage structures, to include location, size, depth, spacing and slope of all open canals, ditches and subsurface drains;
- Construction methods and material specifications;
- Development of preliminary engineering and construction cost estimates;
- Post-construction management requirements.

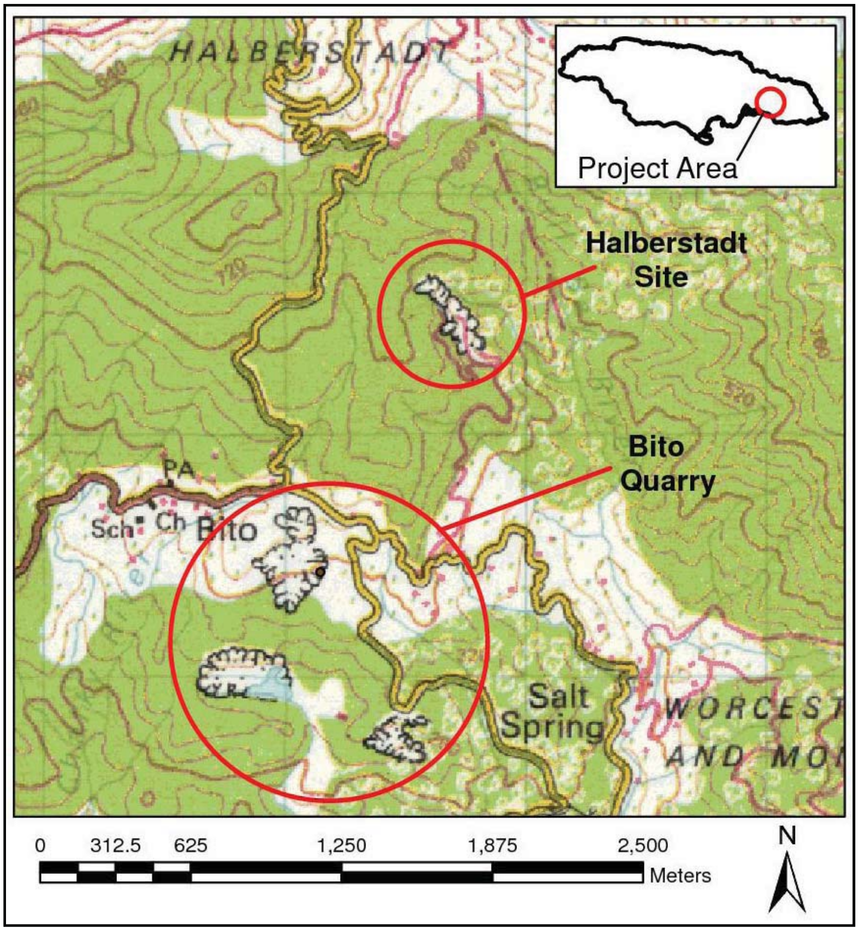


Figure 1.1 Location Plan of the proposed Halberstadt quarry in St. Thomas

1.2 Methodology

The methodology used for the analysis is as follows:

1. Data collection to include project description;
2. Delineating catchments;
3. Description of the environment to include:
    - i. The topography of the catchments
    - ii. Soils
4. Calculation of runoffs using the SCS method;
5. Hydraulic analysis of localized drains;
6. Determination of flooding impacts and mitigation strategies.

2 Description of the Environment

2.1 The Communities

There is a small community known as Benoa of approximately 20 residents located approximately 1km from the deposit. The various residences are relatively spaced closely and in some most instances have no clearly defined boundaries. As is relates to flooding, preliminary interviews conducted within the Benoa community indicated that the natural occurring surface runoff the Halberstadt quarry area does not affect the residents. According to testaments of the residents, due to the high velocities of the runoff, the surface waters cut the banks of the local roads and flows down the mountain slope avoiding the community on a whole.

This community, however, is right beside the access road and will be affected by the noise from the blasting and from trucks transporting the product from the quarry. They will also be affected from ground vibrations emanating from earth moving equipment and blasting. The possibility of relocating these residents will also be explored by the company as a means to mitigate the impact of our mining operations on the residents. The infrastructures within the area consisted of concrete, wood or both while the conditions varied from old to newly constructed. The table below demonstrates some of the structures identified:

 **Plate 2.1 Residence with both concrete and zinc structures**	 **Plate 2.2 Residence with wooden structure**
 **Plate 2.3 Residence with concrete structure**	 **Plate 2.4 Structure constructed of concrete**

2.2 The Catchment

2.2.1 Topography

Topographical data for the proposed site was obtained from a number of sources to include:

1. The survey departments 12,500 map series;
2. Survey points provided by the client;
3. Survey points of the H2K culverts and embankment from commissioned surveyors contracted by CEAC Solutions.

2.2.1.1 Survey Department 1:12,500 map Series

The contour data obtained revealed that the overall project area is mountainous and is sloping in a general North-west to South-east direction. The elevations across the project area vary from a low of 480 metres above Mean Sea Level (MSL) to a high of 620 metres; Most of the project areas are found predominantly in the mid to high ranges.

2.2.1.2 Client Survey Data

Topographic data obtained from the client described the elevation of ground within the quarry deposit boundary vary between 462 metres and 620 metres above MSL. The elevations within the proposed 1 hectare mining site varied from 544 metres above MSL in the highest areas to a low of 500 metres at the south-eastern boundary.

2.2.2 Boundaries (delineation)

It was important to delineate the catchments associated with the proposed site so as to calculate the expected runoff associated with the proposed quarry site. The catchment was delineated using 12,500 contour data and refined with the topographic data provided by the client. Although the catchment associated with the site itself is relatively small, it was important to identify the area associated with it. The area determined to be encompassed by the catchment 16.9 hectares. This catchment does not have a continuous/coherent drainage system. The local parochial roads act as main channels which conduct flows down the site and into the Bull Park River. Where the roads are unable to hydraulically channel the surface runoff, it naturally flows down the side of the mountain and into the river.

Figure 2.1 The overall catchment area associated with the proposed Halberstadt mining site.

2.2.3 Soils

2.2.3.1 Ministry of Agriculture Database

The catchment was superimposed on the ministry of Agriculture's soils map of Jamaica to identify the soils distribution within the watershed. Soils are classified into four Hydrologic Soil Groups (A, B, C, and D) according to their minimum infiltration rate defined by the Natural Resources Conservation Services (NRCS) TR-55 after prolonged wetting. It was noted that the catchment is encompassed by predominantly clays with minor areas of gravelly sandy loam which has low to internal moderate drainage respectively as seen in Table 2.1 below.

Table 2.1 Outline of soil properties obtained from the Soil and Land Use Surveys

Soil Name	Texture	Internal Drainage	Erosion Hazard
Macho	Clay loam	Moderate	High
Cuffy Gully	Gravelly Sandy Loam	Very Rapid	High

The western portion of the site is located predominantly on clay loam which has moderate internal drainage, translating to the runoff on these soils tend to be moderate to high. The Halberstadt site catchment was superimposed on the soils map below in Figure 2.2.

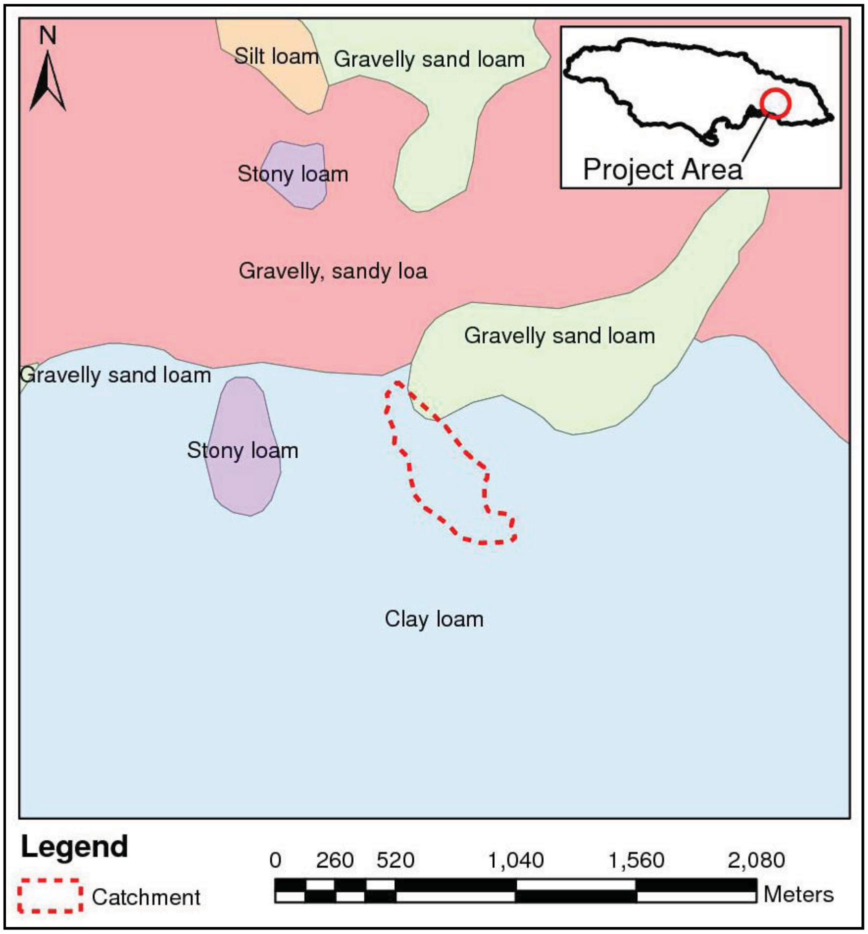


Figure 2.2 Proposed Halberstadt site catchment superimposed on Soils map of Jamaica.

2.2.4 Land Use

The Land use for each catchment was determined from inspection of the Forestry Department land use map as seen in Figure 2.3. Land use was classified into categories consistent with the schedules published by the Natural Resources Conservation Services (NRCS) TR-55 for cover type and hydrologic condition. Based on observations, it was noted that:

1. The western regions of the catchment were observed to have mostly disturbed broad leaf areas.
2. The eastern reaches of the catchment is comprised primarily of disturbed broad leaf forests and fields.

The land use changes that will be generated by the proposed development are discussed in the assessment for the post-development hydrologic condition of the catchment area.

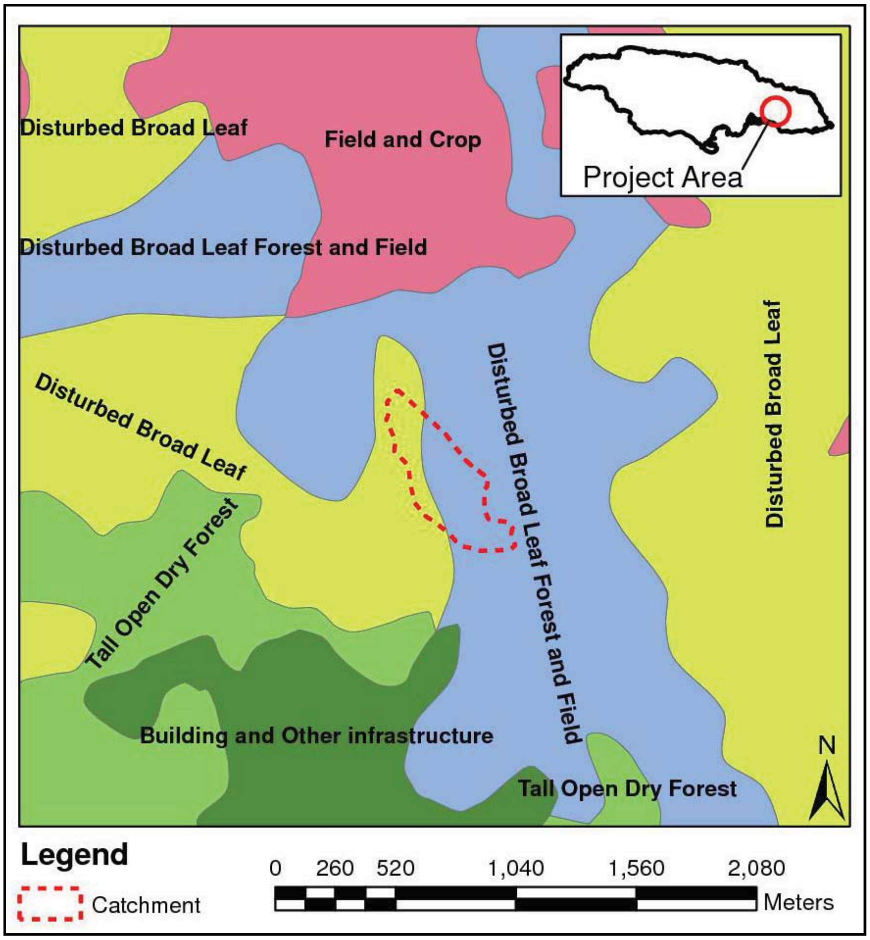


Figure 2.3 Proposed Halberstadt site catchment superimposed on Land Use map of Jamaica.

2.3 Meteorology

2.3.1 CEAC Analysis of Extreme Rainfall

The 24-hour rainfall data for approximately 250 gauges across Jamaica were obtained from the Meteorological Office of Jamaica. Information for the gauges spanned 1930 to 1980 and 1992 to 2008. Both sets of data were subjected to Weibull analysis for the extreme rainfall data ranging for the 2, 5, 10, 25, 50 and 100 year. Historical rainfall extremes for stations across the island for the period 1930 to 1988 were compared with the extremes determined for the period 1992 to 2008. Rainfall depths for corresponding return periods were subjected to comparative analysis in order to determine if there was an overall increase or decrease in extreme rainfall.

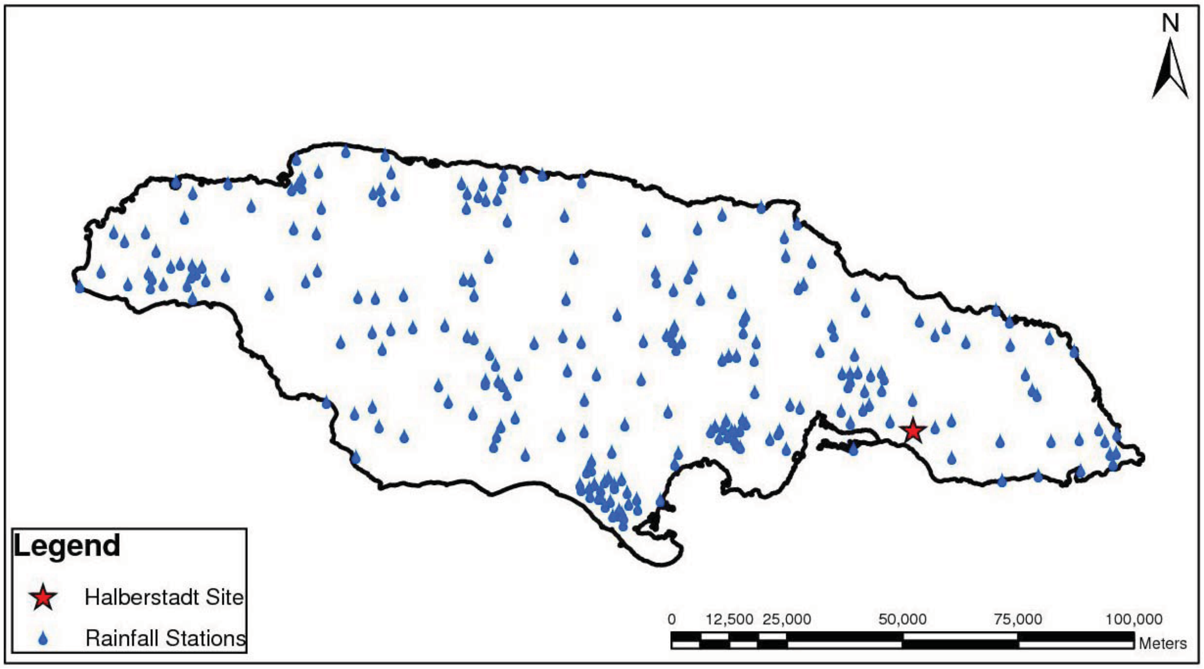


Figure 2.4 Locations of Rainfall stations obtained from Met office of Jamaica

The analysis indicates that there has been an overall increase ranging from 11.7% (for the 2 year Return Period Event) to 1.5% (for the 100 year Return Period event) for all stations. This increase has occurred over a time frame of 21 years (1988 to 2009). This equates to 0.7% to 5.6% increase per decade. See Table 2.2 and Figure 2.4 below.

Table 2.2 Overall increase in 24-hours rainfall intensity for the period between 1988 and 2009

	Return Period (yr)					
	2	5	10	25	50	100
Number of stations considered	117	117	117	117	117	116
Average increase (mm)	14.0	10.0	5.6	5.9	6.3	5.3
Average rainfall depth (mm) 1930 to 1988	119.8	175.0	217.7	268.2	307.8	345.7
Overall increase	11.7%	5.7%	2.6%	2.2%	2.1%	1.5%
Increase per decade	5.6%	2.7%	1.2%	1.0%	1.0%	0.7%

Figure 2.5 Overall increase in 24-hours rainfall intensity for the period between 1988 and 2009

2.3.2 Long term rainfall and Temperature

As seen below in Table 2.3 and Figure 2.6, temperatures are greatest during the months of June to September. Lowest mean minimum temperature of 20.7 degrees Celsius is seen to occur in the month of February and the greatest mean maximum temperature of 31.9 occurs in July. Rainfall is seen to have a yearly peak of 306 mm in October. February and March are seen to be the driest months of the year.

Table 2.3 Mean Climatological Data for St.Thomas (1951-80) obtained from the Metrological Service

1951-80 MEAN CLIMATOLOGICAL DATA FOR SELECTED LOCATIONS							
Station (Altitude)	Year	Max Temp. (C)	Min Temp. (C)	Rainfall (mm)	Rel. Hum.- 7am (%)	Rel. Hum.- 1pm (%)	Sunshine (Hrs.)
Duckenfield (St. Thomas) (alt 15 metres)	JAN	28.7	21.2	92	85	68	7.1
	FEB	28.9	20.7	81	88	67	7.6
	MAR	29.1	21.0	64	88	70	7.5
	APR	30.1	21.5	94	86	67	8.0
	MAY	30.7	22.8	246	87	70	7.1
	JUN	31.3	23.8	177	87	72	7.3
	JUL	31.9	24.2	110	87	71	7.8
	AUG	31.8	23.3	178	87	67	7.6
	SEP	31.2	23.1	227	87	73	6.8
	OCT	30.8	22.4	306	90	75	6.7
	NOV	30.0	22.3	237	88	75	6.7
	DEC	29.2	21.9	158	84	73	6.3

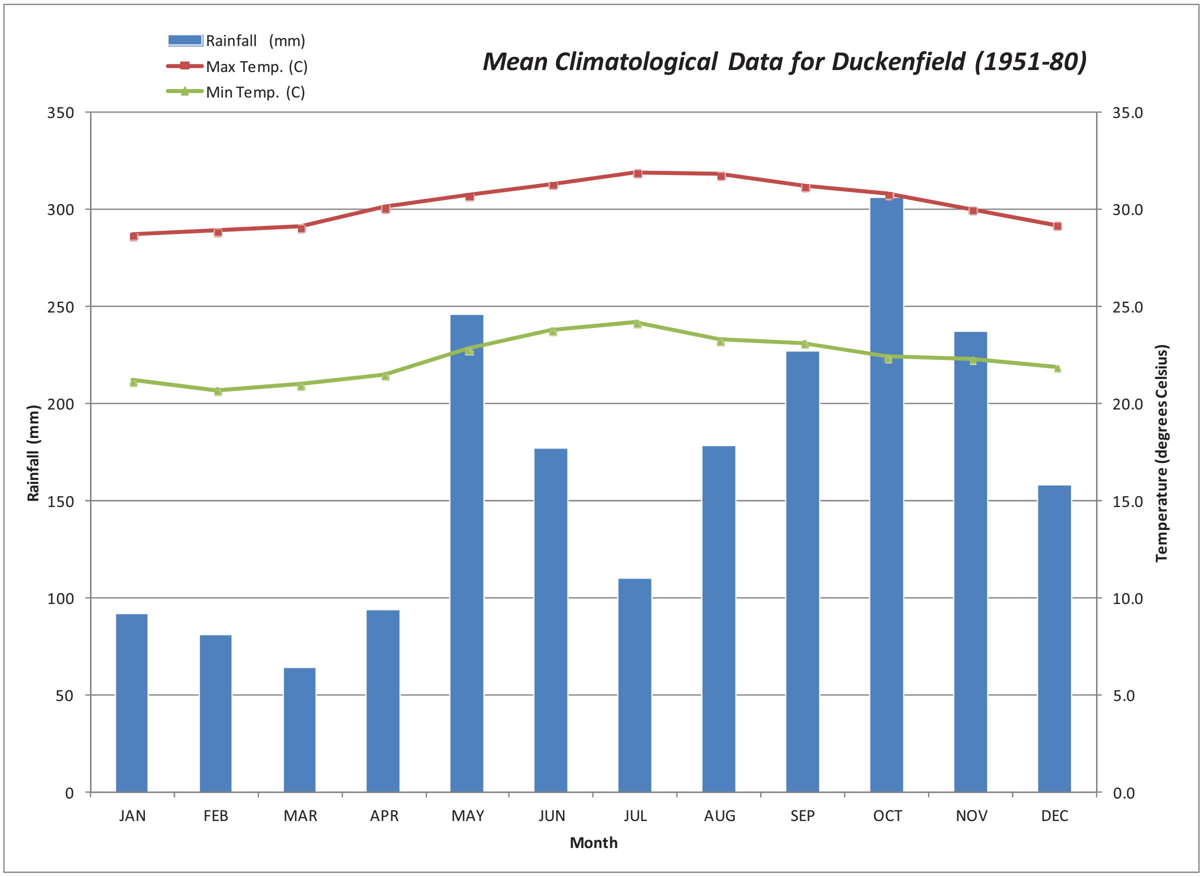


Figure 2.6 Mean Climatological Data for Duckenfield (1951-80) obtained from the Met Service

2.4 Flood Prone Areas and Existing Drainage features

2.4.1 Flood Prone Areas

2.4.1.1 Office of Disaster Preparedness and Emergency Management (ODPEM)

ODPEM currently list Bull Bay (10 Miles) as a flood prone area as shown in Figure 2.7 below. This may be attributed to the ongoing silting of the Bull Park River in the vicinity of the 10 mile bridge (see Plate 2.6 in the following section). ODPEM has, however, not delineated the upstream areas that are more susceptible; one such community is called Benoa. CEAC Solutions therefore interviewed available residents while visiting the Benoa community, located approximately 1km from the deposit.

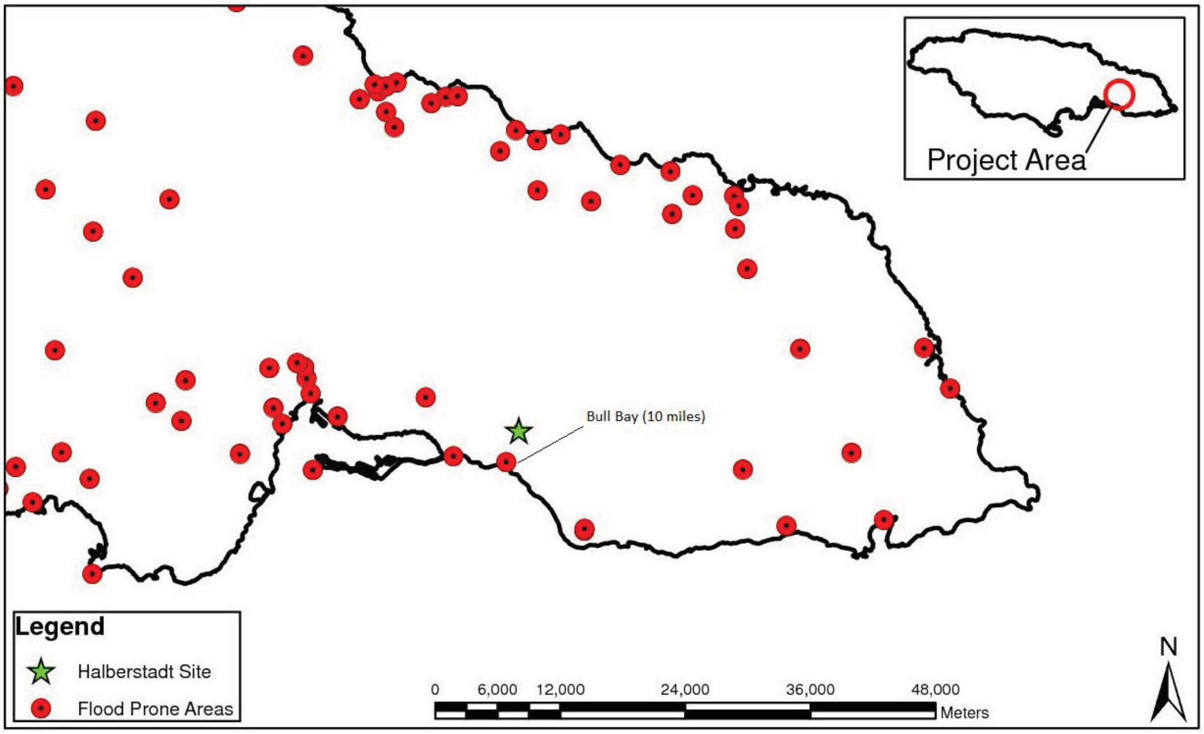


Figure 2.7 Map showing flood prone areas identified by ODPEM in relation to the Halberstadt site

2.4.1.2 Anecdotal Evidence

The anecdotal information, along with our field observations, revealed that the most immediate community, Benoa, is not affected by runoff generated by the quarry site. Due to the absence of systematic drainage along the local roads, the surface runoff often cut the banking of the roads and flow down the mountain slope into the Bull Park River while avoiding the community on a whole.

Table 2.4 Anecdotal data collected throughout the Benoa community.

ID	Name of Interviewee	Age (years)	Time in Area (years)	Storm	Year	Flooding		Comments
						Interview location (WP#)	Depth of water (m)	
1	Roy Dickens	75	75	--	--	529	--	no drainage path; no flooding, dry gully; nearby soil drains quickly
2	Emilita Ambler	66	66	--	--	530	--	no flooding; runoff doesn't affect residents; sand deposited
3	Rohan Robinson	25	25	--	--	531	--	water or debris doesn't affect residents; sand is washed from road
4	Omar Gayle	19	19	--	--	532	--	road gets damaged during heavy rains
5	Adrian Gordon	33	33	--	--	533	--	flooding doesn't affect residence; no debris/silt

2.4.2 Existing Drainage Features

This Halberstadt quarry has been dormant for many years and has seen the return of vegetation. The possibility of drainage infrastructures on site during past operating days is likely, however, based on field reconnaissance, there exists no current drainage system on the project site. This may be due to revegetation, erosion or part of a rehabilitation plan.

Based on observations, the surface runoffs do not have a guided path to discharge into the Bull Park River. The stormwater flows along the local roads where possible but eventually cut the banks of those roads, flows down the mountain slopes and into the Bull Park River. This increases the possibility of contributing sediments to the silting process of the river.

Plate 2.5 Condition of local road after passage of Tropical Storm Chantal (2013);

Plate 2.6 Heavy silting of Bull Park River at the Ten Mile bridge;

Plate 2.7 Sediments transported to sea via Bull Park River;

Plate 2.8 9" corrugated culvert which conducts Bull Park River flows under local road;

Plate 2.9 Section of Bull Park River downstream of the Bito and Halberstadt quarries;

Plate 2.10 Deteriorated roadway following the passage of Tropical Storm Chantal (2013) due to lack of drainage;

Plate 2.11 Deteriorated roadway leading to Halberstadt following the passage of Chantal;

Plate 2.12 Surface runoff flowing along local quarry road.

2.5 Sediment Loading

The steep sided slopes of the Halberstadt site suggest that in times of heavy rainfall, the possibility of landslides is high. All areas influenced by the mining operation should be either benched or geotechnically engineered to prevent downslope movement of material.

One of the most widely used and accepted equations for estimating soil erosion is the Universal Soil Loss Equation (USLE), an empirical equation developed by the U.S. Department of Agriculture. The USLE estimates the annual tonnage of soil eroded from the site attributed only to a sheet and rill erosion. However, not all eroded soil qualifies as soil loss due to the fact that eroded soil may be re-deposited before it leaves a slope and therefore does not factor into soil loss quantity.

2.5.1 Methodology

The method for estimating the average annual soil loss involves the evaluation of all six factors in the USLE. In the USLE, there are five factors (soil erodibility: K, slope length: L, steepness: S, cover management: C, and support practice: P) derived from the surface characteristics and one factor (rainfall erosivity: R), which reflects the raindrop effect and the runoff rate, derived from the rainfall data. Each factor was evaluated in GIS environment and a map of the average soil loss plotted. The total soil loss for a year for the catchment was then computed using map algebra, by multiplying the rate of soil loss by the area of each cell within the catchment and summing. Each of the factors was evaluated as follows:

R-factor

R or rainfall erosivity factor is related to the annual average rainfall by the equation:

$$R = 0.0483 \times P^{1.61}$$

where,

P is the annual average rainfall in mm/yr.

A rainfall raster map was created using rainfall data from the rainfall station across the island. A raster calculator function was then used to create a R-factor raster map using the equation.

K-factor

The soil erodability factor k is dependent on soil type. A database of various soil types across the island were obtained from the Ministry of Agriculture. Each soil type was assigned an erosive number which the level of erosion expected in such soils. These erosive numbers were then given corresponding K-factors ranging from 0.01 for very low erodabilty to 0.65 for highly erodable. The K-factors were then used to create a raster map.

L-factor and S-factor

Both factors are topographic factors and thus can be combined as the LS-factor. The factor is derived though analysis of the digital elevation model (DEM) of Jamaica. The following equation links the two:

$$LS = L \times S\left(10{,}000 + \frac{10{,}000}{s^2}\right)$$

where,

s is the percent rise of the calculated slope

S is the S-factor, $S = \frac{0.43+0.30s+0.043s^2}{6.613}$

L is the L-factor, $L = \left(\frac{30}{22}\right)^m$

The slope gradient ,S, was calculated using the slope percent rise analysis of the 30m DEM. The resulting raster map was then converted from percentage to decimal using map algebra. this percent rise raster was then used to calculate the S-factor using map algebra. The L-factor was the calculated using the equation given where m = 0.5 for slopes > 5%, m = 0.4 for slopes 3.5% and 4.5% and m = 0.3 for slopes< 3%.

C-factor

The cover and management factor was determined for the various types of land cover. A land cover map from the Forestry Department was used to assign the C-factors to the various type of land cover. Table 2.5 below shows the C-factor for the various land covers across the island. According to the land cover map, the site falls in an area which is covered by distributed broad leaf forest and field.

Table 2.5 Summary table of land cover types and associated C-factors

Land Cover Type	C-factor
Bamboo	0.013
Bamboo and Disturbed Broad Leaf Forest	0.042
Bamboo and Field	0.003

Bare Rock	0
Bauxite Extraction	0.5
Bauxite Extraction and Disturbed Broad Leaf Forest	0.45
Building and Other infrastructure	0
Closed Broad Leaves	0.083
Disturbed Broad Leaf	0.14
Disturbed Broad Leaf Forest and Field	0.085
Field and Crop	0.011
Fields and Disturbed Broad Leaf Forest	0.081
Fields or Disturbed Broad Leaf Forest and Pine Plantations	0.13
Herbaceous Wetlands	0
Mangrove	0
Plantations	0.3
Short Open Dry Forest	0.17
Swamp	0
Tall Open Dry Forest	0.19

2.5.2 Results

2.5.2.1 Pre-construction

The site is located in an area with a total soil loss rate of 132 tons/acre/year. Given the size of the quarry site boundary being 58,637 m^2, the annual soil loss volume was found to be 248 tons. This soil loss translates to an overall annual loss of 2.56 mm of soil within the Halberstadt site currently. Figure 2.8 below shows the pre-construction soil loss map generated.

The Bull Park River catchment has an estimated area of 21,966,395 m^2 with a total soil loss rate of approximately 65,585 tons/acre/year. This equates to an estimated annual soil loss volume of 3.40 mm of soil for the overall catchment.

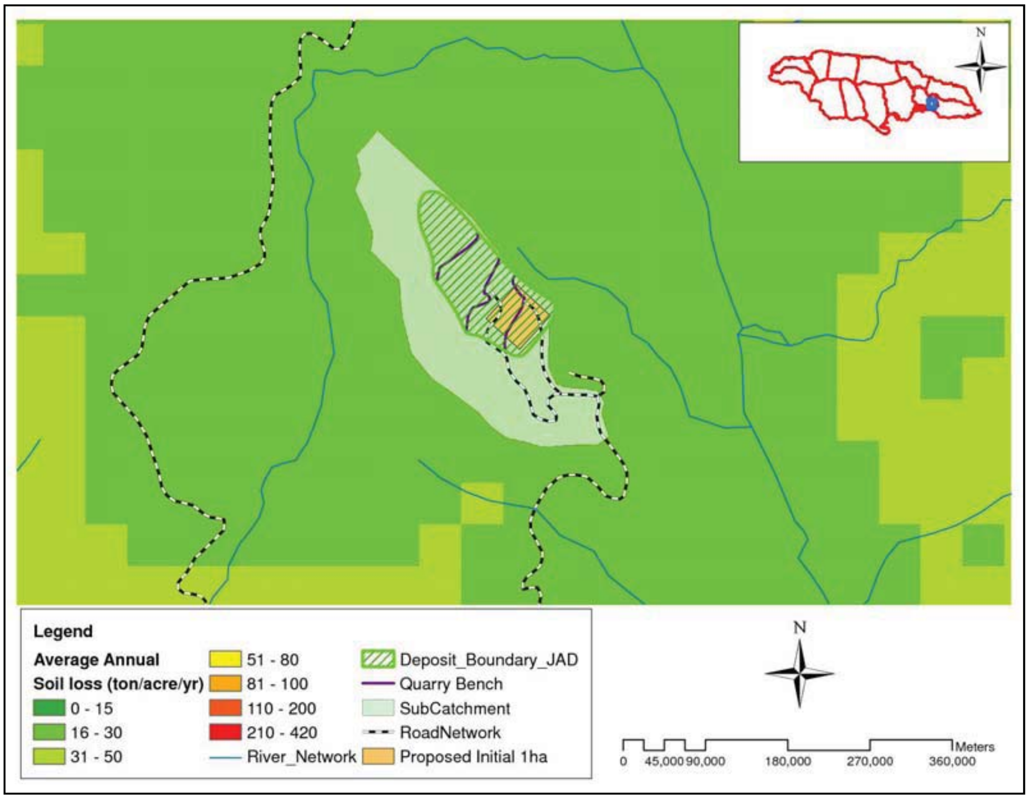


Figure 2.8 Pre construction soil loss map

2.5.2.2 Post-construction

The post construction scenario would involve the clearing of the site which would affect the cover factor. The present land cover of distributed broad leaf forest will be changed and the most closely associated land cover for the quarry would be that of bauxite extraction, which has a cover factor of 0.5 (see Table 2.5).

This change in the cover factor increases the total annual soil loss volumes within the Halberstadt site to 1,370 tons. The overall increase in the depth of soil lost within the site averages 11.60 mm per year. The post construction soil loss map generated is shown below in Figure 2.9. From the map we can see the increase in the soil loss rate indicated by the orange sections inside the catchment.

The Bull Park River catchment has an estimated area of 21,966,395 m^2 with a projected total soil loss rate of approximately 66,183 tons/acre/year. This equates to an estimated post-construction annual soil loss volume of 3.43 mm of soil for the overall catchment.

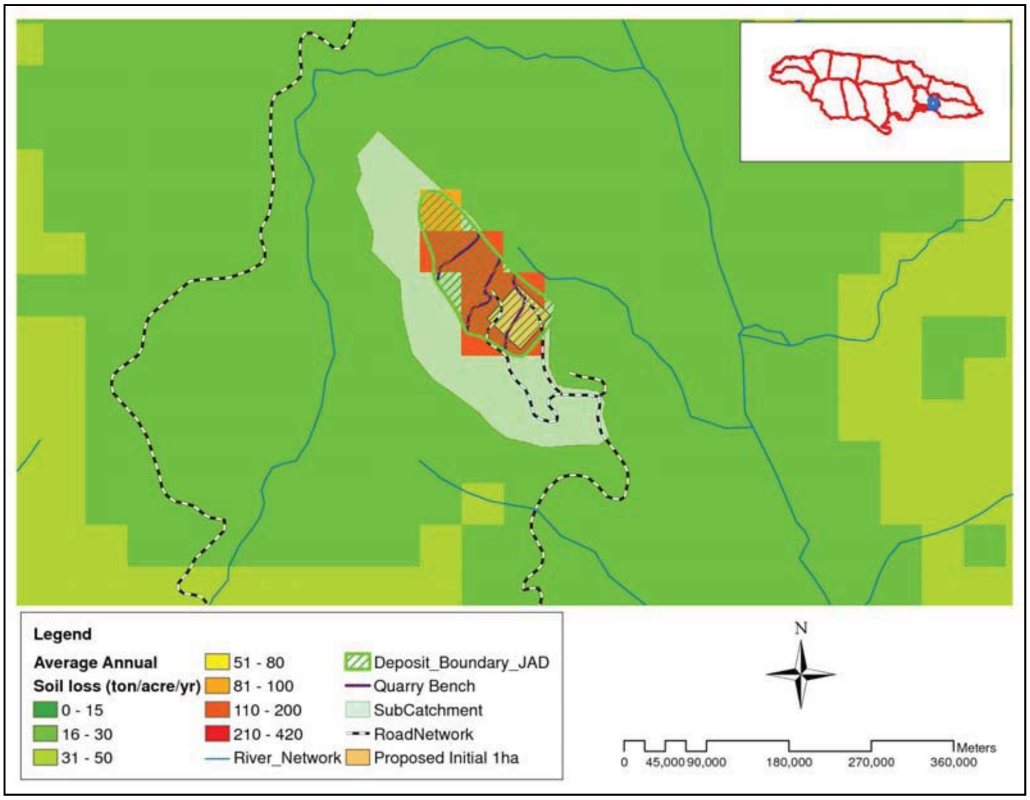
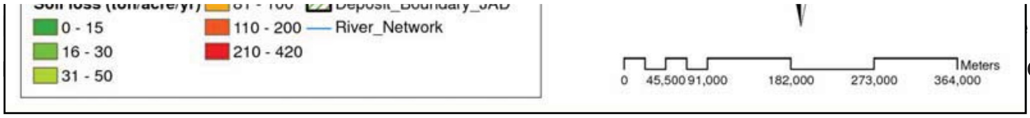


Figure 2.9 post construction soil loss map

2.5.2.3 Summary



nerate increased
own in

Figure 2.10 The overall Bull Park River catchment and Halberstadt deposit boundary superimposed on USLE soil loss map

Table 2.6. The area of the Halberstadt site is a mere 0.27% of the overall Bull Park River catchment. However, the quarry site experiences a 453% increase in soil loss rates from 2.56 mm/yr to 14.16 mm/yr due to the intended removal of vegetation and exposed earth. The overall soil loss volume within the Bull Park River catchment changes from 3.40 mm/yr to 3.43 mm/yr, experiencing a 1% increase.

Based on observations, it can be concluded that the effects of the reopening of the Halberstadt quarry will have a minimal impact (1%) on the soil erosion taking place within the Bull Park River catchment. Although the quarry site itself experiences a 453% increase, this change is limited and bounded by the deposit boundary. In addition, due to its relative small size (see Figure

2.10), the quarry will have negligible impact on the soil loss within the Bull Park River catchment.

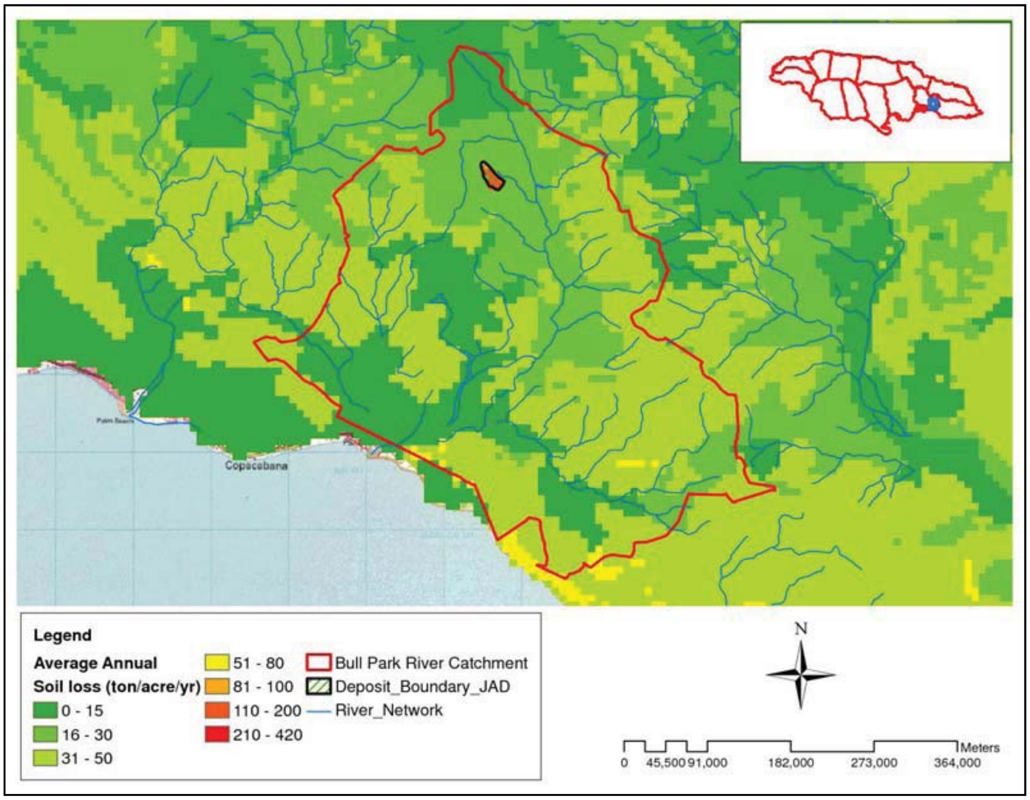


Figure 2.10 The overall Bull Park River catchment and Halberstadt deposit boundary superimposed on USLE soil loss map

Table 2.6 Summary table of the estimated soil loss across the catchment

Scenario	**Area** (m^2)	**Soil loss** (kg/year)	**Soil loss** (ton/year)	**Soil loss** (mm/year)
Present				
Halberstadt Site	58,637.90	247,873.90	247.87	2.56
Bull Park Catchment	21,966,395.34	123,157,649.54	123,157.65	3.40
Future				
Halberstadt Site	58,637.90	1,370,415.92	1,370.42	14.16
Bull Park Catchment	21,966,395.34	124,280,191.57	124,280.19	3.43
Difference				

Halberstadt Site		1,122,542.02	1,122.54	11.60
Bull Park Catchment		1,122,542.02	1,122.54	0.03
% Increase				
Halberstadt Site		453%	453%	453%
Bull Park Catchment		1%	1%	1%

2.6 Water Resources

2.6.1 Sinkholes

Water resources include both sinkholes and wells. Sinkholes represent a point of access to aquifers and production wells as they are often efficient conduits to aquifers. Such a feature would allow contaminated runoff to flow directly from the surface to the aquifer without treatment leading to contamination of the aquifer.

Based on analysis, the topography immediately surrounding the Halberstadt site does not include depressions in which sinkholes occur (see Figure 2.11). While there are no apparent sinkholes, the possibility of discovering more sinkholes during construction is very low due to the absence of karst terrain. The closest sinkhole identified determined to be 1,500 meters from the Halberstadt site. The further the sinkholes are from the Halberstadt quarry, the greater the chance of dilution of the contaminated runoff and the lower the risk associated with each rainfall event.

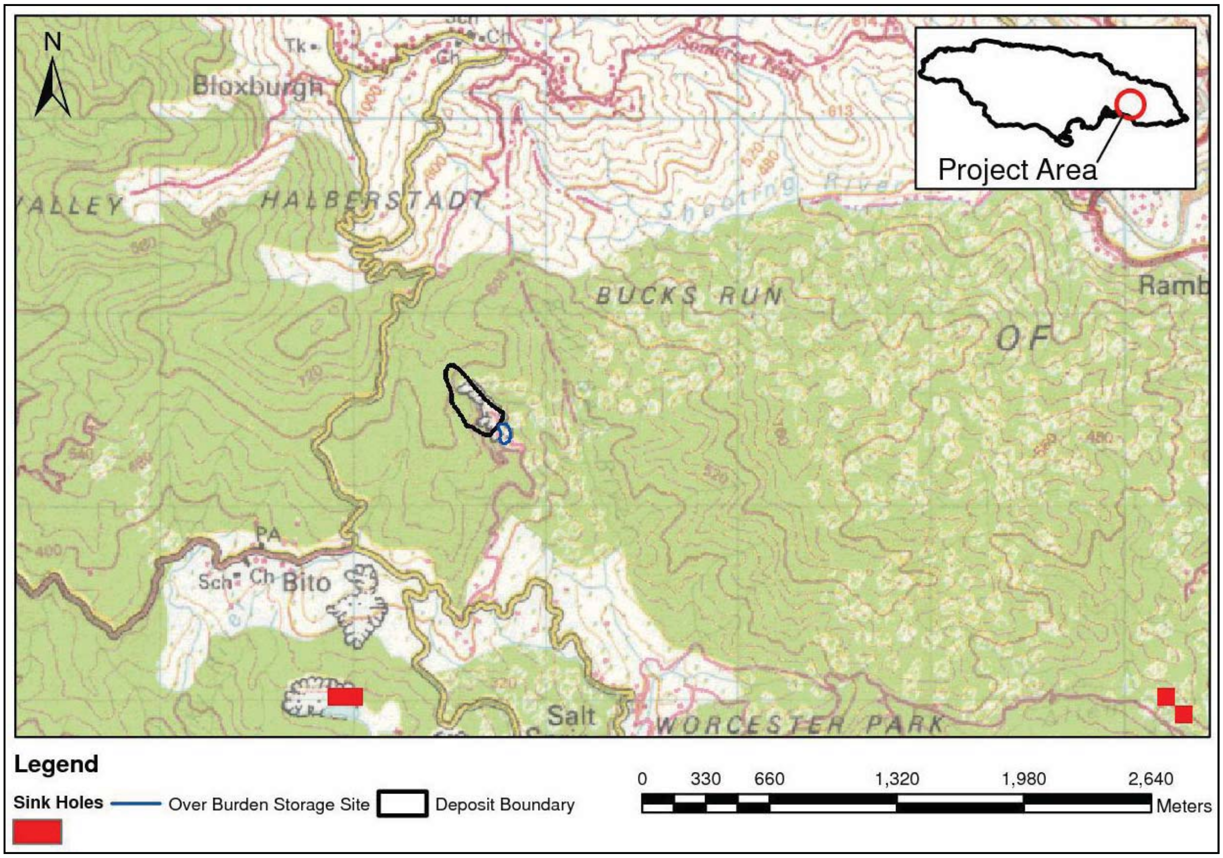


Figure 2.11 Map showing identified sinkholes in relation to the Halberstadt site

2.6.2 Wells

The map below indicates several wells, both pumping and non-pumping, within close proximity of the proposed Halberstadt site. This map should be used as a guide to avoid the covering and/or destruction of wells. These wells are owned and operated by both private and government entities.

Based on observations, the operation of the Halberstadt quarry will not cover any wells and furthermore will not lead to their destruction and/or contamination (see Figure 2.12). Wells in close proximity to the proposed site would be at risk of being contaminated due the discharge and seepage of contaminated highway runoff into the ground and aquifer beneath.

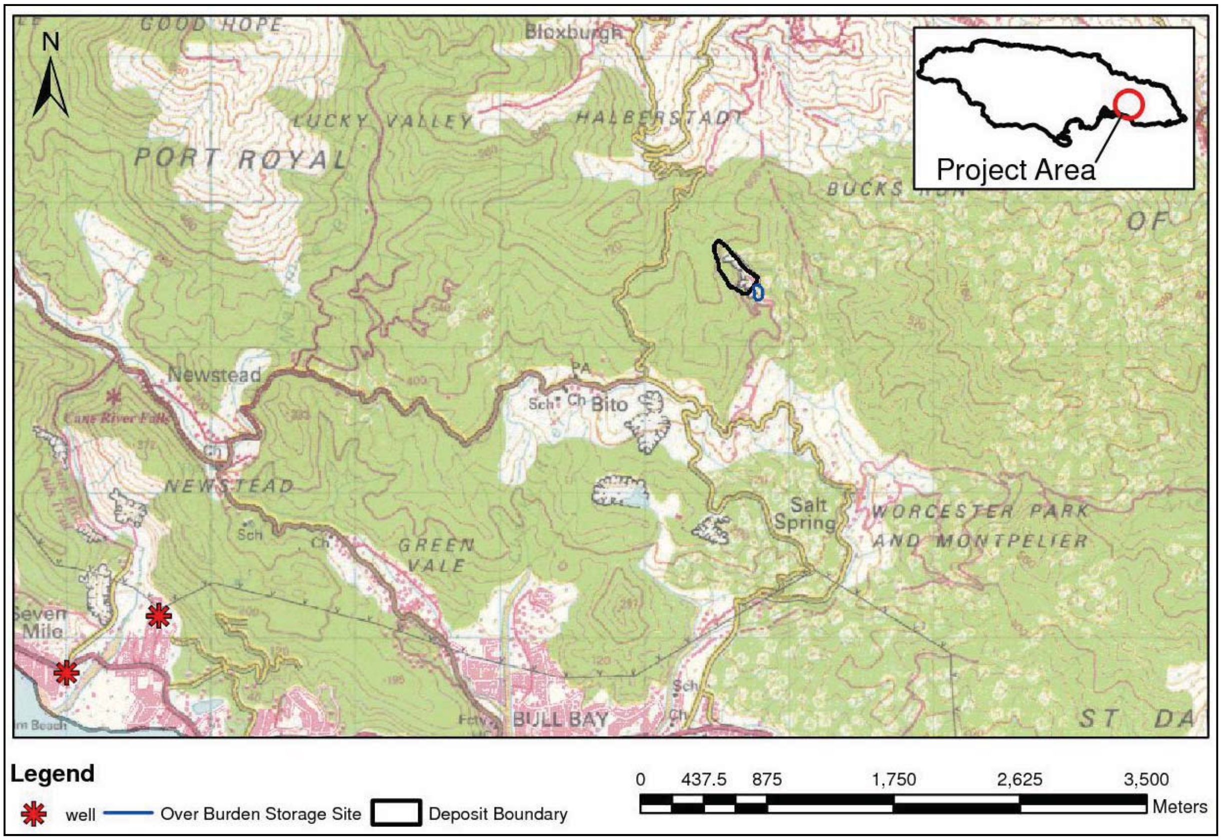


Figure 2.12 Map showing identified sinkholes in relation to the Halberstadt site

3 Hydrology

The methodology used for the analysis is as follows:

1. Data collection to include:
    a. Collection of soils information;
    b. Collection of land use maps;
    c. The topography of the catchments;
    d. Anecdotal data collection.
2. Delineating catchments and confirmation of streams/rivers;
3. Calculating runoffs using the US Soil Conservation Service (SCS) method;
4. Re-calculate runoffs implementing post-development changes throughout the catchments.

3.1 Description of the Models

3.1.1 Soil Conservation Service (SCS)

SCS method is an empirical model for rainfall runoffs which is based on the potential for the soil to absorb a certain amount of moisture. On the basis of field observations, this potential storage S (millimetres or inches) was related to a 'curve number' CN which is a characteristic of the soil type, land use and the initial degree of saturation known as the antecedent moisture condition. Hydrological modelling of the watersheds encompassed three main elements:

- Precipitation;
- Rainfall abstraction model (Curve number method);
- Runoff model (Dimensionless unit hydrograph).

The SCS curve number method was used to determine the rainfall excess P_e using the following equation:

$$P_e = \frac{(P^2 - I_a^2)}{P - I_a} + S$$

Where, P = precipitation

I_a = initial abstraction

S = Potential retention which is a measure of the retention capacity of the soil.

The Maximum Potential retention, S, and the watershed characteristics are related through the Curve number CN.

$$S = \frac{25400 - (254 \times CN)}{CN}$$

Curve Numbers have been tabulated by the NRCS on the basis of soils group, soil cover or land use, and antecedent moisture conditions (initial degree of saturation).

3.2 Surface Runoff

The NWA recommends major systems such as culverts, channels or erosion protective works be designed for 1 in 50 year return period rainfall events. The peak runoffs are generally calculated using the type III rainfall distribution for catchments in Jamaica. The primary inputs into the model are as follows:

- Drainage area size (A) in square miles (square kilometres);
- Time of concentration (Tc) in hours;
- Weighted runoff curve number (RCN);
- Rainfall distribution (see Figure 3.1);
- Total design rainfall (P) in inches (millimeters).

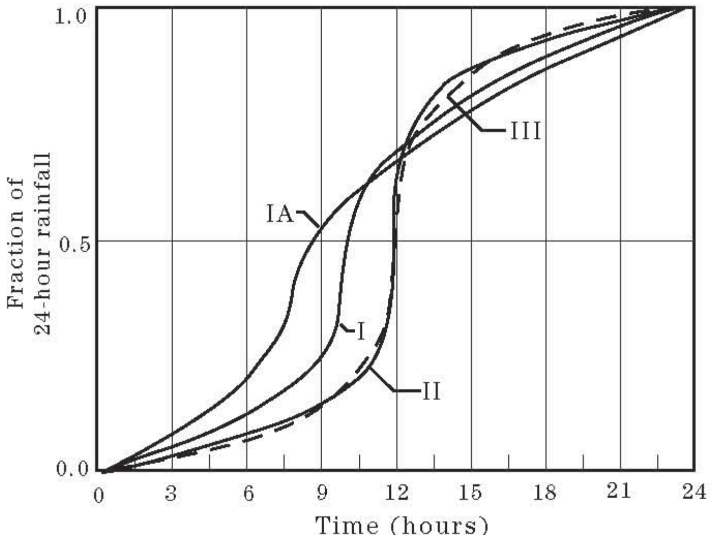


Figure 3.1 SCS 24-hour Rainfall Distributions

3.2.1 Existing and Post Development Conditions

The estimated peak runoffs were generated for the Halberstadt site catchment using the SCS method as described above. The peak runoffs ranged from 2.19 cubic metres per second to just below nine (8.82) cubic metres per second for the 2 year to 100 year return periods under existing conditions.

The post development condition showed a cumulative increase across the site catchment that is predicted to occur as a result of the clearing of vegetation and mining of the land surface; as the mining surface increases so does the surface runoff. The increases in peak runoffs that are estimated to occur are in the range of 0.18% to 0.68% for the 2 year to 100 year return periods under existing conditions.

The corresponding 50 year return period peak runoffs are 7.63 cubic metres per second and 9.25 cubic metres per second under both existing and post development conditions respectively.

Table 3.1 Runoff generated for the pre- and post-developmental conditions

Hydrology	Units	Return Period					
		1:2yr	1:5yr	1:10yr	1:25yr	1:50yr	1:100yr
Catchment area	HA	16.80	16.80	16.80	16.80	16.80	16.80
Catchment slope	%	23.86	23.86	23.86	23.86	23.86	23.86
Tc	hr	0.29	0.29	0.29	0.29	0.29	0.29
Peak runoff							
Existing Conditions	m^3/sec	2.19	3.68	4.84	6.42	7.63	8.82
Post Development	m^3/sec	3.68	5.30	6.49	8.07	9.25	10.42
Difference	%	0.68	0.44	0.34	0.26	0.21	0.18

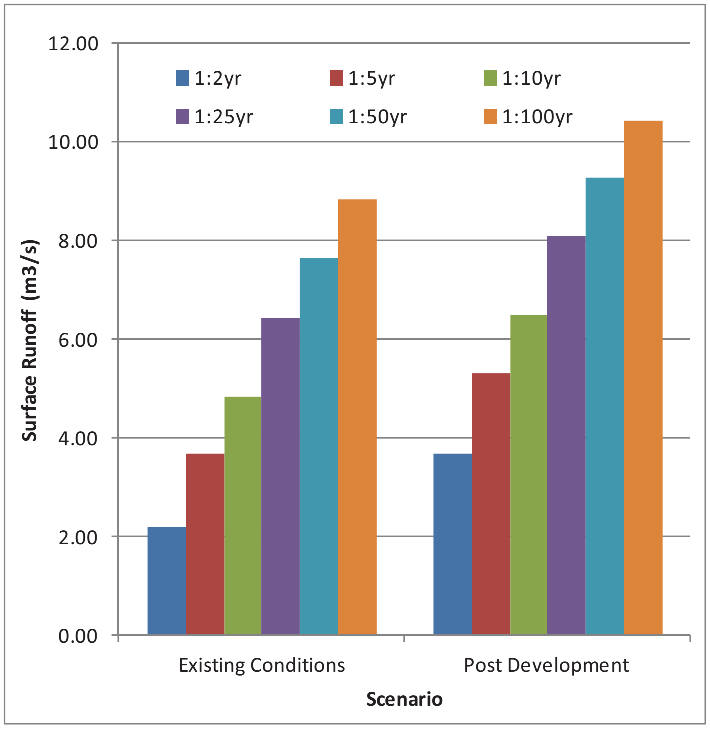


Figure 3.2 Summary of the peak runoffs for the pre and post development scenarios

3.2.2 Future Condition considering climate change

It was necessary to anticipate the impacts of climate change on the hydrology of the Halberstadt site. These impacts are to be taken into consideration given that it is recognized from our analysis as well as other international organisations that there is an increase in rainfall intensities. The rainfall intensities were therefore updated in accordance with Table 2.2 to reflect the impacts of climate change in the future. It is recommended that such parameters are implemented in designing the drainage system to ensure the subdivision is protected should these intense storms occur in the future.

The resulting flows from the catchment showed a maximum flow of 4.97 cubic metres per second to 10.81 cubic metres per second for the 2 year to 100 year return periods under post construction conditions with the consideration of climate change. These peak flows indicate an increase of between 0.04% and 0.35% respectively and can be attributed strictly to climate change.

Table 3.2 Runoff generated for the post-developmental conditions

Hydrology	Units	Return Period					
		1:2yr	1:5yr	1:10yr	1:25yr	1:50yr	1:100yr
Catchment area	HA	16.80	16.80	16.80	16.80	16.80	16.80
Catchment slope	%	23.86	23.86	23.86	23.86	23.86	23.86
Tc	hr	0.29	0.29	0.29	0.29	0.29	0.29
Peak runoff							
Post Development	m^3/sec	3.68	5.30	6.49	8.07	9.25	10.42

Post Development with Climate Change	m^3/sec	4.97	6.13	6.93	8.51	9.75	10.81
Difference	%	0.35	0.16	0.07	0.05	0.05	0.04

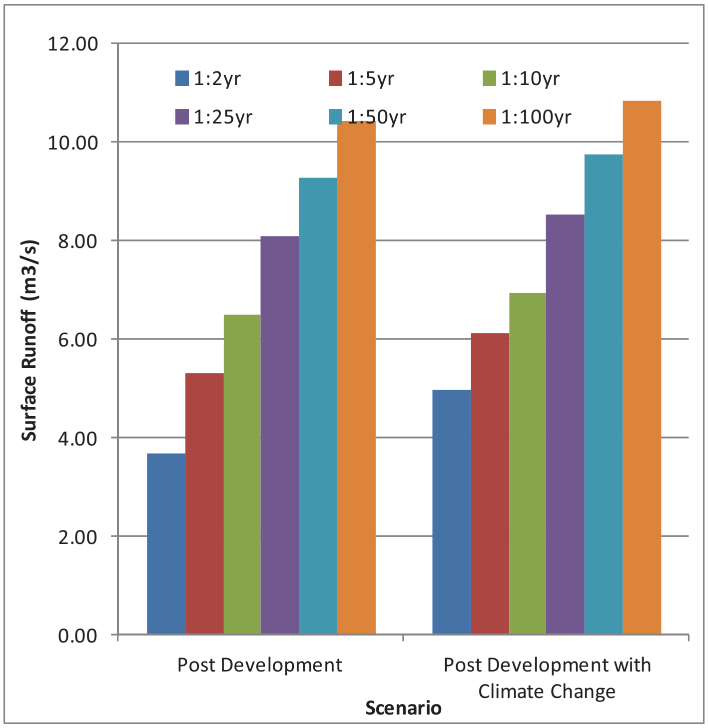


Figure 3.3 Summary of the peak runoffs for the pre and post development scenarios

4 Mitigation Measures

4.1 NWA Requirements

The NWA hydraulics branch requires river and flood protection works to be designed based on a return period not exceeding 1 in 100 years. It also noted that major drainages system (main culvert and channels and erosion protective works) are to be designed for the 1 in 50 years return event. It was therefore envisaged that the flood protection and erosion mitigation works will be designed as follows:

1. The regional drains be designed to handle the 1 in 50 year flows without flooding the proposed site inclusive of check dams;
2. Detention ponds be implemented, where feasible, to reduce the 1 in 25 year peak flows entering the Bull Park River;
3. The proposed conducting culvert, under the roads, be designed to conduct the 1 in 50 year peak flows in the event of an intense rainfall event;
4. Sedimentation forebays will be incorporated within the detention ponds to remove (filter) sediments from the surface runoff and reduce silting of the Bull Park River.

4.2 Detention Pond

4.2.1 Methodology

The flows generated from the site catchment will, where possible, pass through a detention basin prior to final discharge through the proposed culvert. There is a natural depression within the topography of the site where the space required to construct detention ponds is available. It was envisaged that the proposed pond should be capable of reducing up to the 25yr peak future flows without any significant construction.

It is further proposed that the boundaries to the east of the quarry boundary be bermed to prevent the untreated surface runoff from simply flowing down the mountain slopes and into the Bull Park River. The stormwater generated from the west of the quarry boundary will be directed to proposed drains along the roads where it will negotiate a series of check dams and routed through the detention basin.

On passing through the basin, the storm water will first traverse the proposed sediment traps which will aim to reduce the sediments being transported within the runoff. This ‘filtered’ stormwater will then flow over the weir, spread out in the detention basin and reduce the peak flow out of the basin as some of the volume flowing in will be stored and a negligible amount lost to evaporation.

The relationship between inflow and outflow is therefore:

$$\boldsymbol{Inflow} = \boldsymbol{Outflow} + \boldsymbol{Storage}$$

The SCS hydrographs developed for the peak runoff for the catchments used as the input hydrograph for the basin. From this hydrograph and the contour data, the storage versus the depth relationship was developed and the outflow estimated.

The outflow is estimated using the Cipoletti (trapezoidal) weir equation:

$$Q = 3.367LH^{3/2}$$

where,

Q = discharge (design peak flow)

L = length across the weir

H = height of the water over the weir (based on storage versus flow relationship)

4.2.2 Peak Flows

The estimated peak flow from the catchment was reduced by approximately 42.4% for the 25 year storm after being routed through the detention basin. The estimated peak flows to the detention pond for various scenarios are shown in Table 3.1 and Table 3.2. The resulting inflow and outflow hydrographs are shown in Figure 4.1 below. In summary, the following was noted:

- For the catchment of the Halberstadt site, the 25yr post development *maximum* peak flow of 8.64 cubic meters per second is estimated by to be reduced to 6.07 cubic meters per second;
- Approximately 42 percent of the runoff will be contained by the retention pond. The peak flows will be further attenuated, however, when passing through the network of drains and check dams, minimizing any downstream impacts that may arise from the reopening of the quarry.

Table 4.1 below summarizes the pond size and the relative impact on the peak runoff for the catchment.

Table 4.1 Resulting 50yr peak inflow from the catchment and outflow from proposed detention pond

Detention Pond (Routed)		
Parameter	**Value**	**Unit**
Required		
Top surface area	**0.5**	**Ha**
Base surface area	**0.45**	**Ha**
Pond Depth	**4**	**m**
Output		
Length of outlet Weir	3	m
Max water depth above Weir	1.34	m
Peak unrouted flow	**8.64**	**m^3/s**
Peak routed flow	**6.07**	**m^3/s**

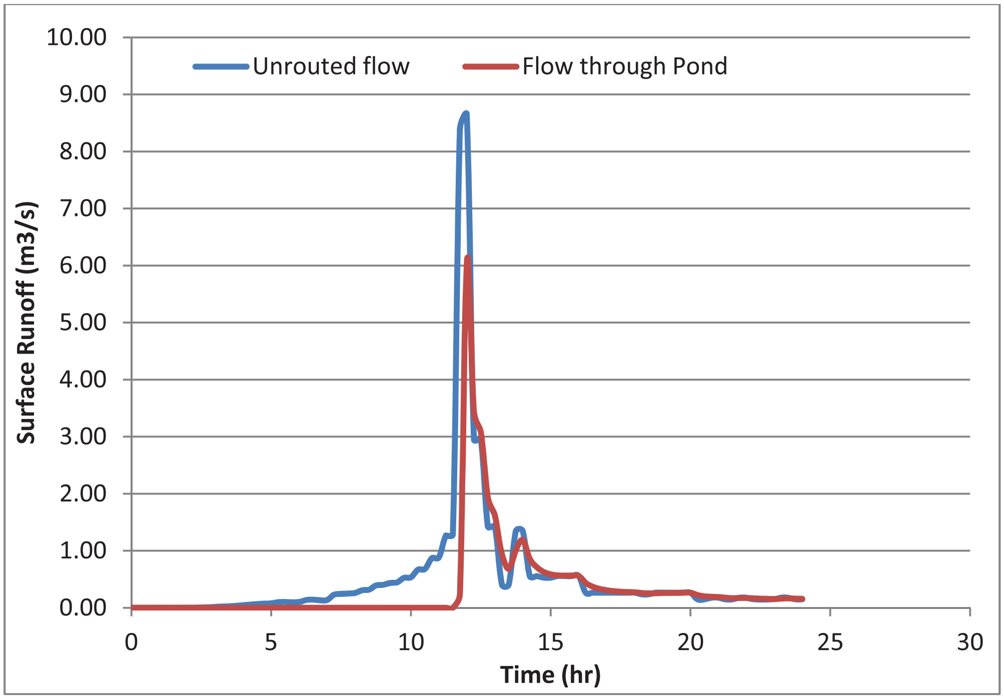


Figure 4.1 Hydrograph showing the resulting peak flows with the effect of the detention ponds

4.2.3 Impacts

The proposed location for the detention basin is along the south-eastern boundary of the quarry deposit. This site was selected due its natural low-lying features where, by observation, most of the surface runoff tends to accumulate and is discharged unto the mountain slope. This discharged runoff eventually enters the Bull Park River and out to Sea. However, the proposed location coincides with the region designated by the client for overburden storage. This would suggest relocating the storage area to accommodate the detention basin which measures an average surface area of 4,750 m^2.

The proposed area for the pond consists of a natural depression-like topography. This site was evaluated for any water resource features such as sinkholes or wells nearby. In concluding the assessment, there were no such features identifiable. Hence, the construction of the proposed detention pond will not have any adverse effects on the groundwater system and its recharging process.

4.3 Major Storm Drains

The surface runoff traversing the site from the north-west to south-east will be channelled through proposed earth swales with implemented check dams where possible. In addition, the drains located on the eastern boundary of the site will be bounded with compacted berms designed to be 0.3m above the estimated water level.

The drains were sized to convey the 50 year flows from the associated site catchment. Based on the location of the proposed drain and the associated contributing sub-catchment, the configuration of the drains varied. The drains were designed with a 5% slope as proposed by the client as the target grading of the site roads. However, if this target is not achieved the drains will be capable of conducting greater flows than designed due to the steep terrain of the site. The resulting drain sizes are as follows as outlined in Table 4.2.

Table 4.2 Summary of main drains to be improved for conducting the 50year flows through the project site

Parameter	Values	Values	Units
Manning's Coefficient	0.035	0.035	
Side slope	1.5	1.5	
Width of channel (at top)	3.00	3.70	m
Flow Depth	0.60	0.80	m
Depth + freeboard	0.75	1.00	m
Width of channel (at base)	0.75	0.70	m
R	0.4	0.6	m
P	3.45	3.58	m
A	1.41	2.20	m^2
Flow	**4.94**	**10.15**	**m^3/sec**

4.4 Maintenance Guidelines

4.4.1 Detention Basin/Sediment Forebays

Properly designed Detention Basins should require little to no maintenance throughout the design life. However, the following recommended practices should be adhered to in order to maintain the efficiency of the structures:

1. Observe depth of sediment basin on an annual basis for potential problems including:
    - Subsidence;
    - Erosion within basin and banks;
    - Sediment deposit around outlet;
    - Changes in pilot channel.
2. Remove debris and litter that accumulates in the sediment forebay during inspections or as needed intermittently;
3. Remove accumulated sediment and dispose of sediments in an upland area and stabilize with vegetation. If necessary, obtain erosion and sediment control permit, prior to performing land disturbance. The recommended timeframe is every 5.5 years or when 5,000 m^3 of sediment has accumulated (see Table 4.3).

Table 4.3 Estimation of the impact of soil erosion (sedimentation) on the detention pond volume

Parameter	Value	Units
Critical bulk density of Clay Loam	1500	kg/m^3
Deposit Area	58,637.90	m^2
Estimated Soil Loss	913.61	$m^{3/}$year
Allowable sedimentation volume	5,000.00	m^3
Time required before cleaning	**5.47**	**years**

4. Inspect outlet control structure (weir) on a quarterly basis and after every storm greater than 1 inch;
5. Maintain records of all inspections and maintenance activity throughout the design life.

4.4.2 Check Dams

The following recommended practices should be adhered to in order to maintain the efficiency of the structures:

- Check dams should be inspected for damage after each storm event - all damage(s) should be repaired immediately;
- Sediment that accumulates behind the check dam should be removed as necessary;
- Additional stone may need to be added to ensure that the check dam retains its design characteristics.

4.5 Impacts of proposed drainage system

The post-construction implementation of a drainage system throughout the Halberstadt site will include a retention pond as well as swales which run parallel to the local quarry roads. The pond will reduce the total runoff as well as the peak flows in the catchments where implemented.

4.5.1 Peak Flows and Total Runoff

The net result of the detention pond will be an overall decrease in the peak runoff across the catchment which does not affect the Benoa community, according to interviews conducted, but indirectly affect residents of Ten Miles, Bull Bay. These peak flows leaving the proposed Halberstadt site will be further attenuated through the lush vegetation of the mountain side. Hence, the anticipated impacts on the downstream developments will therefore be negligible. The total runoff from the subdivision will also show a net decrease as a result of the detention ponds.

4.5.2 Required Erosion and Flood Protection Works

Currently, there exists no drainage infrastructure within the Halberstadt site. However, flooding is not experienced within Benoa, the nearest community in proximity to the proposed quarry. Ironically, ODPEM does classify the Bull Bay area as being flood prone in the same vicinity where the Bull Park River traverses (Ten Miles) so controlling the runoff from the project site remains critical. Mitigation measures are still recommended in order to prevent such an event from occuring. The flood protection strategy for proposed quarry and surrounding environs is to divert and channel upstream stormwater through earth drains and detention ponds.

To facilitate in diverting the peak runoffs generated upstream, it is proposed that the perimeter drain east of the quarry boundary be lined with compacted berms which will facilitate in containing the flows within the channels and prevent erosion of the banks. The constructed berms will provide additional protection should the drains be overtopped by an event of greater magnitude than the 1:50 year storm event.

The swales have been designed to conduct flows generated by the 50 year return rainfall with a 25 percent freeboard that will allow the flows to be conducted with the drains flowing full if no blockage is present.

5 Engineer's Cost Estimate

The engineering estimate prepared for the proposed works as outlined in the attached drawings and described herein indicates the costs for the works is estimated to be J$24,852,533.87. Table 5.1 below summarizes the major cost elements for the overall works while the detailed Bill of Quantities for entire works is shown in Table 7.1 within the Appendix A.

Table 5.1 Summarized Bill of Quantities for proposed drainage infrastructure works

SUMMARY		
Item	**Engineer's Estimate**	
Bill 1: Preliminaries	J$	2,296,000.00
Bill 2: Earth Works	J$	6,097,607.58
Bill 3: Drainage Works	J$	16,093,926.29
Bill 4: Dayworks	J$	365,000.00
TOTAL	**J$**	**24,852,533.87**

6 Conclusions and Recommendations

6.1 Conclusions

The following could be concluded from the analysis conducted to date:

1. The Benoa community located 1km to the south of the proposed quarry site does not experience any flooding as a result of surface runoff from the site or absence of drainage infrastructures according to anecdotal interviews conducted.

2. The catchment for the site corresponds to a drainage area of 16.8 hectares, composed of primarily Clay Loam with regions of Gravelly Sandy Loam.
3. Halberstadt proposed site will generate pre-construction peak runoffs in the range of 2.19 m^3/s to 8.82 m^3/s during the 1:2 year to 1:100 year rainfall events respectively whereas the post-construction runoffs will be between 3.68 m^3/s and 10.42 m^3/s during the 1:2 year to 1:100 year rainfall events respectively. This translates to increases of 0.18% to 0.68% for the associated return periods.
4. Hydraulic analysis has revealed two (2) main trapezoidal drain configurations are required and capable of conducting the 50 year rainfall event: 3.7m wide (top) by 1m deep and 3m wide (top) by 0.75m deep.
5. Based on hydraulic assessment, it was also determined that two (2) concrete box culvert configurations are required to conduct the 50 year flows under the local roads: 2.2m wide by 1.5m high and 1.5m wide by 1.5m high.
6. The implementation of the proposed detention pond with an average surface area of 0.475 hectares will result in a significant reduction of the peak flows being discharged from the site. When compared to the pre-development condition, the post development scenario will reduce the total runoff from the project area as well as result in a net decrease of 2.57 m^3/s in the peak flows from the site.

6.2 Recommendations

The following are our recommendations from the analysis conducted to date:

1. Implement the flood/erosion mitigation measures as outlined in the report and the engineering drawings to ensure the risk of flooding of communities downstream is minimized as well as the risk of silting the Bull Park River. These include a combination of:
    a. Regional drainage infrastructure inclusive of implemented check dams;
    b. Detention basin inclusive of sedimentation forebays;
    c. Box culvert which discharges the peak runoffs from the project site;
2. Relocate the storage overburden site to accommodate the proposed detention pond along the eastern boundary of the quarry deposit;
3. An appropriate site survey should be conducted in order to optimize the proposed drainage plan inclusive of slopes, road dimensions etc;
4. The detention basin is designed to accommodate 5,000m^3 of sediments within the forebay before affecting the efficiency. However, it is recommended to be dredged on an annual basis to maintain the design volumes by removing silt etc. that may be deposited after rainfall events;
5. All swales are to be cleared of debris and dredged as needed by the relevant authorities.

7 Appendix A

7.1 Bill of Quantities

Table 7.1 Bill of Quantities for proposed drainage infrastructure works for the Halberstadt quarry

Proposed Drainage Infrastructure Works for the Halberstadt Gypsum Quarry, St. Thomas, Jamaica					
Bill 1: Preliminaries					
Nr.	**Item**	**Unit**	**Quantity**	**Rate**	**Amount**
	General Provisions				
1.01	Allow For Providing Water For The Whole Of The Works Including That Required By The Nominated Sub-contractors By Whatever Means Necessary, And For Clearing Away Any Temporary Installations At Completion And Make Good All Work Disturbed.	Sum	1.00	J$ 60,000.00	J$ 60,000.00
1.02	Lighting and Power	Sum	1.00	J$ 60,000.00	J$ 60,000.00
1.03	Material Store	Sum	1.00	J$ 30,000.00	J$ 30,000.00
1.04	Insurance 3. Public Liability	Sum	1.00	J$ 350,000.00	J$ 350,000.00
1.05	Mobilisation Guarantee/Bond	Sum	1.00	J$ 100,000.00	J$ 100,000.00
1.06	Performance Bond	Sum	1.00	J$ 100,000.00	J$ 100,000.00
1.07	Tender Bond	Sum	1.00	J$ 100,000.00	J$ 100,000.00

1.08	The Contractor Is To Ensure That The Whole Site Is Kept Free From Water Logging And Drainage By Stormwater Flooding And He Is Deemed To Have Allowed In His Prices For Providing Such Temporary Ditches, And Gullies, Mechanical Pumps, Hoses And The Like As May Be Necessary And For Subsequently Backfilling Excavations, Reinstating Surfaces And Generally Making Good. Any Damage Arising From Non-compliance With This Clause Is To Be Made Good At The Contractor's Expenses.	Sum	1.00	J$ 150,000.00	J$ 150,000.00
1.09	Cover up and Protect	Sum	1.00	J$ 40,000.00	J$ 40,000.00
1.10	Sanitary Facilities	Sum	1.00	J$ 150,000.00	J$ 150,000.00
1.11	Supervision and Management	Sum	1.00	J$ 750,000.00	J$ 750,000.00
1.12	The Contractor Shall Provide For Safety On Site For The Duration Of The Entire Works	Sum	1.00	J$ 126,000.00	J$ 126,000.00
1.13	Provisional Sum Of $100,000 For Engineering Surveys For Use As Directed By The Engineer.	Sum	1.00	J$ 100,000.00	J$ 100,000.00
1.14	Cart away of excess excavated material material	Sum	1.00	J$ 180,000.00	J$ 180,000.00
	SUB-TOTAL				J$ 2,296,000.00

Bill 2: Earth Works					
Nr.	**Item**	**Unit**	**Quantity**	**Rate**	**Amount**
2.01	Excavate to remove vegetable soil 150 - 200m thick, cart away and storage.	m^2	4,194.67	J$ 434.00	J$ 1,820,485.77

2.02	To excavate in soil, provide support to excavation, keep trench free from ground and storm water and level for invert of drain commencing at strip site level not exceeding 0.75m deep and get out.	m^3	728.98	J$ 1,627.50	J$ 1,186,422.78
2.03	To excavate in soil, provide support to excavation, keep trench free from ground and storm water and level for invert of drain commencing at strip site level not exceeding 1m deep and get out.	m^3	1,569.43	J$ 1,790.25	J$ 2,809,676.50
2.04	To excavate in soil, provide support to excavation, keep trench free from ground and storm water and level for gabion baskets and reno mattresses	m^3	70.35	J$ 3,382.50	J$ 237,958.88
2.05	Place and compact backfill material to make up level at finish grade including boundary berm and outlet weir	m^3	28.35	J$ 1,519.00	J$ 43,063.65
	SUB-TOTAL				J$ 6,097,607.58

Bill 3: Drainage Works

Nr.	Item	Unit	Quantity	Rate	Amount
3.01	Non-woven geotextile to base and backfill of check dams: 405 g/m2 minimum 1420 N grab strength, 600mm overlap minimum at joints, .15mm apprent opening size	m^2	323.30	J$ 1,356.25	J$ 438,473.70
3.02	Non-woven geotextile to base and backfill of gabion baskets: 405 g/m2 minimum 1420 N grab strength, 600mm overlap minimum at joints, .15mm apprent opening size	m^2	51.45	J$ 1,356.25	J$ 69,779.06

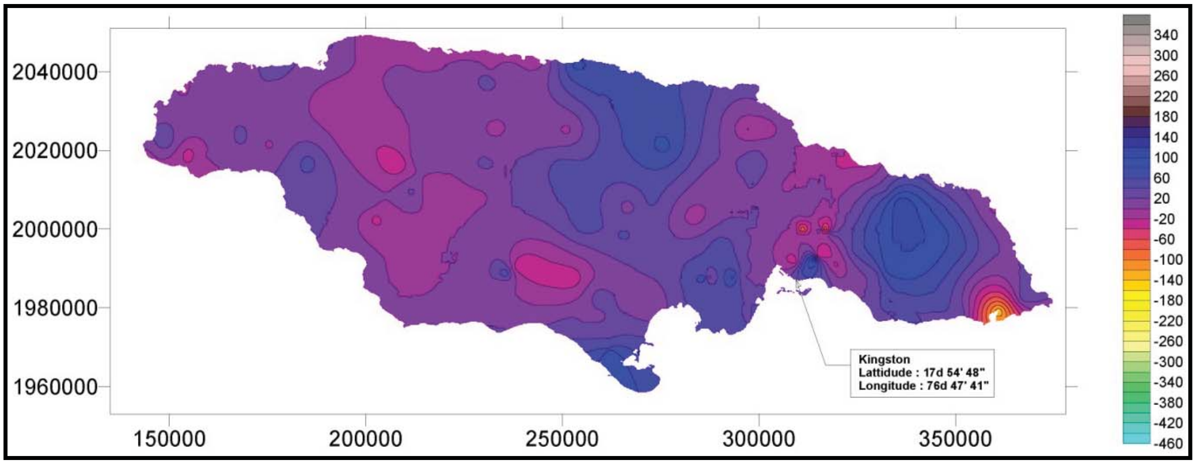
3.03	Check Dams: To banks up to 0.6 metres high. Guage: 75mm x 75mm assembling, tying, fixing, staking and tensioning; fill with 300 to 360 mm stones, compaction and finishes; mesh including cutting and folding to form special units and shapes; bracing and wiring lids.	m^3	136.06	J$ 21,483.00	J$ 2,922,980.36
3.04	Check Dams: To banks up to 0.8 metres high. Guage: 75mm x 75mm assembling, tying, fixing, staking and tensioning; fill with 200 to 260 mm stones, compaction and finishes; mesh including cutting and folding to form special units and shapes; bracing and wiring lids.	m^3	187.24	J$ 21,483.00	J$ 4,022,443.09
3.05	Gabion baskets: Gauge 1 m x 1 m x 1 m nominal dimensions assembling, tying, fixing, staking and tensioning; fill with 300 to 400 mm stones, compaction and finishes; mesh including cutting and folding to form special units and shapes; bracing and wiring lids.	m^3	101.85	J$ 21,483.00	J$ 2,188,043.55
3.06	Reno Mattress: Gauge 6 m x 2 m x 0.17 m nominal dimensions assembling, tying, fixing, staking and tensioning; compaction and finishes; mesh including cutting and folding to form special units and shapes; bracing and wiring lids.	m^3	5.64	J$ 5,859.00	J$ 33,048.28
	Box Culverts				
3.07	To supply and place granular backfill to all sides of concete walls with not more than 30% sand, 200mm thick nominal thickness.	m^3	54.50	J$ 4,882.50	J$ 266,071.84
3.08	To supply and install HT bars for slabs and walls	Ton	6.19	J$195,300.00	J$ 1,209,488.49

3.09	To supply, repair, place, maintain and secure formwork to culvert slabs	m^2	734.68	J$ 3,797.50	J$ 2,789,950.34
3.1	To supply and place 31MPa concrete (cube strength at 28 days) in slabs including provisions for pumping and curing	m^3	79.40	J$ 27,125.00	J$ 2,153,647.59
	SUB-TOTAL				J$ 16,093,926.29

Bill 4: Dayworks					
Nr.	**Item**	**Unit**	**Quantity**	**Rate**	**Amount**
4.01	Provided in respect of the Prime Cost of Labour	Sum	1	J$100,000.00	J$ 100,000.00
4.02	Percentage addition for overhead and profit for Labour	%	J$100,000.00	25%	J$ 25,000.00
4.03	Provided in respect of the Prime Cost of Material	Sum	1	J$100,000.00	J$ 100,000.00
4.04	Percentage addition for overhead and profit for Material	%	J$100,000.00	20%	J$ 20,000.00
4.05	Provided in respect of the Prime Cost of Plant	Sum	1	J$100,000.00	J$ 100,000.00
4.06	Percentage addition for overhead and profit for Plant	%	J$100,000.00	20%	J$ 20,000.00
	SUB-TOTAL				J$ 365,000.00

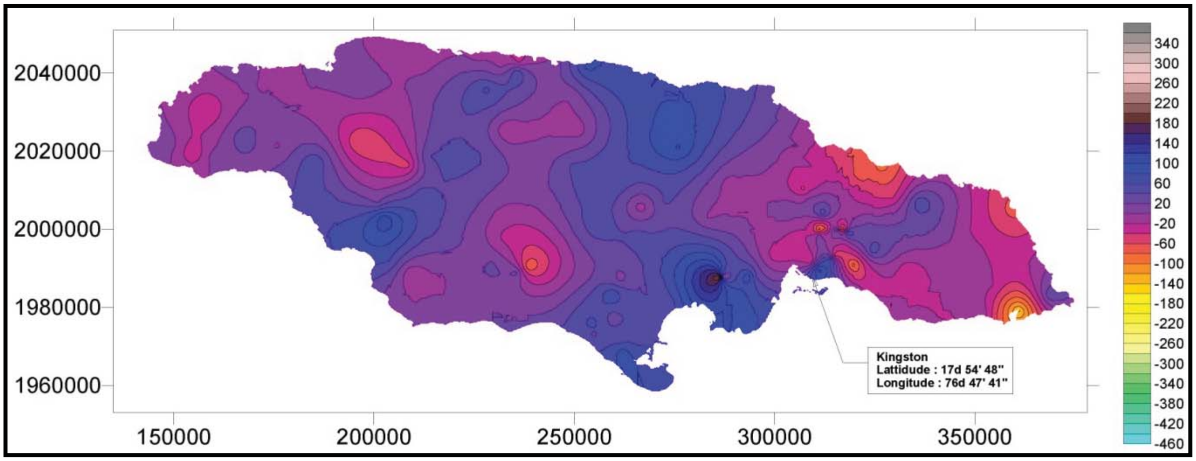
8 Appendix B

8.1 Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall



Kingston
Lattidude : 17d 54' 48"
Longitude : 76d 47' 41"

Figure 8.1 Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 2 Year Return Period Event



Kingston
Lattidude : 17d 54' 48"
Longitude : 76d 47' 41"

Figure 8.2 Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 5 Year Return Period Event

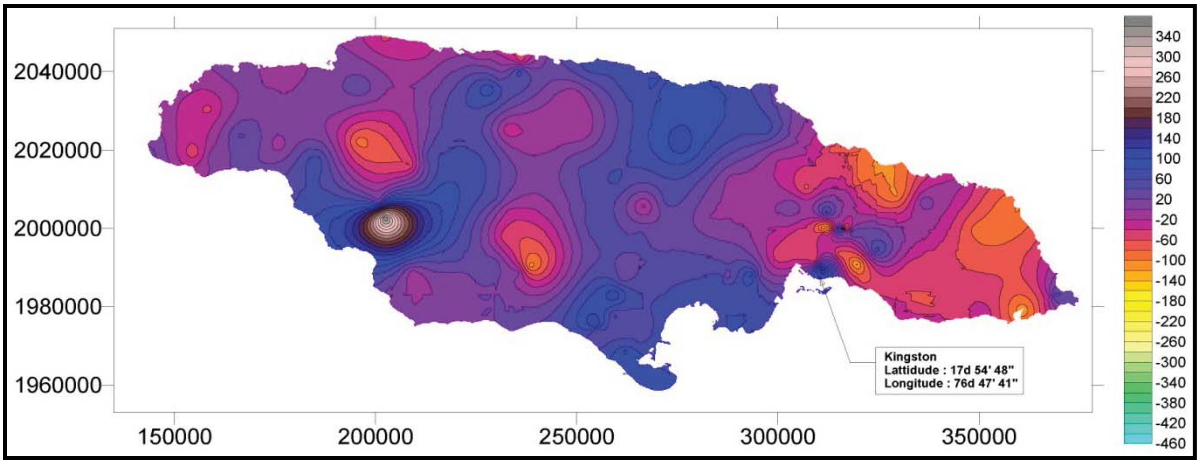


Figure 8.3 Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 10 Year Return Period Event

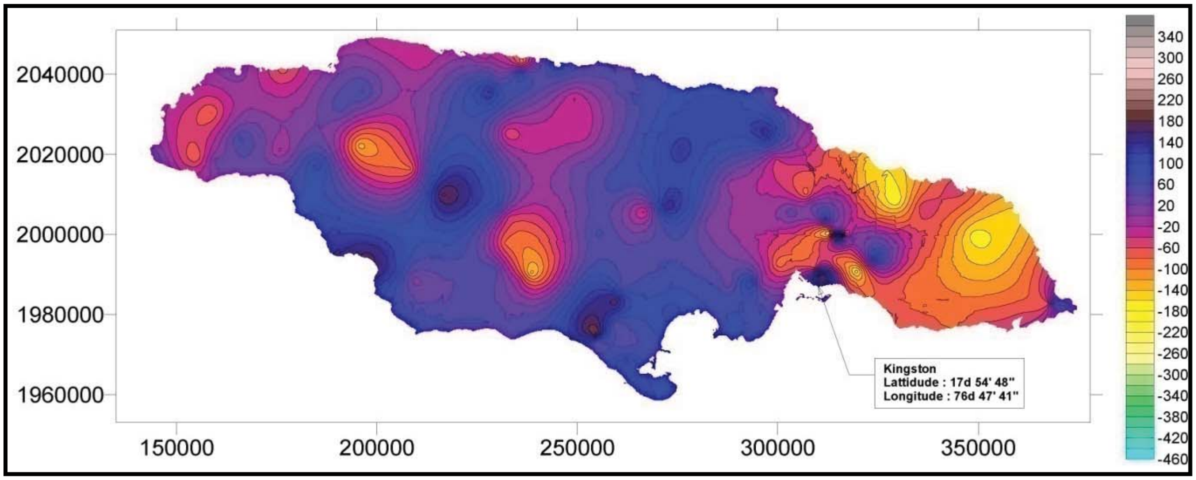


Figure 8.4 Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 25 Year Return Period Event

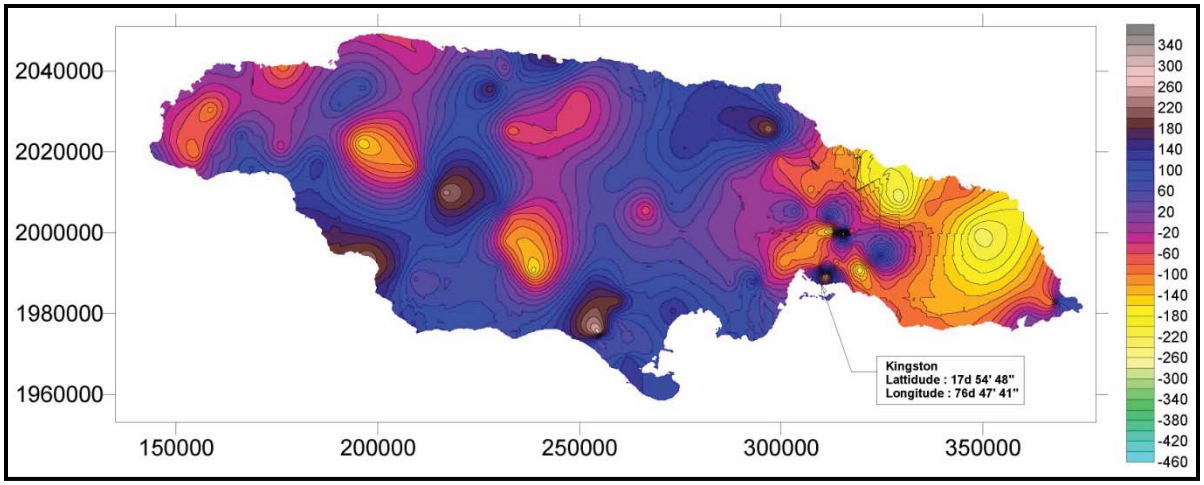


Figure 8.5 Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 50 Year Return Period Event

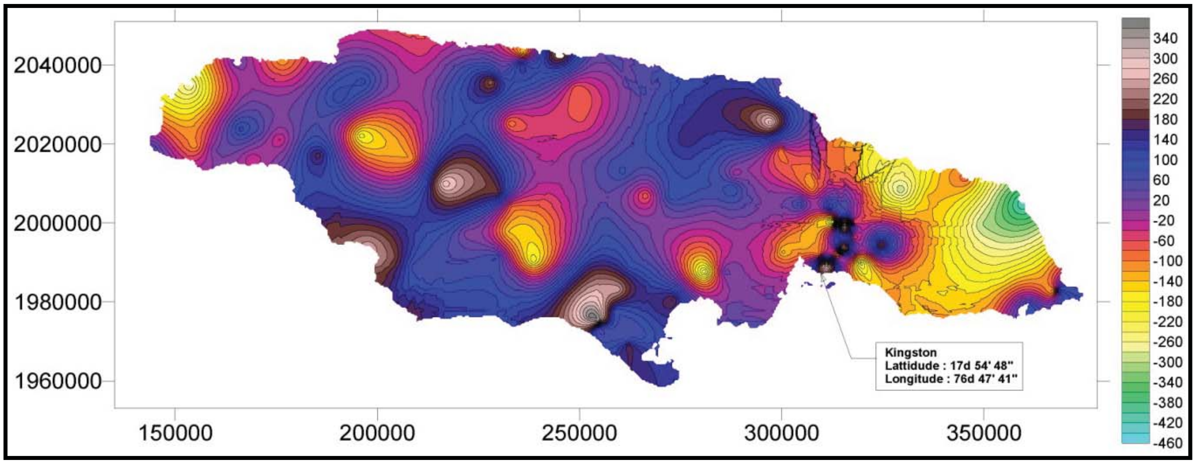
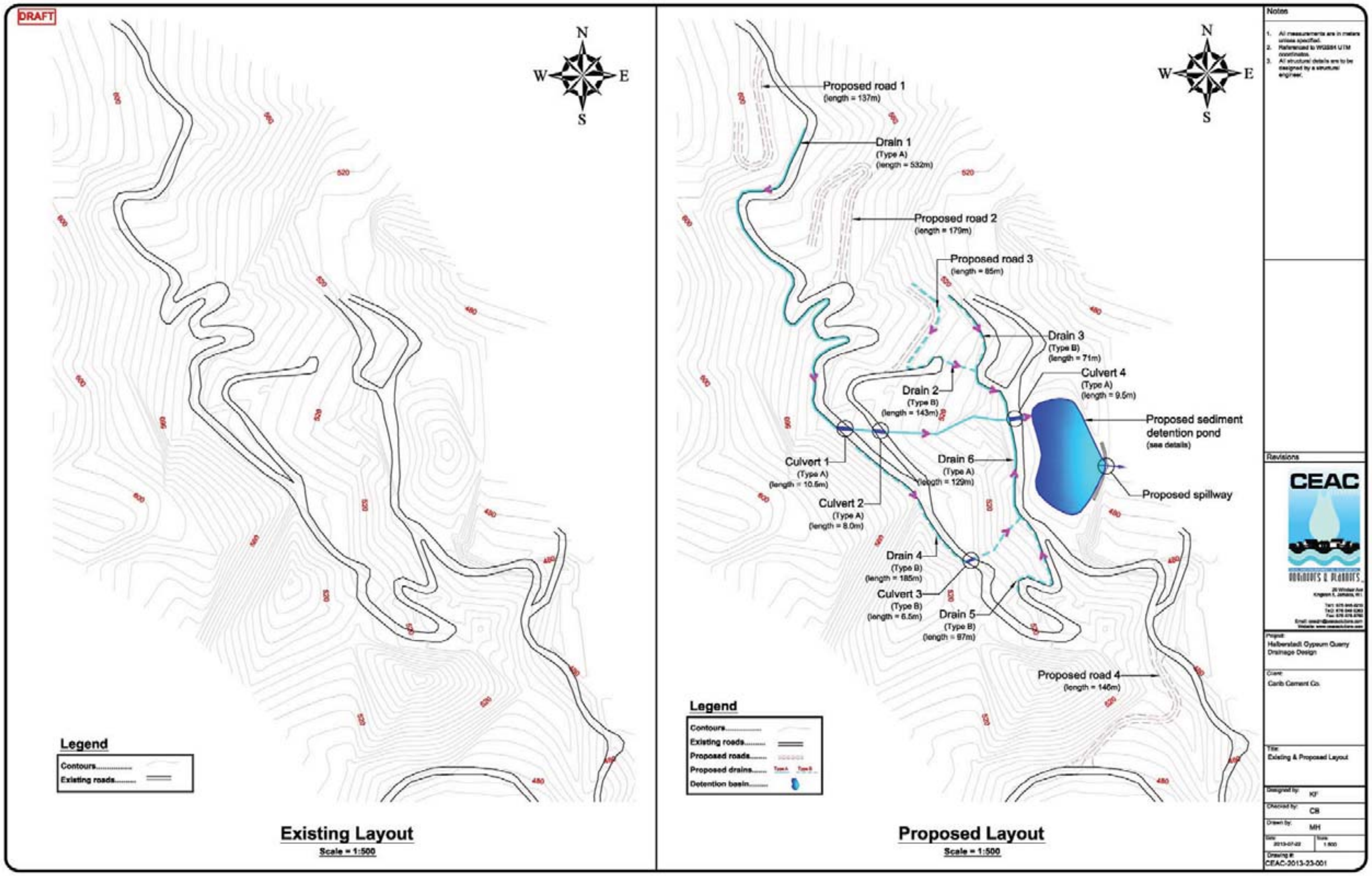
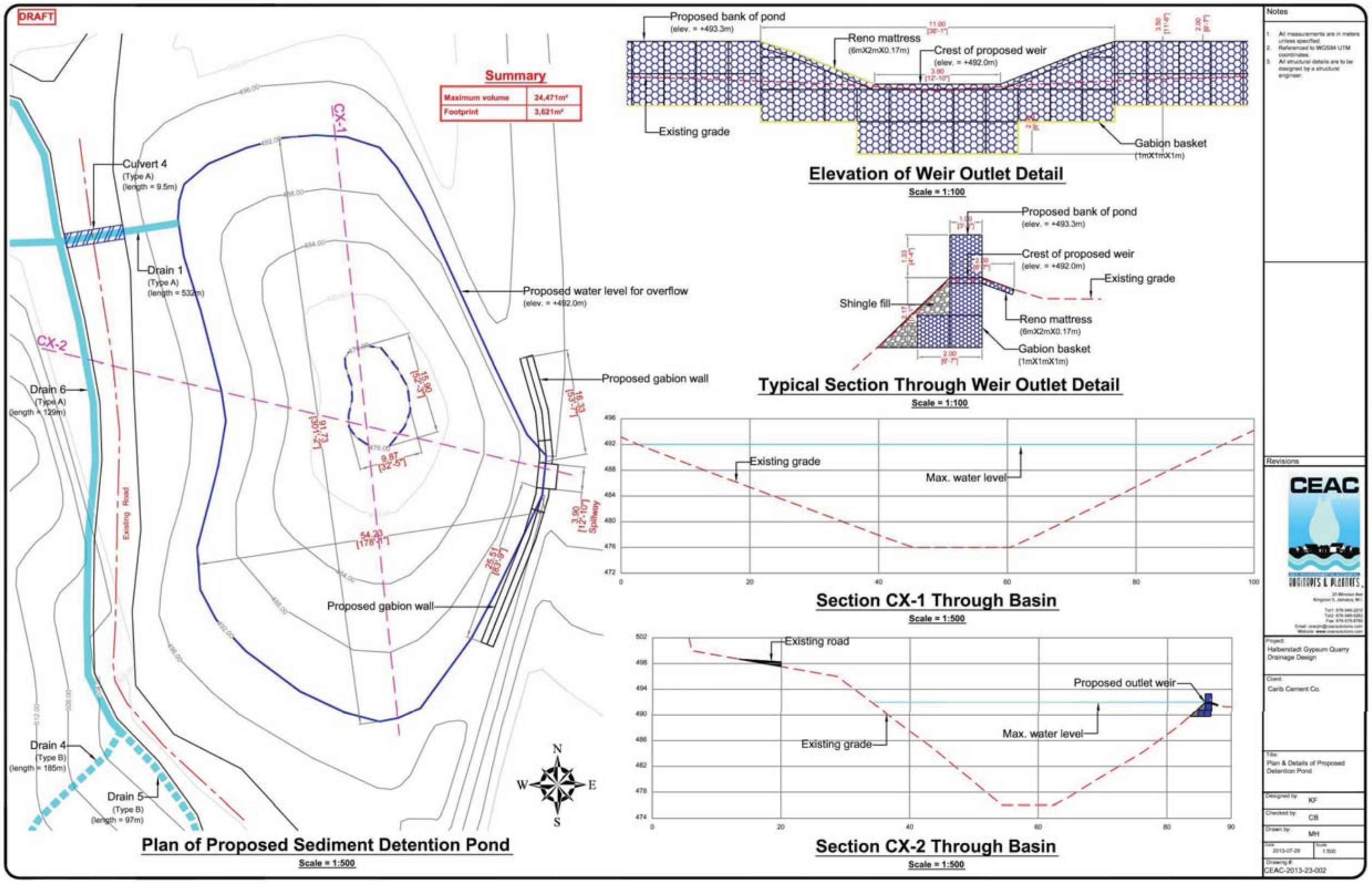


Figure 8.6 Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 100 Year Return Period Event

9 Engineering Drawings



1. All measurements are in meters unless specified.
2. Referenced to WGS84 UTM coordinates.
3. All structural details are to be designed by a structural engineer.


DRAFT

Summary

Maximum volume	24,471m³
Footprint	3,621m²

Plan of Proposed Sediment Detention Pond

Scale = 1:500

Elevation of Weir Outlet Detail

Scale = 1:100

Typical Section Through Weir Outlet Detail

Scale = 1:100

Section CX-1 Through Basin

Scale = 1:500

Section CX-2 Through Basin

Scale = 1:500

Notes

1. All measurements are in meters unless specified.
2. Referenced to WGS84 UTM coordinates.
3. All structural details are to be designed by a structural engineer.

Revisions

CEAC

Engineers & Planners

Project: Halberstadt Gypsum Quarry Drainage Design

Client: Carib Cement Co.

Title: Plan & Details of Proposed Detention Pond

Designed by: KF

Checked by: CB

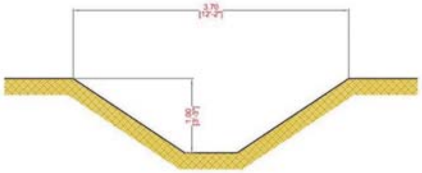
Drawn by: MH

Date: 2013-07-29

Scale: 1:500

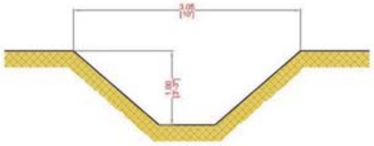
Drawing #: CEAC-2013-23-002

DRAFT



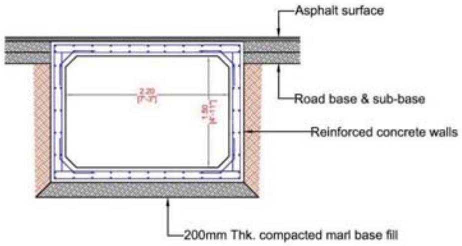
Typical Section Through Drain Type A

Scale = 1:50



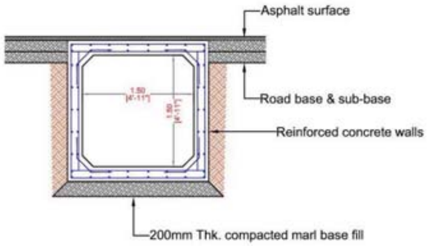
Typical Section Through Drain Type B

Scale = 1:50



Typical Section Through Culvert Type A

Scale = 1:50



Typical Section Through Culvert Type B

Scale = 1:50

Notes

1. All measurements are in meters unless specified.
2. Referenced to WGS84 UTM coordinates.
3. All structural details are to be designed by a structural engineer.

Revisions

CEAC

Engineers & Planners

Project: Halberstadt Gypsum Quarry Drainage Design

Client: Carib Cement Co.

Title: Details

Designed by: KF

Checked by: CB

Drawn by: MH

Date: 2013-07-29

Scale: 1:500

Drawing #: CEAC-2013-23-002