Environmental Impact Assessment

Proposed Highway 2000 North South Link – Moneague to Ocho Rios

Report Version:	**Final**
Date:	**November 2012**
Prepared by:	**CL ENVIRONMENTAL CO. LTD.**
Submitted to:	**NATIONAL ROAD OPERATING AND CONSTRUCTING COMPANY (NROCC)**

CL ENVIRONMENTAL

Taking Care of You and Your Environment.

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED HIGHWAY 2000 NORTH SOUTH LINK – MONEAGUE TO OCHO RIOS

Submitted to:

NATIONAL ROAD OPERATING AND CONSTRUCTING COMPANY (NROCC)

4th Floor, DBJ Building

11A-15 Oxford Road, Kingston 5

Prepared by:

CL ENVIRONMENTAL

22 Fort George Heights

Kingston 9

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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
	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
	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	Milmetre
	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
	NROCC	National Road Operating and Constructing Company (Jamaica)
	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

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

BACKGROUND AND OVERVIEW

The highway will begin in the Silkfield area of Moneague area and is to connect with the existing highway and parochial road networks via an enhanced interchange provision. The highway will then travel north northwest through this region, north of Phoenix Park and south of Retirement, through to Crescent Park Pen. The alignment then climbs north northeast through Golden Grove and turns again heading north northwest through Lydford, Steerfield and Annandale Farms. The alignment runs east of Ewart Town and through Malvern Park where it then heads north northwest through Davis Town and passes Chalky Hill on the west side. There is a sharp easterly turn where it passes south of Steer Town and east of the Roaring River community where it terminates at the main in Mammee Bay, Ocho Rios.

The highway project is expected to be typical, with construction and engineering methods being utilised to develop and clear the rights-of-way, ensure substrate stability, involve the construction of drainage, bridges and overpasses, as well as manipulate the landscape to allow for grade separated interchanges and linkages with existing roadways. The principal construction materials expected to be employed are steel, concrete, asphalt and aggregates of various grades.

The Highway (Moneague to Ocho Rios) is intended to be a four lane controlled-access, tolled motorway with fully grade separated interchanges and intersections built according to modern international standards with a total distance of 20 km.

Highway 2000 is Jamaica's first toll highway and this primarily “Greenfield”; tolled, multi-lane motorway will connect the capital Kingston in the south-east of Jamaica with the tourism centres of Montego Bay in the north-west and Ocho Rios on the north-central coast, covering 230 km when completed.

The National Road Operating and Constructing Company Limited is desirous to continue to directly contribute to the Government’s desire to accelerate development through the implementation of appropriate infrastructure.

In addition to the economic benefits expected from the North South Link, the vulnerability of existing routes to natural disasters makes the development of the North South link even more desirable, given the frequent and recent devastation of the roads in the gorge.

PROPOSED PROJECT

PROJECT RATIONALE

The principal objective for the development of the Highway 2000 Project is to stimulate economic and social development and increase employment and thereby reduce poverty in Jamaica.

Highway 2000 is intended to serve as a catalyst for Jamaica's economy through the following:

a) Direct and efficient links between major economic centres (cities and towns) and growth points as the existing road system is currently very congested;

b) Serve as a catalyst for economic activity such as the liquefied Natural Gas pipe lines, along the Highway corridors and connectivity between the north and south coast of the island in support of the diversification of the tourism industry;

c) Induce additional/collateral economic and developmental activity in the areas served. For example the establishment of adjacent Economic Re-processing Zones (EPZ);

d) Provide for links between markets and, for instance between the container-port at Kingston and the commercial centres at Montego Bay and Ocho Rios, which together serve western Jamaica and the north coast tourist resorts;

e) Reduce the population growth pressure on the major urban areas as commuting from suburban and rural areas to the city will be greatly facilitated;

f) Open access from tourist centres to attractions such as the planned Maroon Theme Park (currently under development) and the Milk River Natural Spa;

g) Spur agricultural activity by opening tracts of land for agricultural development and also improve the transportation of agricultural produce in the country, as well as, the transportation links from agricultural producing areas to major airports and seaports for export crops;

h) Increase safety of motorists and contribute to reduced vehicle operating costs through the use of better standards in highway design.

ECONOMIC BENEFITS

It is well documented that investment in transportation infrastructure generates substantial economic benefits by reducing transportation costs for existing activities, providing access to new areas with economic development potential and triggering investment activities. Additionally, there are measurable savings in vehicle operating costs and savings in travel time cost associated with the development of highways. In road projects, externalities are the major source of benefits and the challenge is to internalise these externalities and thus give a measure and a value of the effects on vehicle operating costs, people's time, people's lives, environment, etc.

The economic benefit in using an expressway can be expressed in various aspects. The main features of savings to the expressway users are shown in terms of savings in vehicle operating cost (VOC) and savings in travel time cost. There are other benefits such as accident saving cost and environmental cost that are difficult to quantify.

Much research has been devoted in recent years to estimating the productivity of investments in infrastructure. Many of these studies, which attempt to link investment in infrastructure to growth in GDP, show very high rates of return in time-series analysis. A number of studies on economic growth and infrastructure also show that infrastructure variables are "positively and significantly correlated with growth in developing countries". While the various econometric models may be deficient in estimating the linkage between infrastructure and growth, it is commonly accepted that investments in highways do have a significant impact on economic growth in developing countries.

An analysis of World Bank funded infrastructure projects over the period 1974 to 1992, showed that the average economic rates of return of highway projects were the highest at 29% among all other types of projects funded. Other estimates have shown rates of return on highway projects in excess of 50%.

The area of importance that has been highlighted in the literature is the impact of infrastructure development on a country's production cost. Studies found that the infrastructure significantly reduces production costs in a number of countries. One estimate suggests that three-quarters of federal investment in highways in the 1950s and 1960s in the United States can be justified on the basis of reductions in trucking costs alone.

For Highway 2000, a number of independent analyses were undertaken including one by Steer Davies Gleaves (SDG) and another by CFAS Limited, assisted by the Planning Institute of Jamaica. As the country develops in the new millennium, the demand for a more efficient transportation system is ever increasing. Expressways with all their facilities provide such services for the transportation needs of the country.

NORTH-SOUTH LINK: MONEAGUE TO OCHO RIOS

NROCC intends to continue to directly contribute to the Government's desire to accelerate development through the implementation of appropriate infrastructure. In furthering this objective, a North South Link, Caymanas to Ocho Rios, is being developed.

ALIGNMENT, CROSSINGS AND TOLL PLAZA

The Moneague to Mammee Bay (Section 3) segment of Highway 2000 requires the construction of a two lane, dual carriageway roadway, with a design speed of 80 km/h.

Moneague to Lydford (km 49+200 to km 58+000)

The alignment begins at the existing Moneague Roundabout, which will likely be converted to an interchange with the A1 Road. This may require some reconstruction of the Mt. Rosser Bypass to accommodate the interchange, and construction of a new underpass or overpass at the interchange.

From the interchange, the highway passes through mountainous terrain varying in elevation from elevation 350m to 450m, with gradients up to 6.5%. Underpasses (field connectors) will be required at km 49+700, km 51+700, km 52+500 and km 53+900 to maintain local access to both sides of the new highway.

A Toll Plaza is proposed in the vicinity of km 54 to km 55 along a tangent section of highway near the abandoned Reynolds Bauxite Mines site, along the east side of Golden Grove.

An interchange is proposed at the intersection with the local road at km 55+200 to provide access to Chalky Hill Road, the A1 Road (to Claremont and St. Ann's Bay), and the A3 Road (to Ocho Rios). These link roads may have to be upgraded to provide adequate serviceability. This interchange will also provide access to neighbouring communities in Golden Grove. Underpasses will be required at the interchange (km 55+200), and at km 56+000 and 57+200 to maintain local access.

Lydford to Davis Town (km 58+000 to km 64+000)

The alignment generally passes through generally rolling topography through abandoned bauxite mined areas from km 58+000 to km 60+000, with an underpass or overpass proposed at km 59+800.

From km 60+000 to km 63+000 the alignment generally runs parallel to Chalky Hill Road through rolling terrain, with an underpass proposed at 60+700, an overpass at km 62+200, and an underpass at Chalky Hill Road at km 63+500.

The alignment passes through a proposed residential subdivision (Davis Town) from km 62+200 to km 62+800, and a forest reserve from km 62+800 to 63+400 before entering the existing Davis Town development at km 63+400 to km 64+000. The alignment through this area will be carefully positioned to minimize any impact to the community.

Davis Town to Mammee Bay (km 64+000 to km 69+000)

The alignment passes along the west side of the existing housing developments on Chalky Hill Road from km 64+000 to 66+000 primarily through forested vegetation, crossing Harbridges Gully at km 65+400, where the highway starts a long decline to the North Coast Highway, from elevation of 320m to elevation 10m, with maximum gradient of 8%.

The alignment passes along the south side of Steer Town in an easterly direction from km 66+500 to km 67+000, and crosses under a local road at km 66+700, and under Chalky Hill Road at km 67+500.

The alignment curves towards the North Coast Highway at km 68+000 where it first crosses the Little River, with a second crossing at km 68+500. The alignment has been positioned to minimize impact to the Great House situated south of the alignment. Further refinement of the alignment may be required to avoid the river crossings, and to avoid any impact to the Great House.

The profile from km 68+200 to the proposed roundabout at km 69+200 is at the maximum gradient of 8%, in order to accommodate the steep topography. The property where the alignment intersects the North Coast Highway is zoned (by UDC) for future commercial development, therefore needing close coordination with UDC.

Crossings

Seventeen (17) crossings have been identified and will be facilitated by overpasses and underpasses. These crossings include rivers, local roads, and field connectors.

Toll Plaza and Equipment

A Toll Plaza is proposed in the vicinity of km 54 to km 55 directly south of the proposed interchange, and along a tangent section of highway near the abandoned Reynolds Bauxite Mines site to the east of Golden Grove.

The gradient along this section may need to be adjusted to provide a flat area for the Toll Plaza, and to integrate the adjacent interchange. Tolling strategy may influence the interchange design, for toll collection (ie toll plazas on the interchange ramps).

PHASING AND TIMETABLE

The project is scheduled to be concluded within 36 months after the commencement certificate has been issued. The project will be divided into phases that will be defined by the construction requirements.

CONSTRUCTION/CAMP/SITE YARD

The location of the construction camp/site yard has not yet been determined. It is anticipated, however, that the camp will be approximately 200m x 200m and will take into consideration storm water and surface water drainage requirements, location of interceptors, as well as wastewater and sewage requirements. All necessary approvals for the construction camp/site yard will be obtained prior to establishment of the site. The construction works will be implemented by the Contractor.

Although the exact location of the site construction camp has not been identified, the previous experience of the Highway 2000 project should be taken into account, with regards to good housekeeping habits, conformance to permitting requirements, and adherence to audit procedures.

CUT AND FILL

All fill materials will be obtained mainly from the cut and transported by trucks to the designated fill areas.

Quarries will be identified based on the following criteria:

1) Proximity to project
2) Type of material required
3) Nature of approval from authorities

If the project requires the establishment of a quarry, the necessary licenses/approvals will be sought.

Transportation Requirements

All motorized vehicles within the site, excluding those on public roads, shall be restricted to maximum speed of 20 km per hour (in site yard) and 50 km per hour (on the alignment). Speed limit signs will be erected as appropriate. Haulage and delivery vehicles will be confined to designated roadways inside the site. The production team will ensure that vehicles transporting earth materials and fines are fitted with side and tailboards. Materials transported by vehicles shall be covered, with the cover properly secured and extended over the edges of the side and tailboards. Dusty materials will be dampened before transportation.

CONSTRUCTION TIMELINE

It is anticipated that the entire construction period for the highway will last 36 months.

PHYSICAL ENVIRONMENT

CLIMATE AND METEOROLOGY

- Temperature values over the assessment at all locations ranged from a low of 24.2^{o}C at Lydford to a high of 32.3 ^{o}C at Roaring River Community.
- Relative humidity values ranged from a low of 54% at Moneague to a high of 99% at Lydford.
- Wind speed ranged from a low of 0.4 m/s at Lydford to a high of 9.4 m/s at Roaring River Community.
- There was some measurable precipitation during the assessment ranging from 4.1mm – 7.9mm.
- Barometric pressure ranged from a low of 970.7 millibar at Lydford to a high of 1017.9 millibar at Moneague.

SOILS AND GEOLOGY

- The physical features along the proposed highway alignment were conveniently divided into two sections.
- Section 1 - Between Moneague (Silkfield) and Malvern Park the proposed route traverses the uplands of the Moneague and Claremont region of St. Ann parish. The topography consists of the middle Tertiary rocks of the White Limestone Group exhibiting a relatively subdued karst, dominated by gentle rises and numerous small, frequently broad depressions (sinkholes and uvalas).
- Section 2 - Between Malvern Park and the north coast of the island at Mammee Bay, the topography slopes steeply down from the Moneague uplands to the sea. The chalky limestone of the Montpelier Formation and marls and clayey limestone of the Coastal Group rocks form a low-permeability barrier, ponding the groundwater of the Moneague Basin to the south from free flow to the ocean.
- The line of the proposed highway lies above the main depressions, and above the level of the Moneague Lake, which very rarely reaches an elevation of about 315 m after prolonged periods of

rain. The bottom of the Lydford depression is at a higher elevation (about 320 m at its lowest point) and has not been known to suffer flooding events. No collapse features are known to have been reported from the Moneague uplands.

- An overview of slope stability in the focus area is described as Generally Good within the harder units, which include the Swanswick, Troy, Claremont and Walderston Units, and Reasonable within the "soft" limestone of the Montpelier Formation. However, it should be noted that along fault scarps large and continuous falls should be anticipated.

TOPOGRAPHY

- The topography of the project area comprises of both gently sloping areas, in the northern end of the alignment, and a mountainous section which the alignment traverses with sharp increases/decreases in elevations along chainage km50+300 to km62+450. The southern tip of the alignment is on relatively gentle sloping lands.
- As the highway progresses through the mountainous regions of Phoenix Park and Retirement, the elevations range from 400 m to 500 m while slopes vary between 1^o and 15^o.
- Here the highway traverses through a valley east of Golden Grove where it continues in a north easterly direction trough the karst Limestone Mountains towards Lydford. The average elevations in this valley region are 380 m.
- The terrain climbs sharply from elevations of 400 m to 450 m on entering the Lydford, north of Golden Grove before increasing gently heading north of Steerfield.

HYDROLOGY

- The Harbridges Gully catchment was observed to have mostly forests, fields and crops with residential settlements on lots more than 1/4 acres in area. However, the northern basin area is comprised of strictly infrastructures and buildings.

- The catchment associated with Little River was determined to have significantly high concentrations of forests, fields and crops (over 80%). Concentrations of urban space were identified along the northern reaches of this catchment.

- It was found that the proposed alignment traverses a number of sub-catchments of a larger catchment area. The overall total area of the sub-catchments that will impact the highway alignment is 15.15 km^2, extending from Malvern Park in the east to Golden Grove in the west and Mammee Bay in the north to Ewart Town in the south. The catchment is approximately 6.14 km long at its longest and 4 km wide.
- The tributaries of Harbridges Gully cross the alignment west of Davis Town and Chalky Hill while those of Little River traverse the alignment east of Steer Town. These rivers are known to have large flood plains and tend to swell rapidly and overtop their banks during extreme weather.

- There exist three (3) areas vulnerable to flooding within 2 km of the alignment (Steer Town, Golden Grove, Moneague). The low-lying areas (valley) within which these communities are situated also contribute to the events of floods in the area. These regions are prone to flooding as they create a ponding effect, similar to wetlands.

QUARRIES

- There are 18 quarries which are closest to the project and are located at distances varying from 0.78 km to 21 km in proximity to the Moneague highway alignment.

HAZARDS

- Over the surface of the Moneague plateau landslips are rare and deemed to be unlikely, except locally in fresh highway cuts during construction.
- It was found that landslide occurrences increase with increasing slope angle. The results revealed that majority of landslides occurred within the ranges of 5^o and 30^o, with lower landslide occurrences, 9% and 7%, within the 0^o - 5^o range and 30^o and 75^o. However, a decrease in landslide occurrences was observed after the slope range 15^o - $30^{o.}$.
- The dominant slopes along the proposed alignment are between 0^o and 15^o. The segment of the alignment which traverses south of Golden Grove, in the region of Crescent Park Pen, comprises of the steepest slopes of up to 26^o

- The soils classifications revealed that approximately 79% of the soils had less than 1% probability of landslide occurring while 19% of soils had 1% - 10% probability of landslide occurrence.
- Flooding is unlikely to affect the proposed line of the highway from Moneague to Malvern Park. On the descent through Malvern Park to Mammee Bay, flooding can occur through overbank discharge from the numerous rivers. Additionally, experience has shown that, during extended periods of precipitation, extreme flooding, erosion and destruction of road beds and property can occur as in Fern Gully and Ocho Rios (Water Resources Authority, 2008).

DEBRIS FLOW

- Debris flow in the rivers and streams typically include soils, trees and other loose materials. To a greater extent, the experience to date is that during continuous torrential rains, animals and old household item are observed flowing downstream. Analysis of the predicted soil loss concluded that the majority of the Moneague alignment traverses moderate soil loss zones. More importantly, high loss regions are crossed between Chalky Hill and Steer Town.

PARTICULATES

- For the PM 10 sampling event all locations had particulate values compliant with the 24-hour US EPA standard of 150μg/m^3.
- For the PM 2.5 sampling event all locations had particulate values compliant with the 24-hour US EPA standard of 35 μg/m^3.

NOISE

- During the daytime (7am – 10 pm), two stations (3 and 5) were non-compliant with the NEPA noise guidelines.
- During the night time (10pm – 7am), three stations (3, 5 and 6) were non-compliant with the NEPA noise guidelines.

BIOLOGICAL ENVIRONMENT

FLORA

- The proposed highway footprint will traverse mainly over large swaths of fenced, pastureland bordered by secondary, roadside, plant communities that were, in many cases, conspicuously rich in floral constituents.
- A total of 219 plant species were identified, 82 of these (or 38%) were herbs and shrubby-herbs. Together, they made up the primary constituents of the flora assessed. Shrubs accounted for 20% of the plant species encountered and tended to occur on ruinate lands. The occurrence of epiphytic and climbing species was quite reduced, compared to the percentages for other growth forms.
- Several isolated stands of trees were observed occurring within and surrounding pastoral communities. A total of 63 tree species were encountered.
- Commonly occurring endemic species were the Search-me-Heart, *Lantana jamaicensis* and *Lobelia viridifolia*.
- In areas where high instances of anthropogenic influence were observed, agricultural crops such as banana, breadfruit, yam, cocoa, coconut orange, lime and grapefruit were frequently seen. Ornamental plants such as Poui, Poinciana, *Ixora*, African Lily and *Hibiscus* were occasional in residential areas.

FAUNA

- Forty six species of birds were identified during the study; 16 are endemic, 27 resident and 3 migrant. The low number of migrant warbler species is as a result of the time the survey was carried out, ie., before the arrival of the migrant birds. Nineteen of Jamaica's Amphibians were recorded from the study site, three species recorded for the first time from this area of Jamaica. Sixteen of Jamaica's fifty reptiles were recorded.
- One hundred and seven species of invertebrates were recorded.
- The biological composition of the Little River was normal for a high gradient stream with low to moderate impacts. Representatives

from thirteen macroinvertebrate taxonomic groups were found, with gastropod (snails) dominating, followed by various insect groups, and crustaceans. No fish were collected; these appeared to be limited in range and abundance, as a result of the desiccation of long stretches of the river.

LAND USE

- The land use within 3km of the proposed alignment was assessed. These include agricultural, commercial, industrial, mined out areas, residential, educational and recreational (Dunns River Falls). Other uses include, airstrip, caves, hydroelectric plant, burial grounds (behind homes or private property), forest estates power lines, wells/pump houses, springs, water pipelines, telecommunication modules and cellular towers.
- Agriculturally, the study area has papaya farming and subsistence farming. Commercially, the study area has offices, restaurants and bars. There are two limestone quarries within the study area.
- There are 27 settlements (residential areas) within the Social Impact Area (SIA) with the major towns being Moneague, Golden Grove and Claremont.

STRUCTURES ALONG ALIGNMENT

- Approximately 64 structures will be impacted by the proposed highway alignment. Of these structures, approximately 25% are found in Zone 1 (49km+100 to 51km+000) and 28% in Zone 6 (66km+100 to 67km+000). These vary from houses and other structures in proximity of and associated with households, such as fowl coups, pens, tanks, out houses and tanks.

SOCIOECONOMICS

- The growth rate for the Parish of St. Ann over the last inter-censal period (2001-2011) was 0.35 % per annum. The population of the SIA was approximately 21,464 persons and is expected to reach

23,423 persons over the next twenty five years, if the current population growth rate remains the same.

- There are more All Age schools than there are High and Junior High schools serving the area. The statistics revealed that the percentage of All Age schools within the SIA were slightly higher than the regional and national figures and likewise the percentage of High Schools were slightly less than the regional and national percentages. The presence of the Moneague Community College might have contributed to a higher percentage of Tertiary educational attainment within the SIA when compared to the regional and national data.

- There were 6238 housing units, 6832 dwellings and 7031 households within the SIA in 2001. The average number of dwelling in each housing unit was 1.10 and the average household to each dwelling was 1.03. The average household size in the SIA was 2.94 persons per household.

- In 2001, 49.6% of the households in the SIA owned the land on which they lived. Approximately 2% leased the land on which they were, 15.8% rented, 19.5% lived rent free, 2.7% "squatted", 1.1% had other arrangements and 9.3% did not report the type of ownership arrangements they had. Squatting in the SIA was seen to be higher than on the parish level although marginally less than the national average. Otherwise, there were lower or comparable percentages seen for all other land tenure categories when compared to the national and regional figures.

- There are a slightly greater percentage of households in Jamaica using electricity when compared with the regional and SIA households. This is consistent with a slightly greater number of households using kerosene at the regional and local level when compared with the national figure.

- The study area is served with landlines provided by Cable and Wireless: LIME Jamaica Limited. Wireless communication (cellular) is provided by Cable and Wireless (LIME) and Digicel Jamaica Limited. A network to support internet connectivity is also provided by Cable and Wireless (LIME).

- The greater portion of SIA households (75%) receives its domestic water supply from the National Water Commission (NWC). This was more than both the regional and national figures of 53% &

73% respectively. On the other hand, households utilizing a private source of water supply (25%) were lower than the regional and national average. Water demand in the SIA is 4,691,163.6 litres per day.

- It is estimated that approximately 3,752,930.88 litres/day of wastewater is generated within the study area. A higher percentage of households used water closets within the SIA when compared to the regional and national data. Conversely, a smaller percentage of SIA households utilize pit latrines when compared to the national and regional data for 2001.

- The National Solid Waste Management Authority is responsible for domestic solid waste collection within the study area. Presently, collection is done twice per week. It is estimated that households in the study area generated approximately 28,897.41 kg of solid waste in 2001. Based on the population growth, it has been estimated that at the time of this study, approximately 32,196.42 kg of solid waste was being generated and it is expected that within the next twenty five years, if the population growth rate remains the same, the amount will be 35,135.17 kg.

- Approximately 25.4% of all respondents had heard of the National Road Operating and Construction Company (NROCC) while 74.6% of respondents indicated they had never heard of NROCC. Based on interviewees' comments and responses, it was thought that some respondents may have mistaken NROCC with other international road construction companies but this could not be confirmed with the interviewee.

- On the issue of concerns and comments related to the project, there were a series of mixed opinions. In general respondents who thought the project would affect their lives commented on the potential ease or difficulty in commuting. Respondents expressed that the introduction of the toll road would significantly reduce the time it takes for them to travel and also result in an increase in public transportation in the communities as there are few public passenger vehicles on the short distance/local routes (Moneague to St. Ann's Bay/Ocho Rios). Individuals interviewed also indicated their expectation of having existing off roads in the vicinity of the proposed areas upgraded as well as an increase in employment in the respective communities for youth.

- Concerns highlighted, related to the possibility making the existing roadway areas inaccessible as well as possible devaluation of property and loss of commercial business. Concern was also expressed about the possible increase in noise and dust pollution and safety of children. The possibility of relocation of homes and/or businesses was also expressed. Of concern was also the issue of potential flooding as a result of the road construction or modification in areas currently not affected by flooding. The need for lighting at the existing Moneague roundabout was mentioned as there have been many motor vehicle accidents since the construction of the roundabout. It was also expressed that the warning signs were too close to the roundabout and need to be repositioned further away from the roundabout to allow for adequate warning to motorists.

- In all, 3 sites have been noted for the area with 2 of these sites showing a Taíno presence. A total of 6 pieces of artifacts were collected from the surface of three sites namely Phoenix Park (2 Taino artifacts), Adstock (skeletal remains found in 1966) and Annandale (3 Taino artifacts found in 1974).

IMPACTS AND MITIGATION

SITE CLEARANCE/PREPARATION AND CONSTRUCTION

Impact	Mitigation
Soil Removal and Blasting	• Directional controlled blasts • Use of alternative methods such as bulldozing and jackhammering. Conduct pre-blast crack surveys • Implement rockfall catchment areas
Soil Erosion and Siltation	• Stockpile fine grained materials away from drainage channels • Low berms placed around stockpiles and covered with tarpaulin • Provision of catch/diversion drains to divert surface flows • Installation of silt fences and coffer dams where necessary • Remove trees only as necessary • Trees with trunks of DBH 20cm and greater should be left intact
Water Resources	• Water resources risk management plan should be created for the recharge area. • Mapping of all sinkholes should be undertaken • Vegetated buffer area should be installed around and within sinkhole drainage area • Culverts and proper drainage should be implemented where the alignment crosses the surface run-off paths for the sinkholes • Installation of oil separators or interceptors within the drainage system
Flora and Fauna	• Vegetation mapping should be done prior to site clearance • Limit rights-of-passage to areas already showing noticeable signs of degradation • Incorporate engineering solutions that will help minimise habitat fragmentation (tunnels, bridges etc) • Fencing off of highway to limit disposal of solid waste into plant communities and restrict encroachment of humans and livestock • Avoid removal of endemic species and do not introduce exotic species • If removal is necessary, a nursery should be established for maintenance and propagation of endemic and naturally occurring plants

Impact	Mitigation
	• A buffer area should be established and maintained between the project area and surrounding limestone forest • Proper planning regarding access points to construction site should be established • Further planning required to establish development zones within nearby lands, villages and towns to prohibit development of nearby areas • Protect and preserve sensitive and unique ecosystems • Only remove vegetation as is necessary • Protect endemic and migratory species
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 (eg 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 and construction site, and adequately designed and covered to prevent access by vermin and minimise odour • The skips and bins at both the construction 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
Storage of Raw Material/Equipment	• A central area should be designated for the storage of raw materials. This area

Impact	Mitigation
	should be lined in order to prevent the leakage of chemicals into the sediment. • Raw materials that generate dust should be covered or wet frequently to prevent them from becoming air or waterborne • Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin to prevent them from being eroded and washed away • Raw material and equipment should be placed on hardstands surrounded by berms to contain any accidental surface runoff • Bulk storage of fuels and oils should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored. In addition, these containers should be surrounded by berms to contain the volume being stored in case of accidental spillage.
Transport of Raw Material/Equipment	• Paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access. • Adequate and appropriate road signs should be erected to warn road users of the construction activities. For example reduced speed near the construction site. • Raw materials such as marl and sand should be adequately covered within the trucks to prevent any escaping into the air and along the roadway. • The trucks should be parked on the proposed site until they are off loaded. • Heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage. • The use of flagmen should be employed to regulate traffic flow.
Emergency Response	• A lead person should be identified and appointed to be responsible for emergencies occurring on the site. This person should be clearly identified to the construction workers. • The construction management team should have onsite first aid kits and arrange for a local nurse and/or doctor to be on call for the construction site. • Make prior arrangements with local health care facilities such as health centres or the hospitals to accommodate any eventualities. • Material Safety Data Sheets (MSDS) should be store onsite.
Worker Safety	• The provision of lifelines, personal safety nets or safety belts and scaffolding

Impact	Mitigation
	for the construction workers. • Adequate communication with workers and signage should be put in place to alert/inform workers of the time, location of such blasting and instructions.
Traffic Management and Travel Costs	• Any detours should be done to minimize any increase in travel distance when compared to the existing routes. • Place adequate and appropriate construction warning signs. • Give adequate and ample notice of the pending road works and detours. • Delivery trucks should operate during off peak hours. • Loading of truck as per NWA axel load guidelines. • Adequate caution signage as per NWA guidelines and the use of flagmen where necessary.
Cultural and Historical	• Further archaeological evaluations should be undertaken in order to ascertain the magnitude of Taíno sites. • The recording of impacted structures should be undertaken prior to destruction. • Monitoring should be conducted during clearing and excavation stages in areas where historic artefacts were discovered. • Ensure the preservation of the historic and cultural sites

OPERATION

Impact	Mitigation
Climate Change and Flooding	• In light of these increases it is recommended that the newer rainfall return intensities obtained from the Met office datasets be used for hydrological models. • Flood plain analysis should be conducted to identify the areas which are prone to flooding and install suitable drainage infrastructure to ensure the alignment does not exacerbate existing conditions. • Suitable drainage mitigation measures should be installed to ensure that the alignment does not exacerbate existing conditions for the 100 year return period • Consider the use of detention ponds or retarding basins which aid in the reduction of the peak flows in the drains crossing the highway • Levees are implemented to impede the collection of water. Levees are embankments composed of soil and earthen material such as sandbags that are used to prevent flooding controlling the rate of runoff • Consider the use of use detention ponds or retarding basins which aid in the reduction of the peak flows in the drains crossing the highway • Create larger openings in relation to drainage and culverts to allow a greater volume of water to flow or escape.
Natural Hazards	• Ensure that the new structures can withstand hurricane, flood and earthquake impacts. • Ensure that the new structures are designed to withstand a 50 –100 year flood event. • Road integrity inspections should be conducted every two (2) years by qualified personnel. • An emergency response plan to address natural and man-made disaster and possible evacuation is required by NEPA and should be developed in close consultation with the Office of Disaster Preparedness and Emergency Management (ODPEM).
Landslides	• 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. • 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.
Debris Flow	• 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). • Sedimentation basins, debris racks (for small culverts or openings) upstream of culverts that can be schedule for maintenance cleaning. • 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.
Runoff	• A detailed study should be conducted to include historical flooding of areas along the alignment. • A detailed flood plain map should therefore be created for the pre and post construction scenarios for both the present and future conditions. • Given the observed climate change trends, it is recommended that the design runoffs for the future scenario be used to implement all drainage infrastructures
Noise	• Conduct annual noise assessment to determine if the traffic from the highway is having negative impact on the environment. • Where necessary noise mitigative structures should be put in place such as noise barriers, etc.
Traffic	• The design of the alignment should consider the preservation of vehicular access at current intersections and round-a-bouts.

	• In the designing of vehicular access points, speed and safety with respect to pedestrian crossings must be primarily considered while costs are considered secondary.
Emergency Response	• Alternate route or routes should be identified beforehand. • Adequate and clearly defined signs should be erected and public announcements will be made if there is a need to use the alternate route(s). • Arrange access points along the highway for emergency vehicles and personnel.

2.0 PROJECT DESCRIPTION

2.1 BACKGROUND AND OVERVIEW

The highway will begin in the Silkfield area of Moneague area and is to connect with the existing highway and parochial road networks via an enhanced interchange provision. The highway will then travel north northwest through this region, north of Phoenix Park and south of Retirement, through to Crescent Park Pen. The alignment then climbs north northeast through Golden Grove and turns again heading north northwest through Lydford, Steerfield and Annandale Farms. The alignment runs east of Ewart Town and through Malvern Park where it then heads north northwest through Davis Town and passes Chalky Hill on the west side. There is a sharp easterly turn where it passes south of Steer Town and east of the Roaring River community where it terminates at the main in Mammee Bay, Ocho Rios (Figure 2-1).

The highway project is expected to be typical, with construction and engineering methods being utilised to develop and clear the rights-of-way, ensure substrate stability, involve the construction of drainage, bridges and overpasses, as well as manipulate the landscape to allow for grade separated interchanges and linkages with existing roadways. The principal construction materials expected to be employed are steel, concrete, asphalt and aggregates of various grades.

The Highway (Moneague to Ocho Rios) is intended to be a four lane controlled-access, tolled motorway with fully grade separated interchanges and intersections built according to modern international standards with a total distance of 20 km.

Highway 2000 is Jamaica's first toll highway and this primarily "Greenfield"; tolled, multi-lane motorway will connect the capital Kingston in the south-east of Jamaica with the tourism centres of Montego Bay in the north-west and Ocho Rios on the north-central coast, covering 230 km when completed.

The National Road Operating and Constructing Company Limited is desirous to continue to directly contribute to the Government's desire to accelerate development through the implementation of appropriate infrastructure.

In addition to the economic benefits expected from the North South Link, the vulnerability of existing routes to natural disasters makes the development of the North South link even more desirable, given the frequent and recent devastation of the roads in the gorge.

Figure 2-1 – Map showing proposed Moneague to Ocho Rios highway alignment

2.2 PROPOSED PROJECT

2.2.1 Alignment, Crossings and Toll Plaza

2.2.1.1 Alignment

The Moneague to Mammee Bay (Section 3) segment of Highway 2000 requires the construction of a two lane, dual carriageway roadway, with a design speed of 80 km/h.

Moneague to Lydford (km 49+200 to 58+000)

The alignment begins at the existing Moneague Roundabout, which will likely be converted to an interchange with the A1 Road. This may require some reconstruction of the Mt. Rosser Bypass to accommodate the interchange, and construction of a new underpass or overpass at the interchange.

From the interchange, the highway passes through mountainous terrain varying in elevation from elevation 350m to 450m, with gradients up to 6.5%. Underpasses (field connectors) will be required at km 49+700, km 51+700, km 52+500 and km 53+900 to maintain local access to both sides of the new highway.

A Toll Plaza is proposed in the vicinity of km 54 to km 55 along a tangent section of highway near the abandoned Reynolds Bauxite Mines site, along the east side of Golden Grove.

An interchange is proposed at the intersection with the local road at km 55+200 to provide access to Chalky Hill Road, the A1 Road (to Claremont and St. Ann's Bay), and the A3 Road (to Ocho Rios). These link roads may have to be upgraded to provide adequate serviceability. This interchange will also provide access to neighbouring communities in Golden Grove. Underpasses will be required at the interchange (km 55+200), and at km 56+000 and 57+200 to maintain local access.

Lydford to Davis Town (km 58+000 to 64+000)

The alignment generally passes through generally rolling topography through abandoned bauxite mined areas from km 58+000 to km 60+000, with an underpass or overpass proposed at km 59+800.

From km 60+000 to km 63+000 the alignment generally runs parallel to Chalky Hill Road through rolling terrain, with an underpass proposed at

60+700, an overpass at km 62+200, and an underpass at Chalky Hill Road at km 63+500.

The alignment passes through a proposed residential subdivision (Davis Town) from km 62+200 to km 62+800, and a forest reserve from km 62+800 to 63+400 before entering the existing Davis Town development at km 63+400 to km 64+000. The alignment through this area will be carefully positioned to minimize any impact to the community.

Davis Town to Mammee Bay (km 64+000 to 69+000)

The alignment passes along the west side of the existing housing developments on Chalky Hill Road from km 64+000 to 66+000 primarily through forested vegetation, crossing Harbridges Gully at km 65+400, where the highway starts a long decline to the North Coast Highway, from elevation of 320m to elevation 10m, with maximum gradient of 8%.

The alignment passes along the south side of Steer Town in an easterly direction from km 66+500 to km 67+000, and crosses under a local road at km 66+700, and under Chalky Hill Road at km 67+500.

The alignment curves towards the North Coast Highway at km 68+000 where it first crosses the Little River, with a second crossing at km 68+500. The alignment has been positioned to minimize impact to the Great House situated south of the alignment. Further refinement of the alignment may be required to avoid the river crossings, and to avoid any impact to the Great House.

The profile from km 68+200 to the proposed roundabout at km 69+200 is at the maximum gradient of 8%, in order to accommodate the steep topography. The property where the alignment intersects the North Coast Highway is zoned (by UDC) for future commercial development, there fore needing close coordination with UDC.

2.2.2 Crossings

Seventeen (17) crossings have been identified and will be facilitated by overpasses and underpasses. These crossings include rivers, local roads, and field connectors.

Additional crossings may be required for streams and rivers. In some instances, field connectors could be combined to reduce the number of crossings. This will be confirmed in the Outline Design.

Table 2-1 shows the types and locations of crossings and structures along Section 3.

Table 2-1 - Types and Locations of Crossings and Structures along Section 3

Chainage	Local Name	Overpass / Underpass	Bridge Type	Structure Type
49+200	Moneague Interchange at A1 Road	Overpass or Underpass	Local Road	
49+700	Access Road	Underpass	Field Connector	
51+700	Access Road	Underpass	Field Connector	
52+500	Access Road	Underpass	Field Connector	
53+900	Access Road	Underpass	Field Connector	
55+200	Interchange at Local Road with connection to A1 Road	Underpass	Local Road	
56+000	Local Road with connection to A3 Road	Underpass	Field Connector	
57+200	Access Road	Underpass	Field Connector	
59+800	Access Road	Overpass or Underpass	Field Connector	
60+700	Access Road	Underpass	Field Connector	
62+200	Access Road	Overpass	Field Connector	
63+500	Chalky Hill & Access Road	Overpass	Local Road	
65+400	Harbridges Gully	Underpass	River Bridge	
66+600	Access Road	Overpass	Field Connector	
67+500	Chalky Hill	Overpass	Local Road	
68+000	Little River	Underpass	River Bridge	
68+500	Little River	Underpass	River Bridge	
69+200	North Coast Highway (A3)	At-grade crossing	Roundabout	

2.2.3 Toll Plaza and Equipment

A Toll Plaza is proposed in the vicinity of km 54 to km 55 directly south of the proposed interchange, and along a tangent section of highway near the abandoned Reynolds Bauxite Mines site to the east of Golden Grove.

The gradient along this section may need to be adjusted to provide a flat area for the Toll Plaza, and to integrate the adjacent interchange. Tolling strategy may influence the interchange design, for toll collection (ie toll plazas on the interchange ramps).

2.3 PHASING AND TIME TABLE

The project is scheduled to be concluded within 36 months after the commencement certificate has been issued. The project will be divided into phases that will be defined by the construction requirements.

2.4 CONSTRUCTION CAMP/SITE YARD

The location of the construction camp/site yard has not yet been determined. It is anticipated, however, that the camp will be approximately 200m x 200m and will take into consideration storm water and surface water drainage requirements, location of interceptors, as well as wastewater and sewage requirements. All necessary approvals for the construction camp/site yard will be obtained prior to establishment of the site. The construction works will be implemented by the Contractor.

Although the exact location of the site construction camp has not been identified, the previous experience of the Highway 2000 project should be taken into account, with regards to good housekeeping habits, conformance to permitting requirements, and adherence to audit procedures.

2.5 CUT AND FILL

All fill materials will be obtained mainly from the cut and transported by trucks to the designated fill areas.

Quarries will be identified based on the following criteria:

4) Proximity to project
5) Type of material required
6) Nature of approval from authorities

If the project requires the establishment of a quarry, the necessary licenses/approvals will be sought.

2.5.1 Transportation Requirements

All motorized vehicles within the site, excluding those on public roads, shall be restricted to maximum speed of 20 km per hour (in site yard) and 50 km per hour (on the alignment). Speed limit signs will be erected as appropriate. Haulage and delivery vehicles will be confined to designated roadways inside the site. The production team will ensure that vehicles transporting earth materials and fines are fitted with side and tailboards. Materials transported by vehicles shall be covered, with the cover properly secured and extended over the edges of the side and tailboards. Dusty materials will be dampened before transportation.

2.6 PAVEMENT STRUCTURE DESIGN

2.6.1 Newly Built Part

- Surface course: Upper surface course AC-16C 4cm
- Middle surface course AC-20C 6cm
- Lower surface course AC-25C 7cm
- Base course: Graded broken stone 15cm
- Subbase course: Caulking crushed stone 48cm

2.6.2 Reconstructed & Expanded Part

- For the original pavement part:
- Surface course: Upper surface course AC-16C 4cm
- Middle surface course AC-20C 6cm
- Lower surface course AC-25C 7cm
- Base course: Graded broken stone 15cm
- Subbase course: Caulking crushed stone l3cm

An asphalt primer and a slurry seal are established on the top surface of the base course, and an asphalt carpet is established between asphalt concrete surface courses.

2.6.3 Toll Plaza Pavement

There are concentrated vehicles and frequent parking and startup in a toll plaza section, and asphalt concrete pavement easily results in tracking and other pavement damages; therefore, reinforced concrete pavement is used in the design.

Toll plaza pavement structure:

- 26 cm reinforced concrete slab
- 15 cm graded broken stone
- 48 cm caulking crushed stone

2.6.4 Bridge Deck Paving

The bridge deck paving structure:

- 4 cm AC-16C (medium grained asphalt concrete)
- 6 cm AC-20C (medium grained asphalt concrete)

Interchange Ramps:

- 4cm AC-16C (medium grained asphalt concrete)
- 6cm AC-20C (medium grained asphalt concrete)
- 15 cm graded broken stone
- 48 cm caulking crushed stone

2.6.5 Auxiliary Road

- 5cm AC-16C (medium grained asphalt concrete)
- 15 cm graded broken stone
- 48 cm caulking crushed stone

2.7 BRIDGES & CULVERTS

2.7.1 Design Specifications

The BSI B.S.5400 specification is used in the design.

Combination of loads and load effect are in accordance with the relevant regulations of B.S.5400: Part 2 and the Manual for Design of Highways and Bridges (DMRB) 1.3.14: Standard BD37/1.

For instance, the used vehicle loads: B.S.5400: Part 2, HA loads (including horizontal distribution force and the concentrated force of the weight of a wheel axle) and B.S.5400: Part2, HB loads of37.5 units.

2.7.2 Design Standards

1) Design reference period: 75 years;
2) Seismic dynamic peak acceleration: 0.3 m/s^2;
3) Designed flood frequency: 1/100.

2.8 OUTLINE OF CONSTRUCTION METHOD

It is anticipated that the entire construction period for the highway will last 36 months. The steps are broken down as per below.

Road bed construction work will take 18 months to complete and will follow the procedures outlined in Figure 2-2 below.

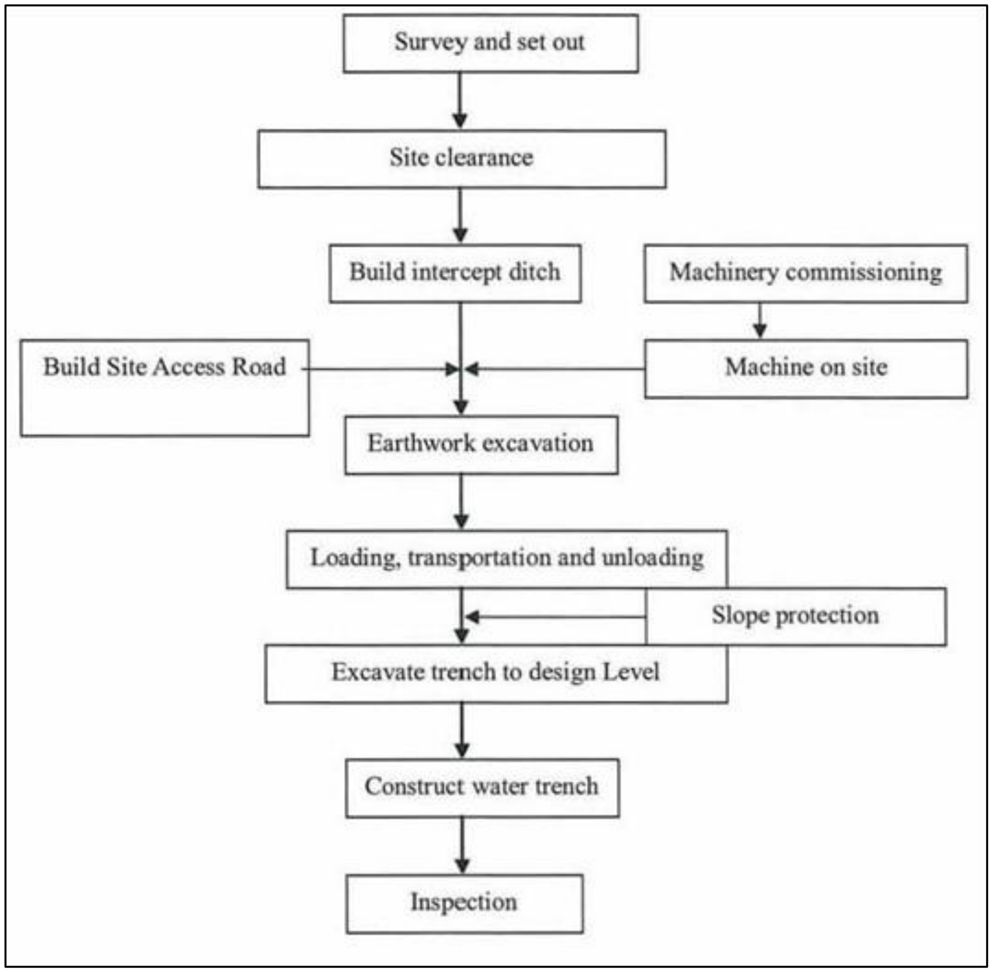

Figure 2-2 - Roadbed construction procedure (source CHEC)

2.8.1 Construction Process of Excavation

2.8.1.1 Earthwork Excavation (Soft Material):

Excavation shall be done in layers from the top downwards (Figure 2-3).

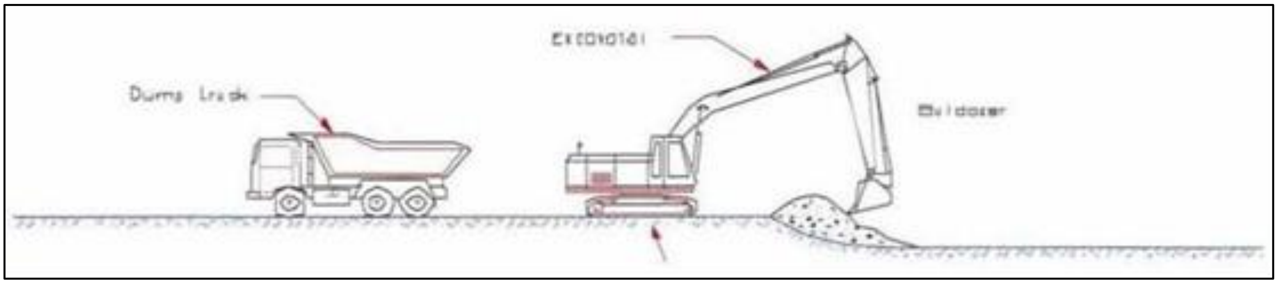

Figure 2-3 - Earthwork excavation (source CHEC)

2.8.1.2 Earthwork Excavation (Hard Material):

Bulldozers and excavators with hydraulic breaker will be deployed to remove the rock.

2.8.2 Roadbed filling

The flow chart below outlines the procedures that will be employed to do roadbed filling (Figure 2-4).

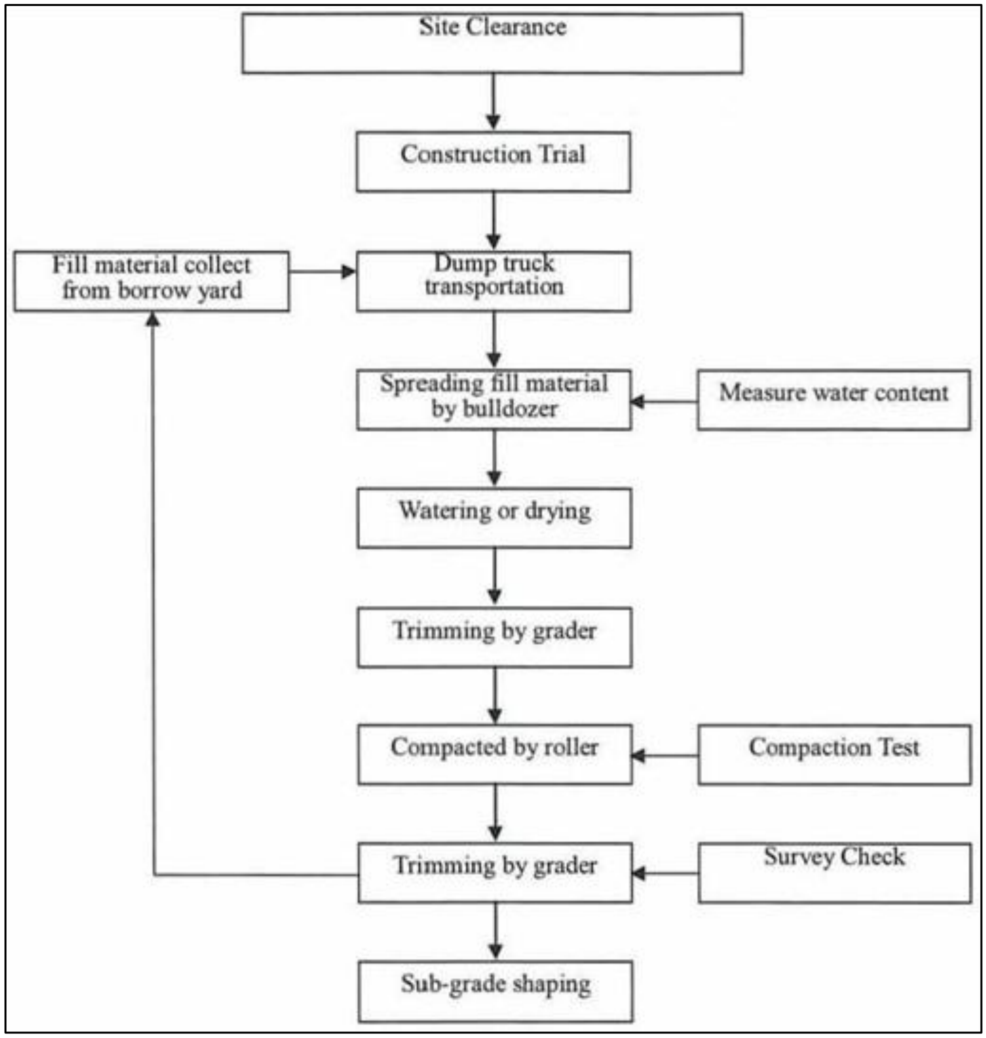

Figure 2-4 - Construction procedure for roadbed filling (source CHEC)

The filling material will be transported to the construction site from the borrow area and dumped in the site, then spreaded by bulldozer and trimmed to control the design level. Then roller will be deployed to compact (Figure 2-5).

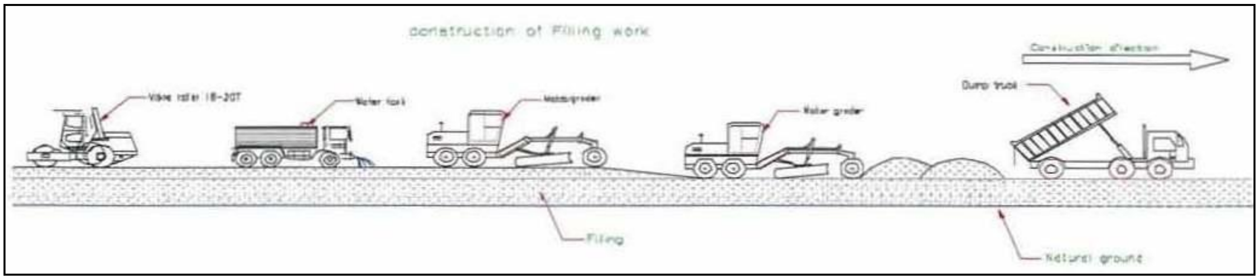

Figure 2-5 - The steps for transporting, spreading and compacting fill material (source CHEC)

Filling work will be started from bottom to top in layer by layer which is shown in the figure below. If uneven ground surface is found, filling and compaction will be applied on the existing ground, and then fill the layer according to requirements. For ensuring the strength and stabilization of road base edge, filling material will be conducted with 30cm overfill in both sides.

In case of filling by sections and at different time, the first section shall be filled by bench method with gradient 1: 1.

2.8.3 Drainage and Retaining Wall Construction

2.8.3.1 Concrete Ditch

Forming the bedding with crushed stone after excavation, concreting to designed level

2.8.3.2 Retaining Wall

The reinforced concrete retaining wall will be constructed by employing backhoe, steel-fixer, carpenter and concreter.

2.8.4 Pavement Construction

It will take approximately six months to finish the pavement. One set of 4000 asphalt batch mixer and three sets of paver will be deployed to execute the pavement works (Figure 2-6).

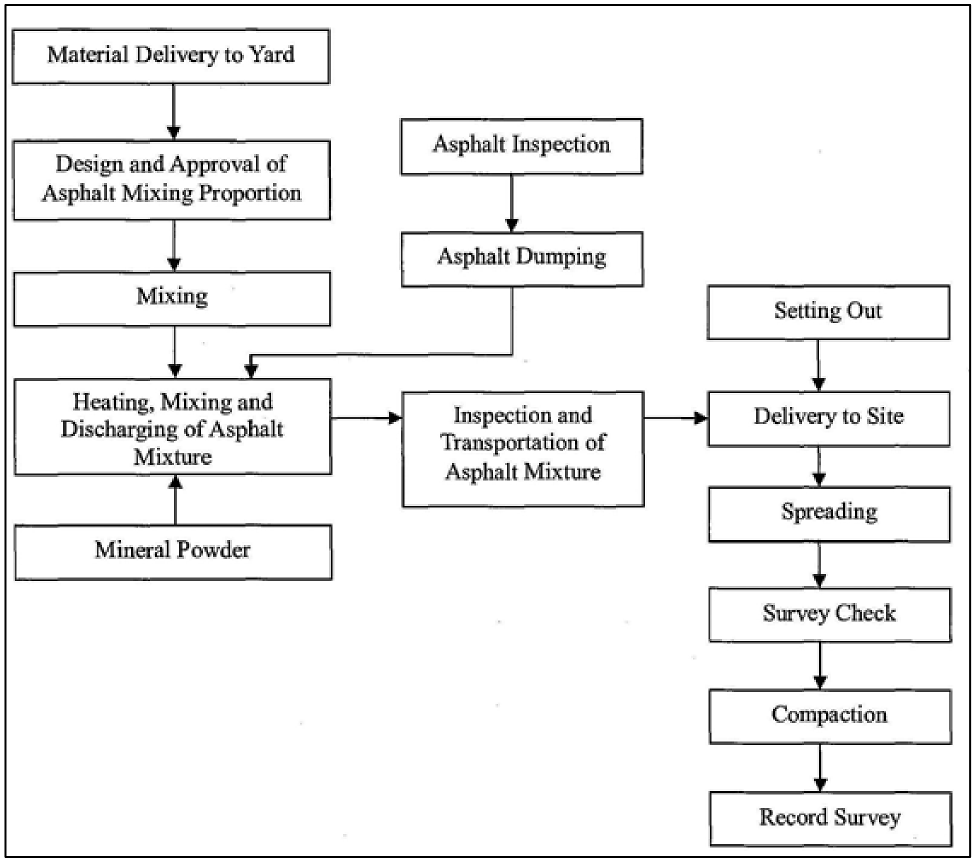

Figure 2-6 - Pavement Construction Schematic (source CHEC)

2.8.4.1 Sub-base and Base Course Work

The thicknesses of base course and sub-base course are 15cm and 48cm respectively. The graded material will be graded by bulldozer, levelled and spread by a spreader and then compacted to required degree of compaction.

2.8.4.2 Prime Coat and Tack Coat Construction

Provide a layer of prime coat or slurry seal on base course and place a layer of tack coat between surface courses (Plate 2-1).

Plate 2-1 - Asphalt Pavement Construction (Spraying) (source CHEC)

2.8.4.3 Asphalt Concrete Pavement

Asphalt concrete shall be transported by dump truck. In order to ensure consecutive spreading work, the dumping truck on site shall not be less than three during laying asphalt concrete (Plate 2-2).

Plate 2-2 - Transportation of Asphalt Concrete (source CHEC)

The asphalt concrete will be spread by three ABG-type Pavers equipped with auto-adjusting thickness devices and auto-levelling device and initially-compacting device. The Paver will be adjusted to the best working condition to ensure the paving surface is even so as to reduce or to eliminate segregation. The elevation control method guided by steel wire shall be applied to spreading. The spreading speed will keep up with the step of material supply and compactors to ensure the consecutive and even spreading without interruption as much as possible (Plate 2-3).

Plate 2-3 -Asphalt Concrete Spreading (source CHEC)

Compaction of asphalt concrete

Asphalt concrete shall be immediately compacted after spreading. The concrete shall be compacted by 10t dual-drum vibration roller immediately after the paving (Plate 2-4).

Plate 2-4 - Spreading and Compacting Asphalt Mixture (source CHEC)

2.8.5 Bridge Construction

Bridge construction will be constructed concurrently with road construction and will take approximately 15 months to complete.

a) Total station method will be applied to surveying.
b) Spread foundation construction

Foundation will be excavated by excavator with the assistance of manpower. After the excavation is finished, the concreting work will be carried out. Five centimetre (5cm) thick concrete blinding will be poured before fixing reinforcements steel. When steel reinforcements transported to the site and fixed, embed pier and abutment and connect with reinforcements.

2.8.5.1 Construction of Pier and U-shaped Abutment

Rough surface will be formed as the construction joints for the pier and abutment. Prefabricated hollow concrete slab/beam and pre-stressed concrete T beam will be adopted for bridge. Prestressed ducts of T beam are formed by using corrugated pipe. Concrete will be transported to site by concrete truck and poker vibrator will be applied to compact the concrete.

2.8.5.2 Post-tensioning of Pre-stressed Concrete T Beam

The tensioning equipment will meet relevant working requirements. Equipment will be frequently checked to ensure the proper operation. Steel strands will be cut in accordance with design drawing. The pre-stressed steel stainless strands shall not be damaged and have no rust. Strands passing through the beam will be carried out by winch with the assistance of manpower.

When the concrete beam achieves the design strength, positive bending moment strands shall be tensioned at both ends in symmetrical way. During tensioning, records will be properly kept and after tensioning, temporary protection treatment will be applied to anchor devices.

2.8.5.3 Jacking to Position

When pre-stressed completed, an Employer's Representative will check the tensioning records. Once approved by Employer's Representative, the surplus tendon can be cut and be ready for jacking. Jacking to position shall be carried out within 14 days. After jacking into position, cement mortar shall be applied to grout to seal the holes.

2.8.5.4 Precast Beam Storage

When the specified strength is achieved, the T beam can be transported to the storage area.

2.8.5.5 Beam Installation

Erect supporting frame between two abutments, then place longitudinal sliding track and put girder on track. A winch is set at the other abutment end to pull the beam onto the support frame. The beam is installed on the abutment by using jack to place the first beam on the edge. Similarly, repeat to place the remaining beams.

Set the transverse sliding track on erected two pieces of beam, then pull the next beam onto erected two beams in longitudinal direction and move it in a transverse direction adjacent to the second beam and finally place it on the abutment by using a jack. In similar way, the rest of beam shall be placed on abutment one by one.

2.8.6 Culvert Construction

The construction procedure is set below (Figure 2-7).

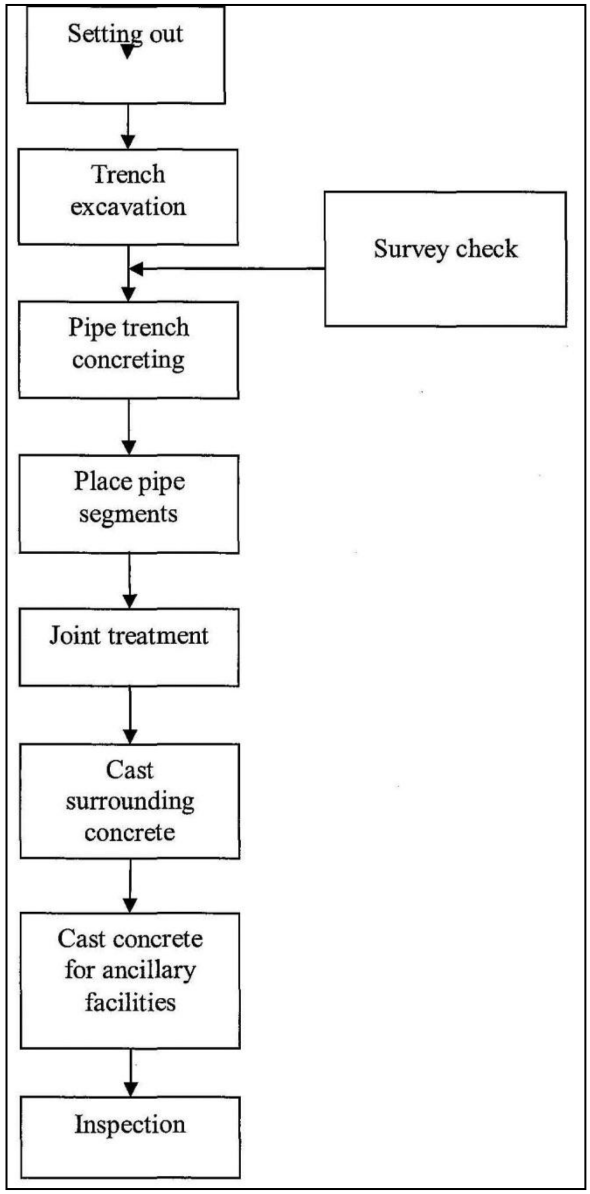

Figure 2-7 - Culvert Construction Procedure (source CHEC)

2.8.6.1 Foundation and Abutment

The foundation will be excavated by an excavator. During the casting of the abutment, observation of the form will be done in case there is any transformation.

2.8.6.2 Concrete Slab

Concrete slabs will be prefabricated on site, and then transported to the position. The strength of prefabricated slab must achieve 90% design strength before being hoisted.

2.8.7 Traffic Signs

Traffic signs in this project include milestones, guide signage and warning sign etc. These signs shall be purchased in Jamaica and erected by mobile crane.

3.0 LEGAL & REGULATORY CONSIDERATIONS

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.

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

- 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 relevant national legislation, regulations/standards, and policies thought to be relevant to the proposed Highway 2000 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 LEGISLATIVE FRAMEWORK

3.2.1 Development Control

3.2.1.1 National Legislation

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.

The Main Roads Act (1932)

The Main Roads Act of 1932 details the legal basis pertaining to main roads and specifically look s at management, laying out of roads, taking of lands, encroachments, offences, lights and carriages, power to arrest and other legalities. In section 5 of this Act, it states that the Minister has the power to declare other roads or parts thereof to be main roads and to also declare that a main road is no longer such. The Chief Technical Director (with permanent staff), under the directive of the Minister, is responsible for the laying out, making, repairing, widening, altering, deviating, maintaining, superintending and managing main roads, and controlling the expenditure of allotted moneys.

The Toll Roads Act (2002)

The designation of toll roads, the Toll Authority establishment, the specification of toll orders, concession agreements and failures and penalties are covered in the Toll Roads Act of 2002. For the purposes of the Act, a body called the Toll Authority is established and is responsible for:

- Regulation of the operation and maintenance of toll roads and such other facilities as may be deemed necessary on or adjacent to toll roads;
- Monitoring compliance of concessionaires with the terms and conditions of concession agreements;
- Advising the Minister on matters of general policy relating to the design, construction, safety, regulation, operation and maintenance of toll roads in Jamaica; and
- Performing such other functions as may be assigned to it by the Minister or by or under this Act or any other enactment.

As stipulated in section 8, the Minister may, by order:

a) subject to subsection (2), designate any road as a toll road for the purposes of this Act;

b) authorize any person, in return for undertaking such obligations as may be specified in an agreement with respect to the design, construction, maintenance, operation, improvement or financing of a toll road, to enjoy the rights conferred in the order, including the right to levy, collect and retain toll in respect of the use of the toll road; and

c) specify the terms and conditions under which a person referred to in paragraph (b) may assign or delegate to any other person, any of the rights or obligations specified in the agreement referred to in that paragraph.

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).

3.2.2 Environmental Conservation

3.2.2.1 National Legislation

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.

3.2.2.2 International Legislative and Regulatory Considerations

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.

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.

3.2.3 Public Health & Waste Management

3.2.3.1 National Legislation

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.

3.3 EIA PROCESS

3.3.1 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.

3.3.2 NRCA/NEPA Process

Under Section 9 of the NRCA Act, all activities associated with the construction of new highways, arterial roads and major road improvement projects will require a Permit for construction and may, under Section 10 of the Act, require an EIA. 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 NROCC that an EIA would be required for their development. NROCC then liaises with the NRCA to determine the scope of the EIA through proposed Terms of Reference (TORs). The TORs are proposed by NROCC using NRCA guidelines and are approved by the NRCA. (Appendix 1) gives the approved TORs for the proposed highway development.

- The EIA is then prepared by a multi-disciplinary team of professionals (Appendix 2) for the team used in this assessment). 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.

3.3.3 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 DESCRIPTION OF THE ENVIRONMENT

4.1 PHYSICAL ENVIRONMENT

4.1.1 Climatology and Meteorology

4.1.1.1 Meteorological Stations within Study Area

Methodology

Temperature, relative humidity, wind speed and direction, rainfall and barometric pressure were recorded at each of three (3) locations where noise monitoring was conducted over the seventy two (72) hours (Friday July 13th – Monday July 16th, 2012) by using a Davis Instruments wireless Vantage Pro2 weather system with a data logger and a complete system shelter erected on a tripod. Data were collected every ten minutes and stored on the data logger. This information was downloaded using the WeatherLink 5.9.2 software.

Plate 4-1 – Weather station deployed at Station N1

Table 4-1 – Locations of weather stations in JAD2001

Location	JAD 2001	
	Northing (m)	**Easting (m)**
Moneague	736932.59	681452.03
Lydford	733534.16	688139.28
Roaring River Community	733567.14	696178.26

Results

Moneague

Average temperature over the noise assessment was 24.4 ^{o}C and ranged from a low of 18.2 ^{o}C to a high of 30.9 ^{o}C.

Average relative humidity was 86.47% and ranged from a low of 54% to a high of 98%.

Average wind speed was 0.5 m/s and ranged from a low of 0 m/s to a high of 8 m/s.

Dominant wind direction was from the northeast.

Measurable precipitation during the noise assessment was 4.1 mm. Barometric pressure ranged from a low of 1011.6 millibar to 1017.9 millibar over the noise assessment.

Lydford

Average temperature over the noise assessment was 24.2 ^{o}C and ranged from a low of 17.8 ^{o}C to a high of 31.7 ^{o}C.

Average relative humidity was 89% and ranged from a low of 64% to a high of 99%.

Average wind speed was 0.4 m/s and ranged from a low of 0 m/s to a high of 7.2 m/s.

Dominant wind direction was from the east southeast.

Measurable precipitation during the noise assessment was 7.4 mm. Barometric pressure ranged from a low of 970.7 millibar to 975.6 millibar over the noise assessment.

Roaring River Community

Average temperature over the noise assessment was 27.6 ^{o}C and ranged from a low of 23.9 ^{o}C to a high of 32.3 ^{o}C.

Average relative humidity was 79.8% and ranged from a low of 63% to a high of 93%.

Average wind speed was 1.1 m/s and ranged from a low of 0 m/s to a high of 9.4 m/s.

Dominant wind direction was from the east southeast.

Measurable precipitation during the noise assessment was 7.9 mm. Barometric pressure ranged from a low of 1008.3 millibar to 1013 millibar over the noise assessment.

4.1.1.2 Meteorological Office of Jamaica Data

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.

4.1.1.3 Rainfall Data

The rain gauge locations were superimposed on the catchment areas to determine rainfall depths that will be used in the hydrology model. See Figure 4-2 and Figure 4-2. A total of 3 gauges were noted inside of and within 10 km of the overall catchment boundaries. The revised rainfall intensities for these stations were increased by 0.7 percent per decade to the 75 year project life to ensure a valid design at the project life. See Table 4-2 below for the current intensities as well as the recommended design values.

Table 4-2 Displaying the rainfall intensities recorded by associated gauges

Station Name	CURRENT RAINFALL DEPTHS (mm/24 hr)				RECOMMENDED DESIGN RAINFALL DEPTHS (mm/24 hr)			
	10	25	50	100	10	25	50	100
BROMLEY	179.6	201.4	216.5	0.0	179.6	201.4	216.5	0.0
COLE GATE	184.5	223.3	252.4	281.2	184.5	223.3	252.4	281.2
MAMEE RIDGE FARM	246.5	294.7	331.2	367.7	246.5	294.7	331.2	367.7

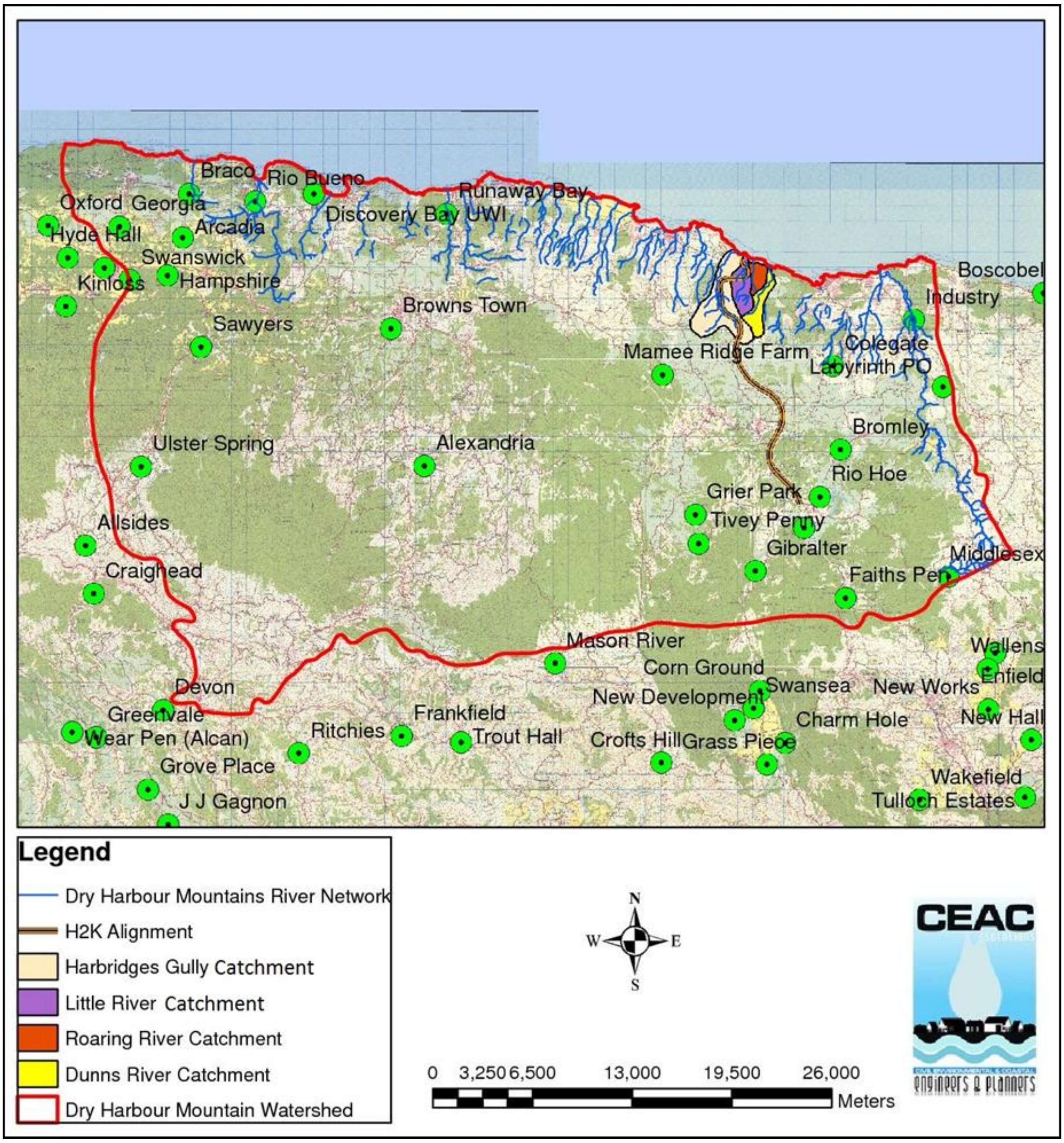

Figure 4-1 Map showing H2K alignment with the associated watersheds and rainfall gauges.

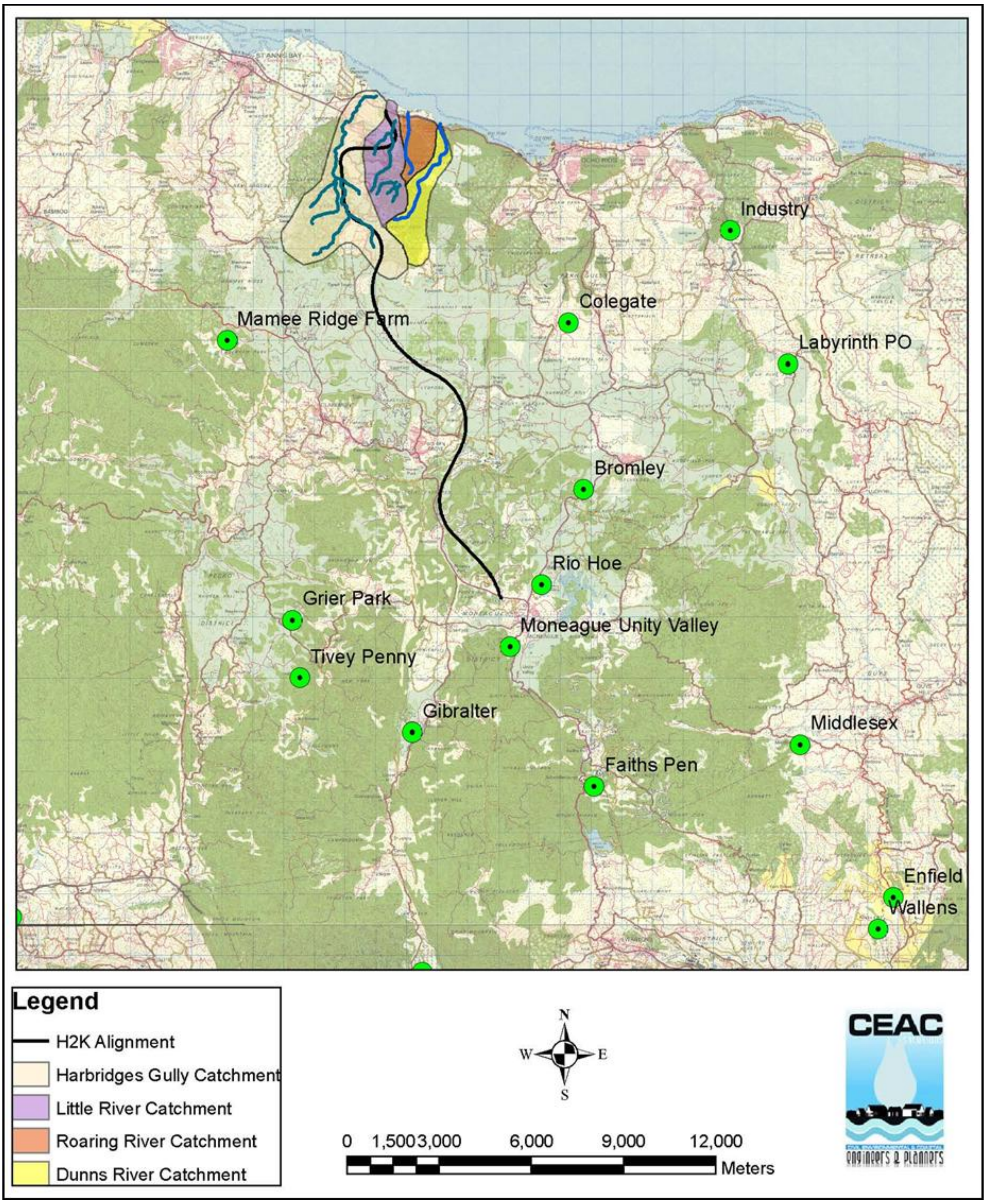

Figure 4-2 Map showing H2K alignment in relation to rainfall gauges and associated watersheds.

4.1.1.4 Climate Change

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 Primack, 2006 and Figure 4-3 below:

Table 4-3 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 4-3 Overall increase in 24-hours rainfall intensity for the period between 1988 and 2009

Given the design life of the project is 75 years, due consideration should be given to the changes in extreme rainfall as the old data appears to be irrelevant in light of the new data supplied by the Meteorological Office of Jamaica.

4.1.2 Soils and Geology

4.1.2.1 Methodology

For this study, geological mapping was undertaken along roads and footpaths in the area with the main emphasis being placed on the area where the proposed road will traverse the descent from the Moneague plateau down to the north coast at Mammee Bay. Representative samples of all the lithological units encountered were collected and remain on file. Differentiation of lithologies within the White Limestone group require fresh surfaces broken off using a rock hammer for texture and fossil content, as external weathering of limestones generally obscures the lithology. Descriptions were made using the Dunham (1962) classification.

Analysis of physical features over the limestone part of the proposed road traverse was carried out using the 1:12,500 scale topographic maps as the main basis. Spot samples were collected along traverses parallel and intersecting the proposed foot print of the high way – proposed route of the high way Moneague to Mammee Bay

4.1.2.2 Main Physical Features

The physical features along the proposed highway alignment are conveniently divided into two sections.

Section 1. Between Moneague (Silkfield) and Malvern Park the proposed route traverses the uplands of the Moneague and Claremont region of St. Ann parish. The topography consists of the middle Tertiary rocks of the White Limestone Group exhibiting a relatively subdued karst, dominated by gentle rises and numerous small, frequently broad depressions (sinkholes and uvalas) (Figure 4-4). These tend to be concentrated along the traces of faults in the area (UNDP/FAO, 1972). At Crescent Park and Golden Grove the proposed route skirts the western side of a broad depression, at the bottom of which Reynolds Jamaica Mines built their Lydford bauxite processing plant in the 1950s-60s. The depression is, about 3 km across, east to west, and over 60 m deep. About 3.2 km to the east of the highway at Silkfield occurs the western edge of the larger depression containing the Rio Ho and the ephemeral Moneague Lake, some 40 m deep and about 4 km across at its widest extent.

Hydrologically the region forms part of the Dry Harbour Mountains Hydrologic Basin, the geological Moneague Basin of authors.

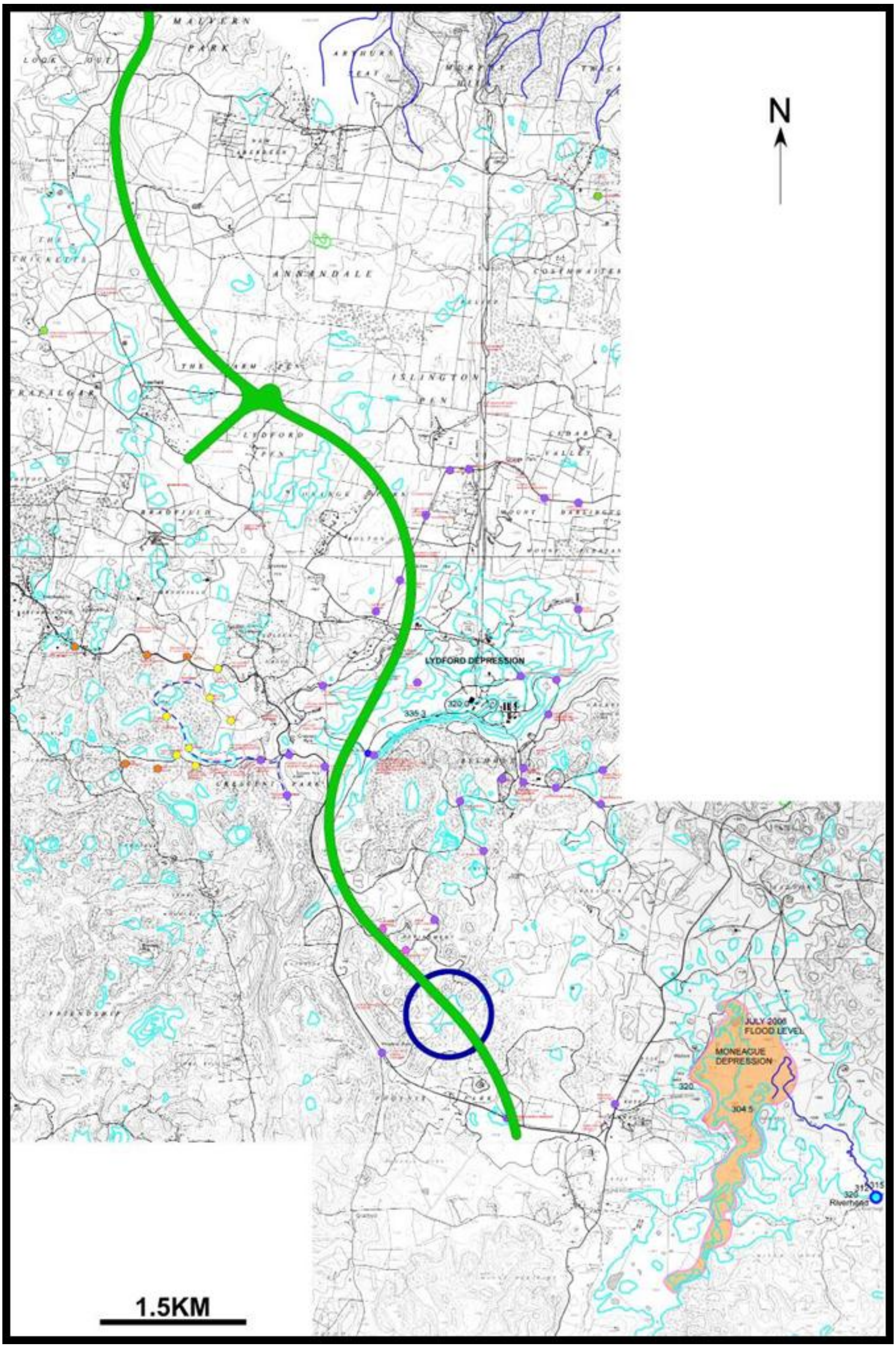

Figure 4-4 - Pale blue enclosures, depressions in the White Limestone. Dark blue lines, river and gully courses. Dark blue circle on highway route, depression crossing. Red circles on highway route, gully crossings. Red print, spot palaeontological data. Coloured circles, spot stratigraphic determinations based on palaeontology: blue, Swanswick limestone;orange, Claremont limestone; yellow, Somerset limestone; pink, possible Walderston limestone; purple, Browns Town/Moneague limestone. Other features are labeled on the figure.

Plate 4-2 - Pond identified on old Bauxite lands (terra rossa evident) within the Walderston limestone unit (N 18°17.768 W 77°07.953).

Section 2. Between Malvern Park and the north coast of the island at Mammee Bay, the topography slopes steeply down from the Moneague uplands to the sea. The chalky limestones of the Montpelier Formation and marls and clayey limestones of the Coastal Group rocks form a low-permeability barrier, ponding the groundwater of the Moneague Basin to the south from free flow to the ocean. The groundwater of the Basin exits through numerous springs to flow over the surface of the Montpelier chalks, feeding the short, steep-gradient rivers discharging to the north coast.

The line of the proposed highway lies above the main depressions, and above the level of the Moneague Lake, which very rarely reaches an elevation of about 315 m after prolonged periods of rain. The bottom of the Lydford depression is at a higher elevation (about 320 m at its lowest point) and has not been known to suffer flooding events. No collapse features are known to have been reported from the Moneague uplands.

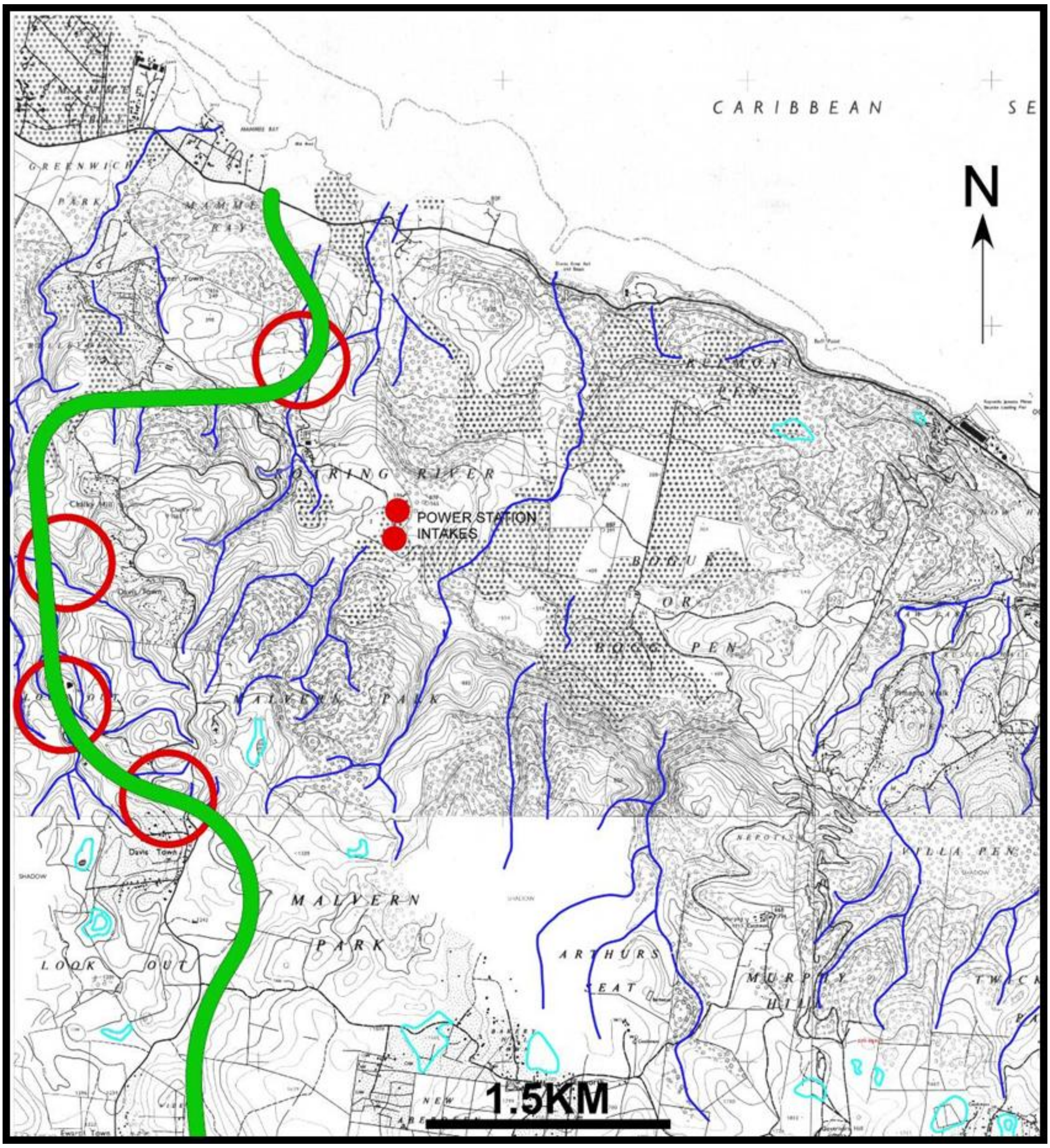

Figure 4-5 - Proposed route of the north-south highway down the north slope of the island, (section 2).

4.1.2.3 Geology

Geological investigations undertaken including spot sampling of the Moneague plateau limestones allowed identification of five traditional units of the White Limestone (Versey in Zans et al. 1963; Robinson & Mitchell, 1999) and debris fans of the Coastal Group in the focus area-Moneague to Roaring River (Figure 4-6).

The geological succession includes the following main units from youngest to oldest:

- Coastal Group
- Limestones of the White Limestone Group. These include the Troy/Claremont, Somerset, Swanswick, Walderston and Montpelier formations of the published literature.

The southern section of the focus area is dominated by the limestone plateau which shows typical karst topography with dry valleys and numerous sink holes. It is composed mainly of hard limestones, resistant to physical weathering, with less resistant chalky (Montpelier) and gravel (Coastal Group) units to the north (Barker 1968).

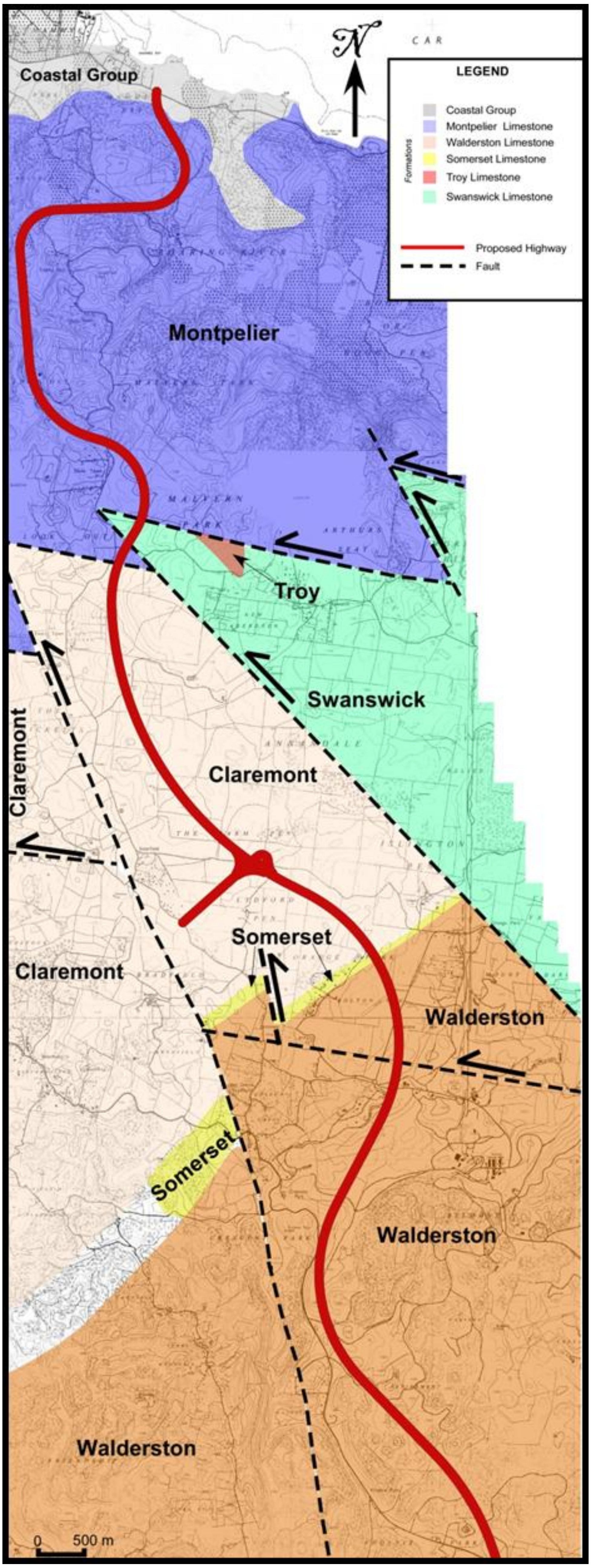

Figure 4-6 - Geological map of the Phase 3 proposed route for the north-south highway.

The geological structure is dominated by strike-slip faulting of otherwise gently Northward dipping units of the White Limestone. Other minor faults within the limestone plateau traverse the proposed highway route at several points.

The area is dissected by multiple set of strike-slip faults the northern margin of the plateau (Figure 4-7).

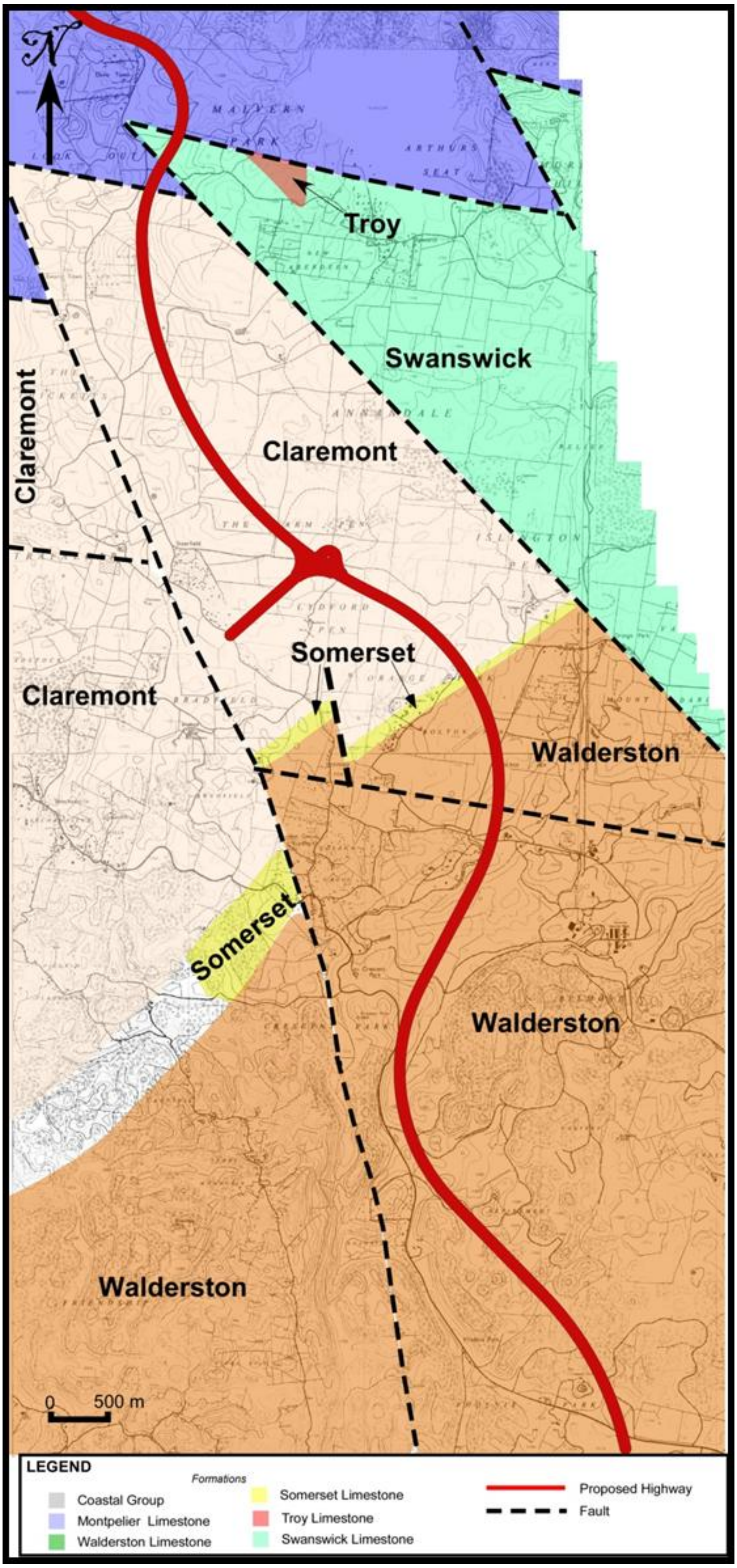

Figure 4-7 - Geology of Section 1 (Enlargement of the southern part of Figure 4-3).

Figure 4-8 shows Section 2 - Between Malvern Park and the north coast of the island at Mammee Bay.

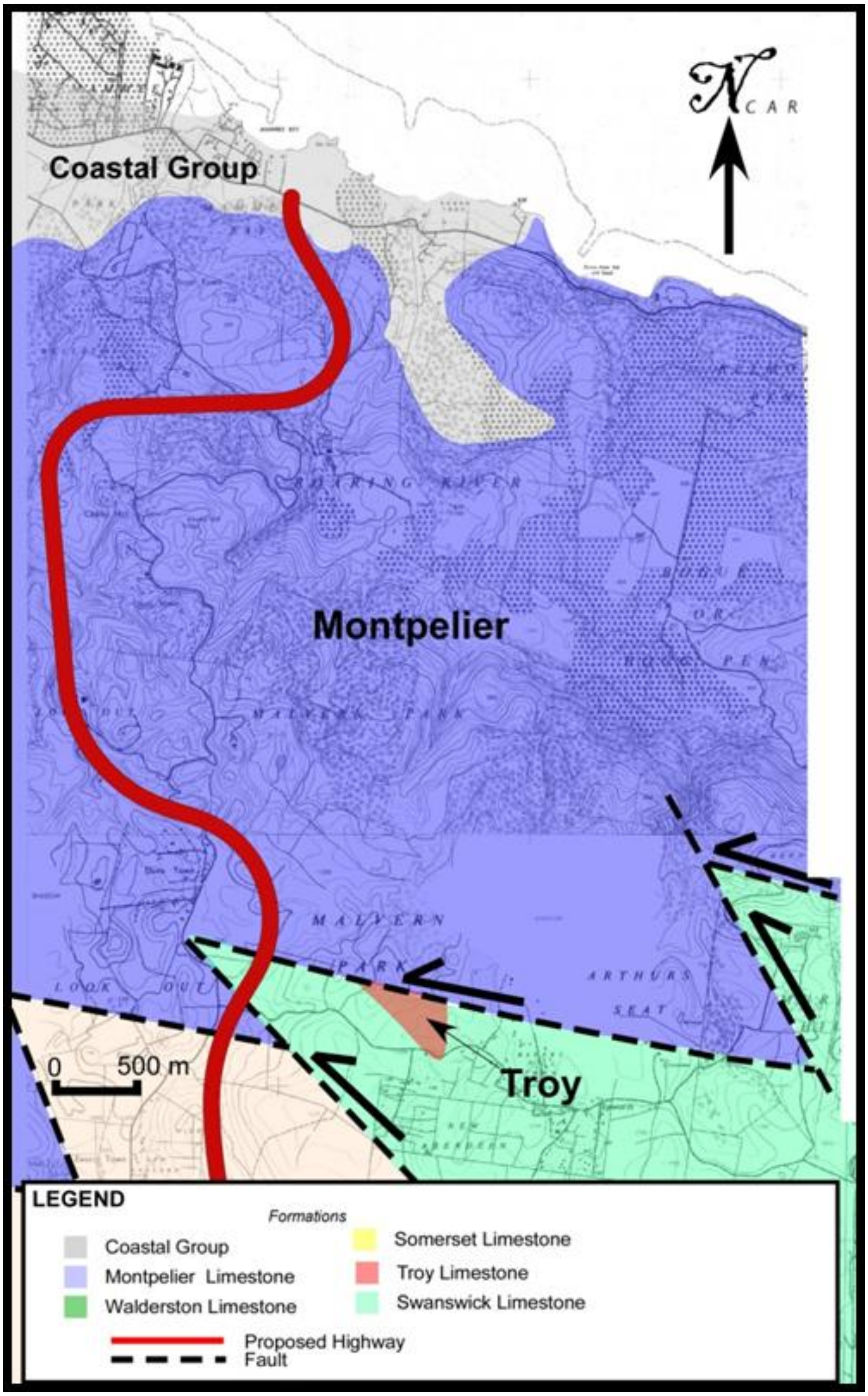

Figure 4-8 – Geology of Section 2

Stratigraphy

The following stratigraphic units were recognized (oldest first).

Swanswick Formation
This name was used by Hose and Versey (1957) for a succession of foraminiferal packstones and grainstones in the hills south of Swanswick in the parish of Trelawny and has been further defined by Mitchell (2004). It consists of dominantly pale (white) grainstones with subsidiary packstones, locally coloured (pink or brown). Bioclasts include abundant foraminifers as well as peloids, molluscan fragments and echinoderm fragments. The bioclasts are well sorted suggesting high-energy deposits. Most samples taken from the Swanswick Formation have a calcite spar cement, but some levels have a micrite matrix; wackestones and packstones are very unusual. The base of the formation is defined at the appearance of extensive grainstones; in general the Swanswick Formation seems to resist dolomitization. It is probably a lateral equivalent of rocks elsewhere described as Claremont or Troy limestones.

Tory/ Claremont Formation – The traditionally described Troy and Claremont formations have often been combined. The Troy formation is a hard compact unit which in hand specimen appears to be crème to pale pink in colour with a sugar texture; it is typically heavily jointed and often shows brecciation. In the study area Troy limestone has been identified only in a small area at Malvern Park east of the proposed highway line. The limestones of the Claremont Formation are typically well bedded micrites and calcarenites in contrast to the Troy Formation limestones which are typically thick beds of poorly to unfossiliferous recrystalized micrites and dolostones. The mineralogy of this unit in the study area varies from limestones to dolostones. Thin packstones and grainstones have also been identified, but form a minor part of this formation (Mitchell 2004). Industrial uses of these limestones include possible uses as aggregate, road metal, dimension stone and rip rap (Fenton, 1981).

Somerset Formation- This formation consists of pale pink and/or grey coloured packstones/grainstones (Mitchell, 2004). Within the study area this unit is a highly fossiliferous packstone with corals, foraminifera and molluscs. Karstic drainage patterns are usually well developed in this unit. Proposed uses of this limestone include: aggregate, road metal, dimension stone, rip rap (Fenton, 1981).

Walderston/Browns Town Formation - The Walderston facies which dominates the southern section of the focus area (Plate 4-3) has been described as a buff-white, compact, partly crystallized, micrograined limestone with a high proportion of microspar. It is composed chiefly of milliolid skeletons small peneroplids (Govt. of Jamaica Survey Dept, 1978). The limestones of this formation have been described as "soft" (Fenton, 1981). These limestones range from non-chalky, soft rubbly units to fossiliferous bands of hard micrite that may be partially recrystallized. Crème and pink packstones and grainstones were commonly identified in the study area however the formation can also appear rubbly in areas typically associated with faults (e.g. Plate 4-3). Karstic development is typically less advanced compared to Troy and Claremont limestones. Sinks, depressions and underground drainage systems exist but are usually fault controlled (O'Hara and Bryce, 1983). Industrial uses of this limestone include road metal, land fill, fillers (whitening) (Fenton, 1981).

Plate 4-3 - Rubbly exposure of Walderston formation

Montpelier Formation- This unit consists of deep water carbonates comprising coccolith and planktic foraminiferal limestones and chalks (Hose & Versey, 1957; Mitchell 2004). There are several horizons where chert layers are common, but in the stratigraphically higher parts chert is lacking. Occasional beds of marl or crystalline larger foraminiferal limestone occur interbedded with chalk or micrite. These are interpreted as submarine slide/flow deposits derived from shallow water settings.

The formation includes marly bands, many of which have been interpreted as volcanic ash beds. At various levels beds containing coarse-grained, frequently graded detritus (sand grade, but up to block size) are also present (Robinson, 1967; Mitchell 2004).

In the study area the Montpelier formation is restricted to the coastal strip, north of Malvern Park (Plate 4-4).

Plate 4-4 - Montpelier Formation exposed on the Steer Town area.

Coastal Group

Coastal Group rocks occur along the coastline between Ocho Rios and St Anns Bay, but in the study area, where the highway line joins the coast road, these are concealed by significant deposits of travertine (as at Dunns River) and by debris fans formed from the gully drainage to the coast. These deposits, of Quaternary age, are relatively unconsolidated in contrast to the underlying Montpelier formation.

Recent deposits of rubbly limestone deposited as outwash fans cover extensive areas. These fans typically consists of pebbles and small boulders flint and limestone that were brought down during heavy rains (floods) from stream beds that are normally dry

Alluvium- travertine has been noted in some stream beds such as Dunns River and Shaw Park Park and frequently obscures the material of the debris fans.

Structure

The middle Tertiary limestones forming the Moneague plateau are in the shape of a broad basin, such that the Eocene limestones (Claremont/Troy and Swanswick limestones) surround a broad outcrop of Oligocene Walderston and Browns Town limestones. They are separated relatively abruptly from the deeper water Montpelier formation, bordering the coast, by a fault zone that more or less parallels the straight north coastline. Numerous smaller faults intersect the limestones both on the plateau and along the coast.

4.1.2.4 Geotechnical properties and industrial uses

Table 1 outlines geotechnical properties described by the Geology Survey Division for the units of the White Limestone Group identified in the study area. The term permeability refers to the rate or speed at which water will flow through it in response to the head provided by a hydraulic gradient- it is the measure of the material's capacity for transmitting water. Two types of permeability are defined; primary permeability which is the intact rock units capacity to transmit water. Secondary permeability develops where fissures and discontinuities in such as joints and bedding planes transmit water. The units bearing capacity describes the ability of the ground to withstand loading without either sheer failure or excessive settlement (O'Hara & Bryce 1983). The term *Dimension stone* is natural stone that has been quarried for production of blocks, slabs or shapes that have required dimension (Fenton, 1987).

Table 4-4 - Geotechnical descriptions of the limestones in the study area adapted from O'Hara and Bryce (1983) and Fenton (1981)

Formation Names	*Permeability*	*Bearing capacity*	*Possible Uses*
Troy Limestone	Primary- Generally low Secondary- Very high	Dependent on clay content and stiffness of soils in depressions. Bearing capacity considered good where sound rock exists at or near the surface. Check for underground cavities for major structures: first 1-2m often "case hardened".	Aggregate, road metal, dimension stone, terrazzo tile chips and rip rap
Claremont Limestone	Primary- Generally low Secondary- Very high	Dependent on clay content and stiffness of soils in depressions. Bearing capacity considered good where sound rock exists at or near the surface. Check for underground cavities for major structures: first 1-2m often "case hardened".	Aggregate, road metal, dimension stone, terrazzo tile chips and rip rap

Formation Names	*Permeability*	*Bearing capacity*	*Possible Uses*
Somerset Limestone	Primary- Generally low Secondary- Very high	Dependent on clay content and stiffness of soils in depressions. Bearing capacity considered good where sound rock exists at or near the surface. Check for underground cavities for major structures: first 1-2m often "case hardened".	Aggregate, road metal, dimension stone, terrazzo tile chips and rip rap
Swanswick Limestone	Primary- Generally low Secondary- Very high	Dependent on clay content and stiffness of soils in depressions. Bearing capacity considered good where sound rock exists at or near the surface. Check for underground cavities for major structures: first 1-2m often "case hardened".	Aggregate, road metal, dimension stone, terrazzo tile chips and rip rap
Walderston Limestone	Primary- Generally low Secondary- May be very high	Dependent on clay content and stiffness of soils in depressions. Bearing capacity considered reasonably good where sound rock exists at or near the surface. Check for underground cavities for major structures.	Road metal. Landfill, fillers (whitening) and chemical uses.
Montpelier Limestone	Primary- Generally low Secondary- May be very high	Dependent on clay content and stiffness of soils in depressions. Bearing capacity considered reasonably good where sound rock exists at or near the surface. Check for underground cavities for major structures: up to 4000 KN/m^2	Landfill, road metal, good concrete aggregate from hard rock and as a raw material for cement

An overview of slope stability in the focus area is described as Generally Good within the harder units, which include the Swanswick, Troy, Claremont and Walderston Units, and Reasonable within the "soft" limestones of the Montpelier Formation. However, it should be noted that along fault scarps large and continuous falls should be anticipated.

4.1.2.5 Soils

Published soil and land use surveys (Barker, 1962; Vernon and Jones, 1958) identify 5 soil types in the study area and we follow their classification in the descriptions below:

Bonny Gate Stony Loam and **St. Ann Clay Loam** dominate on the limestones south of Annadale Pen across the Moneague Platform. The Bonny Gate Stony Loam is typically a thin brown or reddish soil on hard limestone, with bed rock usually at 1-12 inches (2-30 cm) and soil slopes between 20-35°. Surface drainage is identified as excessive and soil permeability is described as extremely rapid. These soils are usually thin on steep slopes and hill tops but may be of considerable thickness in sinks and depressions. Rapid changes in depth to underlying bed rock should be anticipated (O'Hara and Bryce, 1983). The St. Ann Clay is typically a red brown clay loam which also forms in thin layers over bedrock with negligible slopes developing. Surface drainage is good, internal drainage described as extremely rapid and soil permeability is described as very good to excessive.

Bonny Gate Stony Loam -This is a dominant cover over the Montpelier Formation and influences slope stability to the extent that it is dependent on the strength in depressions. They generally have high cohesions and low (5cm) near vertical cuts should be stable in stiff clays. Suitable provisions for drainage should be made to avoid washout faces. Suggestion- solid slopes should be designed 1:2 (26°) if no other data is available (O' Hara and Bryce, 1983)

Chudleigh Clay loam- has been identified in the Annandale area, in isolation and in intermingled with **Bonny Gate Stony Loam** described above**.** The Chudleigh clay loam is a compact sub soil- 20-38 cm thick with average slopes 2-10 deg. Internal drainage very rapid, with fair moisture retention.

Lucky Hill Clay Loam- Compact subsoil 20-38 cm thick with average slopes up to 10 Degrees. Moisture retention is fair with high internal drainage

Killancholly Clay – A 25- 30 cm thick clay with slopes of 10-30 deg. internal drainage is moderate to rapid, with high moisture retention.

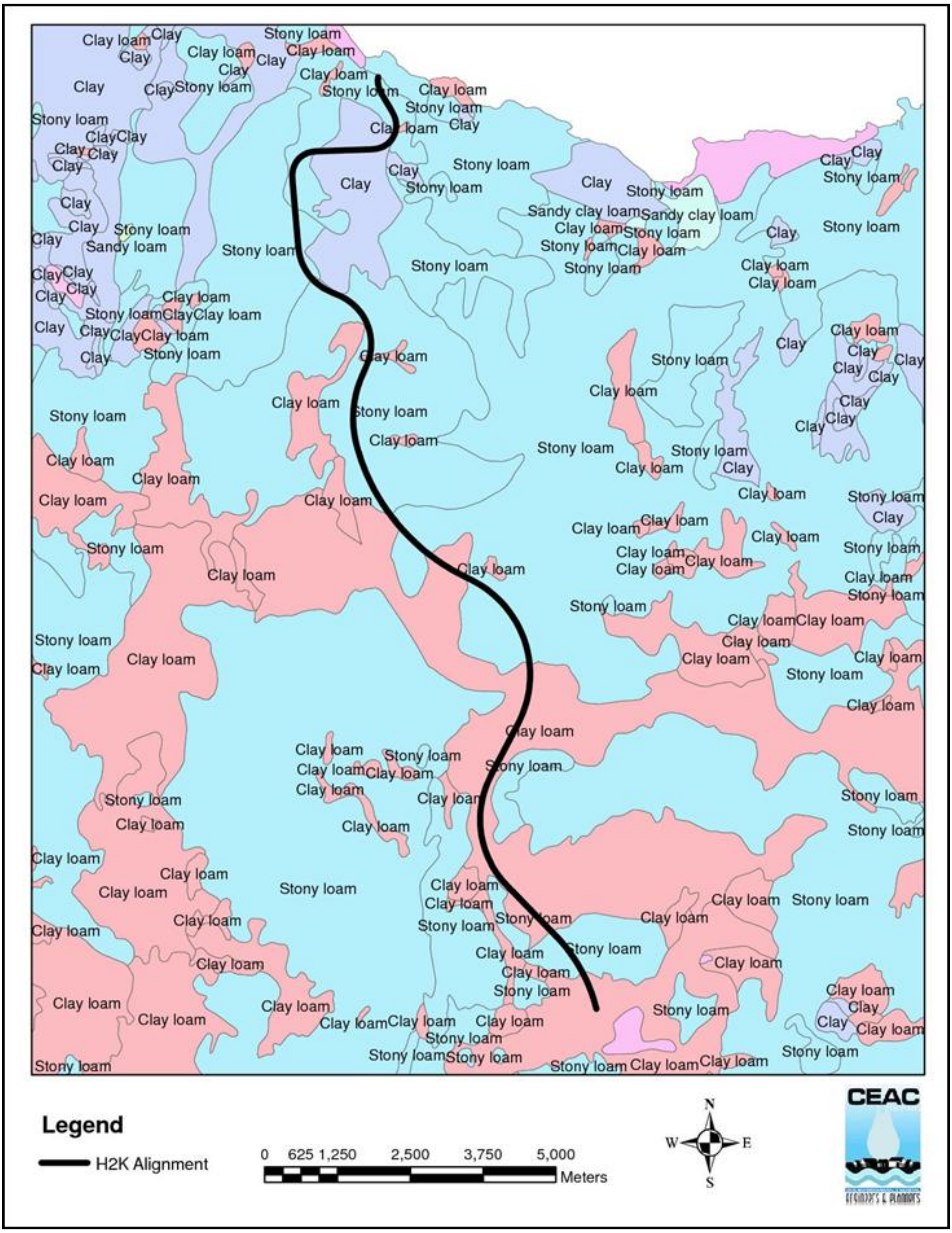

Figure 4-9 – Proposed highway alignment superimposed on soils map of Jamaica

4.1.2.6 Conclusion

- **Bedrock cut and fill** – most rocks along the route can be used in highway construction, except for the more marly parts of the Coastal Group at the northern end of the Section 2 (Between Malvern Park and Mammee Bay).

4.1.3 Topography

The topography of the project area comprises of both gently sloping areas, in the northern end of the alignment, and a mountainous section which the alignment traverses with sharp increases/decreases in elevations along chainage km50+300 to km62+450. The southern tip of the alignment is on relatively gentle sloping lands. The southern section of the alignment lies in the vicinity of Silkfields, east of the Phoenix Park area, at approximately 356 m above Mean Sea Level (MSL). As the highway progresses through the mountainous regions of Phoenix Park and Retirement, the elevations range from 400 m to 500 m while slopes vary between 1^{o} and 15^{o}. Here the highway traverses through a valley (chainage km52+650 to km56+000) east of Golden Grove where it continues in a north easterly direction trough the karst Limestone Mountains towards Lydford. The average elevations in this valley region are 380 m. The terrain climbs sharply from elevations of 400 m to 450 m on entering the Lydford, north of Golden Grove before increasing gently heading north of Steerfield. See Figure 4-10 below which shows the terrain over which the highway alignment passes.

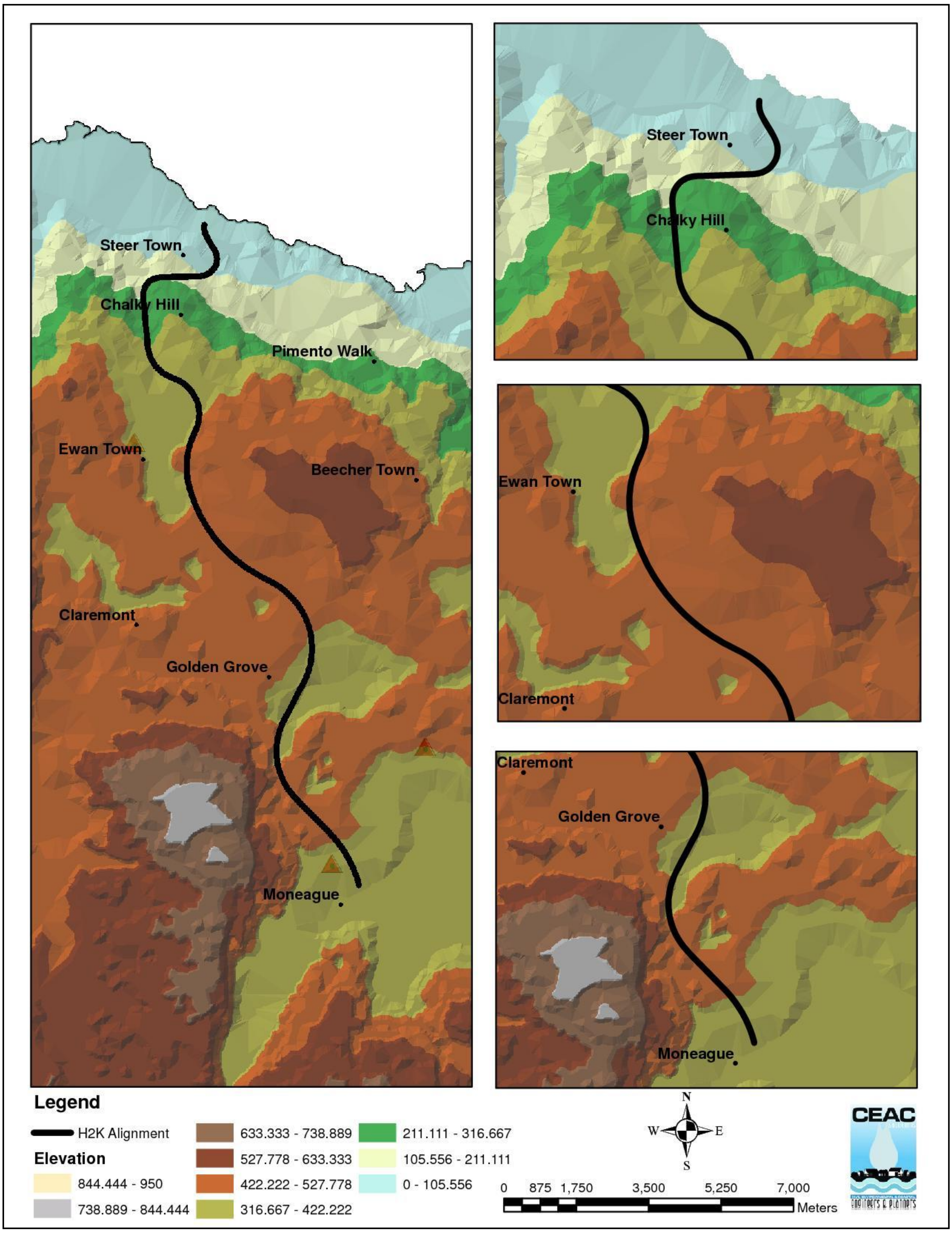

Figure 4-10 H2K Moneague to Ocho Rios alignment superimposed on the digital terrain map of Jamaica

4.1.4 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

4.1.4.1 Description of SCS Model

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)

4.1.4.2 Precipitation

The maximum 24-hour rainfall for the 100 year return period at the rainfall gauges, within the vicinity of the watersheds, was used for the determination of the precipitation to be applied to the model. The rainfall depths across the catchments were determined by creating a rainfall depths contour map over catchments, by using the rainfall gauges in and around the catchments. A weighted rainfall depth was then determined for each watershed. The values are shown in Table 4-5 for the present and future scenarios.

Table 4-5 Weighted rainfall depth determined for each watershed

Hydrology	Units	Location	
		Harbridges Gully	**Little River**
Weighted Rainfall	mm/24-hour	266	263
Recommended design rainfall based on Climate Change	mm/24-hour	280	276

4.1.4.3 Rainfall Abstraction Model

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).

4.1.4.4 Soils

The catchments were superimposed on the ministry of Agriculture's soils map of Jamaica to identify the soils distribution within each catchment. See Figure 4-11. It was found that all the catchments had high proportions of Stony loam with sections of Clay. The soil types are distributed across the catchments as follows:

1. The catchment basin area of the Harbridges Gully has high concentration (over 70%) of Bonnygate Stony Loam while the eastern segment of the basin has a small concentration of Killancholly Clay.

2. Majority of the Little River catchment comprises of Killancholly Clay (over 70%) with the remaining areas containing Bonnygate Stony Loam.

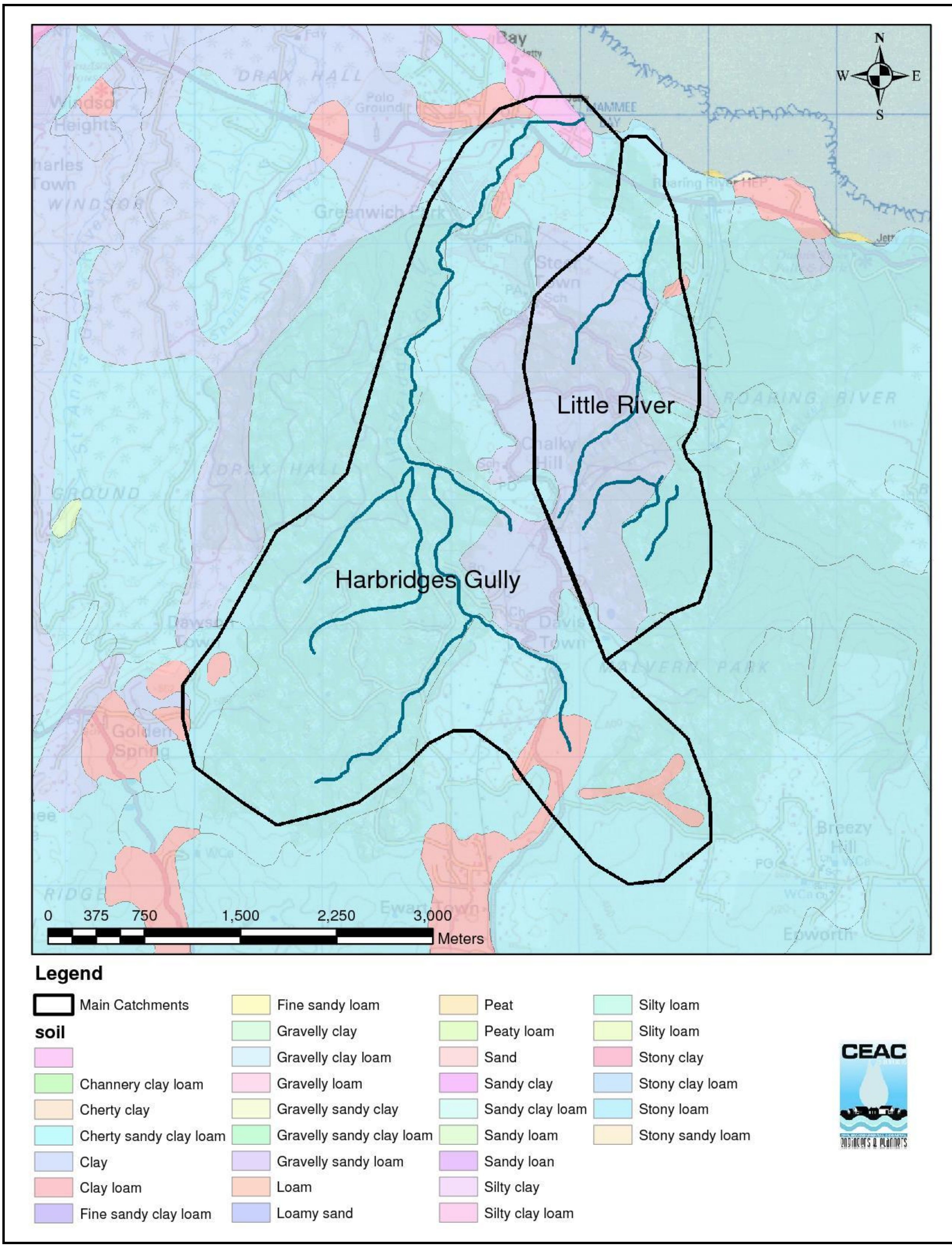

Figure 4-11 Catchment areas superimposed on soils map of Jamaica

4.1.4.5 Land Use

The Land use for each catchment was determined from inspection of the Forestry Department land use map seen in Figure 4-12, as well as satellite imagery of the catchments. The following was noted:

1. The Harbridges Gully catchment was observed to have mostly forests, fields and crops with residential settlements on lots more than 1/4 acres in area. However, the northern basin area is comprised of strictly infrastructures and buildings.
2. The catchment associated with Little River was determined to have significantly high concentrations of forests, fields and crops (over 80%). Concentrations of urban space were identified along the northern reaches of this catchment.

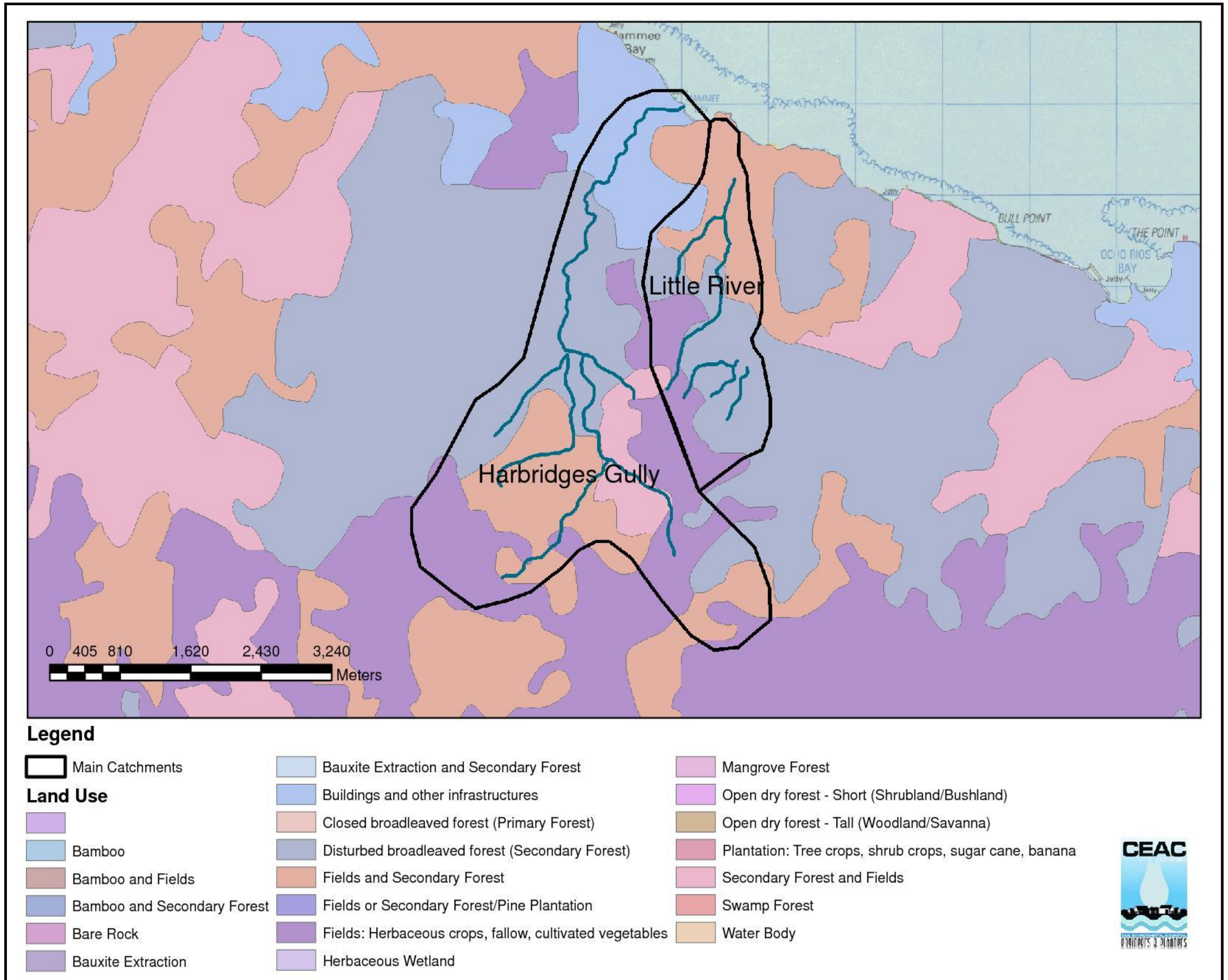

Figure 4-12 Land Use map of Jamaica with superimposed catchments and highway alignment

4.1.4.6 Curve Numbers (CN)

The curve numbers used in the SCS method were selected for normal antecedent moisture conditions (AMC II) as outlined in the 'Storm Design Manual' put together by Niagara county board shown in Table 4-6. The curve numbers for existing conditions were selected for the catchments were as follows:

1. Harbridges Gully - 55 (based on the soil composed mainly of stony loam and the area being predominantly open fields and forests);
2. Little River - 70 (based on the soil mostly composed of clay with the area being predominantly cultivated fields and forests);

Table 4-6 Table showing curve numbers corresponding to appropriate soil type and land usage

Description of Land Use	*Hydrologic Soil Group*			
	A	**B**	**C**	**D**
Paved parking lots, roofs, driveways	98	98	98	98
Streets and Roads:				
Paved with curbs and storm sewers	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Cultivated (Agricultural Crop) Land*:				
Without conservation treatment (no terraces)	72	81	88	91
With conservation treatment (terraces, contours)	62	71	78	81
Pasture or Range Land:				
Poor (<50% ground cover or heavily grazed)	68	79	86	89
Good (50-75% ground cover; not heavily grazed)	39	61	74	80
Meadow (grass, no grazing, mowed for hay)	30	58	71	78
Brush (good, >75% ground cover)	30	48	65	73
Woods and Forests:				
Poor (small trees/brush destroyed by over-grazing or burning)	45	66	77	83
Fair (grazing but not burned; some brush)	36	60	73	79
Good (no grazing; brush covers ground)	30	55	70	77
Open Spaces (lawns, parks, golf courses, cemeteries, etc.):				
Fair (grass covers 50-75% of area)	49	69	79	84

Description of Land Use	*Hydrologic Soil Group*			
Good (grass covers >75% of area)	39	61	74	80
Commercial and Business Districts (85% impervious)	89	92	94	95
Industrial Districts (72% impervious)	81	88	91	93
Residential Areas:				
1/8 Acre lots, about 65% impervious	77	85	90	92
1/4 Acre lots, about 38% impervious	61	75	83	87
1/2 Acre lots, about 25% impervious	54	70	80	85
1 Acre lots, about 20% impervious	51	68	79	84

The curve numbers were then modified for two additional conditions, they were for the present condition plus the development of the highway and for the future condition plus the development of the highway. Resulting curve numbers used in generating runoff are outlined in Table 4-7 below. The development of the highway will impact the curve number and runoff by no more than 0.3 % in any one catchment or river. However, there were significant increases for the future development condition as it was estimated that the rural catchments will see more residential developments whereas the industrial and urbanized areas will become more intense.

Table 4-7 Curve Numbers used in SCS model

Curve Number (CN):	*Watershed*	
	Harbridges Gully	**Little River**
Existing Conditions	55	70
Existing Conditions with H2K	55	70
Future Developed Areas	60.5	77

4.1.4.7 Runoff

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 (Figure 4-13);
- Total design rainfall (P) in inches (millimeters).

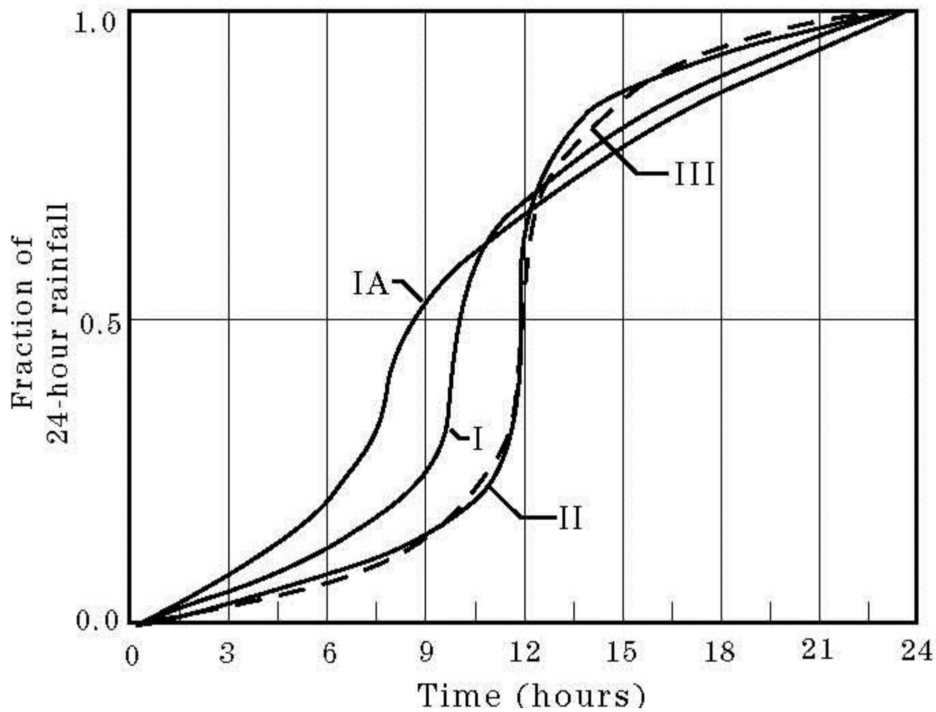

Figure 4-13 SCS 24-hour Rainfall Distributions

The runoff generated for each catchment where the rivers cross the alignment varies from 116 to 146.4 cubic metres per second for the existing condition, 116.6 to 147.8 cubic metres per second and 130.2 to 172.7 cubic metres per second for the expected future flows. The Little River generated the lowest flows while the Harbridges Gully produced the largest peak flows. See Table 4-8 below for a summary of the runoffs generated for each catchment and respective scenario.

Table 4-8 Runoff generated for the different catchments impacted by the H2K Moneague alignment

Hydrology	*Units*	*Location*	
		Harbridges Gully	**Little River**
Catchment area	HA	1130	385
Return period	Years	100	100
Tc	min	12	10
Peak runoff			
Existing Condition	m^3/sec	146.4	116.0
Existing Condition plus Highway	m^3/sec	147.8	116.6
Difference		0.99%	0.56%
Future Flows (fully developed catchment with highway)	m^3/sec	172.7	130.2

4.1.4.8 The Catchments

Topographic maps of Jamaica were assembled over a DEM to determine the extents of the watersheds that will be impacted by the implementation of the proposed alignment. The process of defining the catchments in the GIS environment involved:

1. Smoothing the DEM of sinks;
2. Defining Flow accumulations in streams;
3. Defining catchments after specifying minimum catchment areas for each stream.

It was found that the proposed alignment traverses a number of sub-catchments of a larger catchment area as illustrated in Figure 4-14. These catchments were delineated using a Digital Elevation Model (DEM) obtained from Digital Globe radar information**.** The overall total area of the sub-catchments that will impact the highway alignment is **15.15 km², **extending from Malvern Park in the east to Golden Grove in the west and Mammee Bay in the north to Ewart Town in the south. The catchment is approximately 6.14 km long at its longest and 4 km wide.

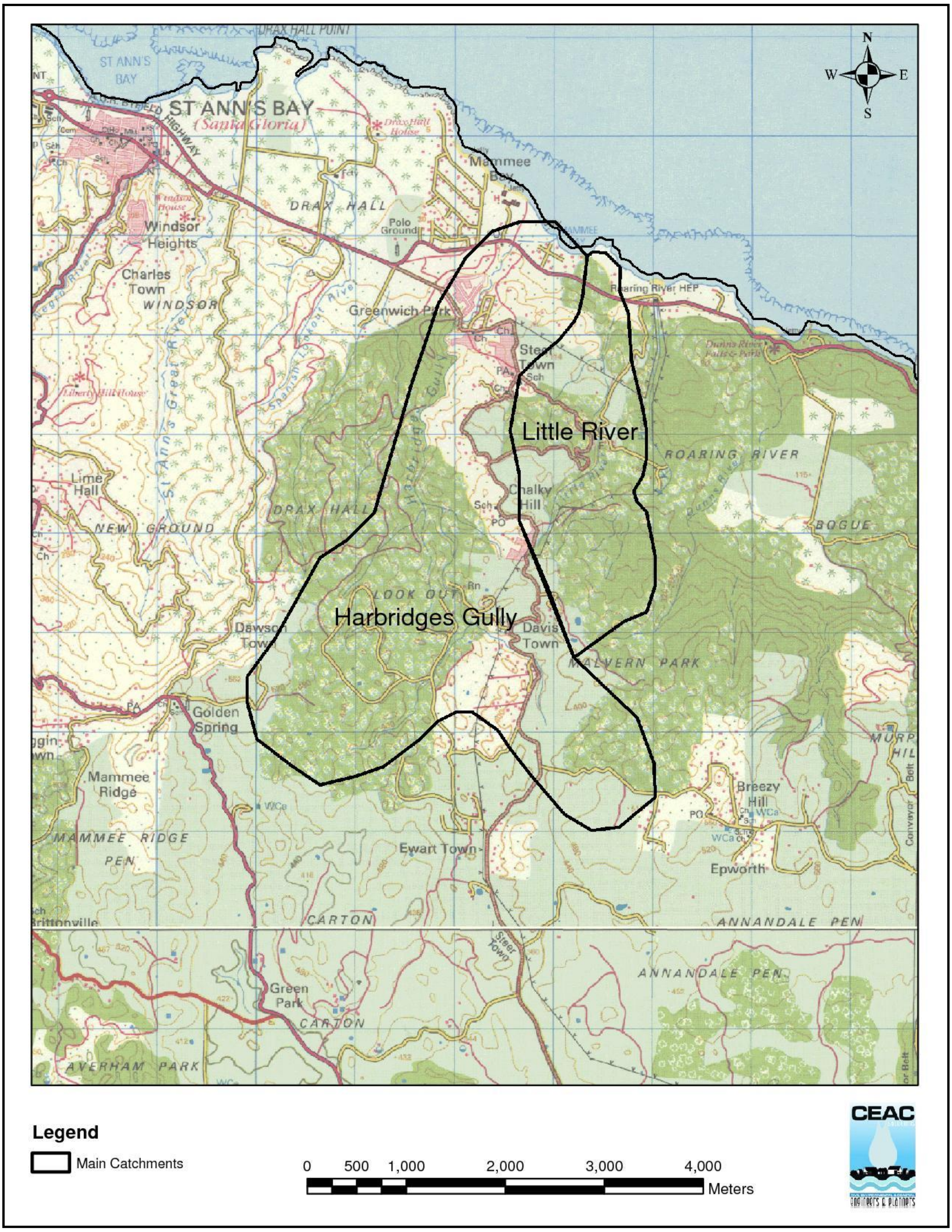

Figure 4-14 The overall catchment area associated with H2K road alignment

4.1.4.9 The Rivers

Based on the sub-catchments and streams identified, the proposed alignment crosses several tributaries of two (2) main rivers. These are shown in Table 4-9

Table 4-9 – Tributaries along highway alignment

Nr	River	Closest Alignment Chainage
1	Harbridges Gully Tributary 1	63+400
2	Harbridges Gully Tributary 2	64+225
3	Harbridges Gully Tributary 3	64+425
4	Harbridges Gully Tributary 4	64+530
5	Harbridges Gully Tributary 5	64+875
6	Harbridges Gully Tributary 6	65+175
7	Harbridges Gully Tributary 7	65+425
8	Little River Tributary 1	67+400
9	Little River Tributary 2	68+025
10	Little River Tributary 3	68+550

The tributaries of Harbridges Gully cross the alignment west of Davis Town and Chalky Hill while those of Little River traverse the alignment east of Steer Town (See Figure 4-15). These rivers are known to have large flood plains and tend to swell rapidly and overtop their banks during extreme weather.

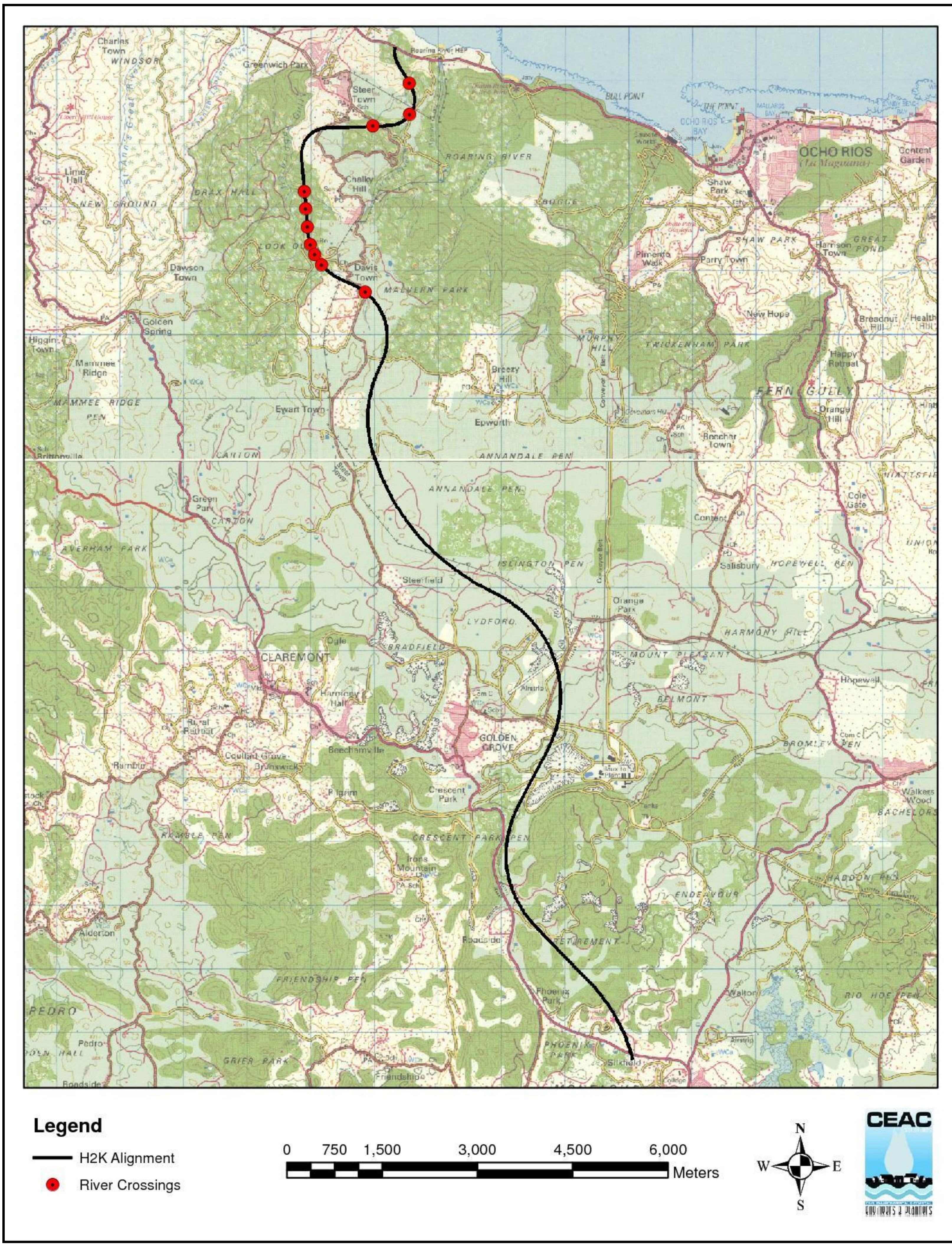

Figure 4-15 Map showing the major rivers which cross the proposed H2K alignment

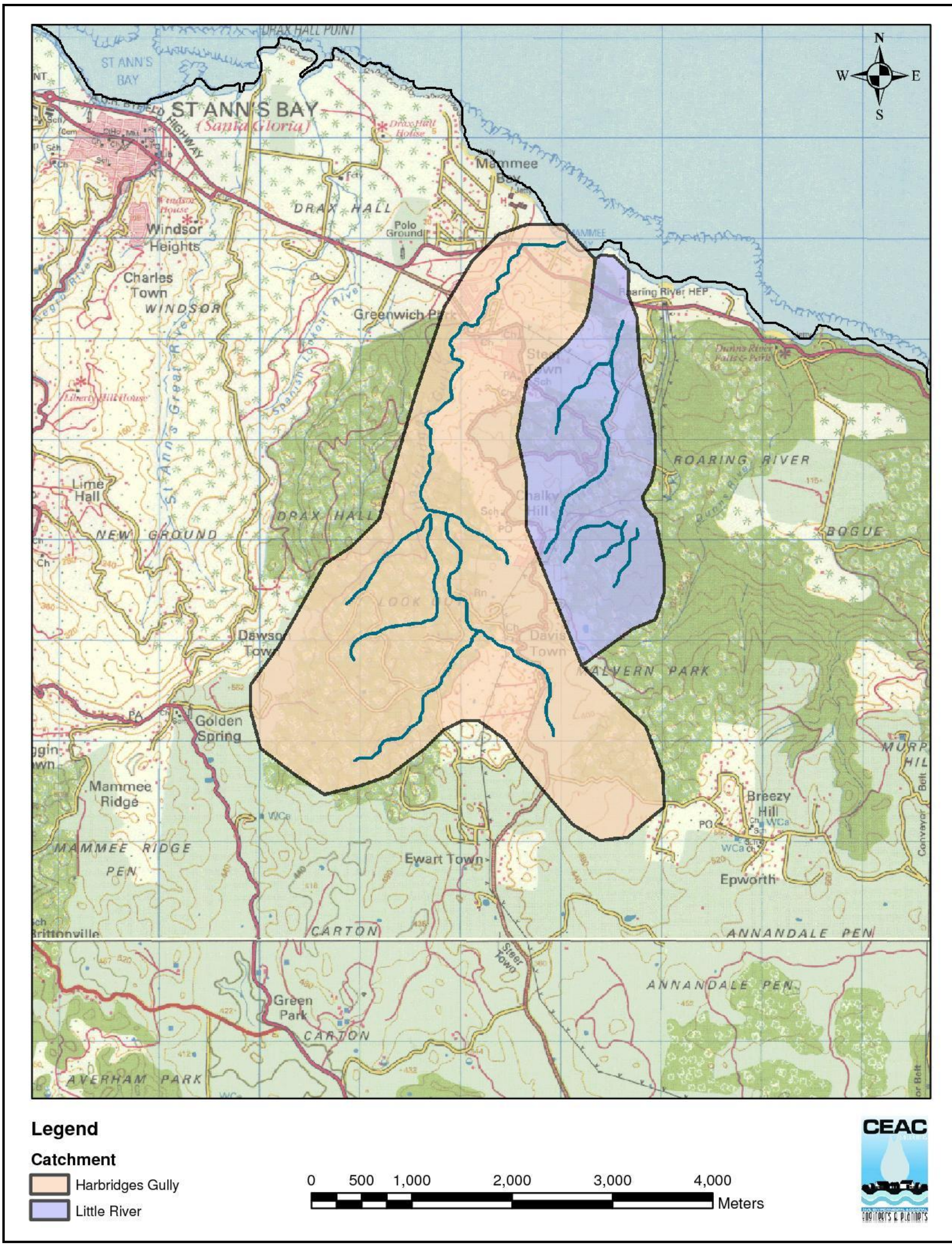

Figure 4-16 Locations of the flowpaths of major rivers and gullies within each catchment

Little River

Main Stream (Little River Tributary 1)

Little River starts in the north of Davis Town, in the region of the Chalky Hill community. It crosses the alignment twice, east of Steer Town at chainages km68+050 and km68+550. A relatively small tributary intersects and discharges flow into this main channel approximately 128 m west of chainage km68+350. The catchment associated with the river crossing the alignment is approximately 254.7 hectares. The river runs through forested fields and open lands where it eventually discharges into the Mammee Bay.

Plate 4-5 Little River upstream of H2K alignment crossing

Little River Tributary 2

The Little River crosses the alignment south-east of Steer Town in a north-south direction, at chainage 67+400. The total catchment area of this river tributary is approximately 70.4 hectares. The catchment extends as far south as Chalky Hill and is bounded on the north by Steer Town. This segment of Little River which crosses the proposed alignment originates in mountainous terrains south-east of Steer Town continues in a north-easterly direction towards the coast of Mammee Bay.

Plate 4-6 Exposed culvert pipe under existing roadway.

Plate 4-7 Illustrating the flow of Little River Tributary 2 under the existing road via pipe culvert.

Harbridges Gully

One tributary associated with the Harbridges Gully crosses the Highway 2000 alignment in the Davis Town and Chalky Hill area, in proximity to the existing main road. This riverbed is often times dry in the absence of rain but quickly fills up during rainfall events in the upper catchment. The catchments associated with this tributary encompass an area of approximately 221.2 hectares. Following the intersection of the river at chainage km63+400, this tributary flows along the proposed alignment and crosses the alignment at various chainages heading north. Harbridges Gully originates in the hilly regions north of Ewart Town, where it flows north and discharges into Mammee Bay.

Plate 4-8 A tributary of Harbridges Gully where it intersects with proposed alignment.

4.1.4.10 Other Major Water Features

There exists two major water features in proximity to the proposed H2K Moneague alignment. The first being the Roaring River, which serves the purpose of supplying hydro-electricity to the surrounding areas via a pipeline to the shoreline. Secondly, the Dunns River (Falls) which serves as an attraction for both tourists and locals. Both water features are situated east of the proposed H2K alignment, where neither the river channel itself nor the catchment are traversed by any segment of the proposed highway (Figure 4-17).

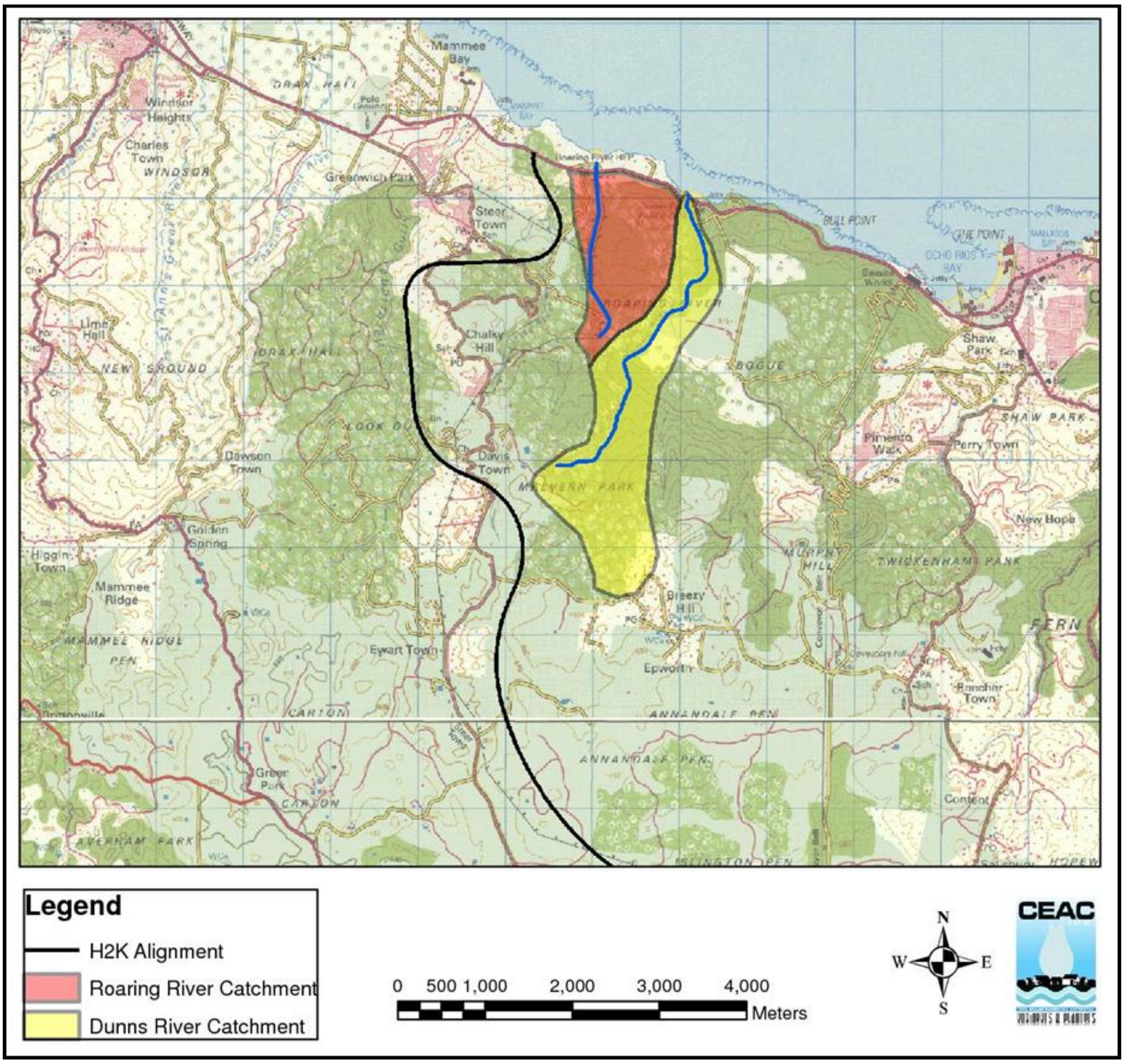

Figure 4-17 Map showing Dunns River and Roaring River watersheds in comparison to the H2K alignment.

Roaring River

This river facilitates the production of electricity via the Roaring River Hydro Electricty Plant, located east of Mammee Bay. The river, spanning 2.1 km in length, originates in the mountainous regions east of Chalky Hill, on the property of the Roaring River Great House, where it flows in a northern direction towards the plant on the shoreline. The total catchment area associated with this river is approximately 70.4 hectares.

The construction of the Moneague leg of Highway 2000 will not have any potential impacts on this catchment due to the alignment not traversing the watershed.

Plate 4-9 A section of the Roaring River located east of the Roaring River Great House

Plate 4-10 Sluice gate implemented within the channel of Roaring River

Dunns River

This river serves as mainly a tourist attraction where local residents often go for recreational purposes. The river extends 4.1km north of Malvern Park and east of Davis Town, and flows in a north-easterly direction towards Dunns River Fall and eventually out to sea. The Dunns River watershed measures approximately 342.2 hectares. This watershed is 4.7 km at its longest and 1.3 km at its widest.

The H2K Moneague alignment does not directly traverse the river nor the overall watershed associated with Dunns River.

4.1.4.11 Flood prone areas along alignment

The Office of Disaster Preparedness and Emergency Management (ODPEM) currently maintains a list of the main flood prone areas in Jamaica Flooding can be influenced by blocked drains which limit the transmission of floodwaters through the channel and across the existing road embankments. Plate 4-11 identifies the blockage of a segment of the Little River which usually flows fluent, caused by the passage of Hurricane Sandy in 2012. This prohibits the free flow of the river which consequently forces the water body to find a new path.

Plate 4-11 Existing channel of Little River blocked after the passage of Hurricane Sandy 2012.

The H2K Moneague alignment was superimposed on a flood prone map created by the ODPEM to determine all susceptible areas in close proximity to the alignment. As shown in Figure 4-18 there exist three (3) areas vulnerable to flooding withn 2 km of the alignment. They area as follows:

- Steer Town
- Golden Grove
- Moneague

The low-lying areas (valley) within which these communities are situated also contribute to the events of floods in the area. These regions are prone to flooding as they create a ponding effect, similar to wetlands.

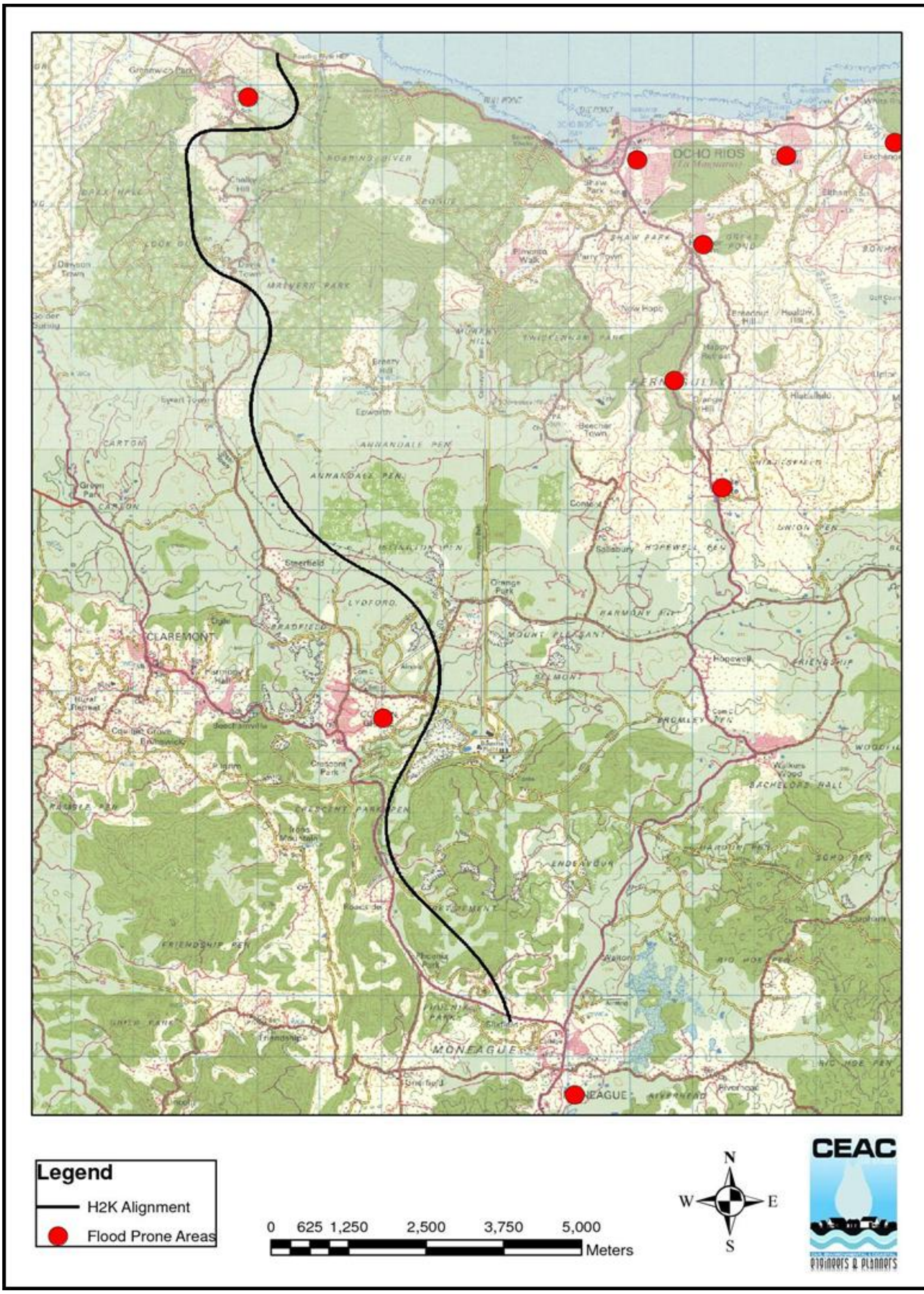

Figure 4-18 - Flood prone areas near to the alignment as identified on ODPEM website

4.1.5 Quarries

The Jamaica Mines and Geology Department database was queried, and found to have 125 licensed quarries. A 2000 Quarry materials Study Report commissioned by the Development bank of Jamaica, highlighted 56 quarries that were investigated across the island, for suitability to supply aggregate. The categories of material required were for:

- Concrete and asphalt mixes for the road surfaces
- Base and sub-base fill for the road
- Common fill

The closest quarries to the project are located at distances varying from 0.78 km to 21 km in proximity to the Moneague highway alignment. See Table 4-10, Figure 4-19 and Figure 4-20 below for the eighteen (18) closest quarries in operation to the alignment. Many of these quarries generate weak limestones which are not suitable for road base construction. The 2000 Quarries report therefore stated that consideration will also be given to the opening of additional quarries to supplement the limited supplies of suitable materials.

It is recommended that the regulations governing the opening of new quarries be adhered to and that the licences of existing quarries be checked for compliance prior to their usage. Contracts with Quarries and haulage contractors should include provisions for safe transporting of the materials as well as dust mitigation measures.

Table 4-10 - Summary of quarries in proximity to the H2K alignment and their respective characteristics

Location	*Parish*	*Owner*	*Quarry License*	*Closest Approximate Station*	*Distance from H2K*	*Rock Type*
Phoenix Park	St. Ann	Ashley Winston	QL 1460	49+850	0.78 km	Limestone
Ewart Town	St. Ann	Island Carbonate Ind.	QL 1290	61+700	1.34 km	Limestone
Endeavour	St. Ann	Warren Shaw	QL 1245	50+750	3.09 km	Marl & Limestone
Hazelwood	St. Ann	Adolph Clarke	QL 897	64+400	10.13 km	Limestone
Concord Pen	St. Ann	William Williams	QL 926	49+100	11.50 km	Marl
Choppenham Park	St. Ann	A.H. Quarries	QL 837	64+400	12.15 km	Limestone

Llandovery	St. Ann	Ryan Levy	QL 1636	69+178	13.55 km	Limestone
Gayle	St. Mary	Leafon Hudson	QL 1481	49+600	13.62 km	Limestone
Retreat	St. Mary	Taino Resorts	QL 1568	56+550	13.89 km	Sand
Retreat	St. Mary	Trevor Nevin	QL 1540	56+350	14.16 km	Limestone
Barclay Town	St. Mary	Ian Silvera	QL 1567	49+100	14.32 km	Sand
Retreat	St. Mary	Taino Resorts	QL 1569	56+650	14.54 km	Sand
Union	St. Mary	Rway Bennett	QL 1051	56+100	17.38 km	Marl
Union	St. Mary	Ruby and Aston Bennett	QL 576	56+200	18.39 km	Marl
Rose Hall	St. Ann	David Lee-Sin	QL 1612	49+100	18.80 km	Limestone
Spicy Grove	St. Mary	Clive Lyons	QL 1268	56+350	20.89 km	Marl
Prospect	St. Ann	Kent Inudstries	QL 1601	49+100	21.45 km	Sand
Clarksonville	St. Ann	Clarence Campbell	QL 1577	49+100	24.15 km	Marl

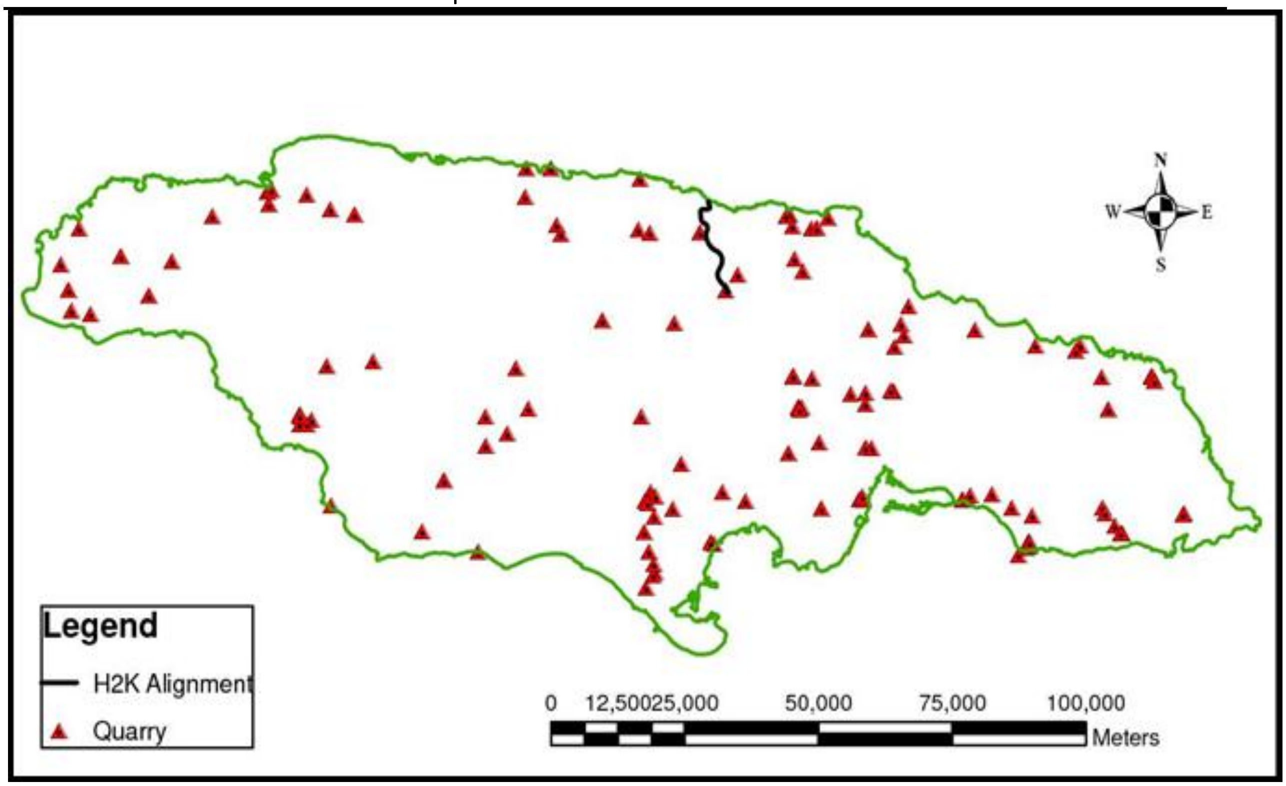

Figure 4-19 - Spatial Distribution of Quarries in Jamaica

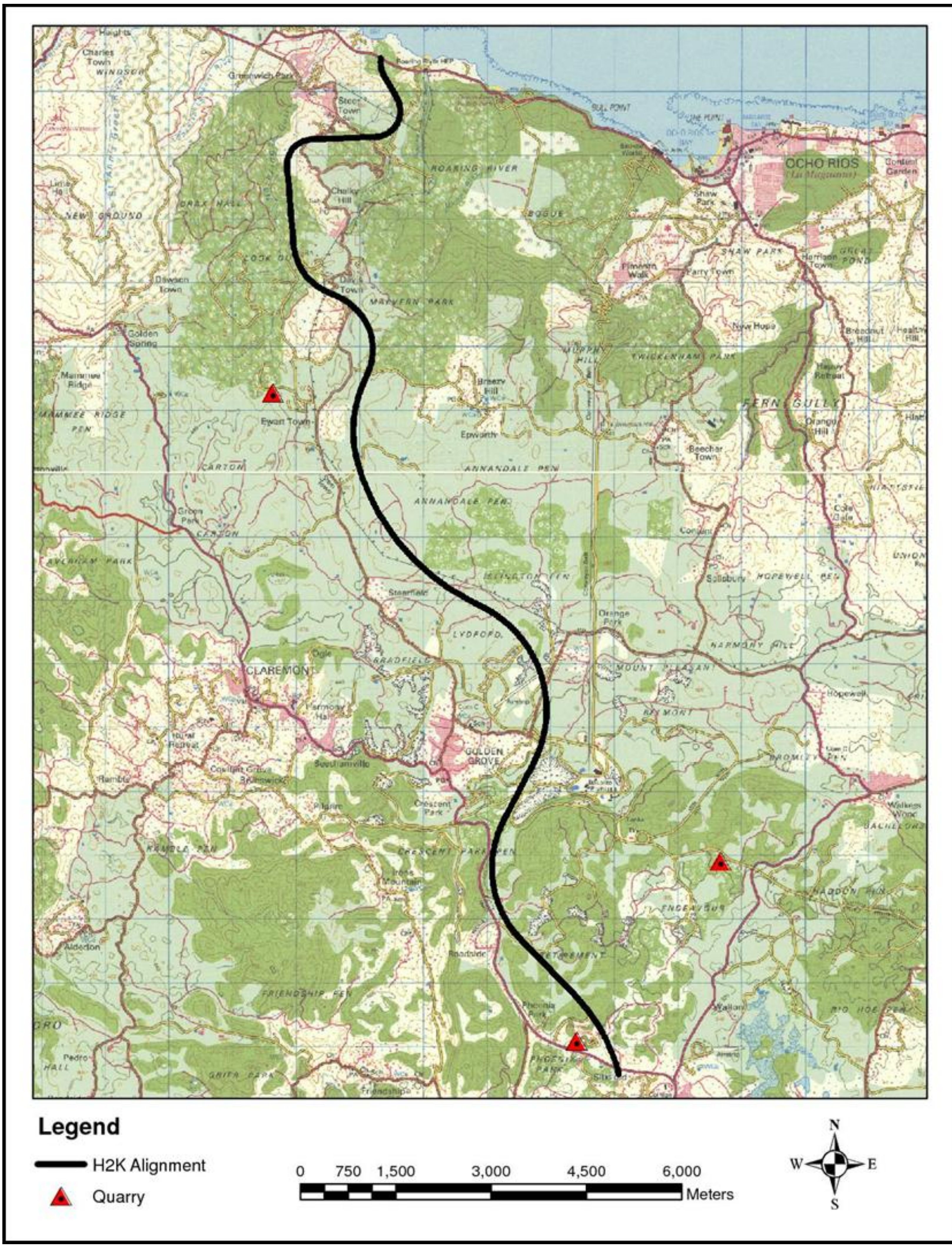

Figure 4-20 - Spatial distributions of quarries in close proximity to the proposed H2K Moneague to Ocho Rios alignment

4.1.6 Hazards

4.1.6.1 Landslide Susceptibility

Over the surface of the Moneague plateau landslips are rare and deemed to be unlikely, except locally in fresh highway cuts during construction.

On the steep northern slopes (Section 2 of the Physical Features above) landslides are to be expected over both chalky (Montpelier) limestones and the softer marls and clayey rocks of the Coastal Group. Such rocks include areas covered by travertine deposits which may exceed 5 to 10 m thickness and with poor bearing capacity. These may conceal older landslip deposits. Severe Seismic events may also promote slope failure in the softer units of the Coastal Group.

Plate 4-12 - Small scale slope failures observed within the Montpelier Formation. These are indicative of the soft rubble nature of this unit (yellow & black GPS unit in photo for scale)

The typical failure types include rock falls, rock slides, rock topples, debris flows and slides and lateral spreads Figure 4-21 identifies failure locations, recorded over the last 100 years, in proximity to the proposed route. It should be noted that the majority of these occur on the northern edge of the area within the units of the Montpelier Formation and the Coastal Group.

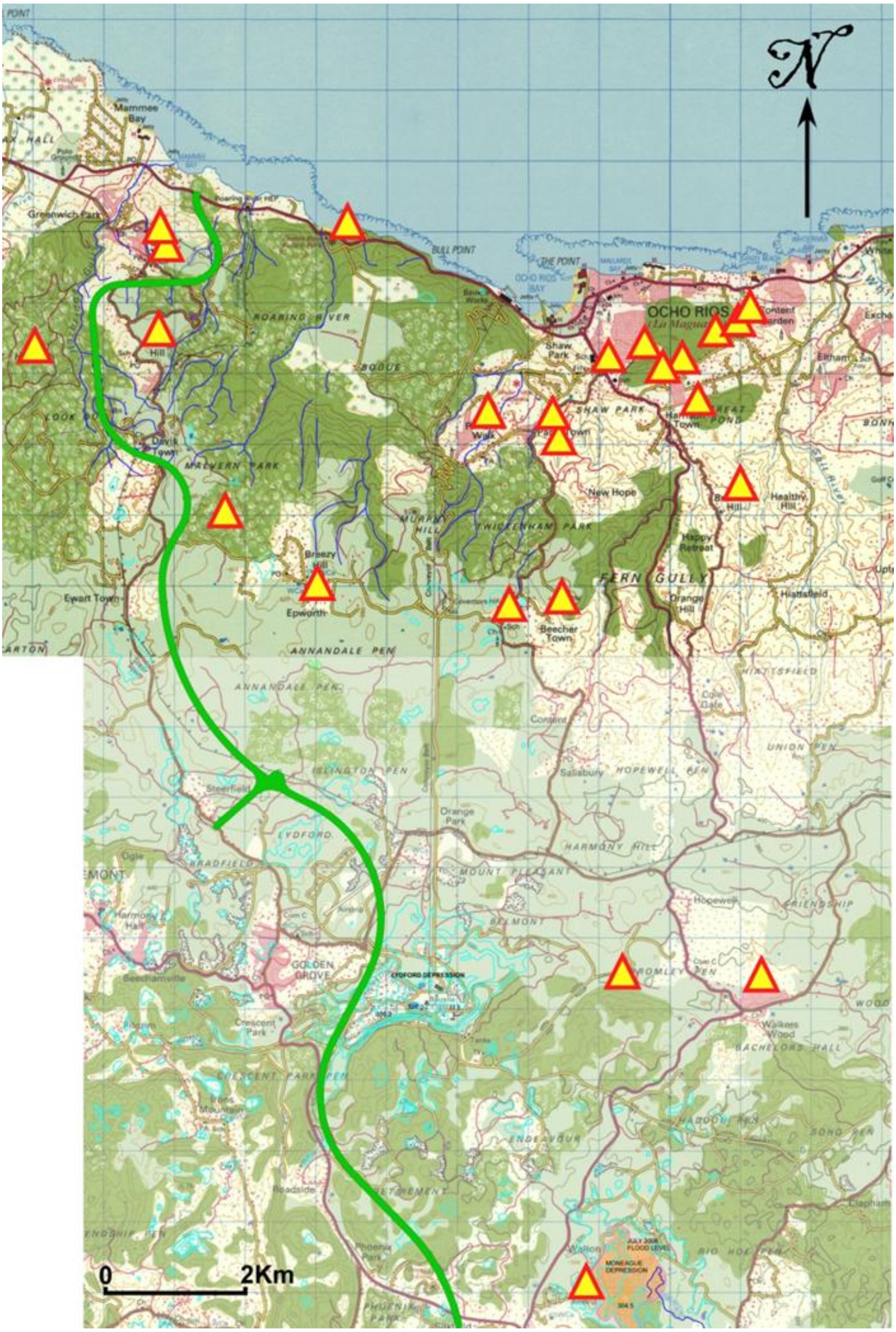

Figure 4-21 - Landslides mapped in the vicinity of the proposed highway (modified from Lyew-Ayee Jr and Ahmad 2012)

Topography - Slopes and Landslides

The Topographic data used in the analysis was obtained from Digital Globe Radar data. A slope analysis was done on the topographic data to highlight the slopes across the island. See Figure 4-22 below. The slopes along the alignment varied from 0 to just over 30 degrees. The slope angles were grouped into four (4) classes based on natural breaks in the frequency histogram. The landslides map obtained was superimposed on the slopes map to determine the occurrence of landslides within each slope ranges.

It was found that landslide occurrences increase with increasing slope angle. The results revealed that majority of landslides occurred within the ranges of 5^o and 30^o, with lower landslide occurrences, 9% and 7%, within the 0^o - 5^o range and 30^o and 75^o. However, a decrease in landslide occurrences was observed after the slope range 15^o - 30^o. The results are summarized in Table 4-11. The various types of landslides which occur within the respective slope ranges are shown below on a histogram (Figure 4-23).

The dominant slopes along the proposed alignment are between 0^o and 15^o. The segment of the alignment which traverses south of Golden Grove, in the region of Crescent Park Pen, comprises of the steepest slopes of up to 26^o (See Figure 4-24).

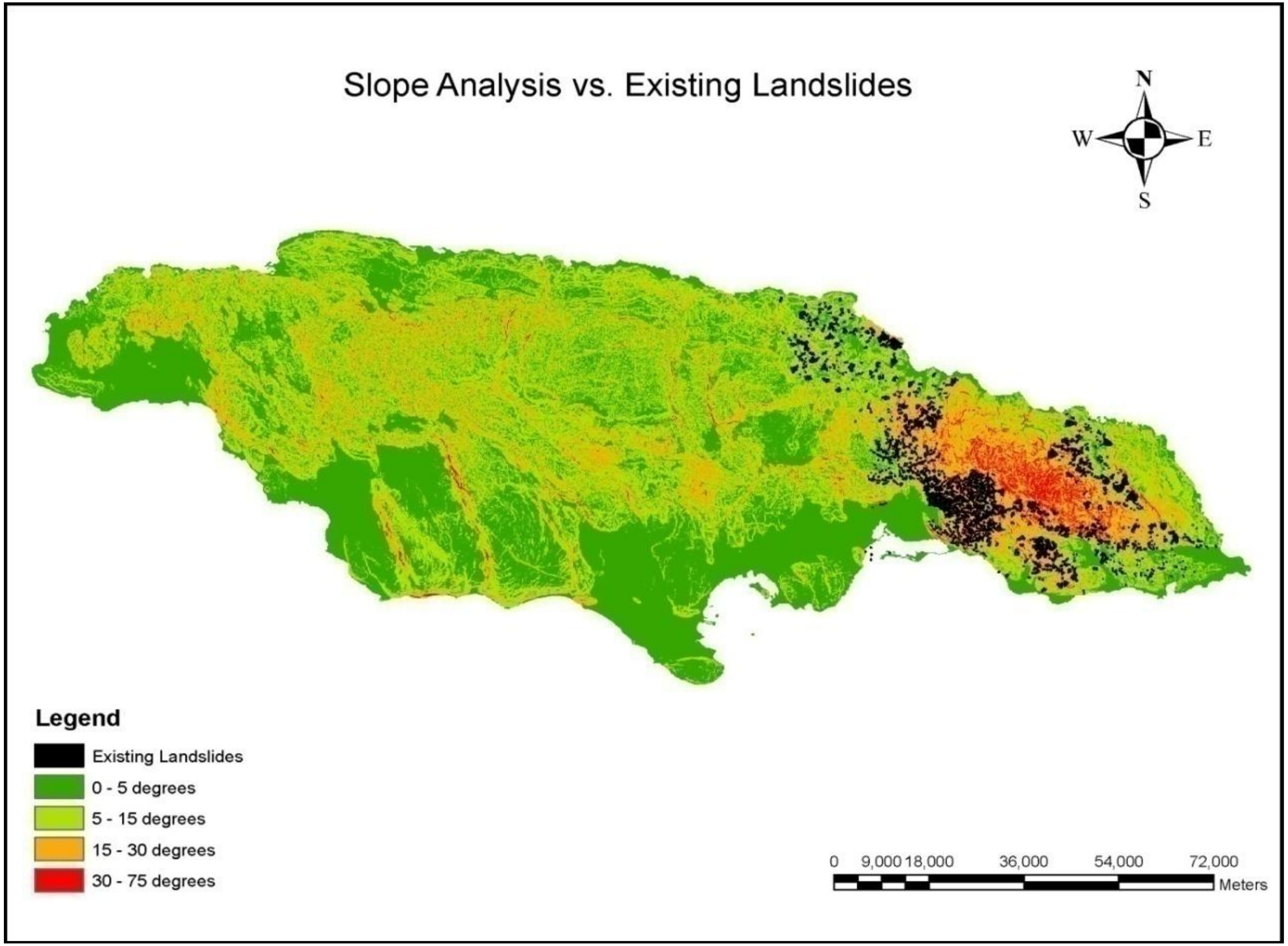

Figure 4-22 Graphical representation of landslide frequencies influenced by slope angles

Table 4-11 Landslide frequencies influenced by slope angles

Class	Slope Range	Landslide Frequency
1	$0^o – 5^o$	9%
2	$5^o – 15^o$	37%
3	$15^o – 30^o$	47%
4	$30^o – 75^o$	7%

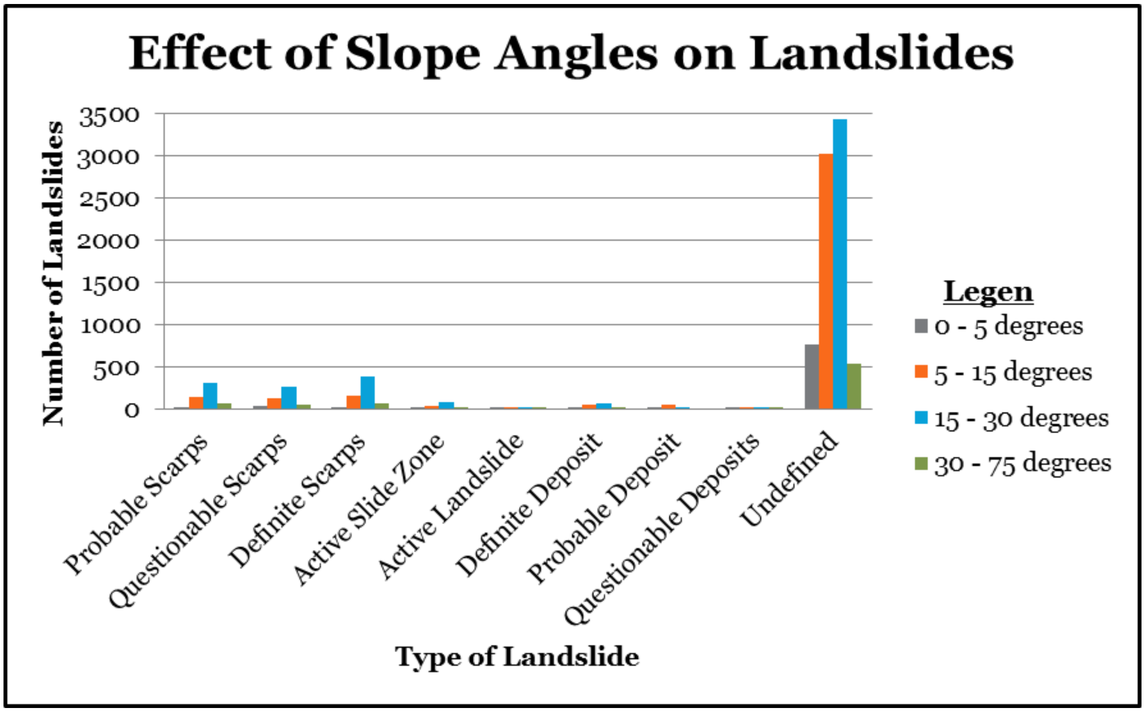

Figure 4-23 Histogram of landslide frequencies influenced by slope angles

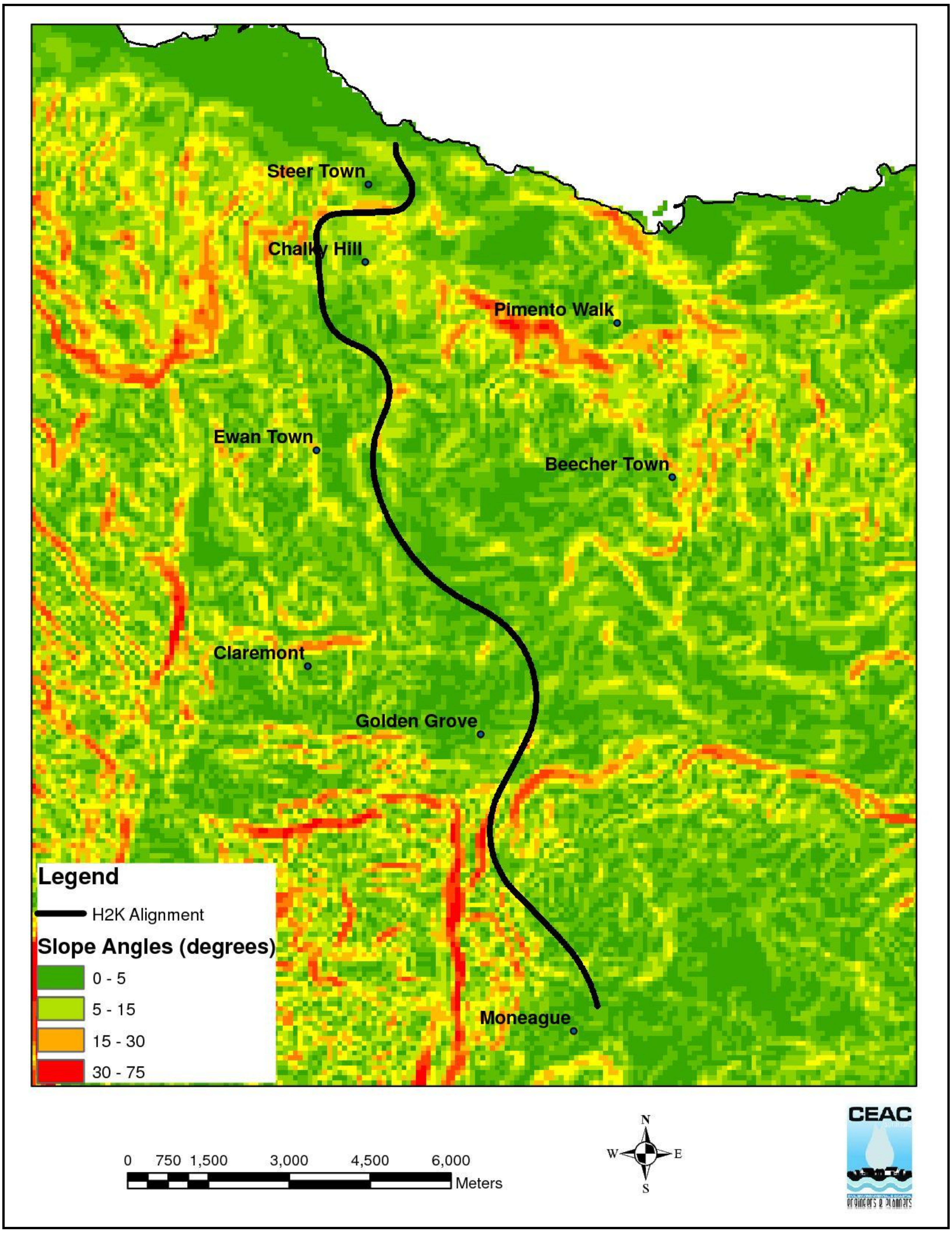

Figure 4-24 Slope analysis of the terrain through which proposed H2K Moneague alignment traverses

Soils and Landslides

The Soils data received had over 203 soil types within the zones where landslides were known to occur across the island. The probabilities of these soils causing a landslide were calculated based on data of existing landslides. The classifications revealed that approximately 79% of the soils had less than 1% probability of landslide occurring while 19% of soils had 1% - 10% probability of landslide occurrence. Only five (5) soils were considered having high probabilities (greater than 10%), they were; Haldane Sandy loam, Cuffy Gully Association, Barracks Silty loam, Island Head Clay loam and Lloyds Clay loam. Table 4-12 below illustrates the classification of soil probabilities.

Table 4-12 Probability of soil types which cause landslides

Class	***Number of Soils***	***Probability Range***	***Soil Frequency***
1	160	< 1%	79%
2	38	1% - 10%	19%
3	5	> 10%	2%

The probabilities landslide occurrences in these soils were plotted in Figure 4-25 and represented graphically in Figure 4-26 below.

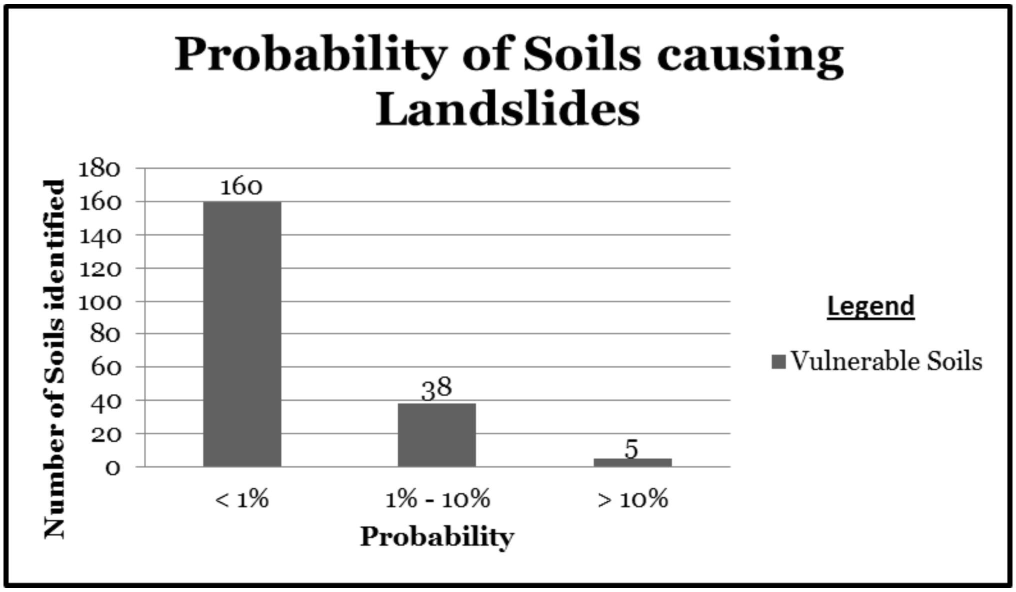

Figure 4-25 Histogram showing soils classified based on their propensity to cause landslides

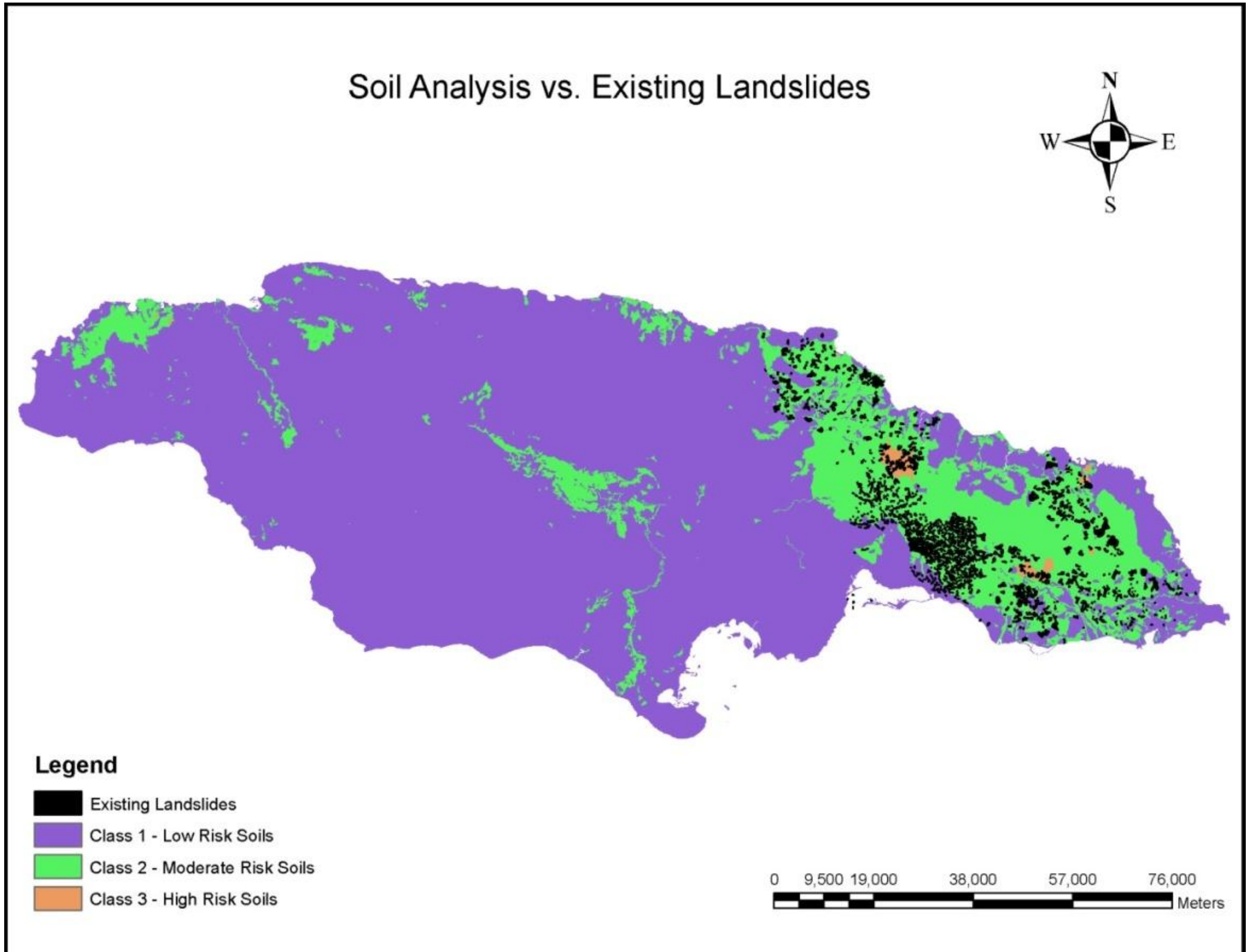

Figure 4-26 Graphical representation of landslide frequencies influenced by soil properties

Faults and Landslides

It was necessary to assess the likelihood of landslides occurring along fault lines. Initial observations indicate a high number of landslides are concentrated near faults in some parts of the map area. In many cases faults have created steep topographic escarpments. It suggests that a number of landslides are caused directly by fault-related fracturing and alteration of the rock in the steep escarpment slopes. Although landslides are concentrated near the faults, but some also occur in the blocks between faults.

The present fault lines throughout Jamaica were analysed according to their respective distances from existing landslides. The distances or fault buffers of all landslides from the nearest fault were determined then the landslide occurrences established as a function of fault distances. It was found that 25% of all recorded landslides occurred exactly along fault lines with over 50 percent occurring within 100m of a fault. Almost all existing landslides seem to occur at least within the range of 1000m of a fault line. Table 4-13 illustrates the number of landslides which occur within a specific range of distances from fault lines (i.e.) landslide densities.

Table 4-13 Landslide frequency in relation to proximity of fault lines

Fault Buffer	***Number of Landslides***	***Landslide Frequency***
0m	748	25%
< 10m	851	29%
< 50m	1195	40%
< 100m	1534	51%
< 200m	2032	68%
< 500m	2649	89%
< 1000m	2887	97%

These tabulated values were plotted on a graph (Figure 4-27) for further analysis and represented graphically in Figure 4-28 below.

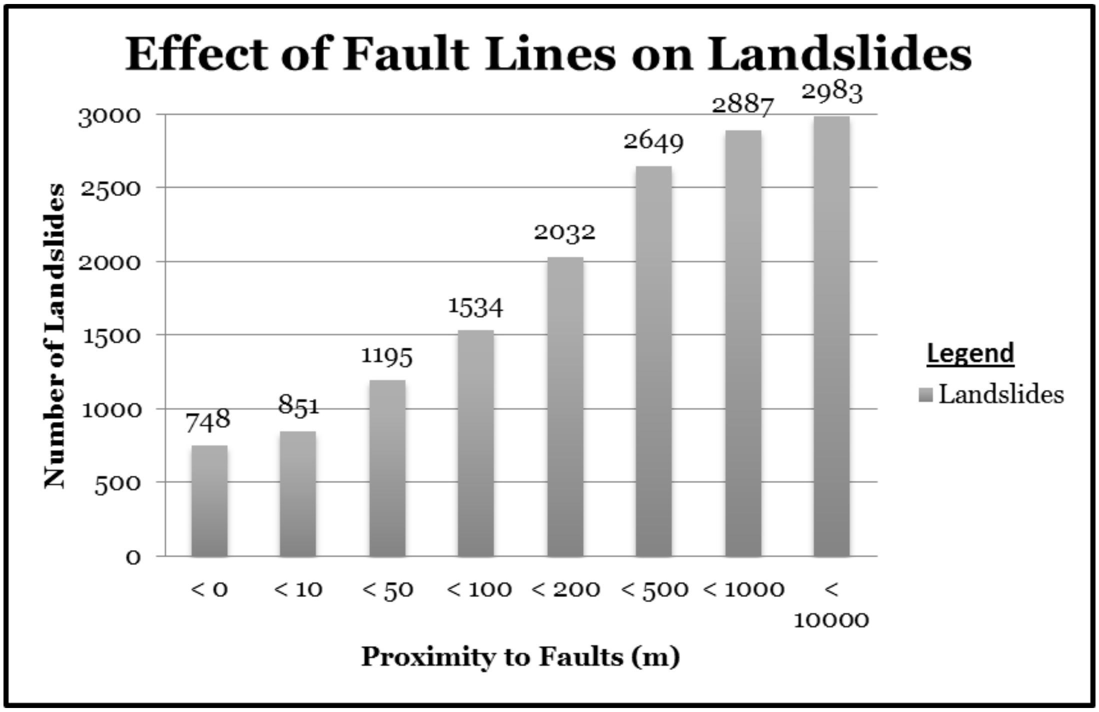

Figure 4-27 Histogram showing landslide frequencies influenced by fault lines

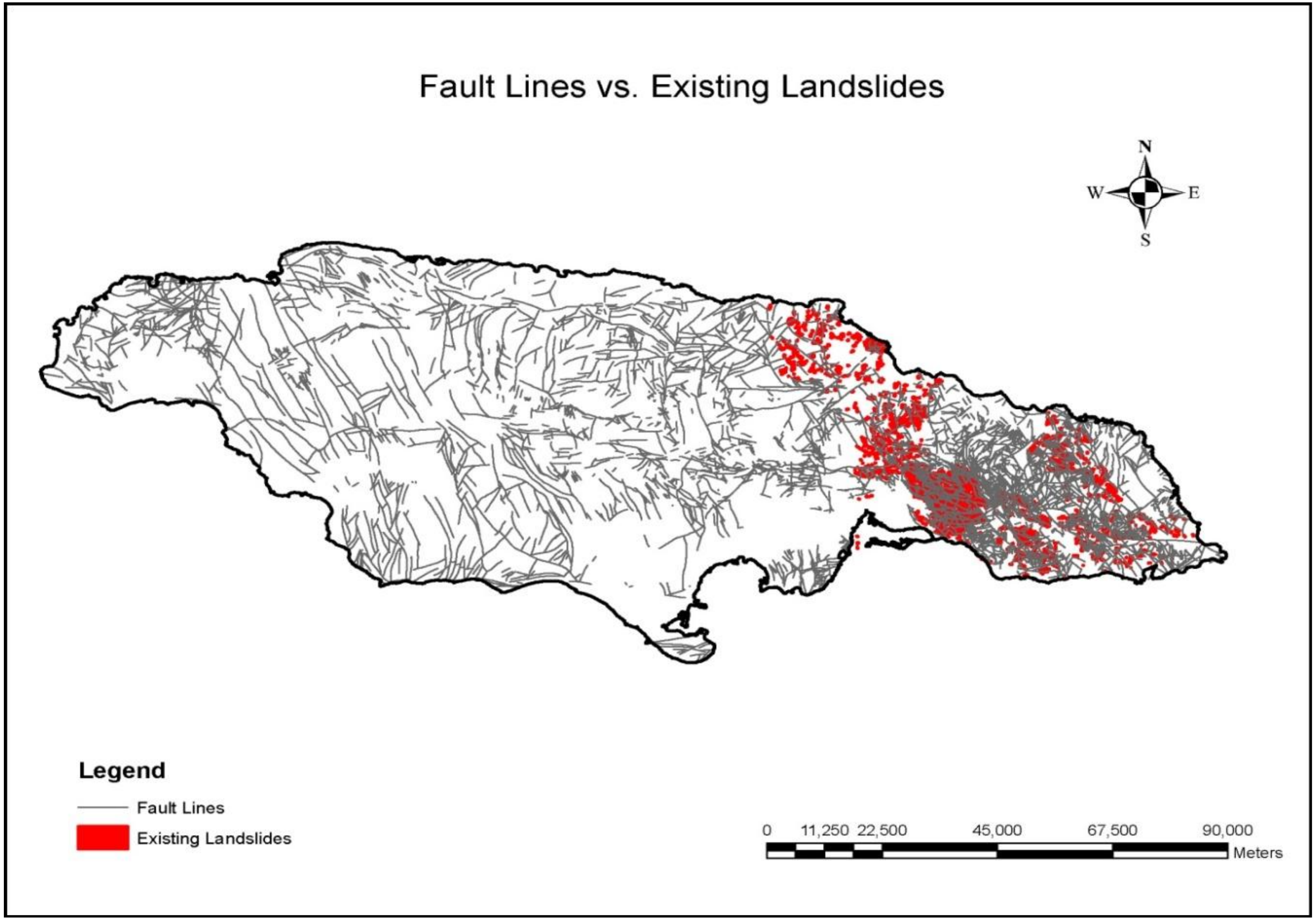

Figure 4-28 Map of landslides superimposed on faults map of Jamaica

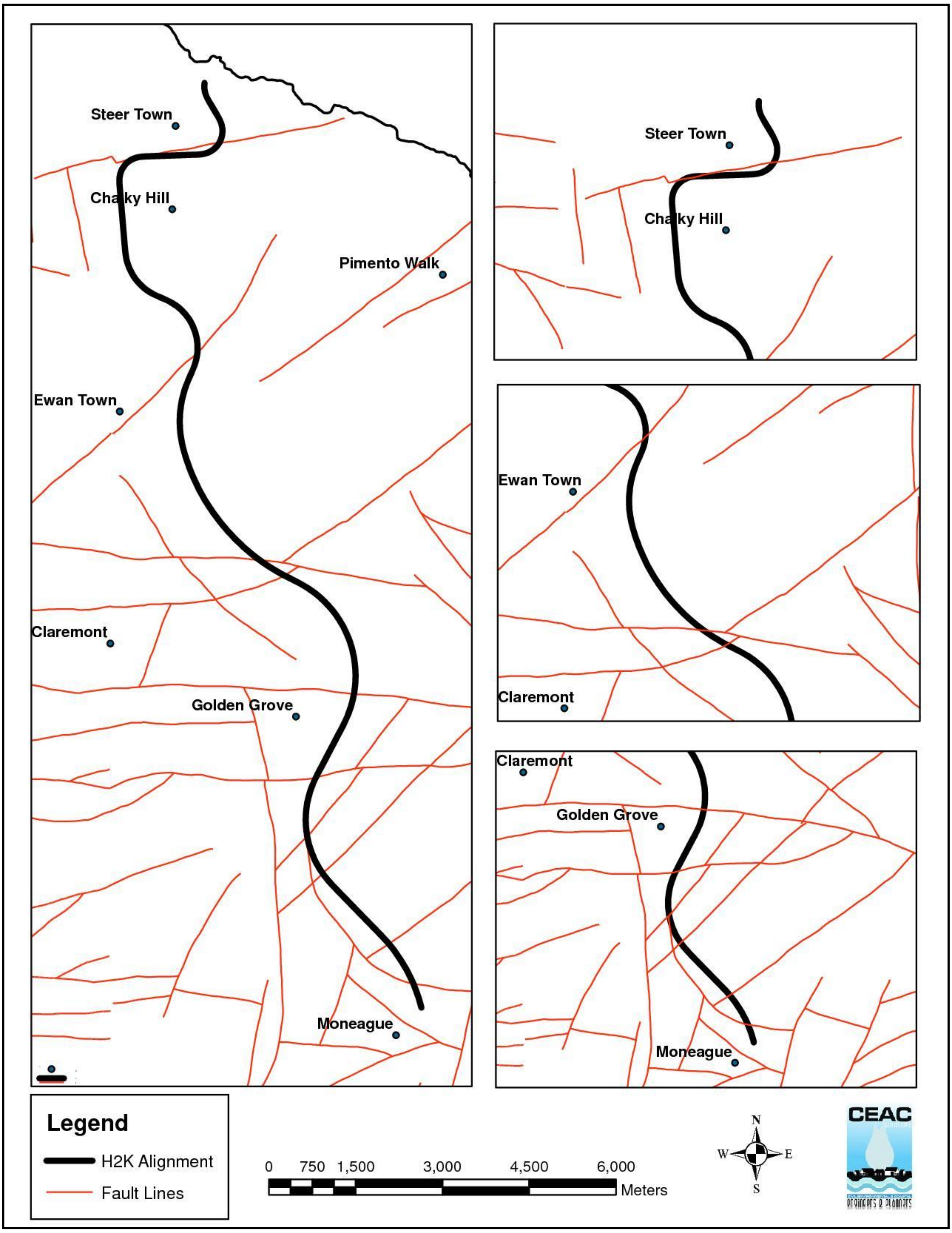

Figure 4-29 The H2K Moneague alignment superimposed on faults map of Jamaica.

Roads and Landslides

The road network which was examined included all the major and minor roads throughout the island of Jamaica. The conclusion was formed that some landslide types appear to correlate strongly with distance to roads. It was observed that as the proximity to the roads (buffer area) increased, there was a sharp decrease in landslide frequencies. Almost 30% of all existing landslides occurred exactly at locations where roads were cut regardless of any other present factors. This gives a basis for developing a relationship between the events of landslides and road locations. In comparison to faults, over one hundred (100) more landslides had transpired within proximity to roads than fault lines. Table 4-14 illustrates the relationship between the frequency of landslides and the proximity to the road network throughout Jamaica.

Table 4-14 Landslide frequency in relation to proximity of roadways

Road Buffer	***Number of Landslides***	***Landslide Frequency***
0m	867	29%
< 10m	986	33%
< 30m	1222	41%
< 50m	1386	46%

The correlation between the number of landslides occurring and their respective proximities to local roads are shown in the histogram below (Figure 4-30) and on the map in Figure 4-31.

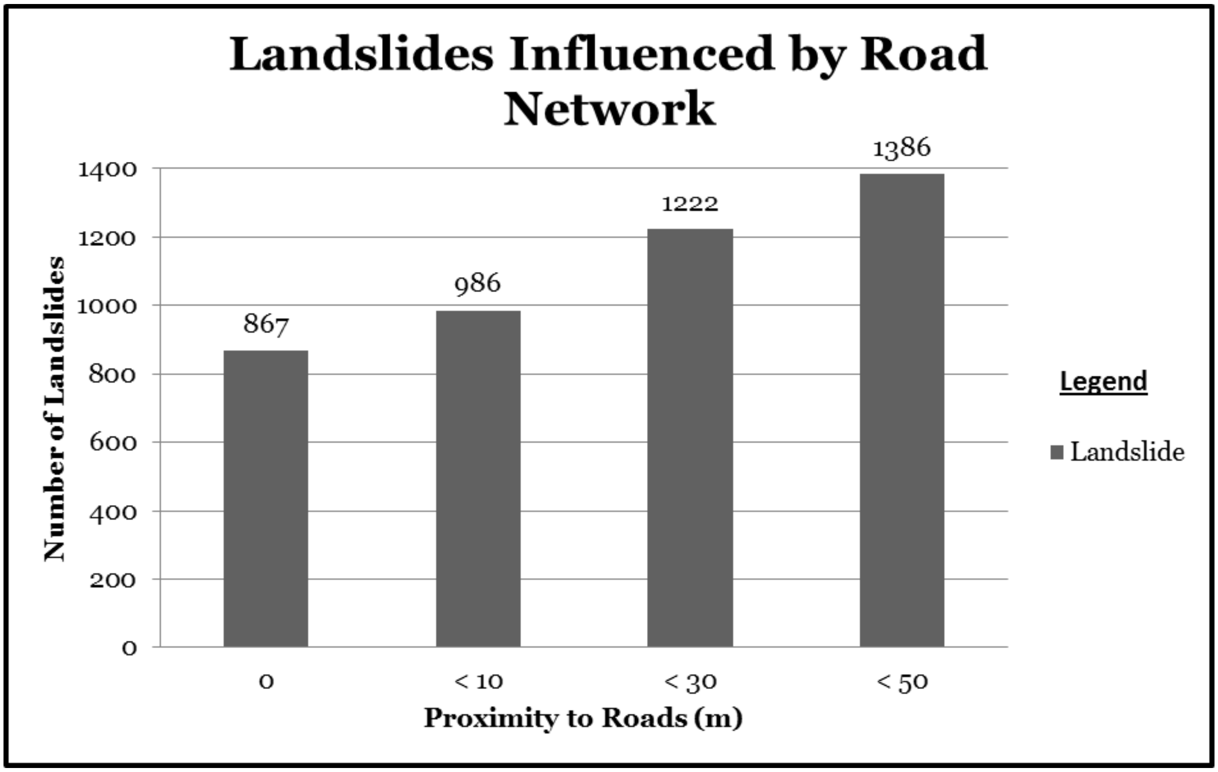

Figure 4-30 Histogram showing landslide frequencies influenced by the road network

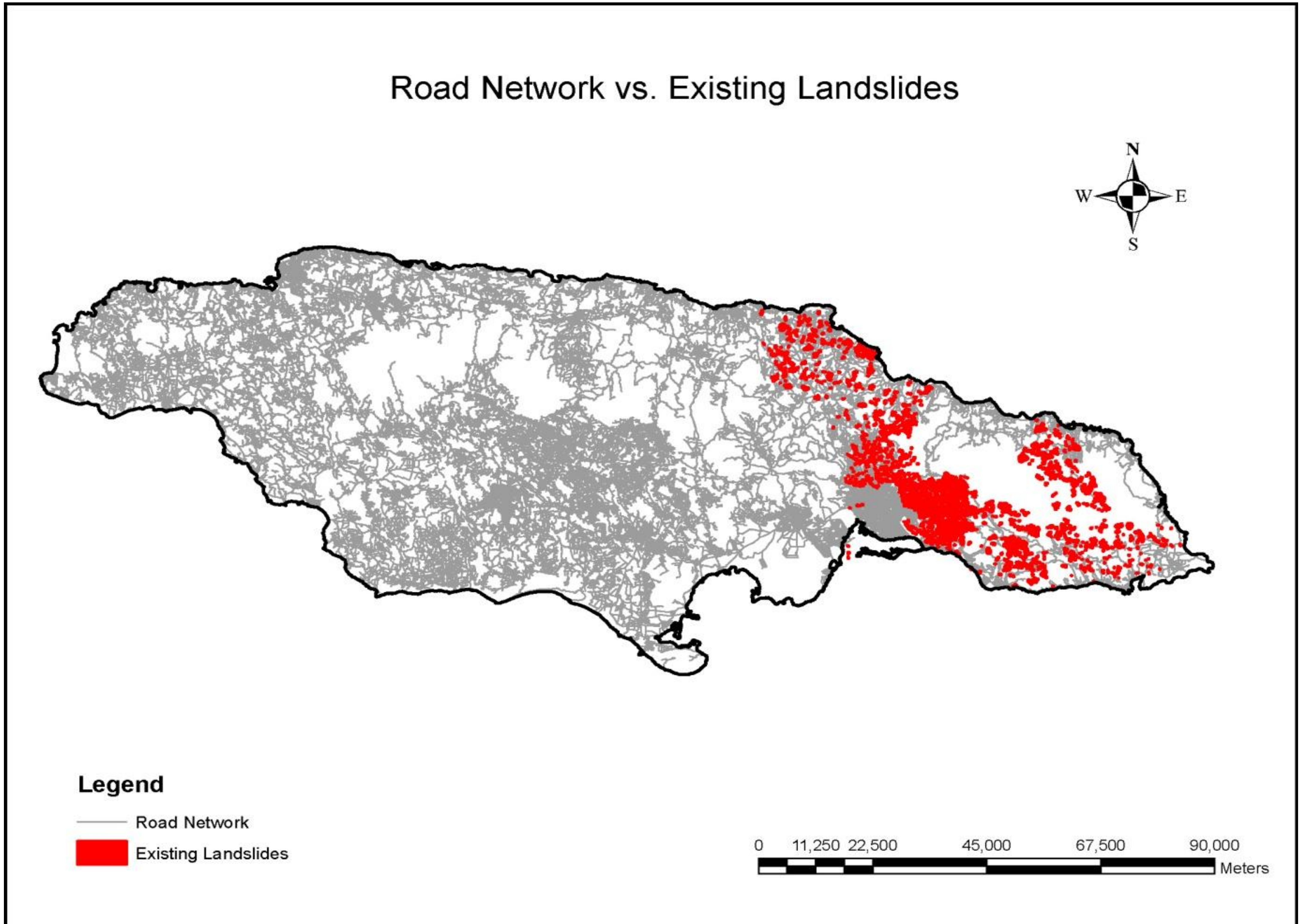

Figure 4-31 Graphical representation of landslide frequencies influenced by the road network

Description of Model

The calculation was performed using a susceptibility matrix approach which relies on an inventory of past landslides. The parameters used within the model were slope, soils, faults, and roads. The maps of these parameters were created and overlaid in GIS environment. Each parameter was assessed using the assigned susceptibility weighting based on a conditional probability that the parameter has occurred given a landslide has occurred, using the following probability formula:

$$P(A|B) = \frac{P(A \cap B)}{P(B)}$$

Each parameter was given a weighting from low to high susceptibility. All the parameters were then equally weighted and the product of the susceptibility of all the parameters was weighted in four classes varying from low to high susceptibility.

$$\text{Landslide susceptibility} = [Slope\ Angles] * [Soil] * [road] * [fault]$$

Model Results and Verification

The model was calibrated using the existing landslide areas where landslide occurrences are high. The model was then applied to the entire island and the landslide susceptibility map for Jamaica is shown in Figure 4-32. The vulnerability of landslides is slight throughout the island with scattered areas of moderate and high susceptibility. Most of the high susceptible areas are within close proximity to fault lines which can be due to the presence of brecciaed stones caused by the faults themselves.

The Moneague alignment was superimposed on the resultant landslide map to facilitate in identifying the susceptible areas prone to landslides. The most vulnerable regions were located in the mountainous sections north of Phoenix Park, north of Chalky Hill and south of Steer Town as Figure 4-33 illustrates. The steep and hilly environs, in close proximity to Steer Town, is determined to have high vulnerability of landslides where 1km of the alignment traverse in an east to west direction. This can be attributed to the high concentrations of Killancolly Clay soils which naturally have moderate to high erosive properties. Other susceptible regions identified include those near to Crescent Park Pen where 2.25 km of the highway is determined to have slight to moderate vulnerability.

In addition, the alignment traverses a fault line south of Steer Town at chainages 66+500, 66+725 and 68+112. Being that landslides frequently occur along fault lines, precaution should be taken when the highway is under construction in this region.

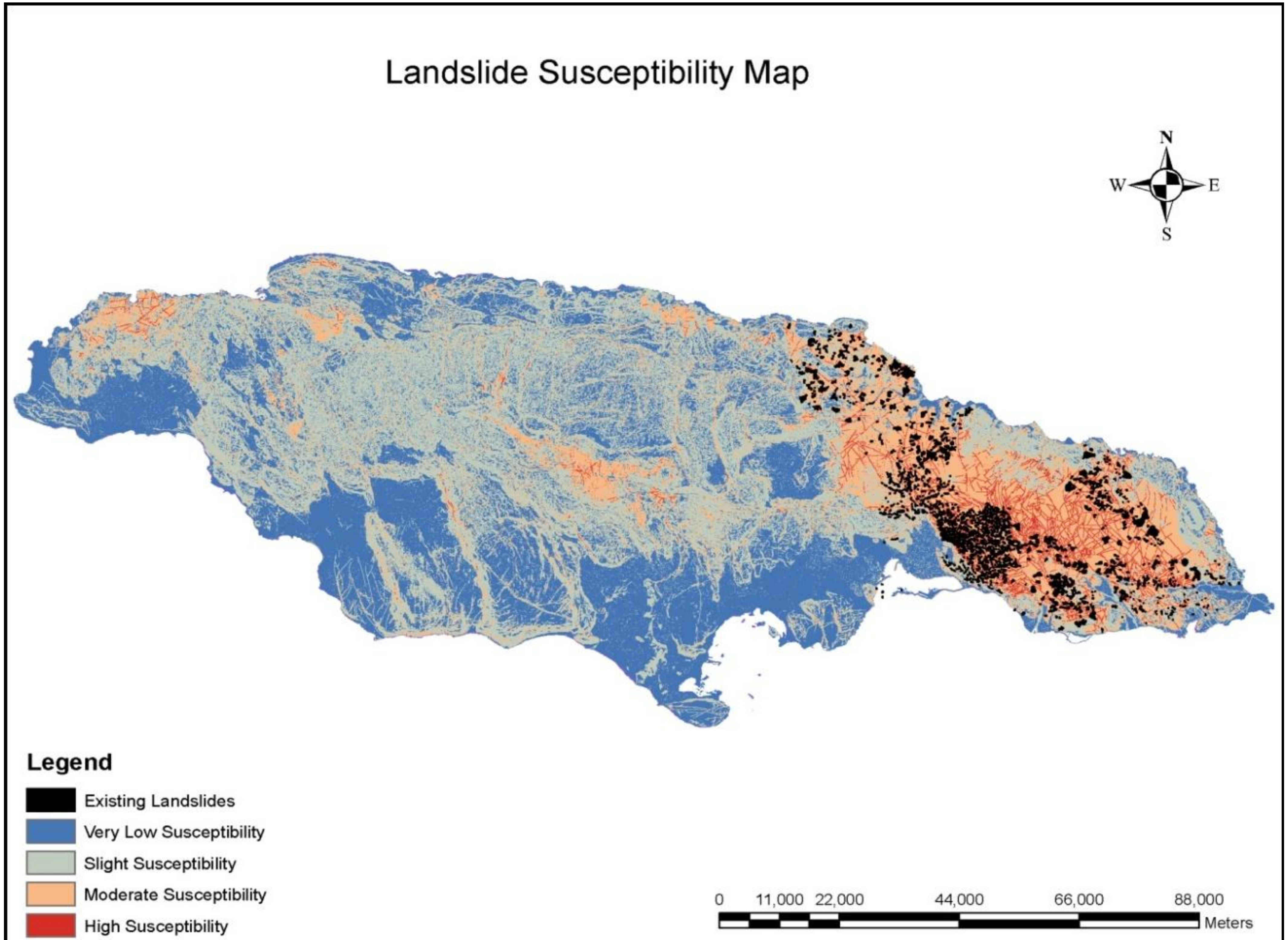

Figure 4-32 Landslide susceptibility map generated from parameters

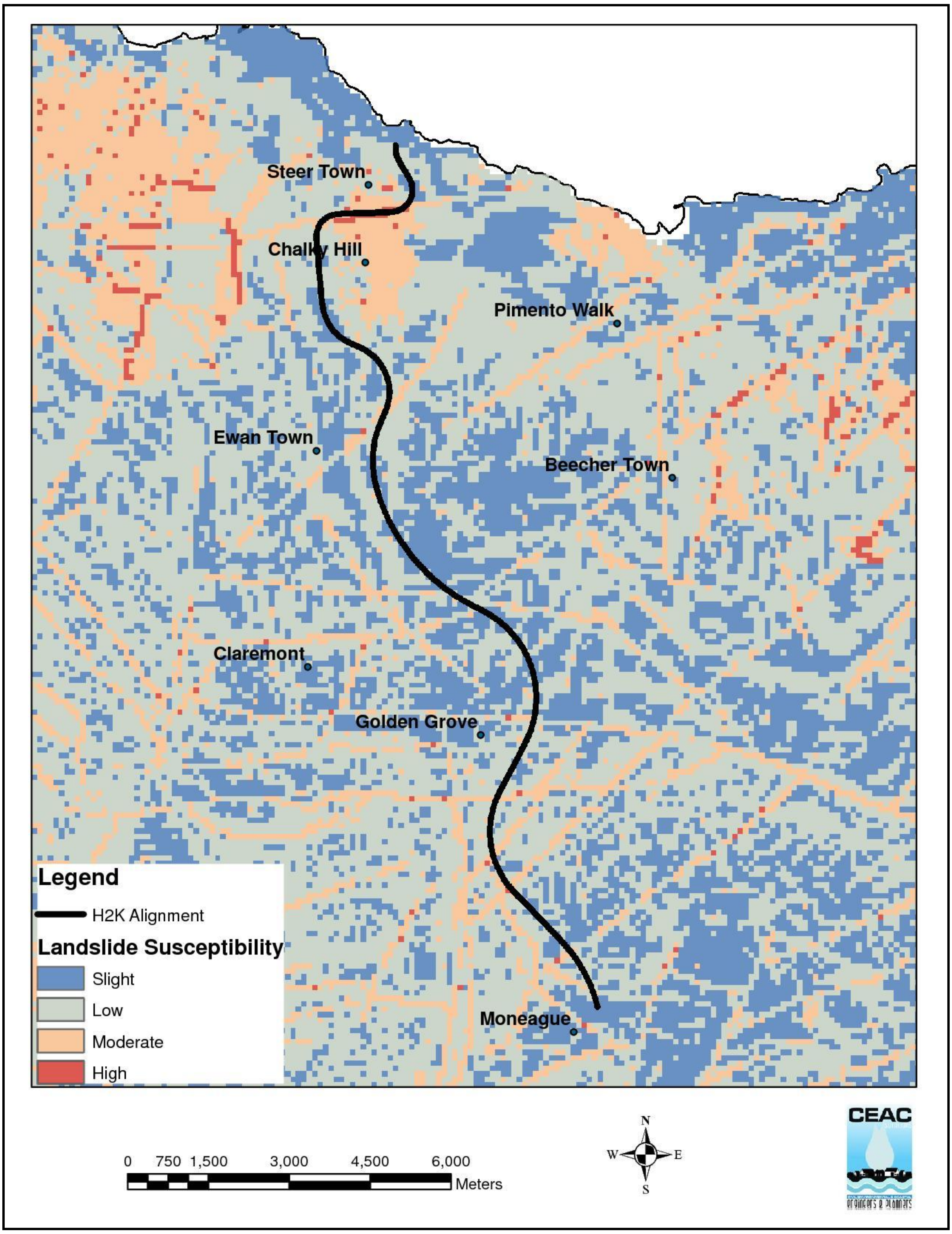

Figure 4-33 Final landslide susceptibility map along H2K road alignment

With the final susceptibility map generated, it is now possible to verify the results. The landslide susceptibility map which was generated demonstrates that there is a group of high vulnerable areas on the eastern end of the island which are prone to landslides. Majority of the existing landslides had occurred in areas where the GIS landslide susceptibility model predicted. The area of existing landslides transpiring within their respective susceptibility classes were tabulated and shown in Table 4-15 and Figure 4-34. These landslide areas can be classified as having moderate to high susceptibility.

Table 4-15 Verification illustrates most landslides have occurred in moderate to high susceptible areas.

Landslide Susceptibility	***Percentage***
Very Low	2%
Slight	15%
Moderate	65%
High	18%

A graphical representation of the landslide susceptible areas and their correlation to actual existing landslides is illustrated in Figure 4-35.

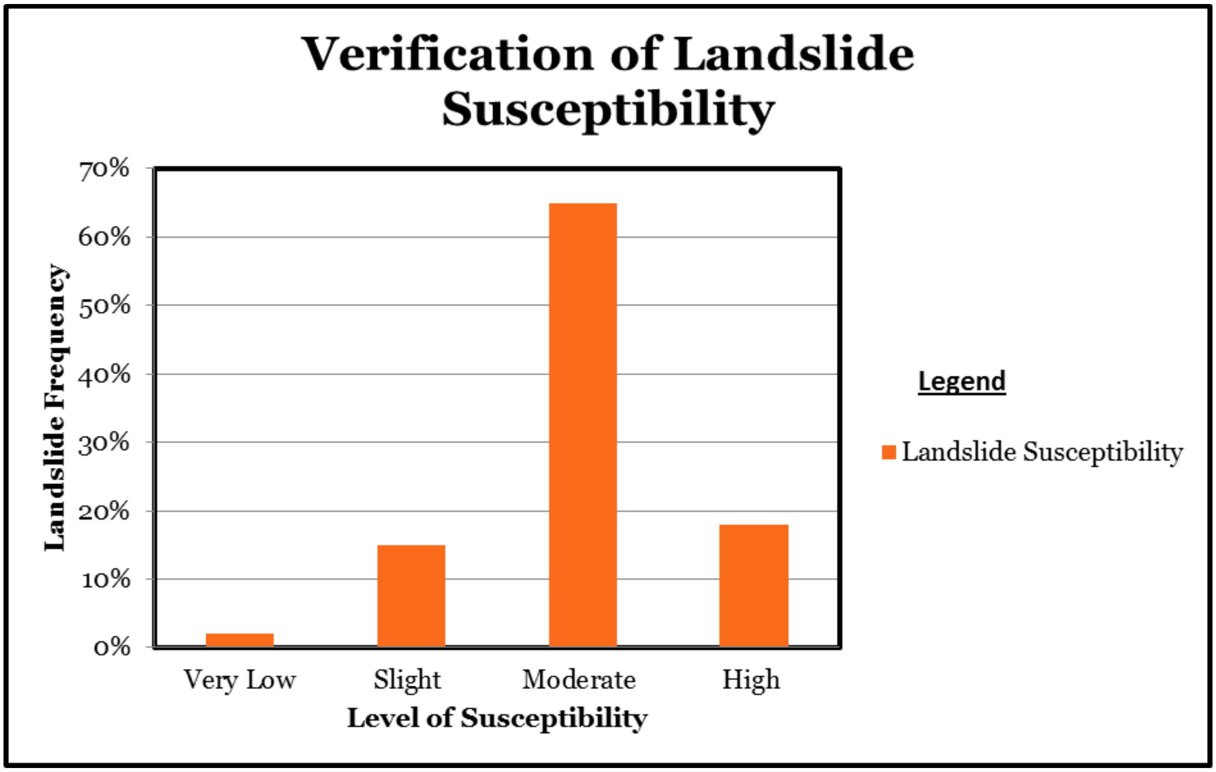

Figure 4-34 Histogram verifying susceptibility for existing landslides

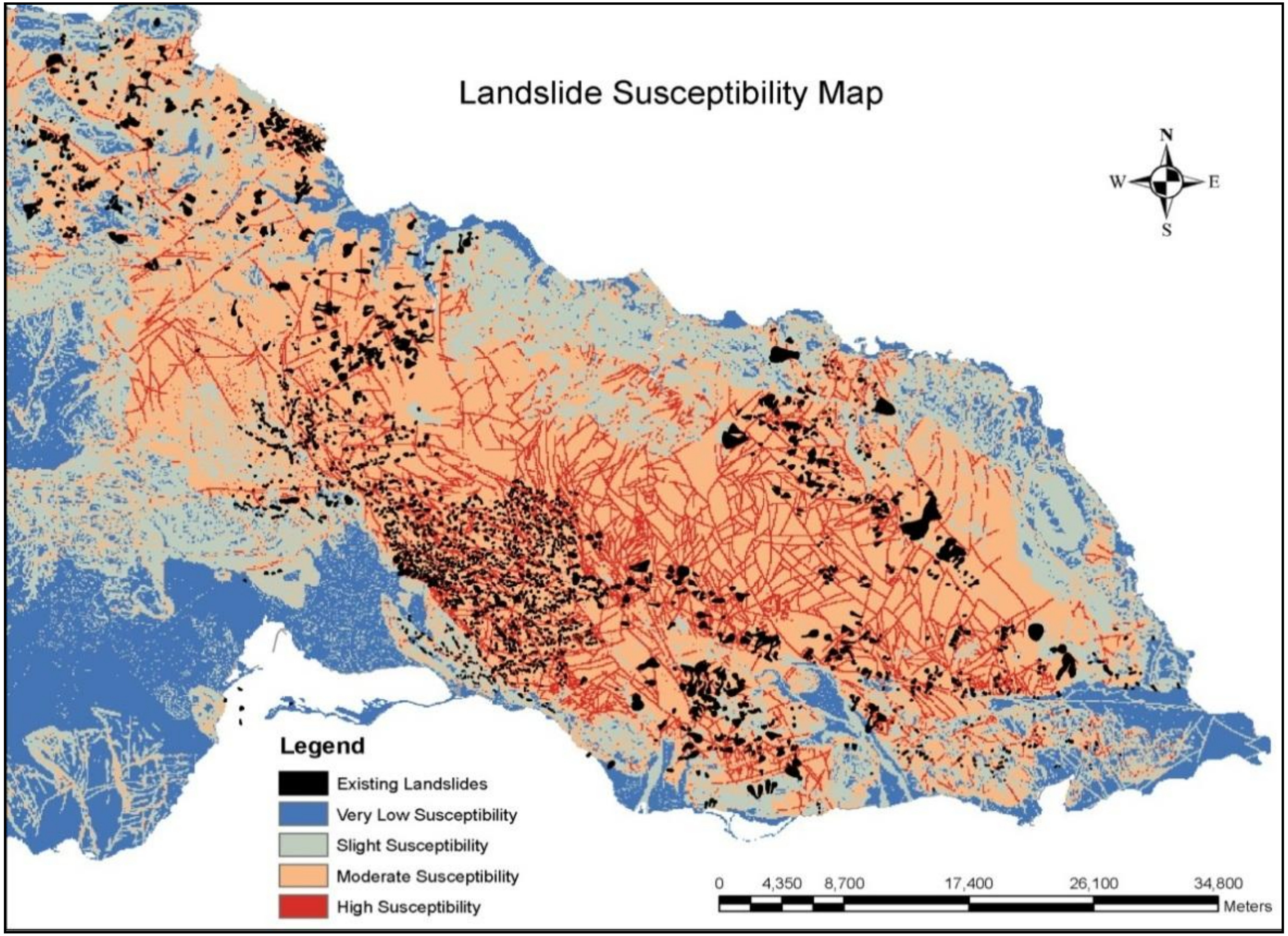

Figure 4-35 Landslide susceptibility shown for existing landslides

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.

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.

4.1.6.2 Collapse Features

The possibility of collapse features developing in the Moneague plateau limestones is small. There appear to be no records of such occurrences. In areas where detailed observations during the building of the highway reveal sections where cave systems are encountered, then a local ground penetrating radar investigation is recommended.

4.1.6.3 Flooding

Flooding is unlikely to affect the proposed line of the highway from Moneague to Malvern Park. The proposed route crosses one depression as indicated on the 12,500 topographic maps (blue circle on Figure 4-36) but flooding has not been reported from that locality.

On the descent through Malvern Park to Mammee Bay, flooding can occur through overbank discharge from the numerous rivers. Additionally, experience has shown that, during extended periods of precipitation, extreme flooding, erosion and destruction of road beds and property can occur as in Fern Gully and Ocho Rios (Water Resources Authority, 2008). The red circles on Figure 4-5 mark those locations where the proposed route crosses Harbridges Gully system a number of times.

Miller et al, 2001 (Water resources assessment of Jamaica), reports that rainfall in this parish is quickly absorbed in to the limestone substrata and that sink holes and collapse features are present. The parish mean annual rainfall was 1,596 millimetres (63 inches) from 1951 to 1980.

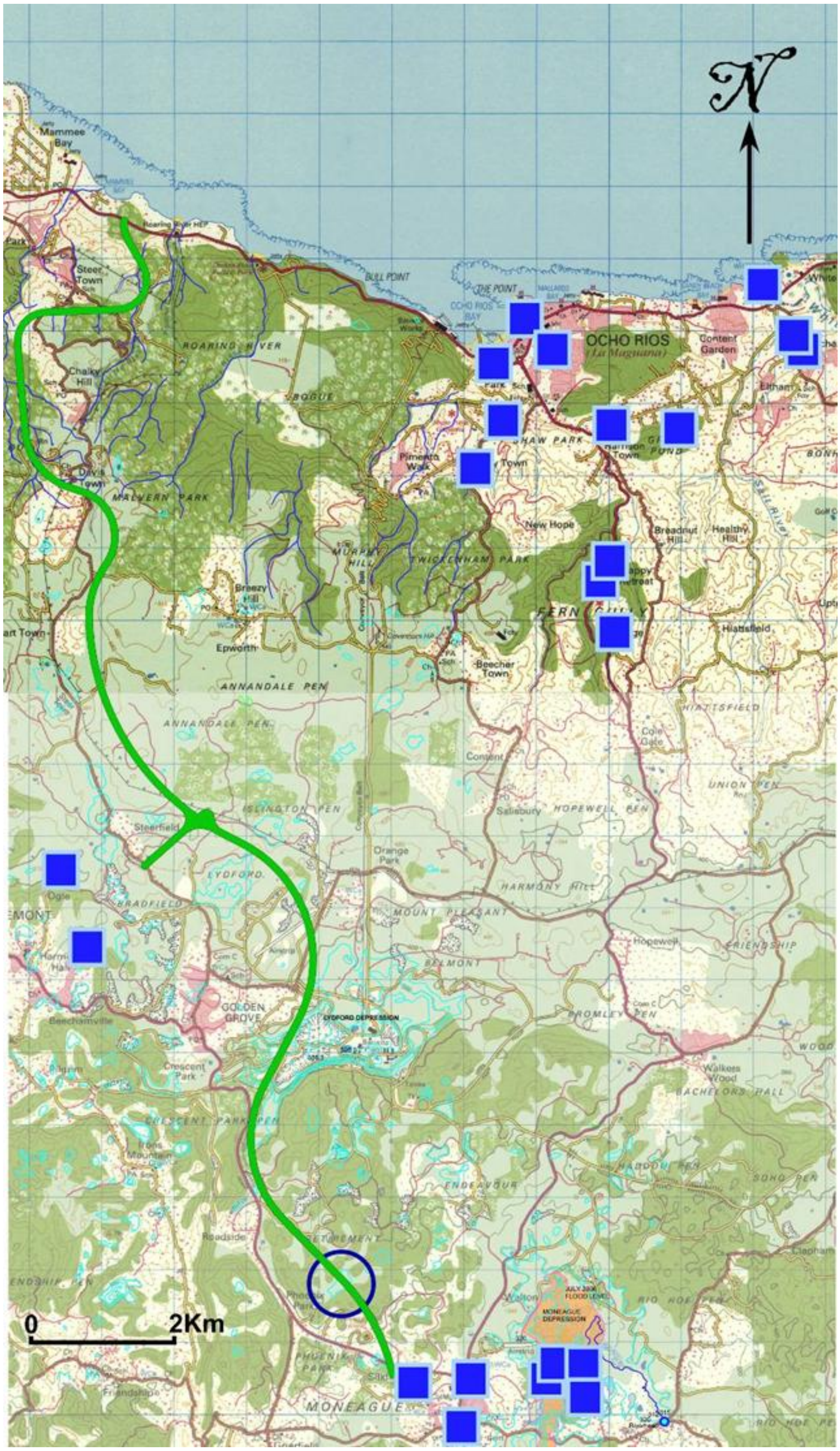

Figure 4-36 - Historical flood events recorded in the vicinity of the proposed highway (modified from Lyew-Ayee Jr and Ahmad 2012)

It is note worthy that one factor that influenced the floods in the Beecher Town - Ocho Rios flood event of 2008 was that of recent road construction that diverted surface run off flow away from their natural paths in to sink holes resulting in run off channelled onto the Fern Gully to Ocho Rios main road (WRA, 2008).

There is low risk of flooding for Section 1 (between Moneague and Malvern Park), but higher risk for Section 2 (Between Malvern Park and Mammee Bay) which crosses several active gully systems. The risk is also greater on the narrow coastal plain where alluvial fans are present.

4.1.6.4 Earthquakes

Figure 4-37 indicates the probability of ground accelerations of a given magnitude being exceeded in a given period. Phase 3 of the North-South Highway project lies within the zone where the probability of exceedence of accelerations between 245 and 270 gals in a fifty year period is 10%. The main concerns will be associated with the geotechnical/engineering issues to be addressed during and after highway excavation, particularly across the northern part from the plateau to the coastline.

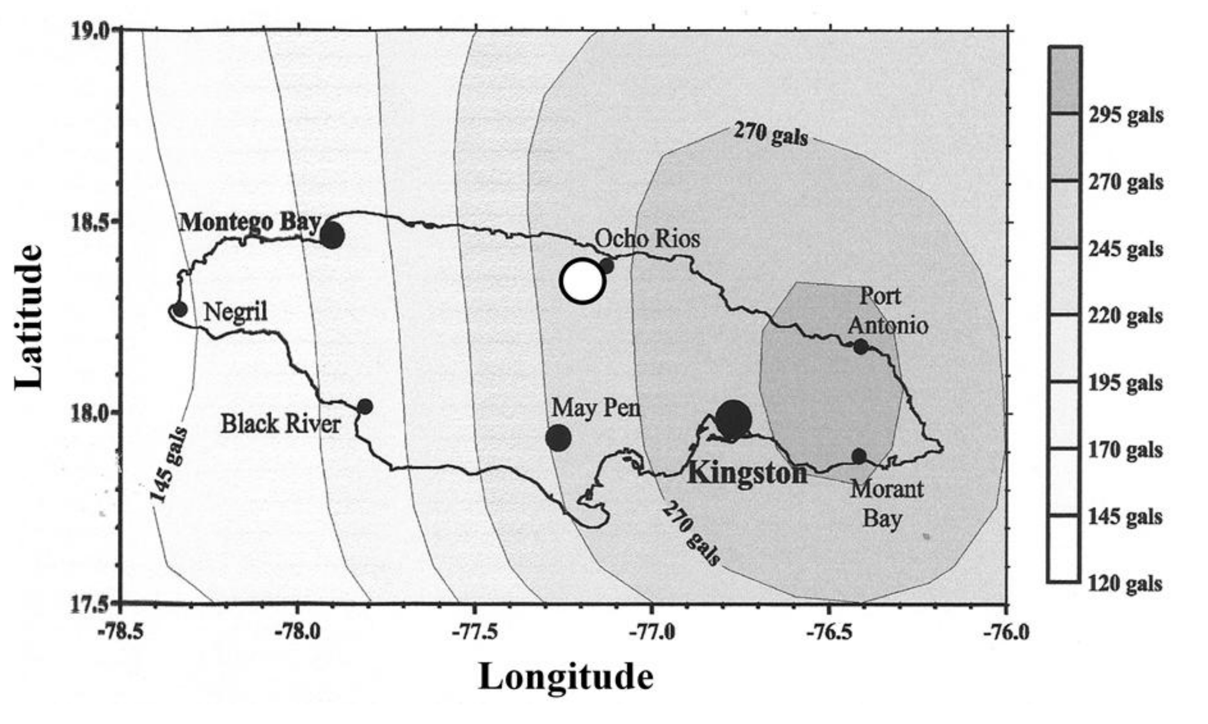

Figure 4-37 - Horizontal ground acceleration with 10% probability of exceedence in fifty years (Shepherd et al. 1999 in CDMP 2001), Contour interval is 25 gals (2.5%g). Modified from Robinson & Khan, 2012 and corrected from CDMP 2001. White spot is Phase 3 highway location of the Rio Cobre Gorge *bypass (Robinson & Khan, 2012), while Ocho Rios lies adjacent to the northern end of Phase 3.*

Slope failure will be of low risk on Section 1 (between Moneague and Malvern Park) apart from local rock falls induced by heavy rain or earthquakes and during construction. A greater risk exists on Section 2 (Between Malvern Park and Mammee Bay) which traverses chalky limestones of variable resistance to rain or seismic events. More detailed geotechnical mapping should be carried out to evaluate the rock quality. Debris fans along the coast could be susceptible to slope movement and may be obscured by thick travertine deposits.

Earthquake Epicentres

Historically, there were three (3) known earthquake epicentres within one (1) kilometre of the proposed Moneague to Ocho Rios alignment (Figure 4-38). These occurred in February 18, 1917 in the Crescent area of Moneague with an intensity of V on the Modified Mercalli (MMI) scale, also on February 18, 1917 in the Drax Hall area (MMI V) and on March 21, 1930 in the Silkfield area of Moneague (MMI IV).

Figure 4-38 - Map showing historic earthquake epicentres within 1km of the Proposed Moneague to Ocho Rios alignment

4.1.7 Debris Flow

4.1.7.1 Methodology

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. The formula for USLE is:

$$A = R \times K \times LS \times C \times P$$

Where A is the average annual soil loss measured in tons/acre, R is the rainfall erosion index, K is the soil erodibility factor, LS is the length-slope factor, C is the cover factor and P is the erosion control practice factor.

The rainfall erosion index (R) is the product of the total raindrop energy (E) and the maximum 30-minute intensity (I_{30}). The I_{30} values for a specific location were obtained by summing the I_{30} values for significant storms from a maximum 22-year record to obtain an average annual index value. The values of EI_{30} were obtained using:

$$EI_{30-annual} = 12.142(abc)^{0.6446}$$

where a is the annual precipitation, b is the annual maximum daily precipitation and c is the annual maximum hourly precipitation, all derived from rainfall datasets, so that average annual total of the storm EI values (R-factor) may be computed as:

$$R = \frac{1}{N}\sum_{1}^{N} EI_{30-annual}$$

where N is the year period.

The K factor is an empirical value representing the erodibility per rainfall erosion unit. Generally, soils with $K < 0.23$ are low-erodibility soils and soils with $K > 0.41$ are considered highly erodible.

The combined topographic effects of length and steepness of a slope are accounted for in the LS factor. LS values range from less than 1 for short, flat slopes to nearly 50 for long, steep slopes, as demonstrated by the equation:

$$LS = \left(\frac{L}{72.6}\right)^m \left(\frac{430x^2 + 30x + 0.43}{6.574}\right)$$

Where L is the slope length in feet from the point of origin of overland flow to either the point where slope decreases to the extent that deposition occurs or the point where runoff enters well-defined channels, m = 0.5 for slopes ≥ 5%, m = 0.4 for slopes 3.5% and 4.5%, m = 0.3 for slopes ≤ 3%, x = sin θ where θ is slope angle in degrees.

The C factor is essentially a ratio of the soil loss from a specific cover condition to the soil loss from a clean, tilled, fallow condition for the same soil, slope and rainfall conditions. It is an index of the type of ground cover and the condition of the soil over the area.

The P factor is defined as the ratio of soil loss with a given surface condition (contouring, control structures, roughening the soil) to soil loss with up-and-down hill ploughing. This factor accounts for ground surface conditions that affect the runoff velocity.

4.1.7.2 Results

Debris flow in the rivers and streams typically include soils, trees and other loose materials. To a greater extent, the experience to date is that during continuous torrential rains, animals and old household item are observed flowing downstream. Analysis of the predicted soil loss map (Figure 4-39) concluded that the majority of the Moneague alignment traverses moderate soil loss zones. More importantly, high loss regions are crossed between Chalky Hill and Steer Town. Thus the designers should take the necessary precautions as outlined in the following section to have sediment traps or adequate clearance under the openings to ensure sufficient hydraulic capacity during the life of the bridges/openings. Figure 4-40 and Figure 4-41 illustrates the recommended culvert/bridge openings along the proposed H2K Moneague alignment.

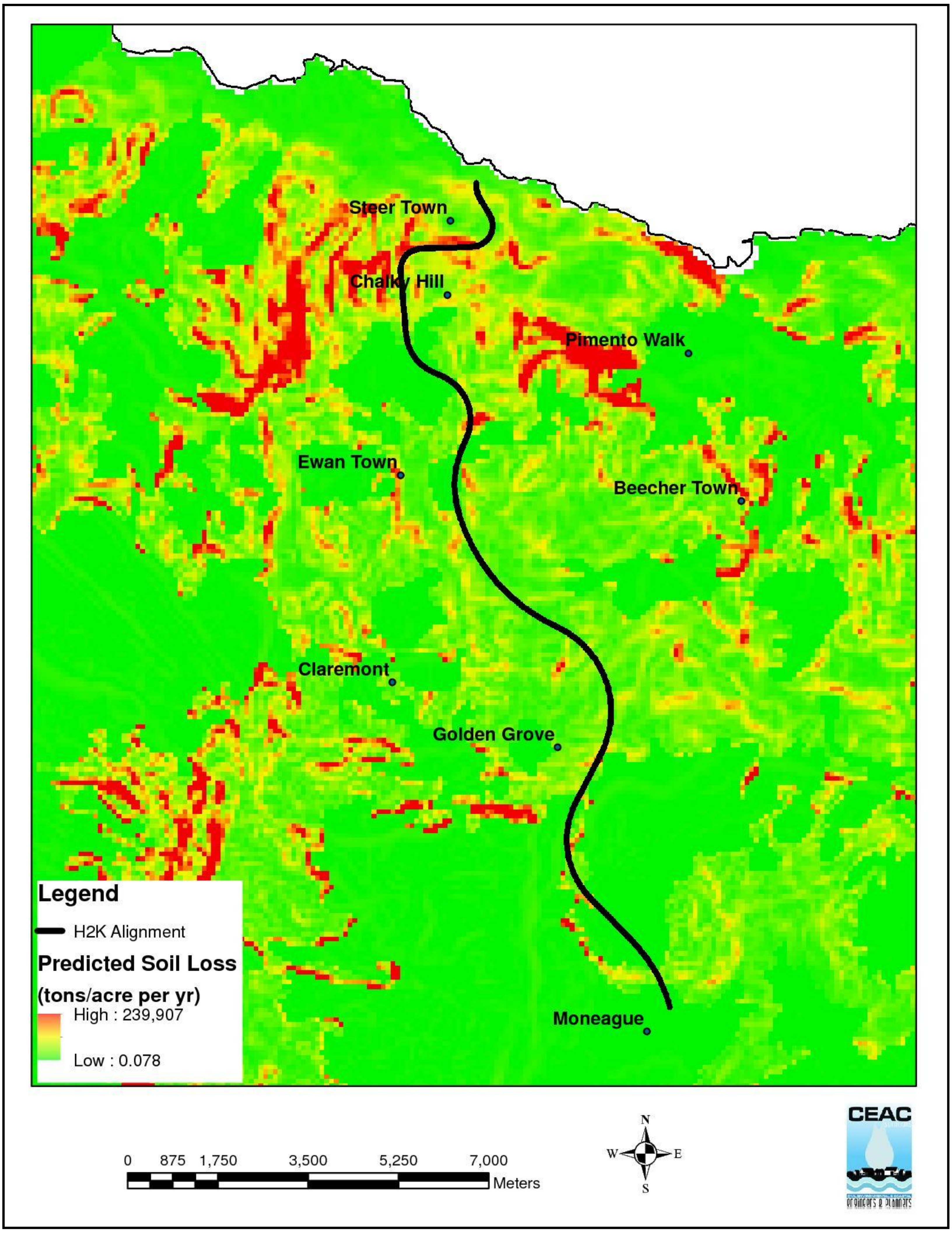

Figure 4-39 Graphical representation of predicted soil loss (T/acre.hour) along the alignment

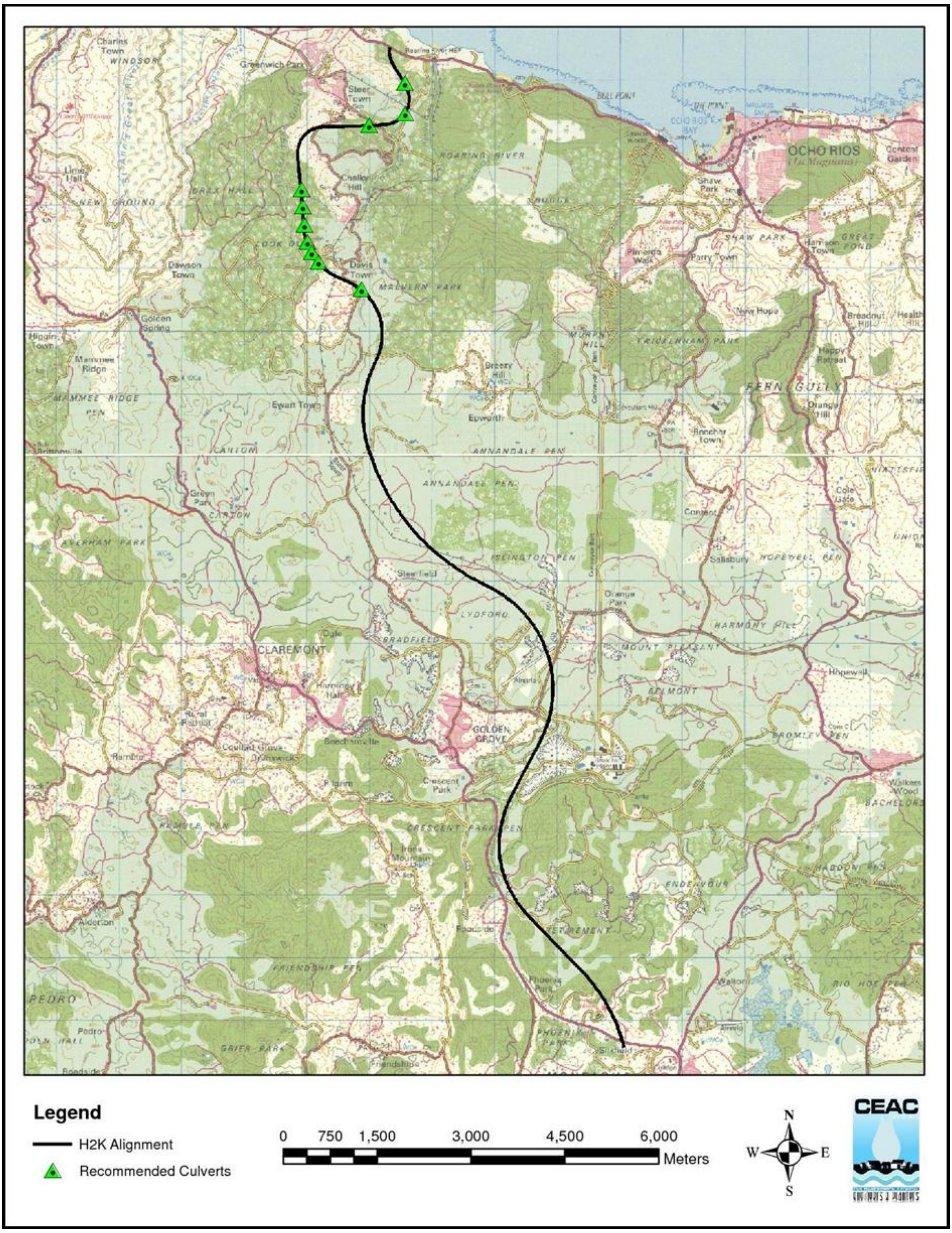

Figure 4-40 – Map Showing recommended culvert and bridge openings

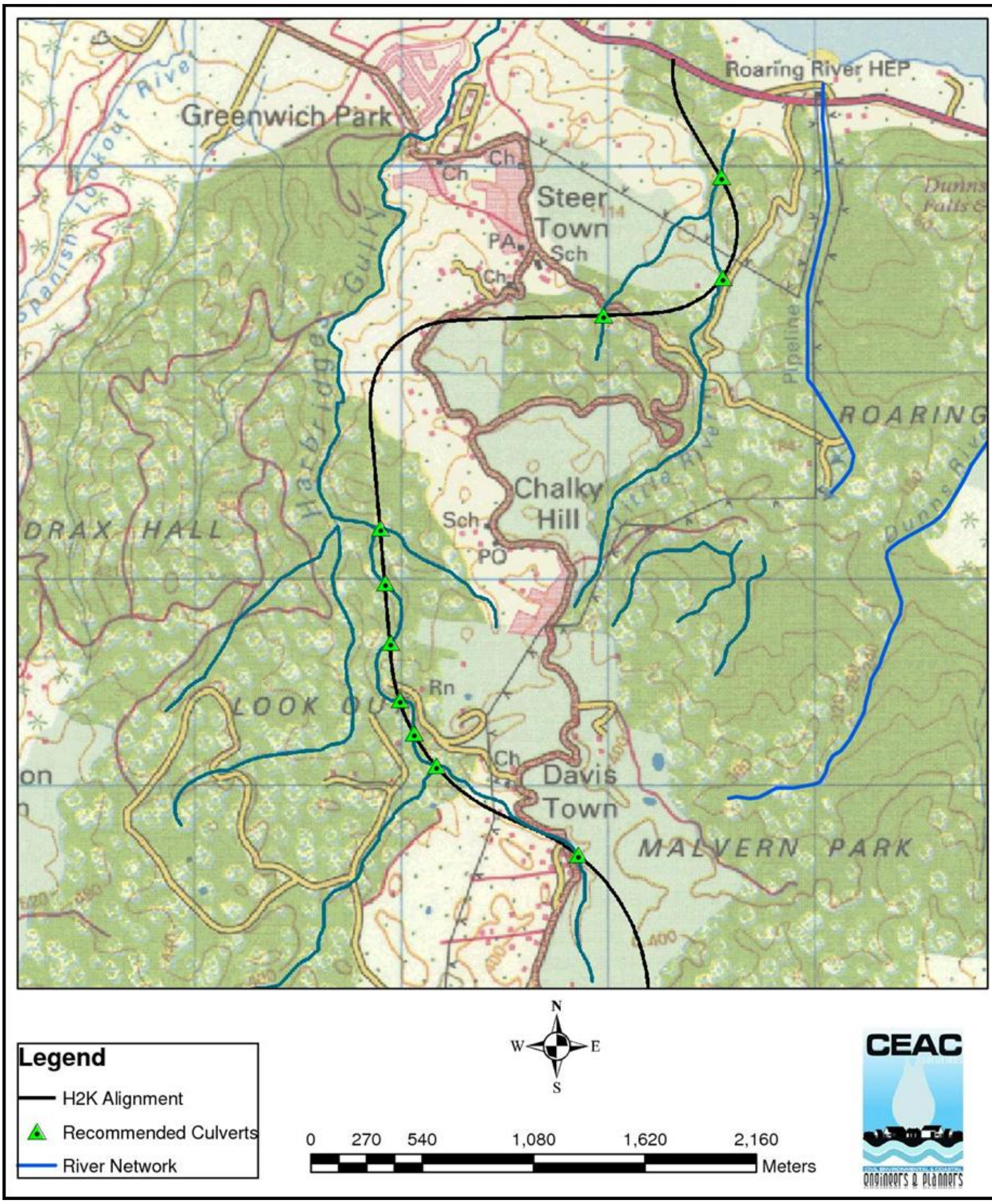

Figure 4-41 Map Showing close up view of recommended culvert and bridge openings

4.1.8 Water Quality

4.1.8.1 Methodology

A total of three water quality exercises were conducted.

The first water quality sampling exercise was conducted on August 15th 2012 between the hours of 9:00am and 3:00pm. Weather conditions were fair and sunny at the time of sampling.

The second water quality sampling exercise was conducted on August 22nd, 2012 between the hours of 9:30am and 1:00pm. Weather conditions were partly cloudy at the time of sampling.

The third water quality sampling exercise was conducted on August 30th, 2012 between the hours of 11:00am and 1:30pm. Weather conditions were fair and sunny at the time of sampling. During the week prior to this, there had been heavy rainfall island wide due to Tropical Storm Isaac.

Physicochemical data at each location was recorded using a Hydrolab Datasonde DS-5 water quality multiprobe (See Appendix 4 for calibration certificate). These parameters included temperature, salinity, conductivity, dissolved oxygen, pH and turbidity. At each location, samples were collected in pre-cleaned plastic and glass bottles, stored on ice and sent to Caribbean Environmental Testing and Monitoring Services for analysis of Total Suspended Solids (TSS), nitrates, phosphates, faecal coliform and Fats Oil and Grease (FOG). Water quality values obtained were compared with the Draft NEPA Ambient Freshwater Quality Standards.

The water sampling locations and coordinates are shown in Table 4-16 and Figure 4-42.

Table 4-16 – Water quality sampling locations and coordinates

STATION	LOCATION	TYPE OF WATER	JAD 2001	
			Northing (m)	Easting (m)
WQ1	Laughing waters river mouth	Surface Water	734204.724	696789.785
WQ2	Headwaters of Roaring river	Surface Water	734232.283	694878.834
WQ3	Tributary of Roaring river	Surface Water	733541.224	695340.589
WQ4	Thicketts well #4	Groundwater	732435.249	690371.689

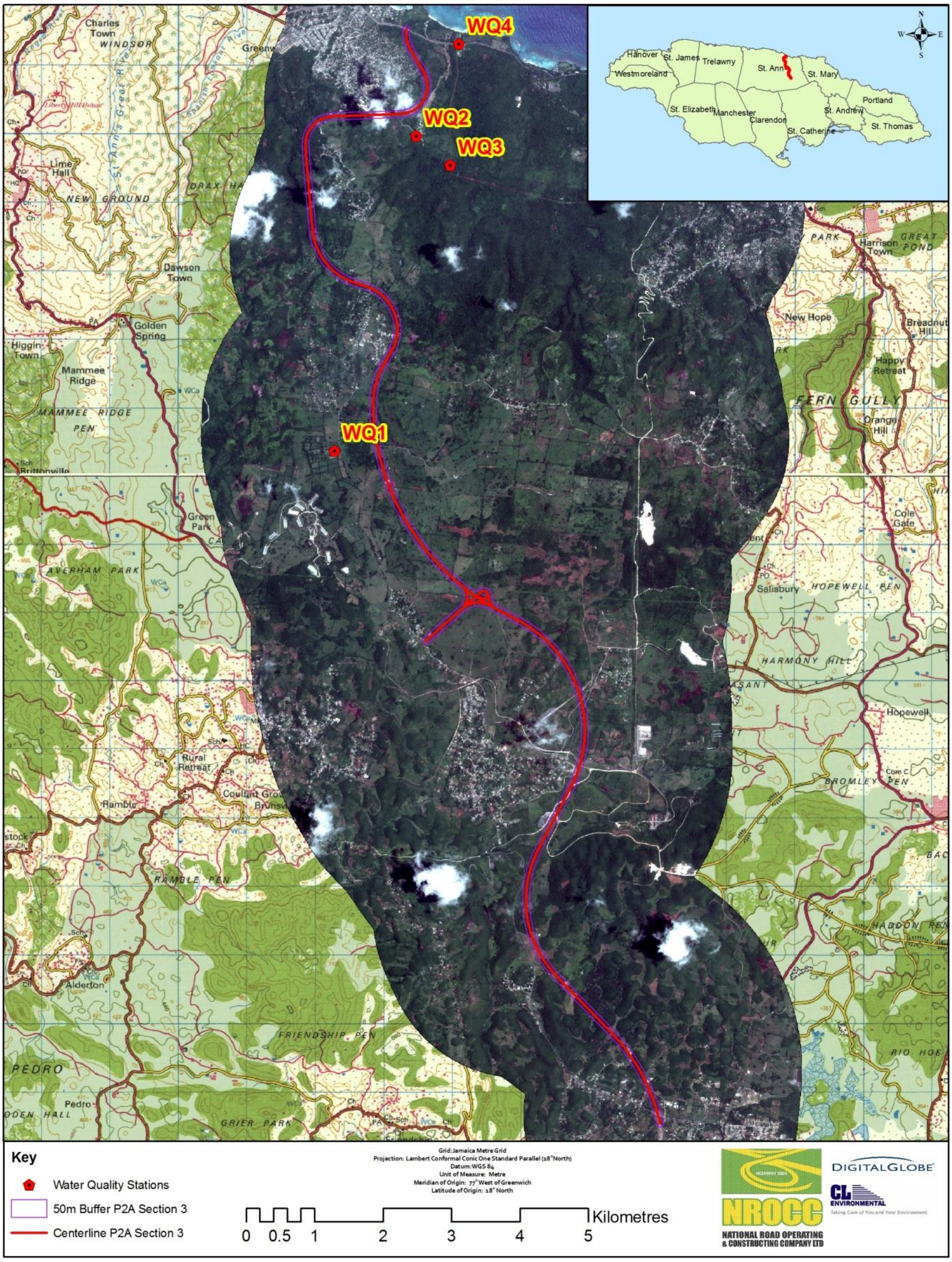

Figure 4-42 – Map showing water quality sampling locations

Plate 4-13 - Photo showing WQ4– Thickets well #4

Plate 4-14 - Photo showing WQ3 – Tributary of Roaring River

Plate 4-15 - Photo showing WQ2– Headwaters of Roaring River

Plate 4-16 - Photo showing WQ1 – Laughing Waters

4.1.8.2 Results

Table 4-17 and Table 4-18 show physical and biochemical water quality result at the various sampling stations.

Table 4-17 –Physical water quality results (mean, low and high)

Stn.	Temp. (C°)	Low	High	Sal. (ppt)	Low	High	DO (mg/l)	Low	High	pH	Low	High	Turb. (NTU)	Low	High
WQ1	22.61	22.57	22.68	0.18	0.18	0.18	5.25	0	7.97	8.06	7.74	8.29	2.23	0	4.2
WQ2	24.61	24.17	25.10	0.21	0.20	0.21	4.61	0	6.92	8.21	8.03	8.35	0.00	0	0
WQ3	23.66	22.78	24.71	0.17	0.16	0.18	8.27	8.19	8.36	8.30	8.18	8.59	0.94	0	2.63
WQ4	24.43	23.79	25.11	0.19	0.19	0.19	7.46	7.35	7.53	7.89	7.58	8.22	0.00	0	0
NEPA Ambient Freshwater Std.				-			-			*7 – 8.4*					

Table 4-18 –Chemical and Biological water quality results (mean, low and high)

Stn.	TSS (mg/l)	Low	High	Nitr. (mg/l)	Low	High	Phosph. (mg/l)	Low	High	FOG (mg/l)	Low	High	F. coli (MPN/100ml)	Low	High
WQ1	3.33	2	5	1.23	1.1	1.4	0.03	0.02	0.05	1.81	0.57	4	63.67	<11	160
WQ2	1.33	1	2	0.90	0.7	1.2	0.07	0.06	0.08	2.10	1.43	2.57	143.00	69	230
WQ3	9.00	3	19	0.97	0.3	1.4	0.14	0.04	0.27	2.10	1.14	2.86	136.67	<20	230
WQ4	0.33	0	1	1.07	1	1.1	0.12	0.03	0.17	2.29	1.14	3.43	14.00	<11	<20
NEPA Ambient Freshwater Std.	-			*0.1 – 7.5*			*0.01 – 0.8*			-			-		

Values highlighted in red are non-compliant with NEPA Standards

Temperature

The average temperature across the stations varied, ranging from 22.61 – 24.61 ^{o}C. Station WQ2 had the highest average temperature whereas station WQ1 had the lowest average temperature.

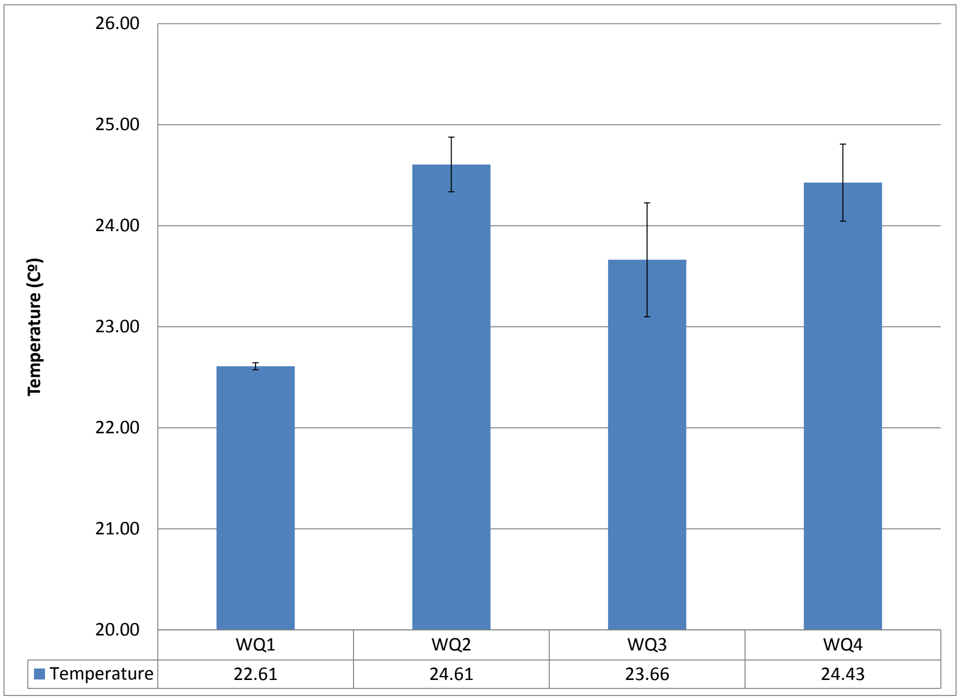

Figure 4-43 - Average temperature values for stations WQ1 – WQ4 with standard error.

Salinity

Average salinity values across the stations were generally low ranging from 0.18 – 0.21 ppt. The highest average value was obtained at station WQ2 whereas station WQ3 had the lowest value.

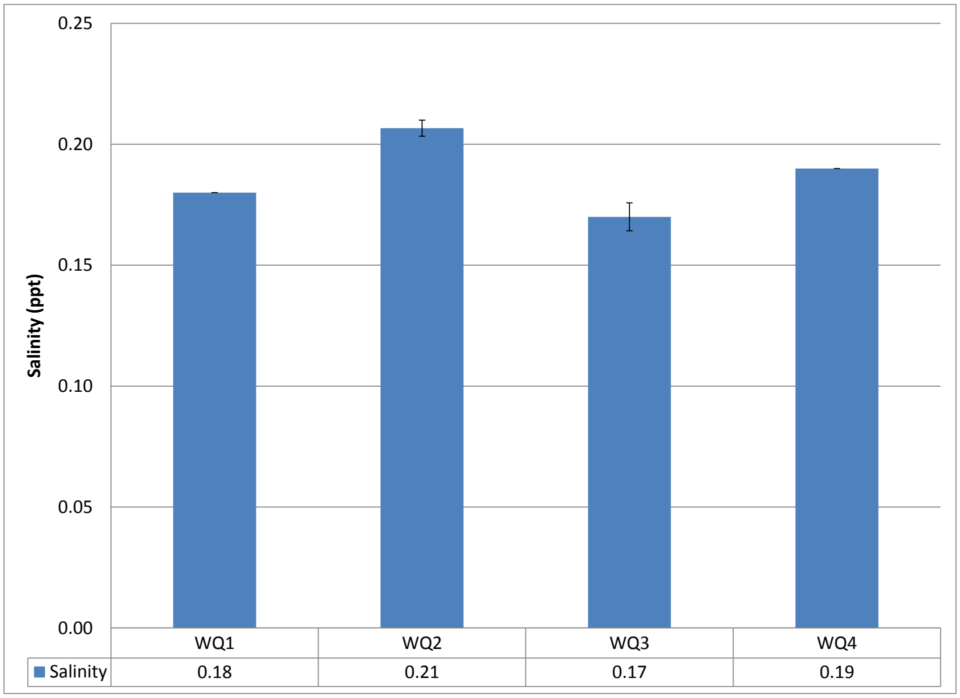

Figure 4-44 Average Salinity values for stations WQ1 – WQ4 with standard error.

Dissolved Oxygen

Average dissolved oxygen values varied across the stations ranging from 4.61 – 8.27mg/l. The lowest average was obtained at station WQ2, whereas the highest average was obtained at station WQ3.

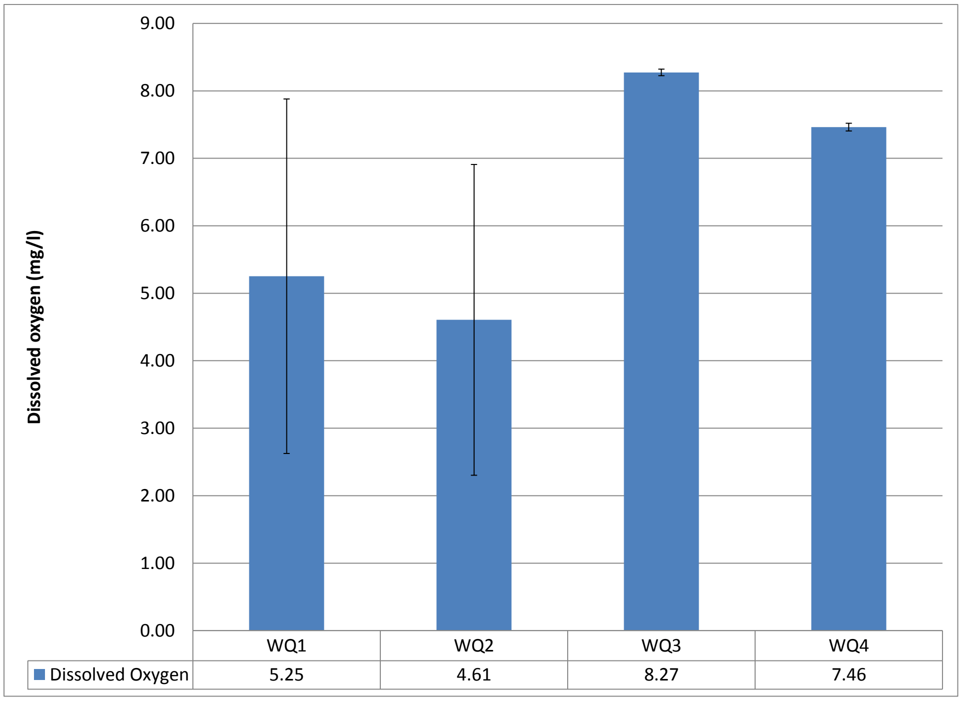

Figure 4-45 Average dissolved oxygen values for stations WQ1 – WQ4 with standard error.

pH

Average pH values varied little across the stations ranging from 7.89 – 8.3. The highest average pH was obtained at station WQ3, whereas the lowest average value was obtained at station WQ4.

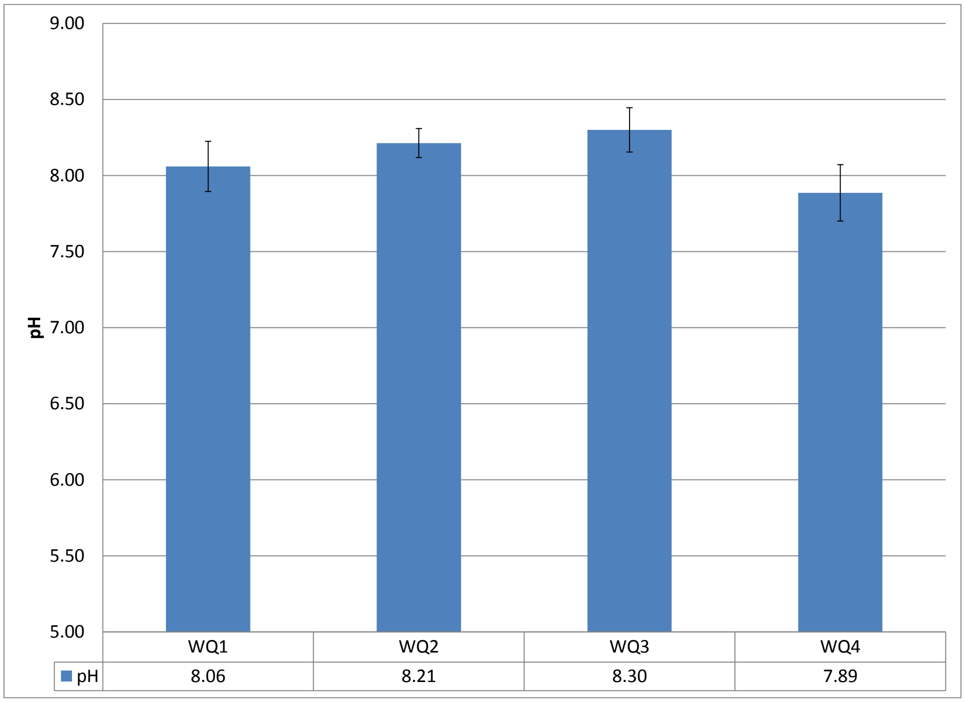

Figure 4-46 Average pH values for stations WQ1 – WQ4 with standard error.

Turbidity

Average turbidity values varied across the stations ranging from 0.00 – 2.23 NTU. The lowest average values were obtained at stations WQ2 and WQ4, whereas the highest average was obtained station WQ1.

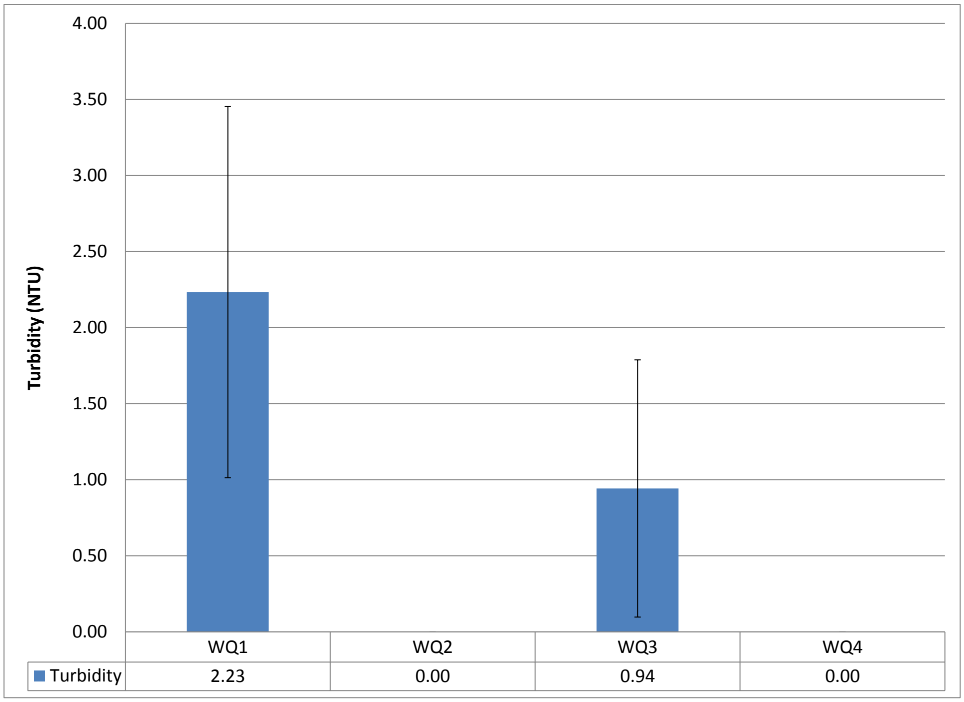

Figure 4-47 Average turbidity values for stations WQ1 – WQ4 with standard error.

Total Suspended Solids (TSS)

Average TSS values varied across the stations ranging from 0.33 – 9mg/l. The highest average value was obtained at station WQ3, whereas the lowest average value was obtained at station WQ4.

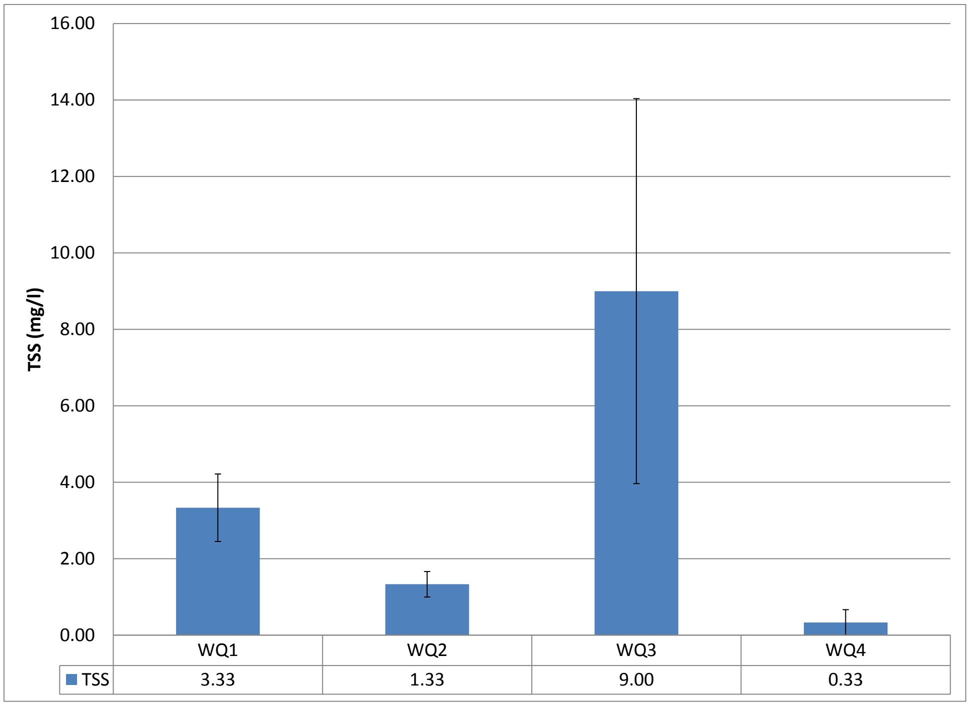

Figure 4-48 Average TSS values for stations WQ1 – WQ4 wih standard error.

Nitrates

Average nitrate values varied across the stations ranging from 0.90 – 1.23mg/l. The highest average value was obtained at station WQ1, whereas the lowest average value was obtained at station WQ2.

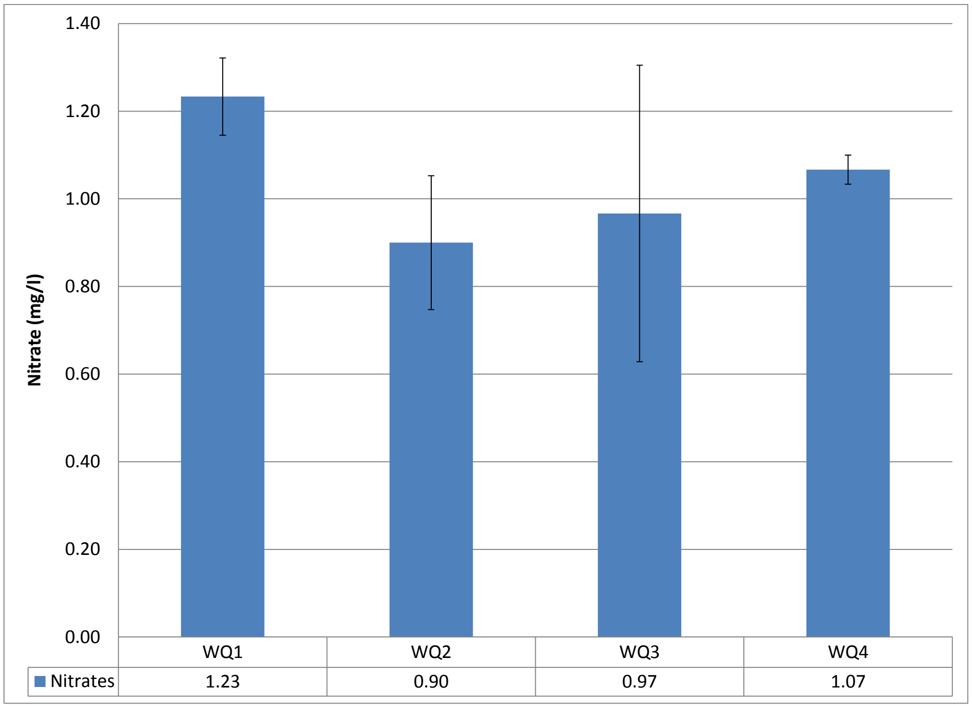

Figure 4-49 Average Nitrate values for stations WQ1 – WQ4 with standard error.

Phosphates

Average phosphate values varied across the stations ranging from 0.03 - 0.14mg/l. Lowest values were obtained at station WQ1, whereas the highest value was obtained at station WQ3.

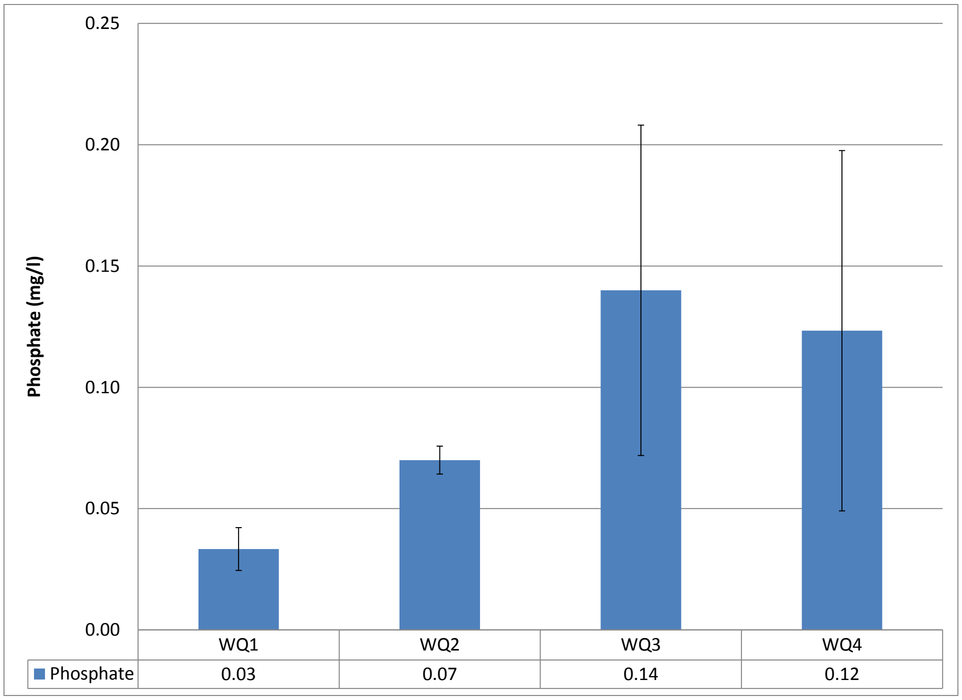

Figure 4-50 Average phosphate values for stations WQ1 – WQ4 with standard error.

Oil and Grease (FOG)

Mean FOG values varied little across stations ranging from 1.81 – 2.29mg/l. The highest average value was obtained at station WQ4, whereas the lowest value was obtained at station WQ1.

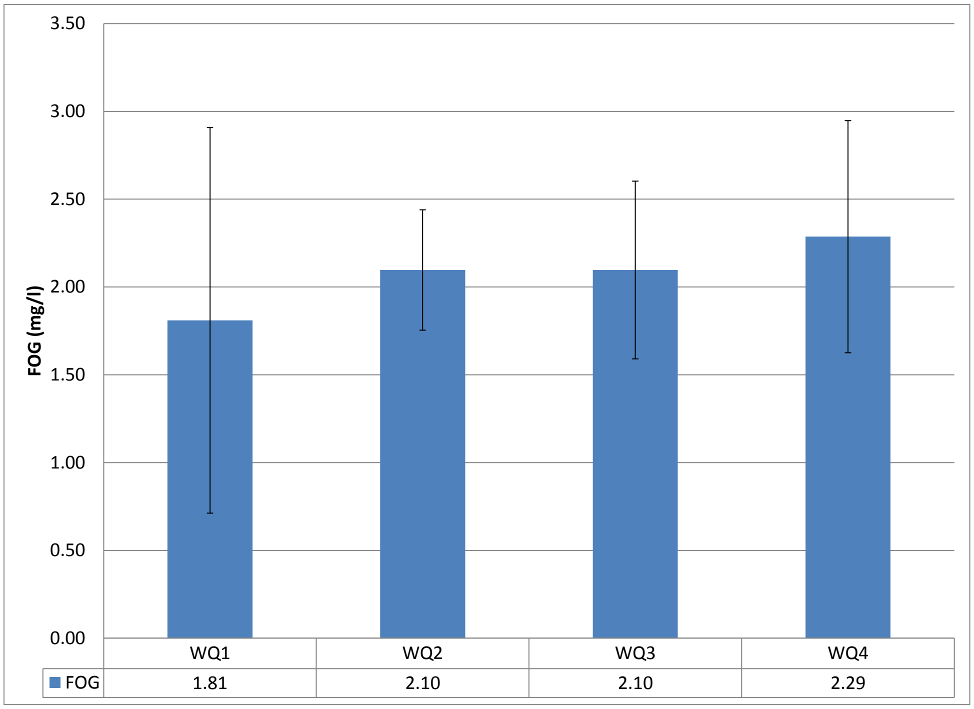

Figure 4-51 Average FOG values for stations WQ1 – WQ4 with standard error.

Faecal Coliform

Average faecal coliform values varied greatly across the stations ranging from 14 – 143 MPN/100ml. The lowest average value was obtained at station WQ4, whereas the highest average value was obtained at station WQ2.

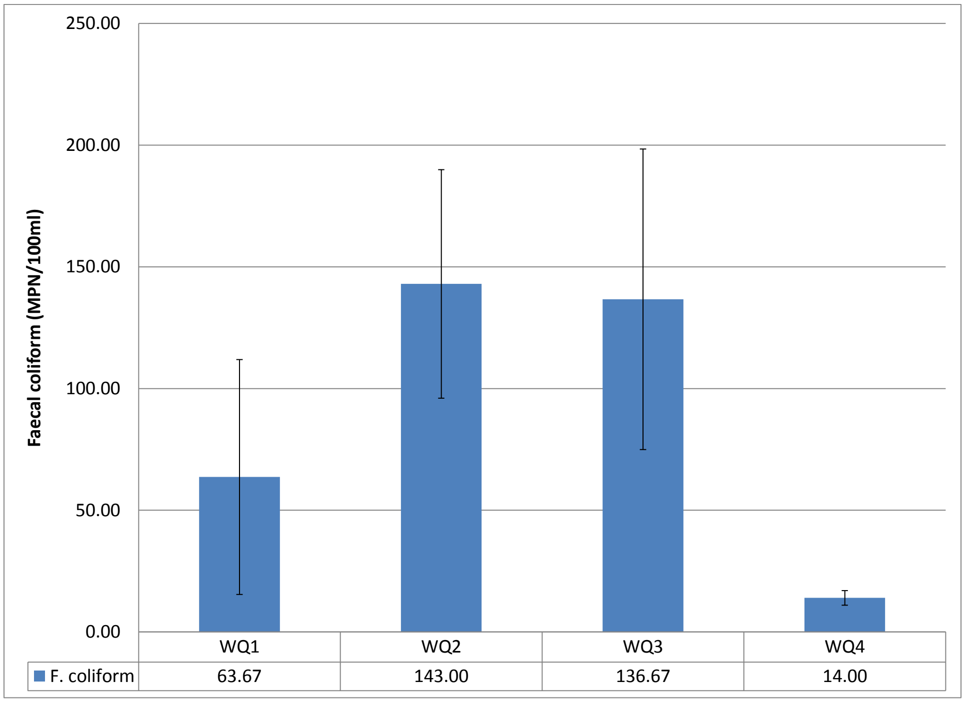

Figure 4-52 Average faecal coliform values for stations WQ1 – WQ4 with standard error.

4.1.9 Ambient Particulates (PM 2.5 & PM 10)

Coarse particles are airborne pollutants that fall between 2.5 and 10 micrometers in diameter. Fine particle are airborne pollutants that fall below 2.5 micrometres in diameter.

Sources of coarse particles include crushing or grinding operations, and dust stirred up by vehicles traveling on roads.

Sources of fine particles include all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes.

4.1.9.1 Methodology

PM2.5 and PM10 particulate sampling was conducted for 24 hours using Airmetrics Minivol Tactical Air Samplers (Plate 4-17). A total of three (3) PM2.5 sampling events and three (3) PM10 sampling events were conducted, each on separate occasions.

The first PM10 sampling exercise was conducted from 12:00am on July 13th, 2012 until 12:00am July 14th, 2012. The second PM10 sampling exercise was conducted from 12:00am on July 29th, 2012 until 12:00am

July 30th, 2012. The third PM10 sampling exercise was conducted from 12:00am on July 31st, 2012 until 12:00am August 1st, 2012.

The first PM2.5 sampling exercise was conducted from 12:00am on August 2nd, 2012 until 12:00am August 3rd, 2012. The second PM2.5 sampling exercise was conducted from 12:00am on August 4th, 2012 until 12:00am August 5th, 2012. The third PM2.5 sampling exercise was conducted from 12:00am on August 9th, 2012 until 12:00am August 10th, 2012.

PM10 and PM2.5 ambient particulate measurements were conducted at four (4) locations along the proposed highway route (Table 4-19 and Figure 4-53).

Table 4-19 - Particulate sampling locations in JAD 2001

STATION	LOCATION	JAD 2001	
		Northing (m)	Easting (m)
P1	Moneague	736,932.590	681,452.034
P2	Lydford	733,534.166	688,139.289
P3	Steer Town All Age School	732,765.414	694,549.276
P4	Roaring River Community	733,567.140	696,178.264

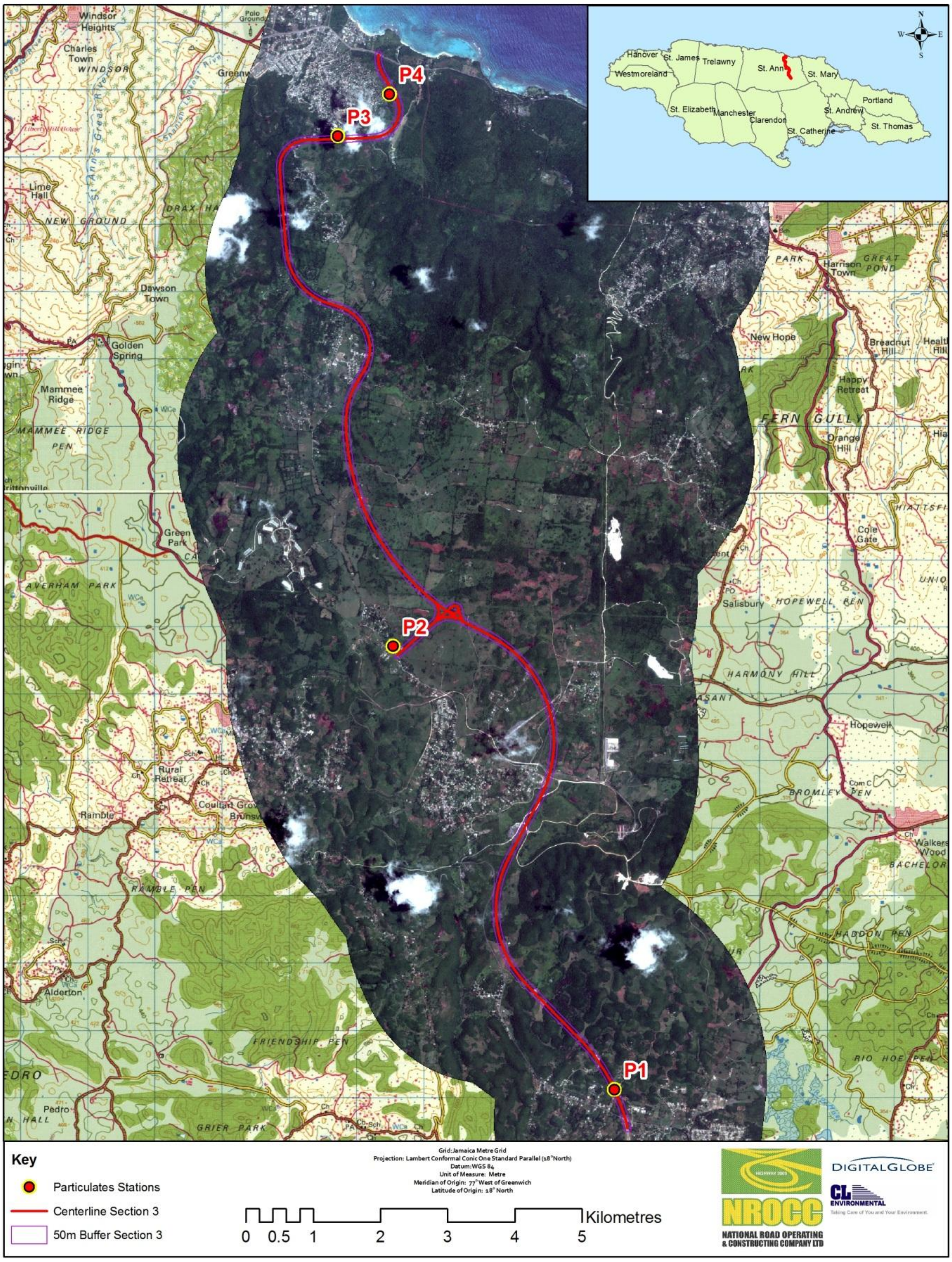

Figure 4-53 – Map showing particulate sampling locations

Plate 4-17 – Photo showing particulate sampler

4.1.9.2 PM 10 Results

For the PM 10 sampling event all locations had particulate values compliant with the 24-hour US EPA standard of 150µg/m3. Station P2 had the highest mean value of 63.7µg/m3 as this station is situated next to the main road and as such will be affected by particulates stirred up from vehicular traffic such as cars and trucks. Station P1 had the lowest mean PM 10 value of 37.06µg/m3. This station is located at a house within a quiet Moneague residence far away from the main road and as such is prone to minor dust nuisance.

The mean results of the PM10 sampling runs are shown in Table 4-20 below.

Table 4-20 - PM 10 Results

STATION	Average Result (µg/m3)	Range (Low to High) (µg/m3)	*US EPA Std. (µg/m3)*
P1	37.06	29.02 – 51.38	**150**
P2	63.7	34.86 – 104.3	**150**
P3	48.42	36.38 – 67.63	**150**
P4	50.51	35 – 61.81	**150**

4.1.9.3 PM 2.5 Results

For the PM 2.5 sampling event all locations had particulate values compliant with the 24-hour US EPA standard of 35 µg/m³. However, on August 2nd, 2012, Station P4 had a value of 36.25 µg/m³ which was non compliant with the standard. Station P4 therefore had the highest mean value of 22.22µg/m³. This community has a lot of mosquitos and as such there is a possibility of burning and "smoking out" the mosquitos which could have resulted in high PM2.5 values. Station P1 had the lowest mean PM 2.5 value of 10 µg/m³. This station is located at a house within a quiet Moneague residence far away from the main road and as such is prone to minor dust nuisance and smoke from vehicular traffic.

The mean results of the PM2.5 sampling runs are shown in Table 4-21 below.

Table 4-21 - PM 2.5 Results

STATION	Average Result (µg/m³)	Range (Low to High) (µg/m³)	*US EPA 24-hr Std. (µg/m³)*
P1	10	6.67 – 13.47	**35**
P2	10.32	6.67 – 15.69	**35**
P3	10.96	9.16 – 12.63	**35**
P4	22.22	13.47 – 36.25	**35**

4.1.10 Ambient NO_x and SO_2

Ambient Nitrogen Oxide and Sulphur Dioxide levels are expected to be low as the alignmentmainly runs through areas of vegetation.

4.1.11 Ambient Noise Climate

4.1.11.1 Methodology

A data logging noise survey exercise was conducted to establish baseline conditions along the proposed highway alignment and its environs. The data logging exercise was conducted for seventy two (72) hours between 7:00 hrs Friday 13th July, to 7:00 hrs Monday 16th, July 2012. The readings were taken at six (6) locations (Stations N1 – N6) listed below in Table 4-22 and depicted in Figure 4-54.

Table 4-22 – Noise Station numbers and locations in JAD2001

STATION	LOCATION	JAD 2001	
		Northing (m)	Easting (m)
N1	Moneague	736,932.590	681,452.034
N2	Golden Grove	735,850.499	686,043.205
N3	Lydford	733,534.166	688,139.289
N4	Annandale Farms	733,374.565	690,033.214
N5	Steer Town All Age	732,765.414	694,549.276
N6	Roaring River Community	733,567.140	696,178.264

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 5). 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 …. N

A windscreen (sponge) was placed over the microphone to prevent measurement errors due to noise caused by wind blowing across the microphone. Plate 4-18 shows one of the noise monitoring outdoor kits.

Plate 4-18 - Photo showing noise meter at Station N4

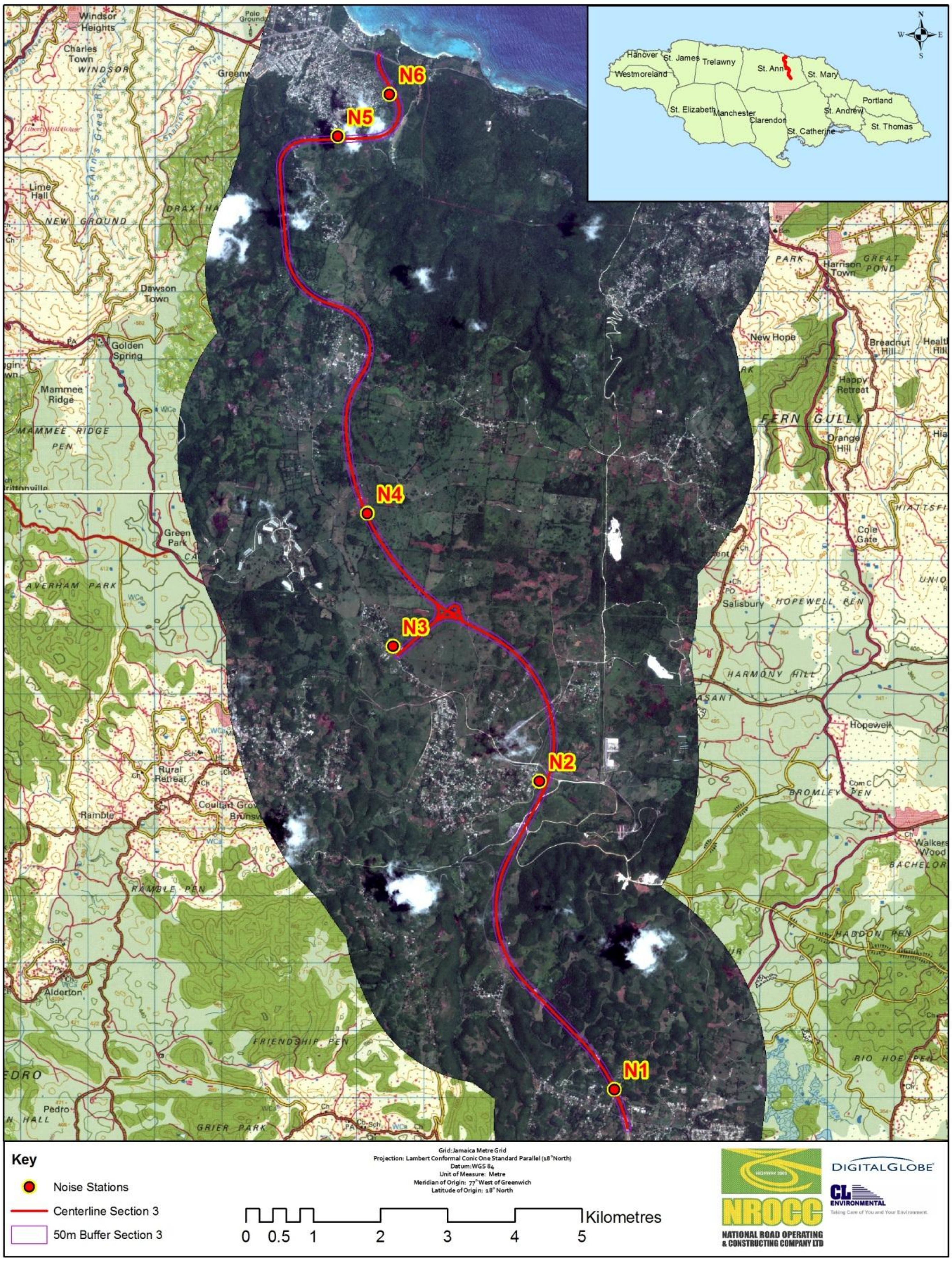

Figure 4-54 – Map showing locations of noise survey stations

4.1.11.2 Results

This section outlines the results of the seventy two (72) hour noise monitoring exercise at the six (6) monitoring stations.

Station 1- Moneague

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 27.2 dBA which occurred at 16:15:30 pm on July 14, 2012 to a high (Lmax) of 84.5 dBA which occurred at 17:03:30 pm on July 13, 2012. Average noise level for this period was 48.8 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-55.

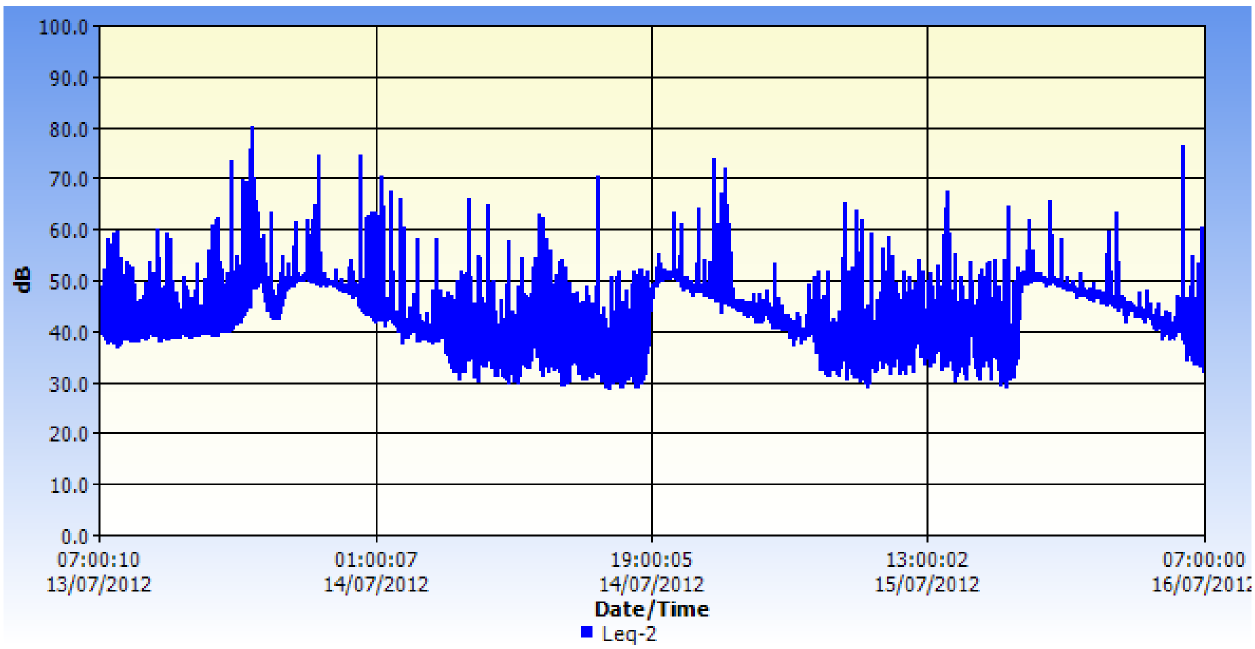

Figure 4-55 - Noise fluctuation (Leq) over 72 hours at Station 1

Octave Band Analysis at Station 1

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz. (octave frequency range is 11 - 14 Hz) (Figure 4-56).

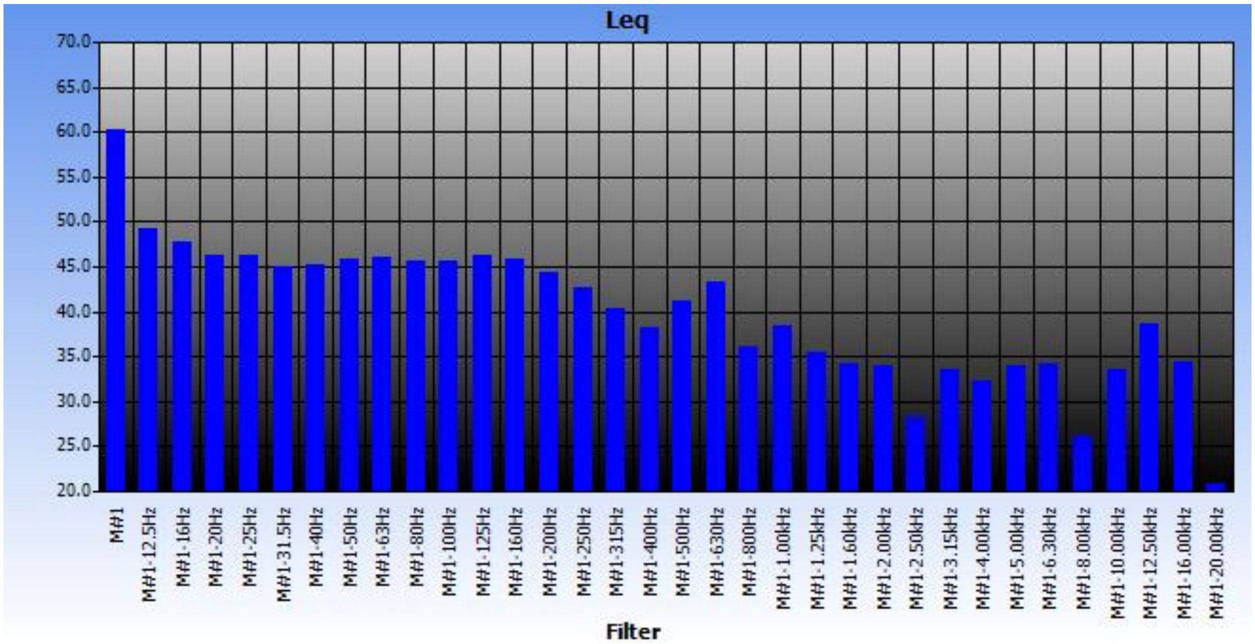

Figure 4-56 - Octave band spectrum of noise at Station 1

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 4-57 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) ≈56.9% of the time, no significant fluctuations (L10 – L90) ≈43.1% of the time and no large fluctuations 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 34.5 dBA respectively.

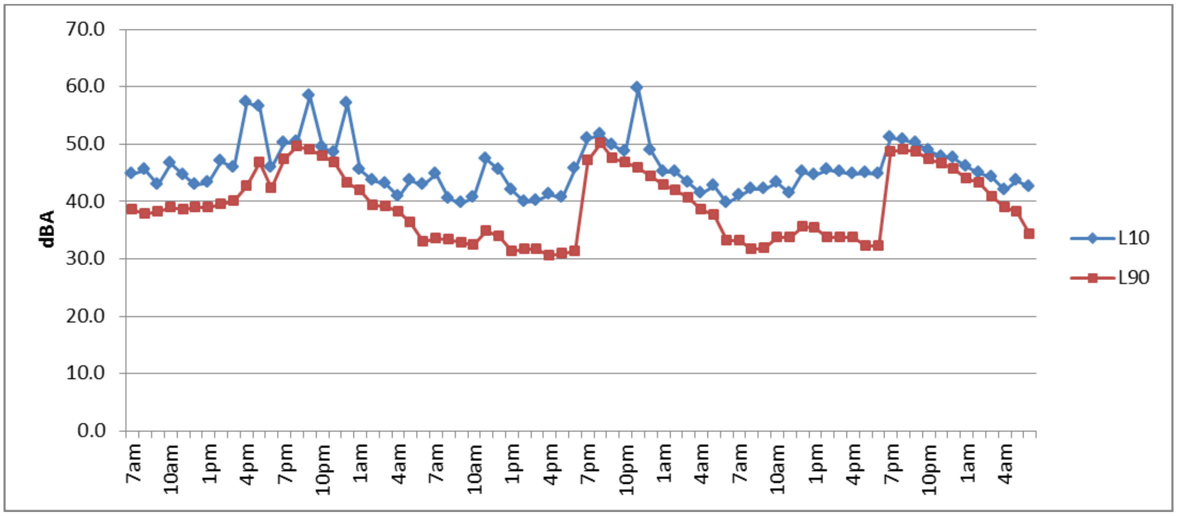

Figure 4-57 - L10 and L90 for Station 1

Station 2 – Golden Grove

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 28.3 dBA which occurred at 17:29:20 pm and 6:09:00 am on July 15 and 16, 2012 respectively, to a high (Lmax) of 89.5 dBA which occurred at 16:59:00 pm on July 13, 2012. Average noise level for this period was 50.6 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-58.

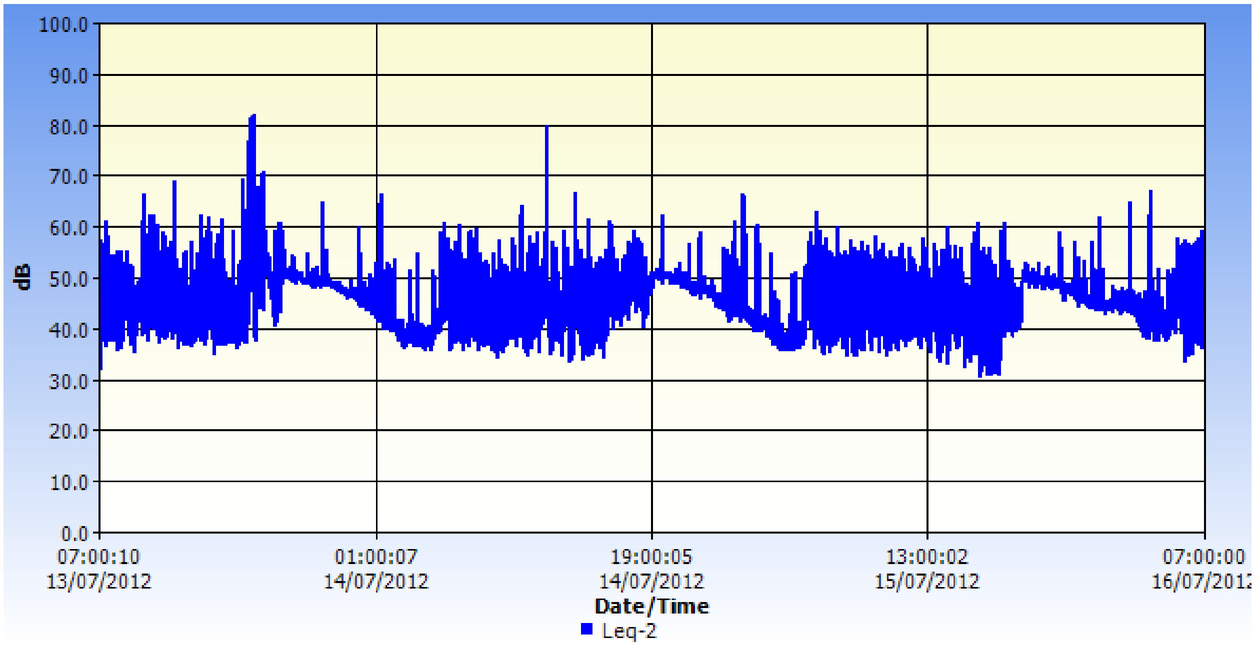

Figure 4-58 -Noise fluctuation (Leq) over 72 hours at Station 2

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 80 Hz. (octave frequency range is 71 - 90Hz) (Figure 4-59).

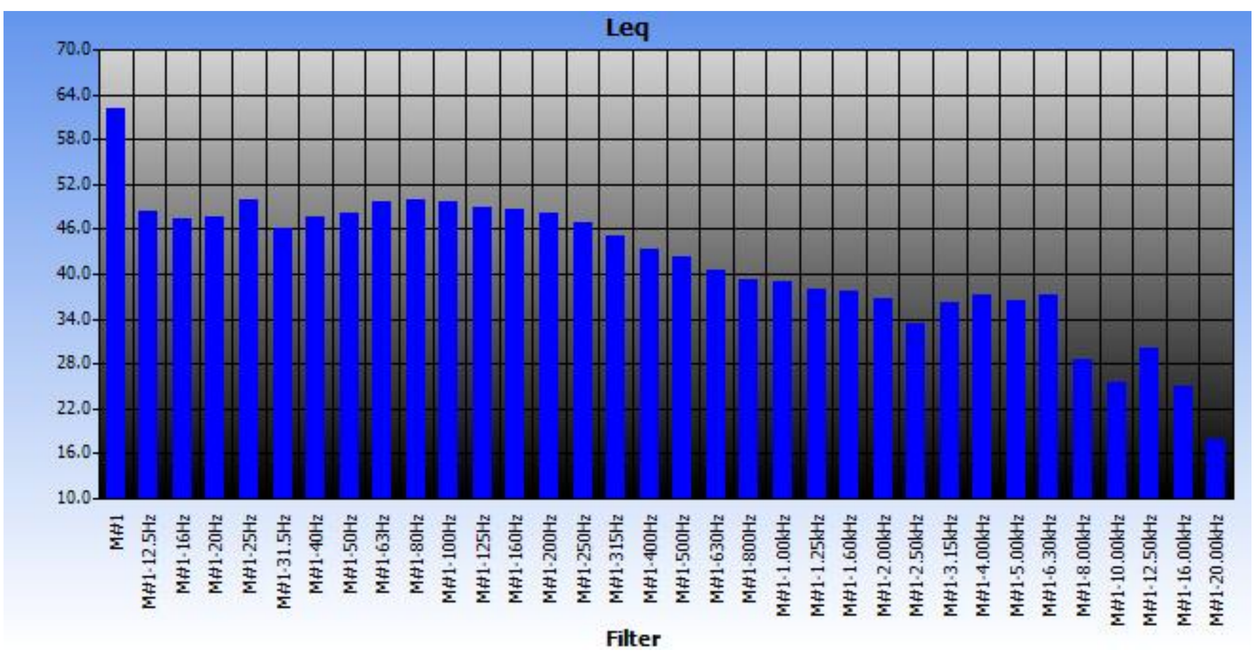

Figure 4-59 -Octave band spectrum of noise at Station 2

L10 and L90 – Station 2

Figure 4-60 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) ≈58.38% of the time, no significant fluctuations (L10 – L90) ≈31.9% and large fluctuations (L10 – L90) ≈9.72% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 50.9 dBA and 38.4 dBA respectively.

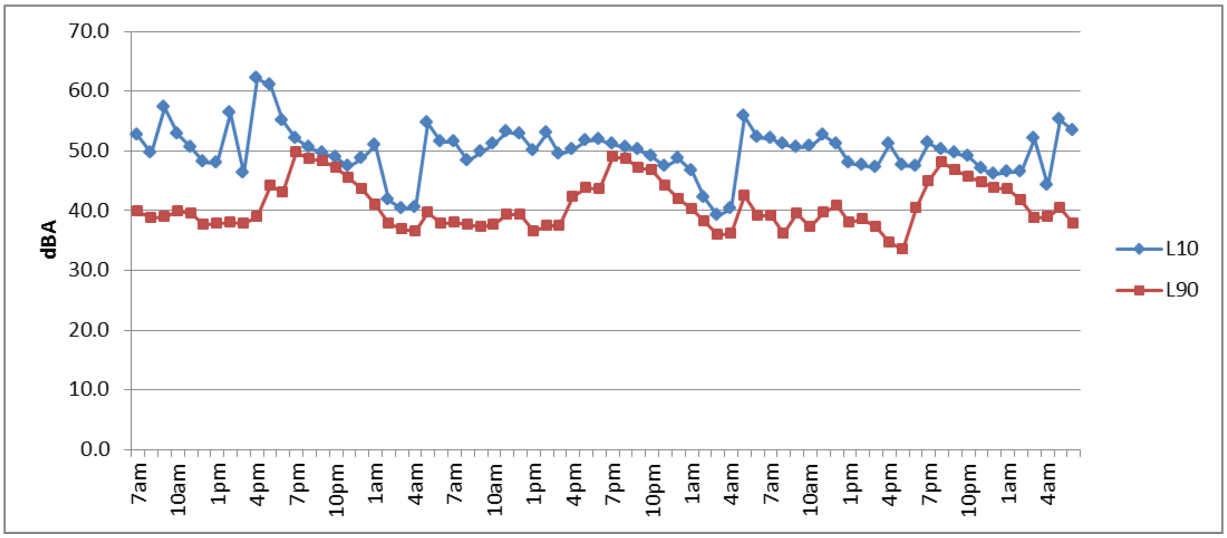

Figure 4-60 - L10 and L90 for Station 2

Station 3 – Lydford

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 28.7 dBA which occurred at 6:15:00 am on July 15, 2012 to a high (Lmax) of 90.1 dBA which occurred at 23:39:20 pm on July 13, 2012. Average noise level for this period was 57.8 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-61.

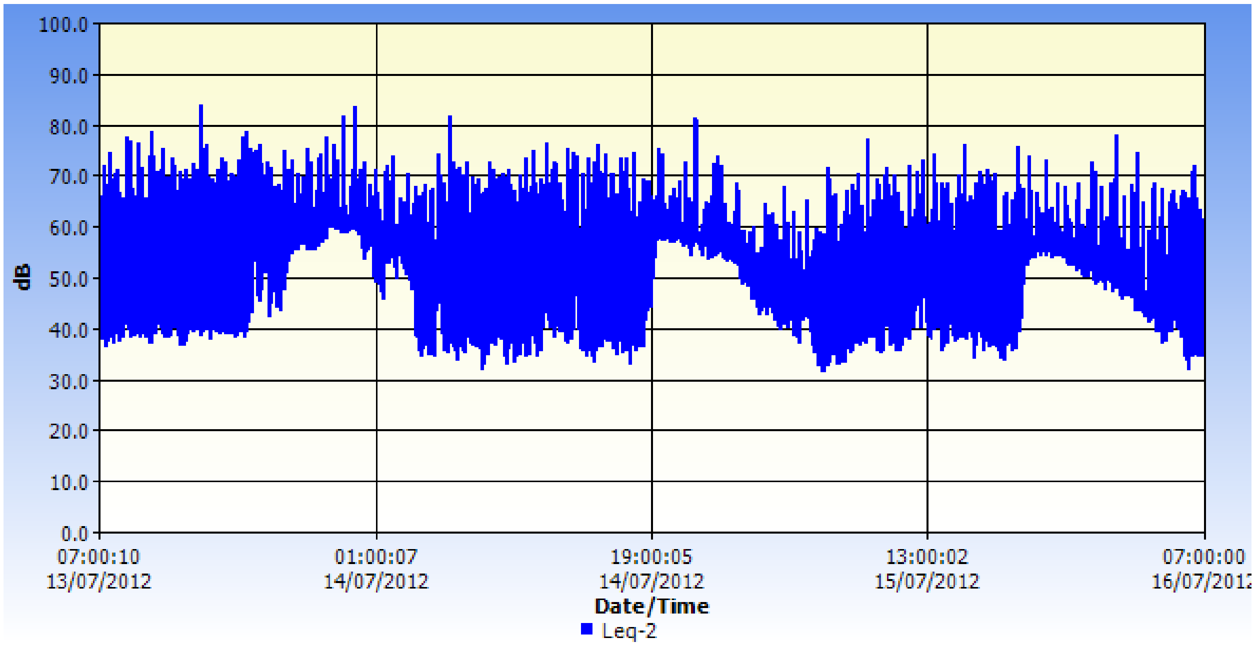

Figure 4-61 - Noise fluctuation (Leq) over 72 hours at Station 3

Octave Band Analysis at Station 3

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz. (octave frequency range is 56 - 71 Hz) (Figure 4-62).

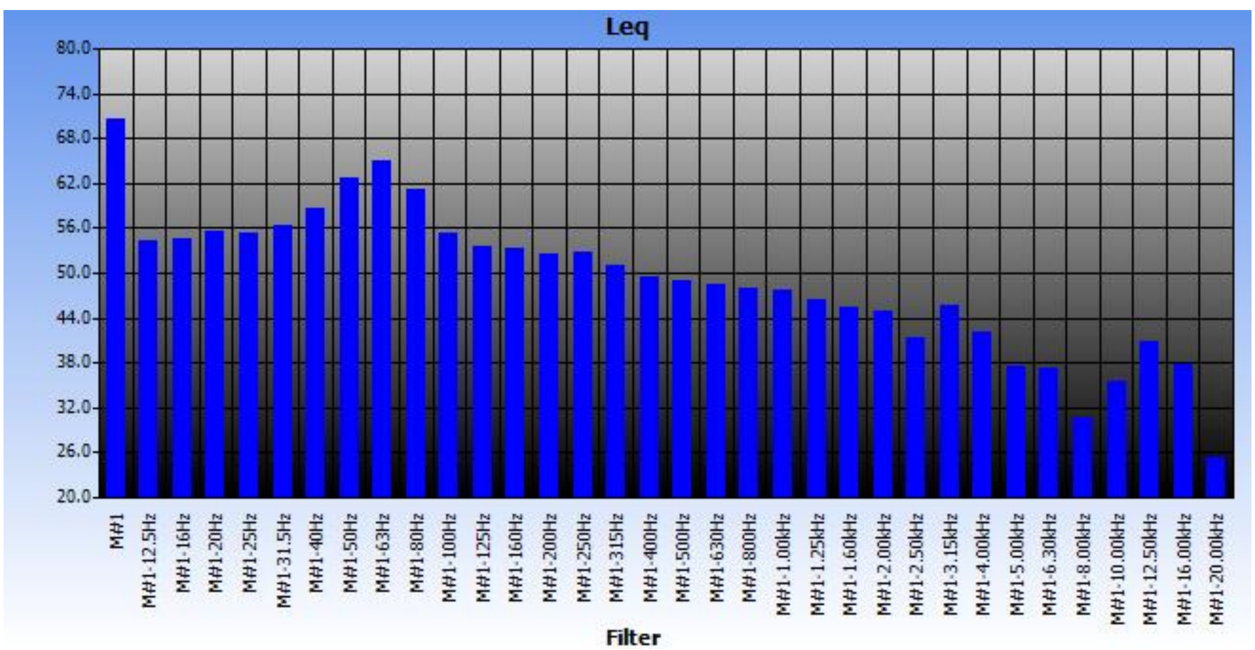

Figure 4-62 - Octave band spectrum of noise at Station 3

L10 and L90 – Lydford

Figure 4-63 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) ≈52.79% of the time, moderate fluctuations in the noise climate (L10 – L90) ≈29.16% of the time and no significant fluctuations (L10 – L90) ≈18.05% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 59.9 dBA and 40.2 dBA respectively.

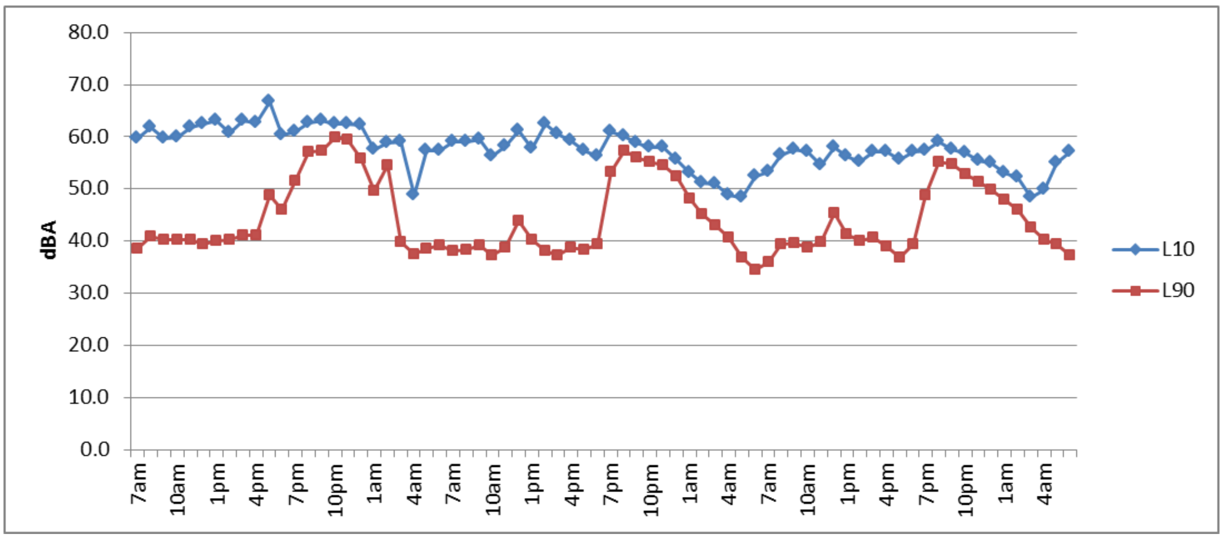

Figure 4-63 - L10 and L90 for Station 3

Station 4 – Annandale Farms

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 29.2 dBA which occurred at 6:28:10 am on July 15, 2012 to a high (Lmax) of 99.2 dBA which occurred at 17:32:00 pm on July 13, 2012. Average noise level for this period was 55.3 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-64.

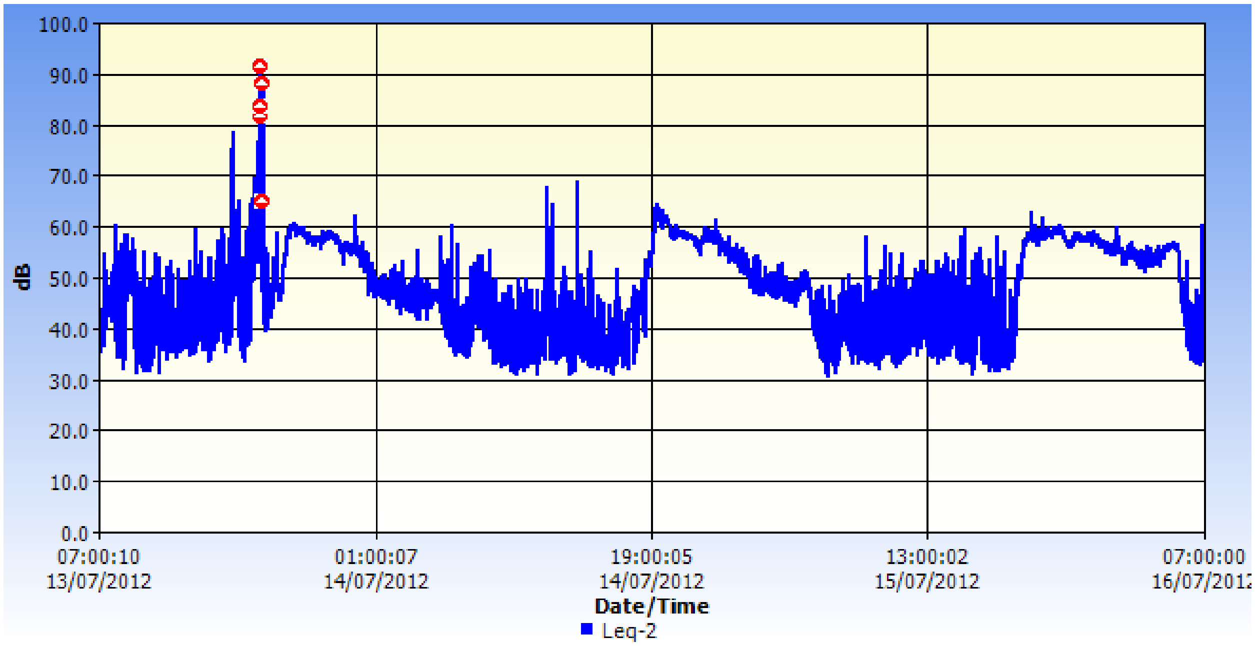

Figure 4-64 - Noise fluctuation (Leq) over 72 hours at Station 4

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 4-65).

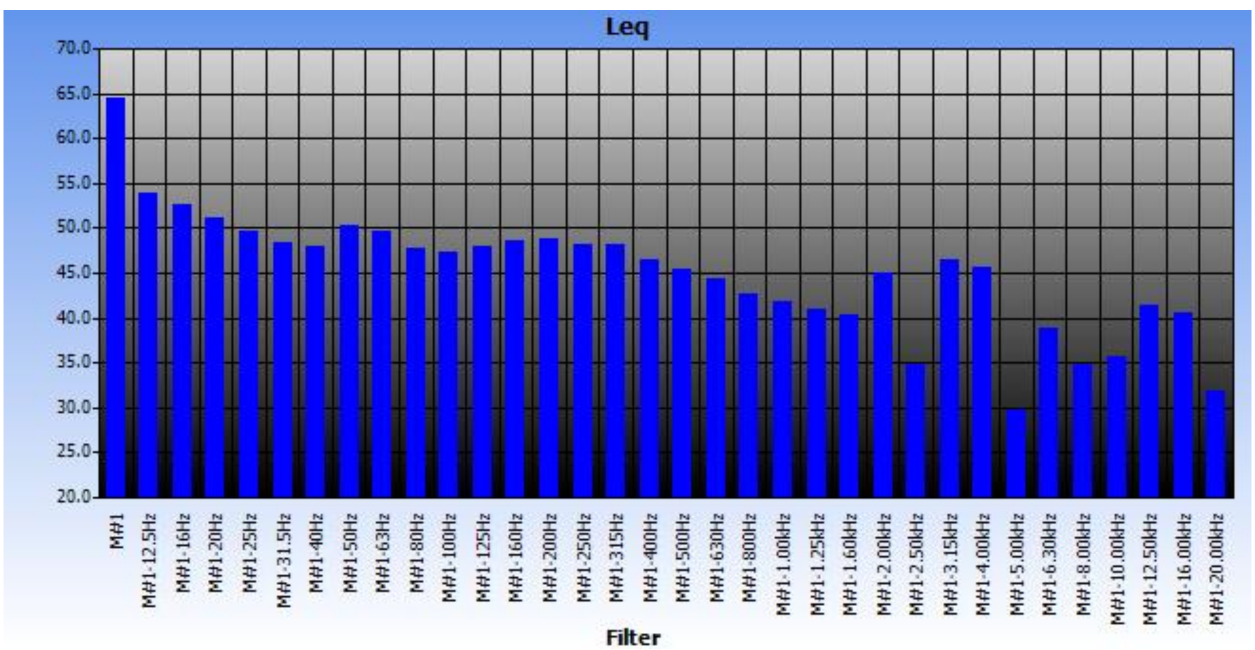

Figure 4-65 - Octave band spectrum of noise at Station 4

L10 and L90 – Station 4

Figure 4-66 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) ≈55.56% of the time, no significant fluctuations (L10 – L90) ≈33.33% of the time and large fluctuations in the noise climate (L10 – L90) ≈11.11% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 58.0 dBA and 35.4 dBA respectively.

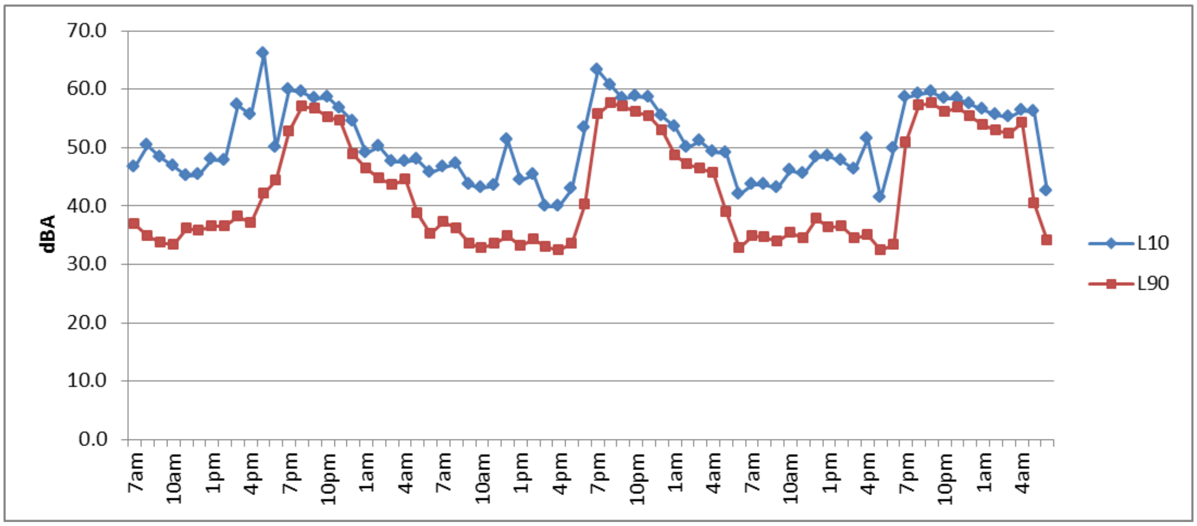

Figure 4-66 - L10 and L90 for Station 4

Station 5 – Steer Town All Age School

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 30 dBA which occurred at 6:02:10 am and 6:35:00 am on July 15, 2012 to a high (Lmax) of 89.2 dBA which occurred at 6:07:00 am on July 14, 2012. Average noise level for this period was 53.9 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-67.

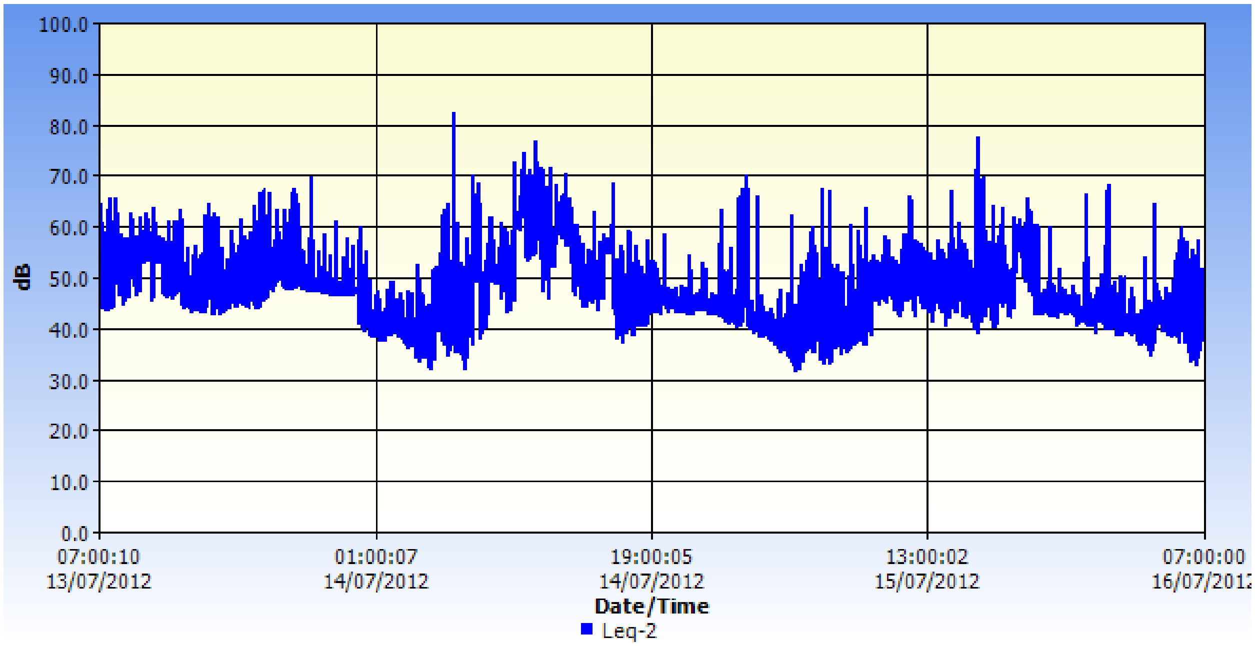

Figure 4-67 - Noise fluctuation (Leq) over 72 hours at Station 5

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 31.5 Hz. (octave frequency range is 28 - 35 Hz) (Figure 4-68).

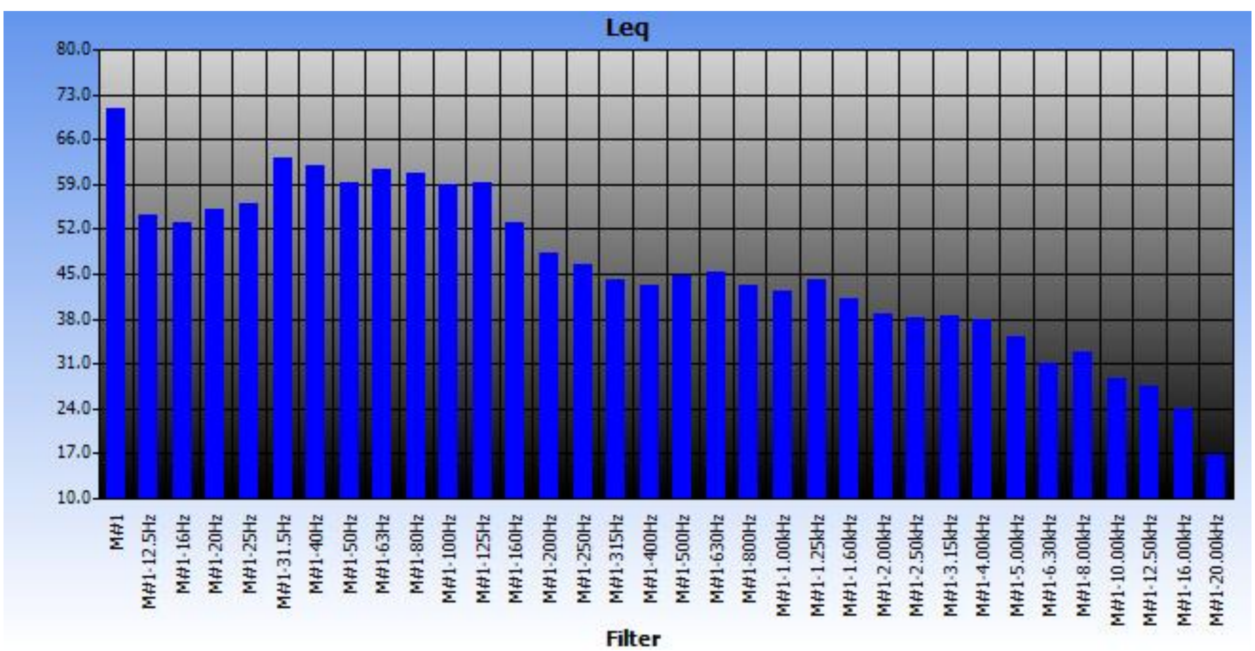

Figure 4-68 - Octave band spectrum of noise at Station 5

L10 and L90 – Steer Town All Age School

Figure 4-69 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) ≈70.84% of the time, large fluctuations in the noise climate (L10 – L90) ≈6.94% of the time and no significant fluctuations (L10 – L90) ≈22.22% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 55.8 dBA and 39.6 dBA respectively.

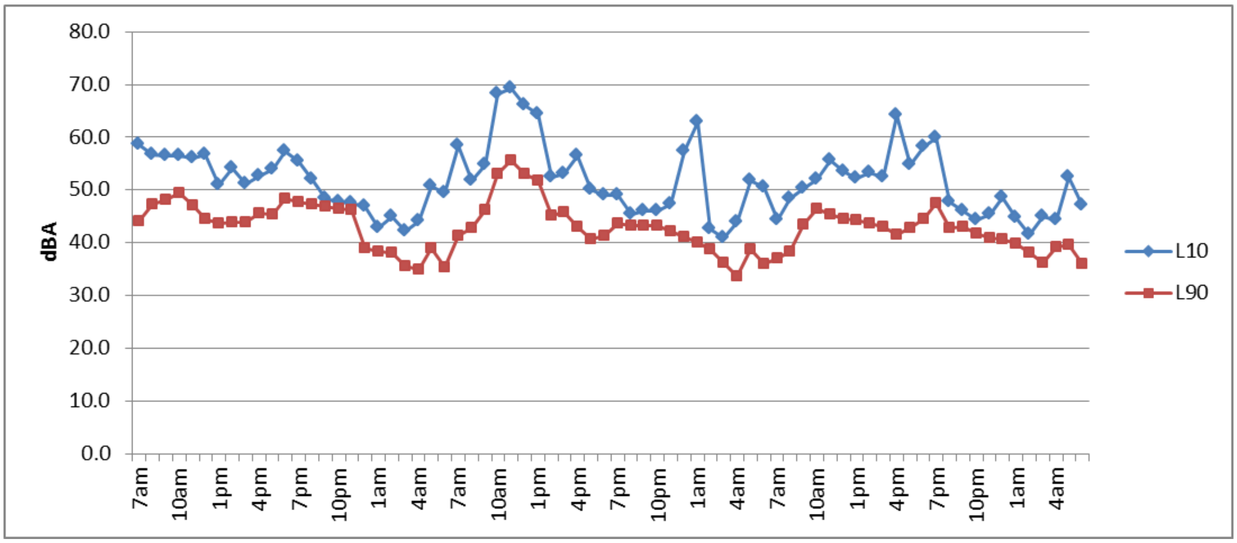

Figure 4-69 - L10 and L90 for Station 5

Station 6 – Roaring River Community

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 30.1 dBA which occurred at 4:21:00 am on July 14, 2012 to a high (Lmax) of 79.2 dBA which occurred at 19:54:00 pm on July 15, 2012. Average noise level for this period was 51.7 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-70.

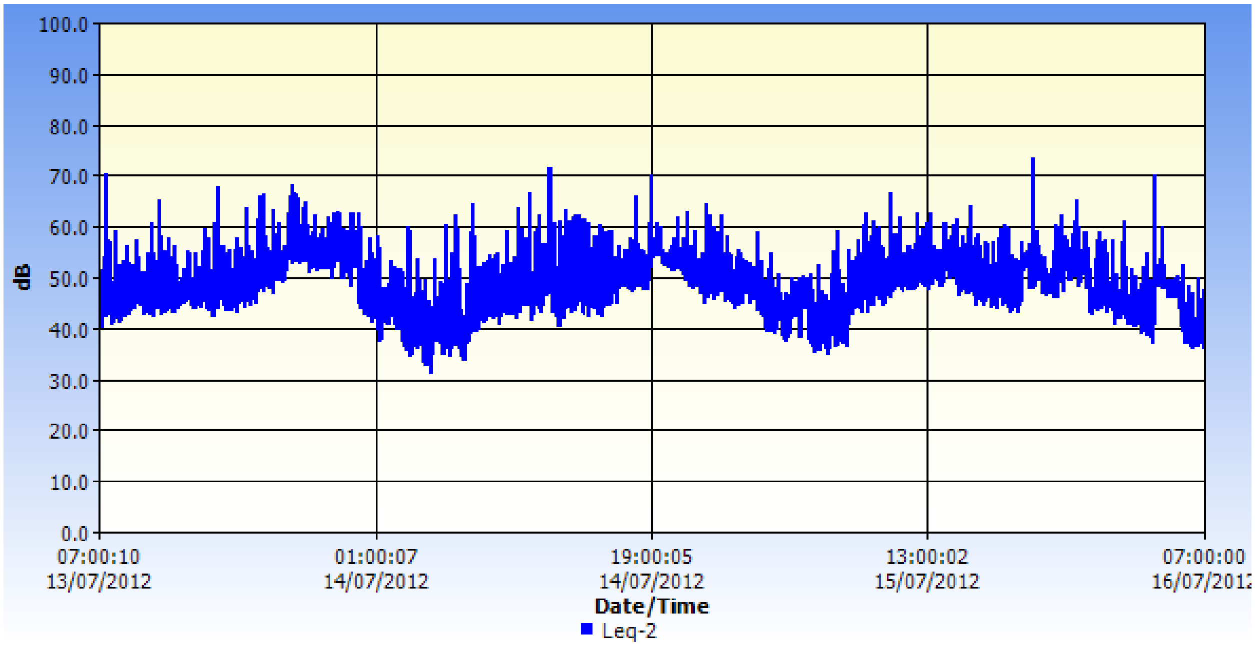

Figure 4-70 - Noise fluctuation (Leq) over 72 hours at Station 6

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 80 Hz. (octave frequency range is 71 - 90 Hz) (Figure 4-71).

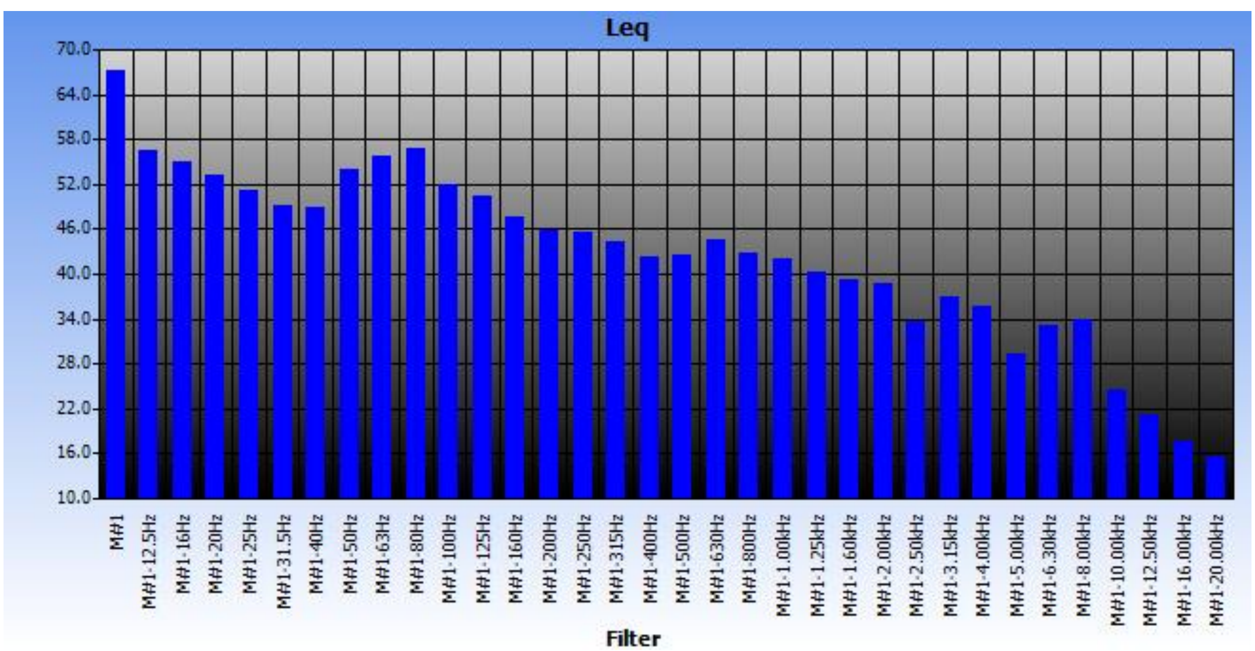

Figure 4-71 - Octave band spectrum of noise at Station 6

L10 and L90 – Roaring River Community

Figure 4-72 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) ≈76.38% of the time, no significant fluctuations (L10 – L90) ≈22.22% of the time and large fluctuations in the noise climate (L10 – L90) ≈1.4% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 55 dBA and 41.7 dBA respectively.

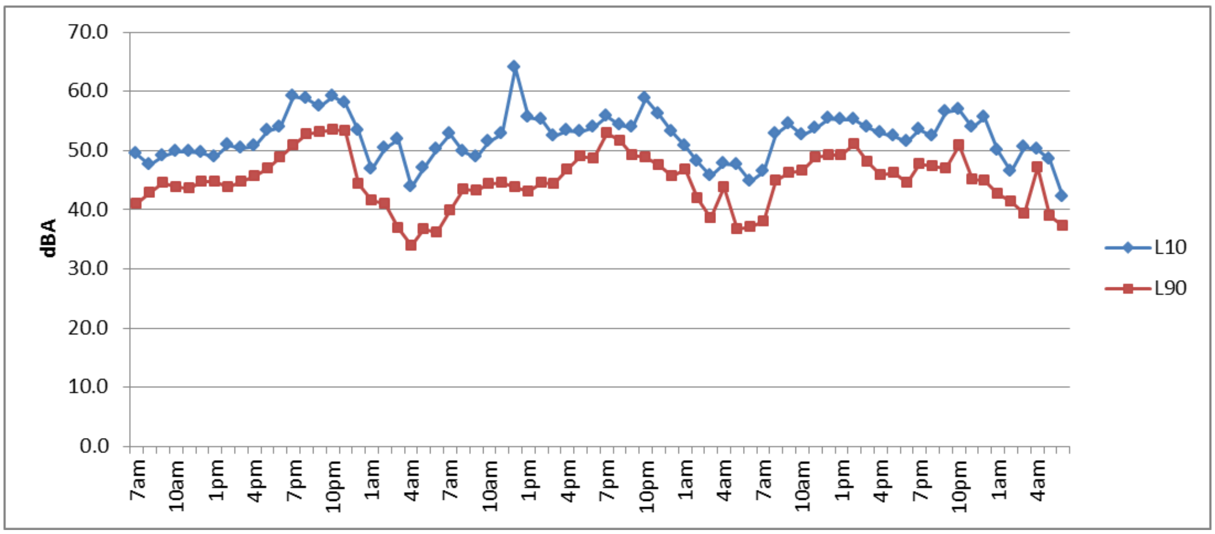

Figure 4-72 - L10 and L90 for Station 6

4.1.11.3 Comparisons of Ambient Noise Levels with NEPA and FHA Guidelines and Standards

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 4-23. Two stations (3 and 5) were non-compliant with the NEPA noise guidelines during the daytime (7am – 10 pm). During the night time three stations were non-compliant with the NEPA guidelines. These stations were 3, 5 and 6.

Table 4-23 - 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)
1	Residential	48.7	55	49	50
2	Residential	51.8	55	47.4	50
3	Residential	58.2	55	57.1	50
4	Commercial	56.2	65	53.5	60
5	Silent	55.4	45	49.6	40
6	Residential	52.3	55	50.5	50

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

FHWA Standard

Noise standards issued by the Federal Highway Administration (FHWA) for use by state and Federal highway agencies in the planning and design of highways are depicted below in Table 4-24.

Table 4-24 - FHWA noise standards for use by state and Federal highway agencies for planning and design of highways

Land Use Category	Design Noise Level-L10	Description of Land Use Category
A	**60dBA** (Exterior)	Tracts of lands in which serenity and quiet are of extraordinary significance and serve an important public need, and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose. Such areas could include amphitheatres, particular parks or portions of parks, or open spaces which are dedicated or recognized by appropriate local officials for activities requiring special qualities of serenity and quiet.
B	**70dBA** (Exterior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, picnic areas, recreation areas, playgrounds, active sports areas, and parks.
C	**75dBA** (Exterior)	Developed lands, properties or activities not included in categories A and B above.
D	-	For requirements on undeveloped lands see paragraphs 5a(5) and (6), this PPM.
E	**55dBA** (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries,

Land Use Category	Design Noise Level-L10	Description of Land Use Category
		hospitals and auditoriums.

Based on the land use categories in Table 4-24, Category B is the most apt to describe the land use within the study area of the noise assessment.

Comparisons with the FHA standard (Category B) with L10 noise levels has indicated that all were in compliance with the FHWA standard for the 72 hours measured (Figure 4-73 to Figure 4-78).

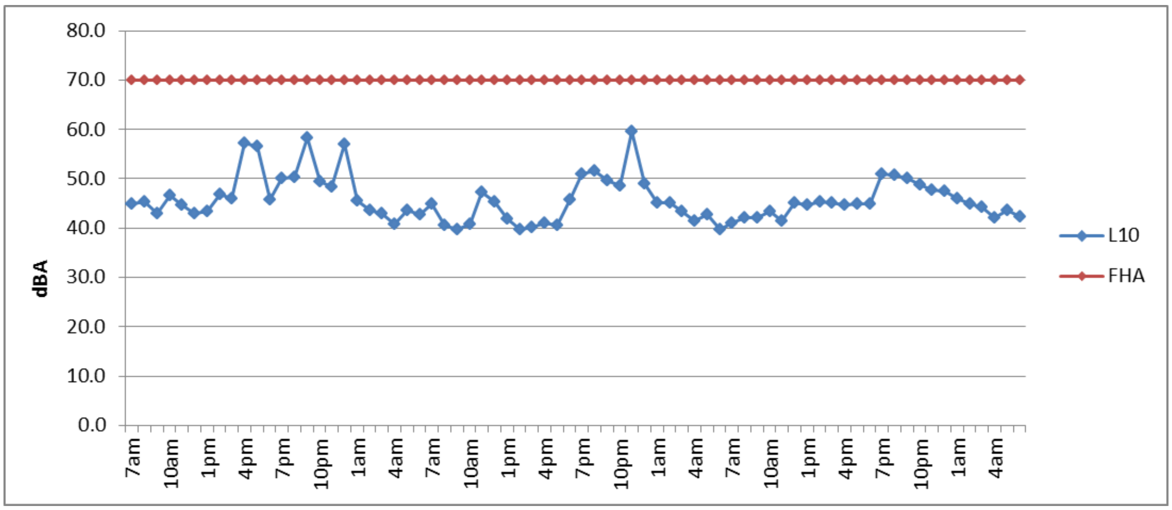

Figure 4-73 - Comparison of L10 at Station 1 with FHA standard

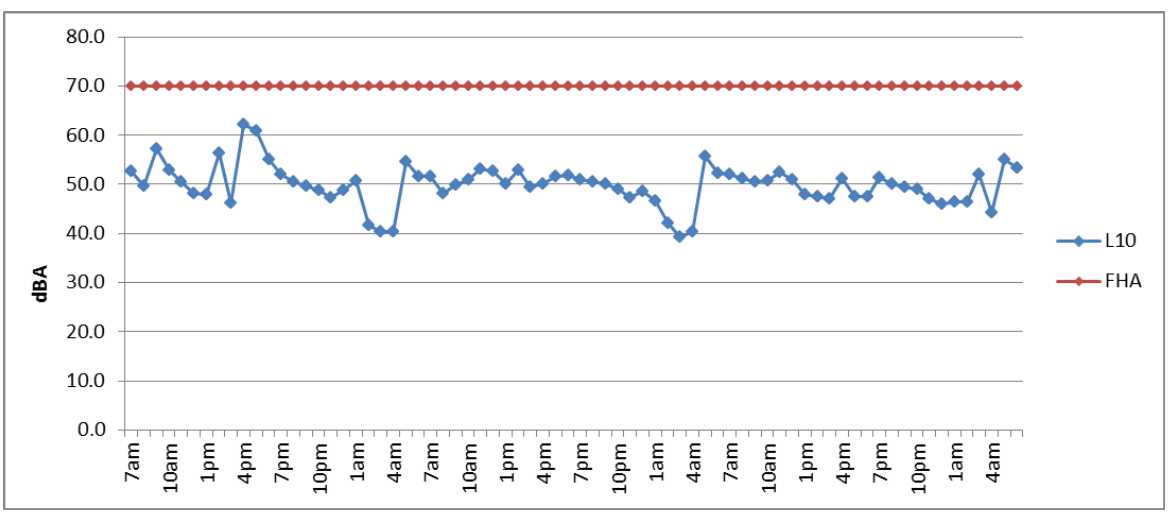

Figure 4-74 - Comparison of L10 at Station 2 with FHA standard

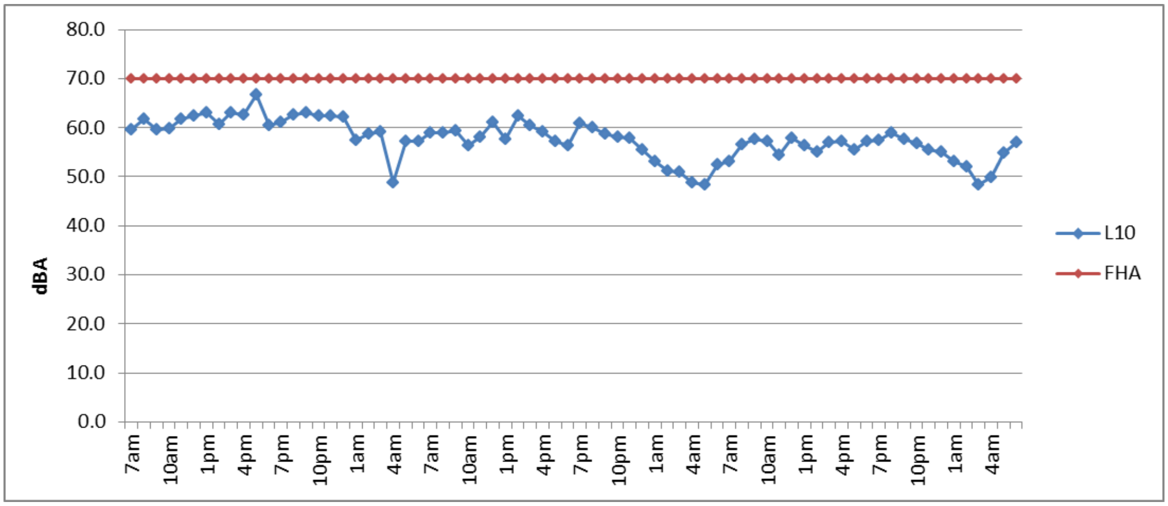

Figure 4-75 - Comparison of L10 at Station 3 with FHA standard

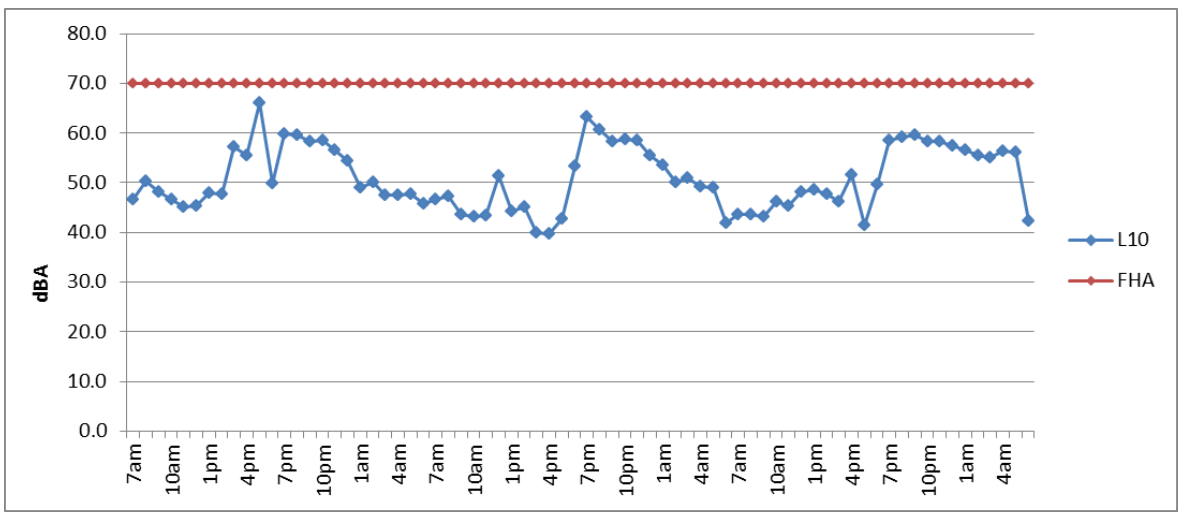

Figure 4-76 - Comparison of L10 at Station 4 with FHA standard

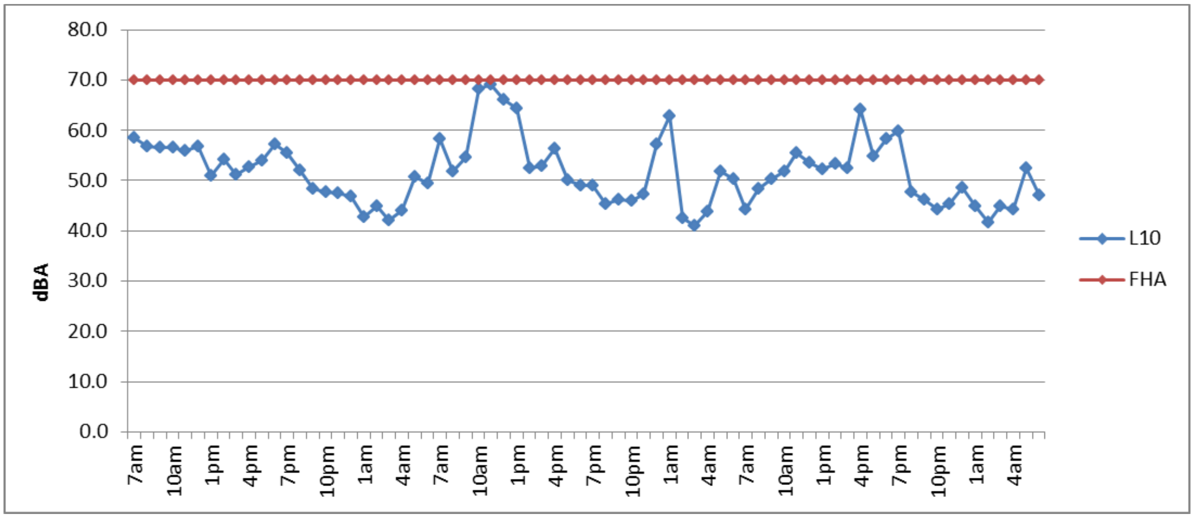

Figure 4-77 - Comparison of L10 at Station 5 with FHA standard

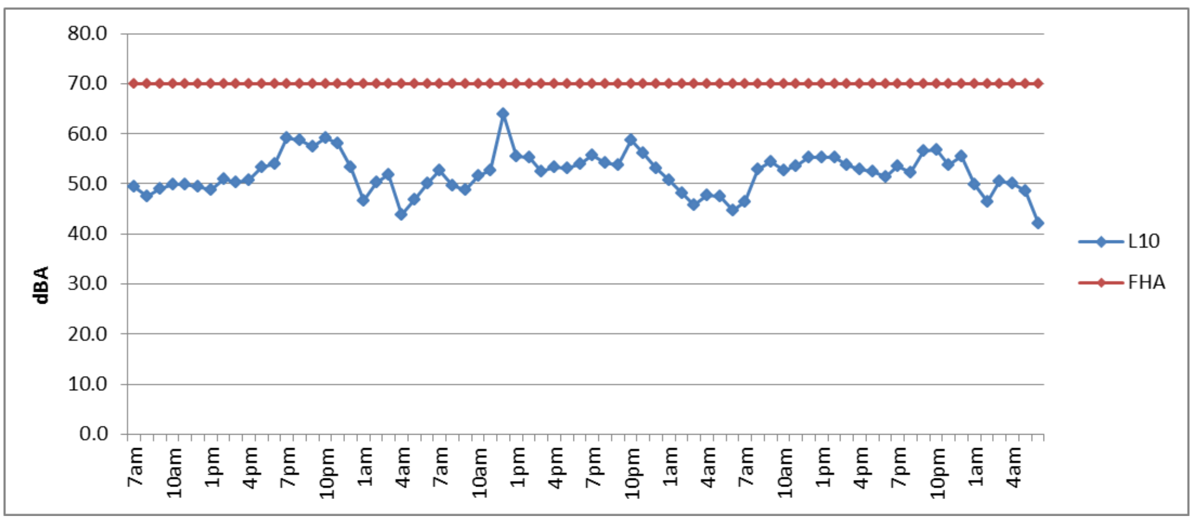

Figure 4-78 - Comparison of L10 at Station 6 with FHA standard

4.2 BIOLOGICAL ENVIRONMENT

4.2.1 Flora

4.2.1.1 Introduction

This report entails the results and recommendations derived from a series of inland vegetation surveys conducted July 28 – 29, 2012 and August 19, 2012 which represent the flora component of an Environmental Impact Assessment (EIA) for the third and final leg of a planned highway development spanning eastern St. Ann, Jamaica, W.I. According to the latest planned alignment, the highway will begin in the Moneague area and connect with the terminus of the existing Linstead-Moneague segment of Highway 2000 via an enhanced interchange provision. The highway will then travel north over the hills in this region, through or near the communities of Retirement, Reynolds, Islington Pen, Malvern Park and Steer Town, eventually terminating in the vicinity of Roaring River on the parish's north coast.

The lands of Malvern Park and Roaring River lie adjacent to the existing Dunn's River Watershed Management Unit as well as form a part of a broader, Urban Development Corporation's (UDC) development plan. In the late 1970's and mid 1990's these areas were earmarked for agricultural development, primarily for cattle raring and the growth of woodland crops (e.g. Pimento) (Johnson, 1979; Agrocon, 1994). Land-use information for 1994 showed that 995 ha (2,335 acres) of land were utilized for pasture and commons, while only 80 ha (197 acres) were forested (Agrocon, 1994).

By 1998, however, the entire Roaring River property was removed from former agricultural enterprises. It was proposed that the land be reallocated for community, housing, tourism and environmental developments – including the reforestation and protection of 129 ha (319 acres) of watershed and forested areas (Agrocon, 1998). Similarly, in Malvern Park, 223 ha (552 acres) were to be set aside for reforestation with cash-crop trees (Table 4-25). However, the majority of remaining lands (264 ha or 652 acres) were to be used in cattle operations. The forestry department, in 1997, had proposed that consideration be given to declaring these areas a forest reserve (Agrocon, 1998).

The highway project is expected to be typical, with construction and engineering methods being utilised to develop and clear the rights-of-way; ensure substrate stability; involve the construction of drainage, bridges and overpasses; as well as manipulate the landscape to allow for grade separated interchanges and linkages with existing roadways. The principal construction materials expected to be employed are steel, concrete, asphalt and aggregates of various grades.

Table 4-25 - Proposed tree species for use in reforestation plans for Malvern Park and Roaring River in 1997 (from Agrocon, 1998)

Species	*Common Name*
Pinus caribbea	Caribbean Pine
Cordia gerascanthus	Spanish Elm
Swietenia mahogoni	Jamaican Mahogany
Cedrela odorata	Cedar
Hibiscus elatus	Mahoe
Terminalia latifolia	Broadleaf
Tectona grandis	Teak
Simarouba glauca	Bitter Damson
Chlorophora tinctoria	Fustic
Piscidia piscipula	Dogwood
Azadirachta indica	Neem
Acacia sp.	Acacia
Pimenta dioca	Pimento

The direct environmental impact from a highway development is typically linear and extends along its length. The effect is realised mainly during the preparation and construction phases of most highway projects where the existing vegetation is typically removed to accommodate the rights-of-way for the roadway. Therefore, the loss of biomass and species (invasive, local or endemic) are likely. The subsequent impacts entail habitat destruction due to fragmentation; increased surface runoff of rainwater and sediment; the encouragement of urban sprawl and increased human intrusion into relatively low-impacted areas (Primack, 2006; Smith & Smith, 2006). These factors will be discussed further in the recommendations section of this study.

The main objective of this scope of work was to characterise the terrestrial botanical communities that occupied the area in which activities would be conducted with special reference to endemic and/or rare vegetation constituents. Potential construction and post-construction impacts on the flora were also identified and their possible mitigations examined.

4.2.1.2 Methodology

Based on preliminary observations, the planned rights-of-way for the highway development bisected or ran adjacent to several large parcels of fenced-in, undulating, agricultural land and residential communities (Plate 4-19). These areas were commonly interspersed by patches of modified woodlands or bordered by marginal (yet diverse) roadside vegetation. In light of restricted site access, in some instances, and the homogenous nature of the majority of the vegetation encountered, Window Surveys were considered to be the most efficient sampling method to employ.

Plate 4-19 - Undulating grassland/pastureland typical of several enclosed hectares of land found along the proposed highway route

Access to the planned highway footprint was achieved by utilising roadways and tracks that ran adjacent to or across the alignment. At these points of intersection, notes were made regarding the plant species encountered and the land-use types observed. Stops were made at regular intervals to conduct walk-throughs for more thorough investigations. This approach had been applied in rapid ecological studies (REA) prior to this, such as the Jamaican REA for ground-truthing remote imagery (Grossman et al., 1991). Plant species encountered during the field surveys were identified *in-situ* or samples collected and taken to the University of the West Indies (UWI) Herbarium for later identification.

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 coordinates of the highway path.

The floral sampling sites are illustrated in Figure 4-79.

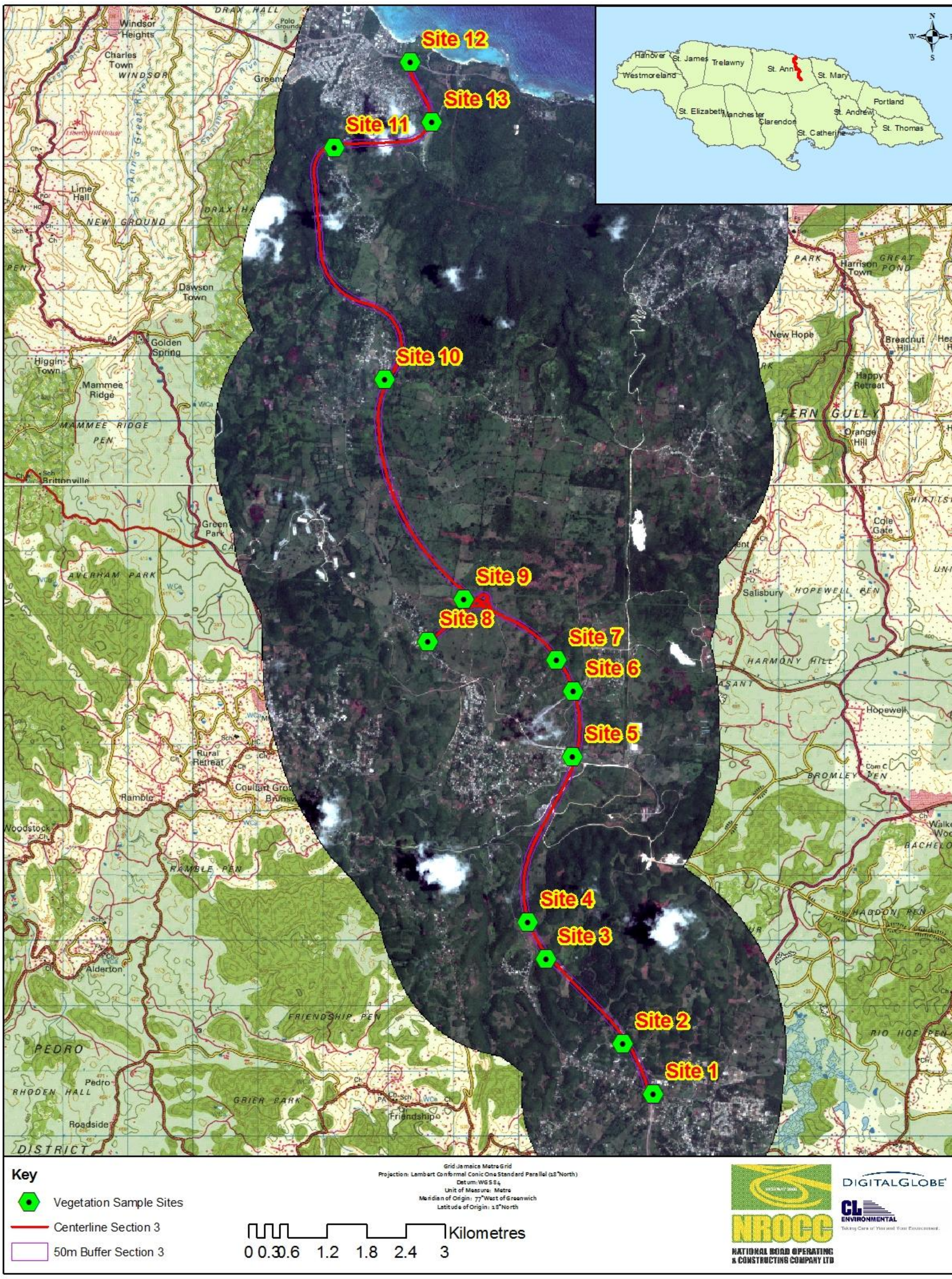

Figure 4-79 – Map showing floral sampling stations

4.2.1.3 Results and Discussion

A typical highway development may traverse one or more ecological communities and land-use types. Accordingly, this section will attempt to categorise the major vegetation communities to be affected within the study area as well as list some of the indicative and ecologically important plant species present.

The field assessment began at the highway's proposed origin in the south, near Moneague and continued due north until its termination near Roaring River. The proposed highway footprint will traverse mainly over large swaths of fenced, pastureland bordered by secondary, roadside, plant communities that were, in many cases, conspicuously rich in floral constituents (Plate 4-20).

Plate 4-20: Fenced secondary community, adjacent a fallow agricultural plot and Class C road

Often, the lands to be impacted (or sections thereof) appeared to have been left fallow, which in turn, gave them a ruinate appearance (Plate 4-21). Marginal and abandoned lands in Jamaica are often termed ruinate. Asprey and Robbins (1953) explained that the term *ruinate* could be used for "infinitely varied, secondary growth types of vegetation developing after burning, catch cropping, and abandonment." Arguably, the majority of lands to be used for the highway fell on ruinate lands.

A total of 219 plant species were identified, 82 of these (or 38%) were herbs and shrubby-herbs (Figure 4-80). Together, they made up the primary constituents of the flora assessed. Plants such as Bidens pilosa (Spanish Needle), *Borreria verticillata* (Wild Scabious), *Desmodium adscendens* and *Bryophyllum pinnatum* (Leaf-of-Life) were the most common herb/shrubby-herb species encountered (found in at least eight of the 13 sites visited). These species were observed in pastoral fringes, waste-places and the banks of secondary and tertiary roadways where their distribution may have been assisted by passing animal, pedestrian and vehicular traffic. Ferns were also common in these areas, with *Nephrolepsis* sp. and *Polypodium phyllitidis* (Cow Tongue Fern) thriving in the often shaded and moist conditions present. *Panicum maximum* (Guinea Grass) and *Ambrosia peruviana* (Wormwood) were common pasture constituents, with *Wedelia trilobata* (Creeping Ox-eye), *Stachytarpheta jamaicensis* (Vervine) and the melastome, *Miconia* sp. occurring mainly on the fringes.

Plate 4-21: Abandoned runway and surrounding ruinate community near the Reynolds Bauxite Plant. Runway intersects proposed highway development.

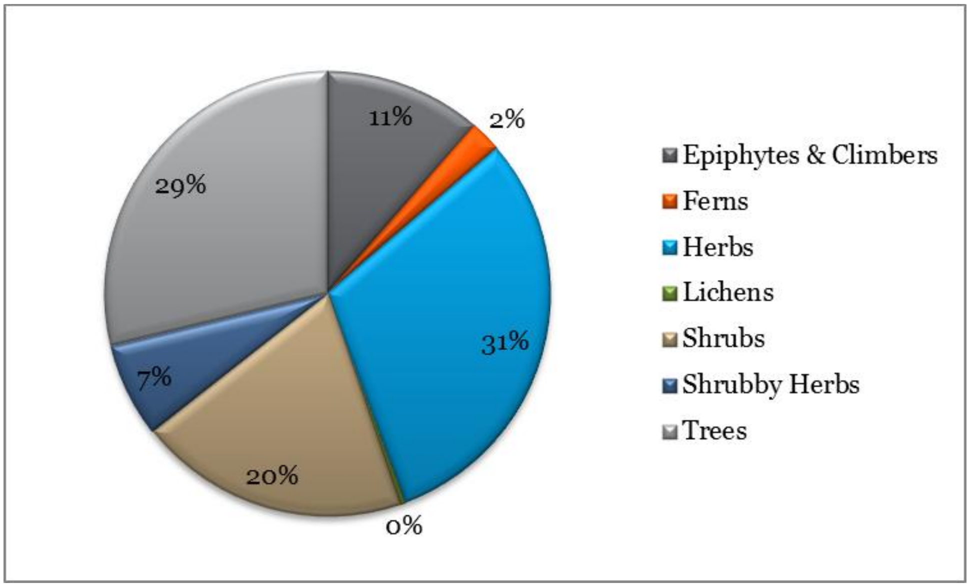

Figure 4-80: Percentage breakdown of plant species encountered by habit.

Shrubs accounted for 20% of the plant species encountered and tended to occur on ruinate lands. Species such as *Lantana camara* (Wild Sage), *Allamanda cathartica* (Yellow Allamanda) and several *Sida* spp. (Broomweeds) were virtually omnipresent. *Piper* spp., *Chromalaena odorata* (Christmas Bush) and the medicinal endemic, *Rytidophyllum tomentosum* (Search-me-Heart) were also common, especially along steep-banked roadsides.

Several isolated stands of trees were observed occurring within and surrounding pastoral communities (Plate 4-22). Species, such as *Ficus* sp. (Fig), *Comocladia pinnatifolia* (Maiden Plum), *Cecropia peltata* (Trumpet Tree) and *Nectandra antillana* (Long-leaved Sweetwood), were widely distributed throughout the pastoral communities as well as *Terminalia catappa* (West Indian Almond), *Spathodea campanulata* (African Tulip Tree) and *Delonix regia* (Poinciana). Woodland stature and species composition (including the presence of epiphytes - Plate 4-23) varied considerably, depending upon the prevailing ecological conditions (i.e. level of anthropogenic influence, moisture, substrate, etc.). A total of 63 tree species were encountered.

Plate 4-22: Woodland community surrounding pastureland.

The occurrence of epiphytic and climbing species was quite reduced, compared to the percentages for other growth forms; however, *Ipomoea* spp. were quite ubiquitous and *Mikania micrantha* (Guaco) and *Centrosema virginianum* were common climbers. At some localities several *Hohenbergia* plants were observed conspicuously occurring along the branches of large *Samanea saman* (Guango) trees. *Tillandsia* spp. were also common constituents of Guango-branches (Plate 4-23). The lichen, *Usnea* sp., although not common, tended to occur on large, semi-isolated trees (Plate 4-24) in damp, open areas (sites 1, 3, 7 and 9).

Plate 4-23: Samanea saman *(Guango) tree bearing several epiphytic species (*Hohenbergia *and* Tillandsia *spp.). The species was typically found along roadsides and border vegetation.*

Plate 4-24: Tree-member of the Bignoniacea family covered by Usnea sp.

A list of endemic species encountered during this survey may be found in Table 4-26. Commonly occurring endemic species were the aforementioned Search-me-Heart, *Lantana jamaicensis* and *Lobelia viridifolia*. Coincidentally, many of the endemic species encountered, including orchids, were found primarily along shaded or leeward hillsides as well as along the banks of unpaved Class 'C' roads and tracks. In these locations a mesic environment appeared to prevail. Site 9 was one such location and most of the orchid species, such as the endemic *Oncidium tetrapetalum* (Pimento Orchid), *Trichocentrum undulatum* (syn. *Oncidium luridum*) (Brown Gal), and *Ionopsis satyrioides* (Plate 4-25) were found there.

Table 4-26: Table of endemic species encountered during the survey.

Species	*Common Name*
Cordia bullata	
Hylocereus triangularis	God Okra
Lantana jamaicensis	
Lobelia viridifolia	
Oncidium tetrapetalum	Pimento Orchid
Oryctanthus occidentalis	Godbush, Scorn-the-Earth
Piper amalago* var. *nigrinodum	Black Jointer
Piper fadyenii	
Roystonea altissima	Mountain Cabbage
Rytidophyllum tomentosum	Search-me-Heart

Plate 4-25: The endemic orchid *Ionopsis satyrioides*.

The endemic species richness for each site is shown in Figure 4-81. Sites 9 – 13 represent the northern sections of the highway development. Sites 9 and 10 had the highest endemism, where representatives of all endemic species encountered in this survey were found at these sites. However, the endemic palm, *Roystonea altissima* (Mountain Cabbage), was observed at sites 1 and 3 only. In terms of number of species per site, sites 1, 9 and 13 were notably richer with 68, 73 and 71 species encountered, respectively (Figure 4-82).

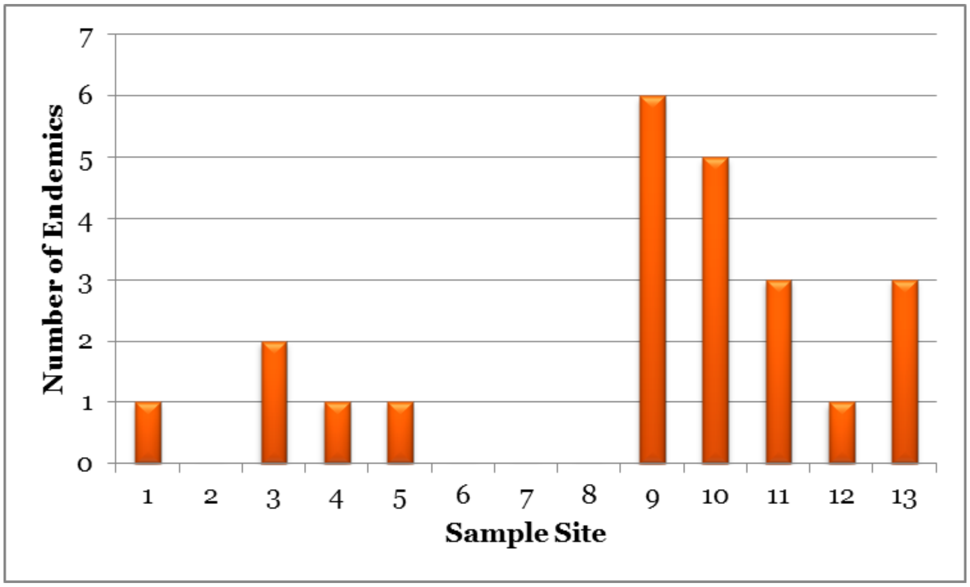

Figure 4-81: Endemic species richness by site.

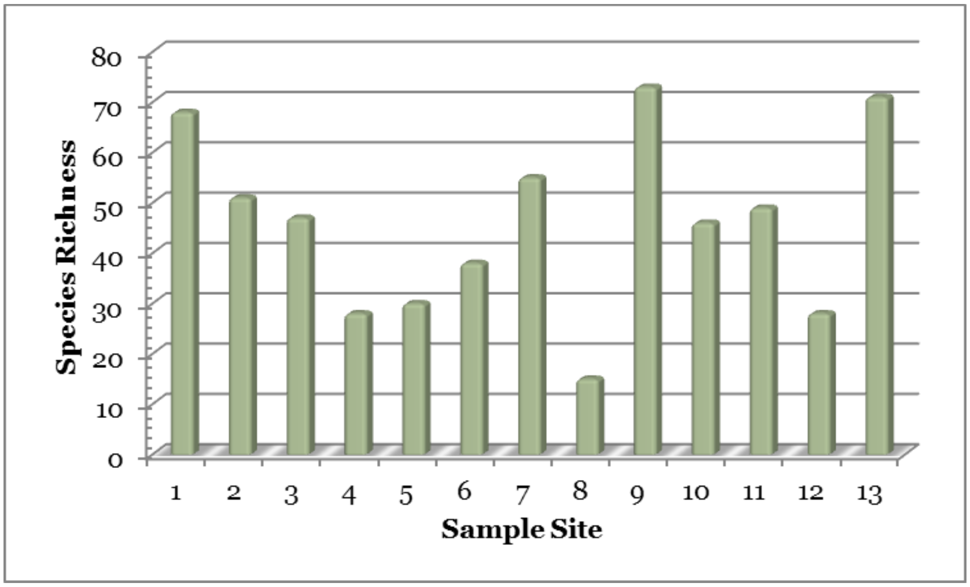

Figure 4-82: Overall species richness by site.

In areas where high instances of anthropogenic influence were observed, agricultural crops such as *Musa sapientum* (Banana), *Artocarpus altilis* (Breadfruit), *Dioscorea* sp. (Yam) (Plate 4-26), *Colocasia esculenta* (Cocoa), *Cocus nucifera* (Coconut) and *Citrus* spp. (e.g. orange, lime and grapefruit) were frequently seen. Ornamental plants such as *Tabebuia* sp. (Poui), *Delonix regia* (Poinciana), *Ixora* sp., *Agapanthus africanus* (African Lily) and *Hibiscus rosa-sinensis* (Shoe Black) were occasional in residential areas.

*Plate 4-26: Yam (*Dioscorea *sp.) cultivation located on lands adjacent to proposed development.*

A comprehensive listing of the plant species encountered, according to location and growth form can be found in Appendix 6.

4.2.2 Fauna

4.2.2.1 Site Description

The general areas in which the proposed highway will be constructed from Linstead to Ocho Rios consist of mostly old bauxite-mine out lands. The characteristics of these lands are mind out pits, which are usually separated by small limestone hills which were not mined. These small limestone hills form karst "Cockpit" land features. Most of the old bauxite lands are used for farming (cattle rearing and small crops) and also for housing. In addition, the vegetation in other areas has regrown into woodland and forest.

Sample sites for the faunal surveys were selected along the route or near the area for the proposed highway, with the aid of the Forestry Department of Jamaica Landsat maps and also site visits in the field. The sample sites represent the different vegetation zones in the areas, which the roads will pass through. It should be noted that access to conduct fauna surveys at the sample sites was also another factor used in the selection process.

The proposed road will pass through two vegetation zones according to the forestry Landsat map (2001) (**Fields:Herbaceous crops, fallow, cultivated and vegetables**; and **Secondary Forests and Fields**). It should be noted that the zonation used by Forestry Department Land Use maps is not uniform and also not current. Hence, further zonation was carried out in the field.

Fields: Herbaceous crops, fallow, cultivated and vegetables

Pasture land were the common agricultural feature within this zone. There are several large cow pastures in the area. Large trees are planted in, along boundary and along the roads to the pastures. The height of these trees ranges from 15 – 20m. There are also several small farms growing traditional cash crops (cabbage, bananas and cassava). Some of the pastures in the area have been abandoned and the vegetation has overgrown into woodland.

Listed below are the faunal sampling sites (See Figure 4-83):

a) Site 1 (18° 16.987'N, 77° 7.412'W) - Farm and forest
b) Site 2 (18° 17.006'N, 77° 7.843'W) - Woodland, houses and fruit trees
c) Site 4 (18° 20.848'N, 77° 8.534'W) - Pastures and vegetation along the road
d) Site 5 (18° 23.554'N, 77° 9.939'W) – Farm (pastures)
e) Site 7 (18° 24.243'N, 77° 10.027'W) - Houses, pastures and woodland

Secondary forest and field

The original vegetation in the project area can be categorised as limestone forest. The general project area receives varying level of rainfall and can be further categorised as an intermediate between dry limestone and wet limestone forest. In other areas, where the rainfall is high, such as the Chalky Hill area, the forest has characteristics of a wet limestone forest. The original vegetation in most of these areas was once cleared for mining, agriculture and housing and has regrown in some areas. There are also several pastures and woodland within this zone, for example the Roaring River property.

It should be noted that there is vegetation along the large natural water channels that are intact and were referred as “Gully Forest”. Some of these channels are located in the pastures. The trees in the Gully forest can reach heights of 25 m. In addition, trees which are not seen in the general area are seen in the “Gully forest”.

Listed below are the sample sites which were placed in different vegetation zone (Figure 4-83):

a) Site 3 (18° 18.009'N, 77° 8.532'W) - Farms, pastures and forest
b) Site 8 (18° 24.643'N, 77° 9.306'W) – Woodland and pastures
c) Site 6 (18° 23.744'N, 77° 10.211'W) – Pastures, Gully forest and woodland

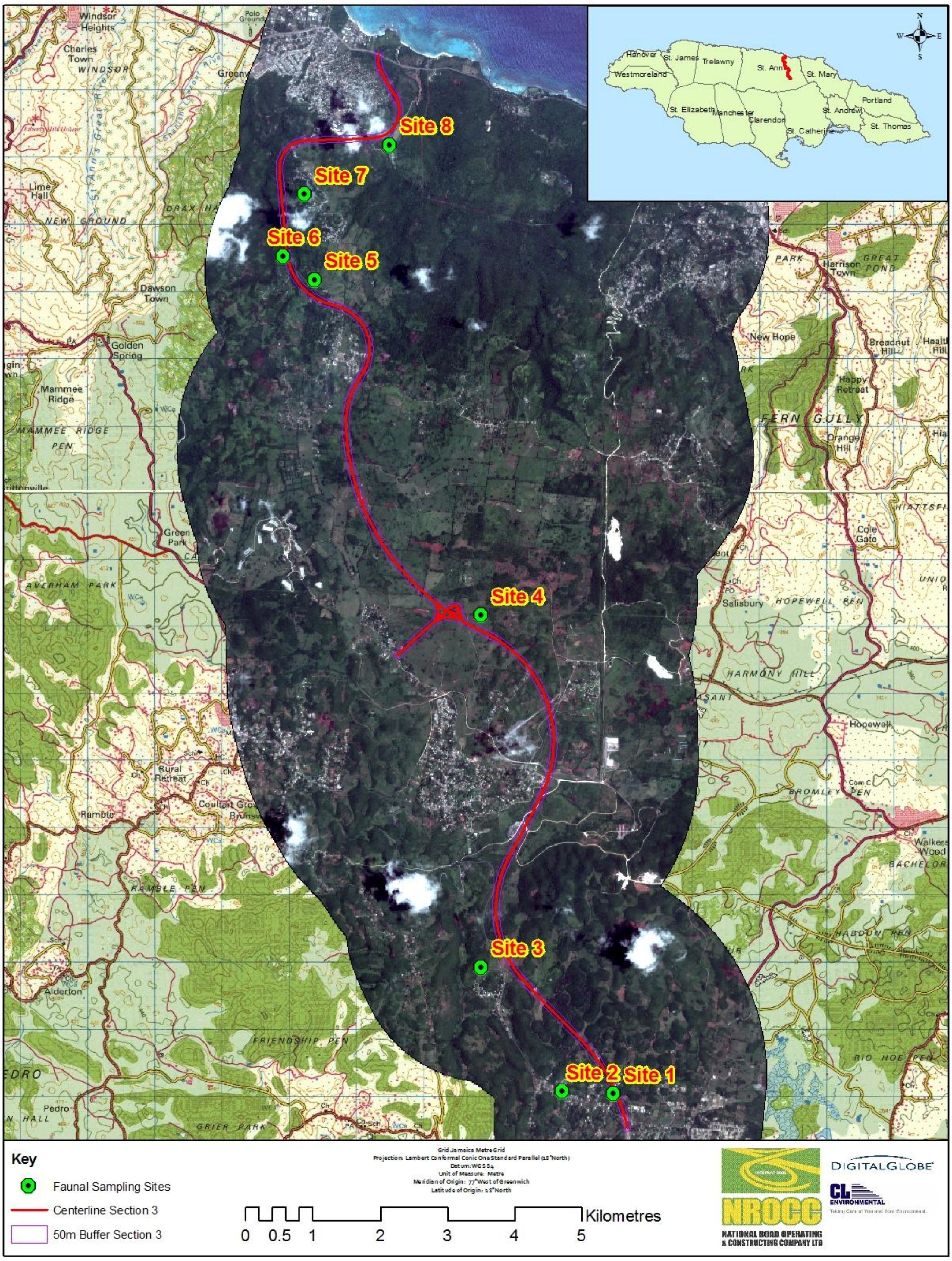

Figure 4-83 – Map showing faunal sampling site locations

4.2.2.2 Summary

Forty six species of birds were identified during the study; 16 are endemic, 27 resident and 3 migrant. The low number of migrant warbler species is as a result of the time the survey was carried out, ie., before the arrival of the migrant birds. Nineteen of Jamaica's Amphibians were recorded from the study site, three species recorded for the first time from this area of Jamaica. Sixteen of Jamaica's fifty reptiles were recorded. One hundred and seven species of invertebrates were recorded; this was dominated by the Homoptera (plant bugs) and the Lepidoptera (butterflies and moths). The Little River was the only significant water body in the study site; the physico-chemical parameters collected is normal for such a small intermittent stream, with significant dry areas in the low rainfall seasons. The biological composition of the river was normal for a high gradient stream with low to moderate impacts. Representatives from thirteen macroinvertebrate taxonomic groups were found, with gastropod (snails) dominating, followed by various insect groups, and crustaceans. No fish were collected; these appeared to be limited in range and abundance, as a result of the desiccation of long stretches of the river. The Little River exhibits the expected physico-chemical conditions and invertebrate fauna expected of an unpolluted intermittent limestone stream at elevation.

Large highway projects usually have an impact on the natural ecosystem especially in areas that are largely undisturbed by human activities, although it is reduce in heavily agricultural regions. However, the area in which the highway will pass through have been modified by the bauxite mining, human habitation and farming. Hence the impact will not be significant. The road construction processes includes removal of vegetation, blasting excavating will scare a number of the fauna such as birds away, however the species occurring here are generalist, capable of surviving a large variety of habitats and they will be expected to return. No species requiring specific conservation measures were identified. However, many species play key roles in the environment and all measures should be employed to reduce habitat disturbance. The Little River is in good condition and all effort should be made not to disturb the vegetation close to the river, or to introduce pollutants related to construction.

4.2.2.3 Avifauna

Method

Line Transect Census Method

The Line transect census method was used for the avifauna survey as a result of the easy accessible roads and trails. This method entailed walking slowly for a given distance or time period along selected routes, noting all the birds seen or heard in the area (Wunderle 1994). It should be noted that birds seen in the area which were not recorded in the survey was noted.

The method was carried out along trails and foot paths on the 8 selected study sites.

Results

Table 4-27 below gives the results of the avifaunal survey.

Table 4-27 - The endemic birds identified during the avian survey. The DAFOR (Dominant ≥ 20; Abundant 15 – 19; Frequent 10 – 14; Odd 5-9; Rare <4) scale is used to rank the birds.

Proper Name	*Scientific Name*	Forest dependent	Fields: Herbaceous crops, fallow, cultivated and vegetables					Secondary forest and fields		
			S 1	S 2	S 4	S 5	S 7	S 3	S 8	S 6
Jamaican Euphonia	***Euphonia Jamaica***	No			**R**				**F**	**R**
Jamaican Lizard-cuckoo	***Saurothera vetula***	No		**R**		**R**			**R**	
Jamaican Mango	***Anthracothorax mango***	No				**R**				**R**
Jamaican Oriole	***Icterus leucopteryx***	No		**R**		**R**	**O**	**R**		**R**
Jamaican Woodpecker	***Melanerpes radiolatus***	No	**R**		**O**	**O**	**R**	**O**	**O**	**O**
Red-billed Streamertail	***Trochilus polytmus***	No	**R**	**R**	**R**		**O**	**O**		**O**
Yellow-shouldered Grassquit	***Loxipasser anoxanthus***	No	**O**	**O**	**R**			**O**	**O**	**R**
Chestnut-bellied Cuckoo	***Hyetornis pluvialis***	Yes								R
Jamaica Tody	***Todus todus***	Yes			**R**				**R**	**O**

Proper Name	*Scientific Name*	Forest dependent	Fields: Herbaceous crops, fallow, cultivated and vegetables					Secondary forest and fields		
			S 1	S 2	S 4	S 5	S 7	S 3	S 8	S 6
Jamaican Crow	***Corvus jamaicensis***	Yes		**O**	**O**	**F**	**O**	**F**	**O**	**O**
Jamaican Elania	***Myiopagis cotta***	Yes	**R**						**R**	
Jamaican Pewee	***Contopus pallidus***	Yes			**R**				**R**	
Jamaican Vireo	***Vireo modestus***	Yes			**O**			**R**	**R**	**O**
Orange Quit	***Euneornis campestris***	Yes								R
Sad Flycatcher	***Myiarchus barbirostris***	Yes		**R**		**O**			**R**	
White-chinned Thrush	***Turdus aurantius***	Yes	**R**					**R**	**F**	**O**

Discussion

Overall, approximately 46 species of birds were identified during the study. Of that number 16 are endemic, 27 resident and 3 migrant (Appendix 7). Of the 16 endemic birds 7 or non-forest dependent and 9 are forest dependent. The low number of migrant warbler species is as a result of the time the survey was carried out before the arrival of the migrant birds. In addition, a low number of waterfowls were encountered in study, because no wetland or large bodies were present in the project area.

Fields: Herbaceous crops, fallow, cultivated and vegetables

Thirty five (37) species of birds were identified during the assessment of the five sites in zone. The number of species at the sites ranges from the lowest of 12 species to the highest of 21 species (Appendix 7). The pastures and the woodland had the largest number of bird's species. Several trees are present at the pastures which encourage birdlife. The trees provide a habitat for several forest specialist species which are not expected to be in the area. Several birds typical of cultivated areas were seen in the pastures in the cultivated areas such as grass quits, kingbirds, doves, vireos and flycatchers (Downer and Sutton, 1990).

Fourteen (7 forest dependent and 7 non-forest dependent) of the 28 endemic birds to Jamaica were located within this zone (Appendix 7). Only one (3) migrant warbler was observed during the assessment. The low number of migrant birds was as a result of the time the survey was carried out before the arrival of the migratory bird season.

Secondary forests and fields

Forty five (45) species of birds were identified during avian assessment at the three sites. The number of species range from the lowest of 21 species to the highest of 36 species (Appendix 7). The largest number of species was identified in the forest near the Roaring River Great property. The Gully forest also had high bird diversity. There was a mixture of birds identified in the survey which are typical of species of both dry and wet limestone forest. Birds such as Caribbean Dove, Parakeets, Hummingbirds, Jamaican Woodpeckers, Orioles and Warblers which are typical of dry Limestone forest were observed. While other species that are normal found in wet forest such as the Jamaica Crow were present.

Sixteen (9 forest dependent and 7 non-forest dependent) of the islands twenty eight (28) endemic birds were identified in the area (Appendix 7). The high number of endemic forest specialist suggests that the forest is in good health.

Conclusion

Large highway projects usually have an impact on the natural ecosystem especially in areas that are largely undisturbed by human activities, although it is reduced in heavily agricultural regions (Southerland, 1994). However, the area in which the highway will pass through have been modified by the bauxite company and farming. Hence the impact will not be significant. However the construction of the highway is not confine to the areas that are heavily impacted by man. Both the construction of paved roadways and the removal of vegetation will cause a loss of habitats. For example the road construction processes includes removal of vegetation, blasting and excavating, which will scare away fauna such as birds. However several of them will return.

4.2.2.4 Herpetofauna

Introduction

The specified area has similarities to the Cockpit Country including a terrain with an “egg carton” formation when viewed from above. This area however has significantly more inhabitants and has towns that date back to between the 17^{th} and 18^{th} century.

This differs to the Cockpit Country which stands as one of our pristine rainforest with very little damage or change to the layout of its vegetation. The specified area has been transformed into large cattle farms and small mixed farms. Stonewalls now run throughout the selected area marking property borders. The small knolls that were once covered with wet limestone forest have been mowed down to produce open grasslands. Only small pockets of forested areas remain and are in danger of being removed to make room for new housing projects in conjunction with the highway projects and farms.

The stonewalls however are a lifeline for the rare species of frogs and reptiles as it provides great refuge from the domestic dogs and cats and minimises the effect of mongoose on the native or even endemic population. A large percentage of the Jamaican herpetofauna are terrestrial and all have been in found in conjunction with stonewalls. This improves the chances of finding large and rare reptiles and amphibians.

The area also has large trees and bromeliads present in high numbers. The large trees provide sanctuary for arboreal *Anolis* and geckos. The bromeliads are home to herpetofauna that are only known to inhabit this form of vegetation. There are several forms of bromeliads and they are in great abundance. The presence of large trees and bromeliads in the these high numbers improves the possibility of spotting arboreal species and also increases the chances of finding arboreal species that are yet to be described from this area.

Method

A map of the specified area was provided and several sections were selected for specimen collection. At each stop the GPS locator was used to mark the points and we were allotted time to venture out on a set route for a protracted period of time. The macro habitats were first identified and pictures taken. The micro-habitats were then identified and pictures taken when necessary. Once the habitats had been identified, the list of reptiles and amphibians of Jamaica was used to determine which species are expected. Active specimen collection was then conducted and pictures were taken.

This was repeated at each stop throughout the specified area. A total of 5 spots were selected. However several minor stops were made along the way for further specimen collection or identification.

The method was carried out along trails and foot paths on the 8 selected study sites

Results

Amphibians

Nineteen of Jamaica's Amphibians were recorded from the study site (Table 4-28), three species recorded for the first time from this area of Jamaica.

Table 4-28 – Amphibians recorded at study sites

Genus	Species	DAFOR Scale
Rhinella	*marina*	Frequent
Eleutherodactylus	*cundalli*	Occasionally
Eleutherodactylus	*gossei gossei*	Dominant
Eleutherodactylus	*grabhami*	Rare
Eleutherodactylus	*jamaicensis*	Abundant
Eleutherodactylus	*johnstonei*	Occasionally
Eleutherodactylus	*junori*	Rare
Eleutherodactylus	*pantoni*	Occasionally
Eleutherodactylus	*planirostris*	Occasionally
Eleutherodactylus	*sisyphodemus*	Rare
Osteopilus	*crucialis*	Rare
Osteopilus	*marianae*	Rare
Osteopilus	*ocellatus*	Rare
Osteopilus	*wilderi*	Rare
Lithobates	*catesbianus*	Not Present

Reptiles

Sixteen of Jamaica's fifty reptiles were recorded from the study site. These are listed in Table 4-29 below.

Table 4-29 – Reptiles recorded at study sites

Genus	Species	DAFOR Scale
Celestus	*barbouri*	Rare
Celestus	*crusculus cundalli*	Occasionally
Celestus	*hewardii*	Rare
Aristelliger	*praesignis*	Occasionally
Hemidactylus	*mabouia*	Occasionally
Sphaerodactylus	*argus argus*	Occasionally
Sphaerodactylus	*goniorhynchus*	Rare
Anolis	*garmani*	Frequent
Anolis	*grahami grahami*	Frequent
Anolis	*lineatopus neckeri*	Occasionally
Anolis	*lineatopus merope*	Occasionally
Anolis	*opalinus*	Frequent
Anolis	*sagrei*	Frequent
Anolis	*valencienni*	Rare
Hypsirhynchus	*funereus*	Rare
Typhlops	*jamaicensis*	Occasionally

Discussion

R.marina was seen throughout the area. *E. cundalli* was found in rock walls and in log piles. *E. gossei* was found throughout the area and was heard making calls when the area became overcast or after rains had stopped. *E. jamaicensis* was found in most bromeliads searched throughout the area. The colouration varied from one specimen to the next. *E. johnstonei* and *E. planirostris* was found around houses and was seen closer to the coast. *E. pantoni* was found in areas where the cockpits were more defined and was heard calling from the edge of forested areas in the "valley" sections of the cockpit. The *Osteopilus* species were heard but never seen. Their calls were heard coming from tank bromeliads above 10-15 feet from the ground. The juveniles for a *Osteopilus* species was found throughout the area however they were not properly identified as they were put into another bromeliad soon after discovery and were not taken back to the lab for further study.

Celestus is found throughout the area due to stonewall that traverses the countryside. *C. crusculus* cundalli is the most abundant and is found even in open fields and in the forested areas. *C. barbouri* is found throughout the area however is rarely seen and is found only in pocket populations. There is a large *Celestus* species that is yet to be described, is found throughout the area in pocket populations normally associated with stonewalls. This species is only known from this area and their range extends across to Claremont and south towards Moneague.

Anolis has its usual species present including *A. garmani, A. grahami graham, A. opalinus, A. lineatopus merope* and *A. sagrei sagrei* found throughout the area. *A. valencienni* is known from the area however was not seen.

Sphaerodactylus has 3 species known from the area include *S. argus argus, S. goniorhynchus* and *S. richardsoni richardsoni*. All have been seen on previous trips to this area. There is a *Spaerodactylus* species seen in arboreal bromeliads. There is no description of bromeliad dwelling species from the area.

The other geckos seen in the area include *A. praesignis praesignis* and *H. mabouia*.

The only snake seen on this trip was *H. funereus*. Other snakes are known from the area however they are very rare and the *Tropidophis* species from the area is rarely seen by local residents.

Conclusion

The species known to occur in this part of Jamaica were well represented throughout the area. However, there are particular species that are found in this part of Jamaica and every effort should be made to reduce the disturbance of key habitats such as stone walls which, if left untouched, will help to keep these populations healthy.

4.2.2.5 Invertebrates

Method

Arthropod Survey

Larger specimens such as butterflies and spiders were recorded directly. Flight nets, sweep nets, light trap, beating tray, and direct search of quadtats 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 and the Institute of Jamaica. A DAFOR rating was established for all recorded species.

Freshwater Survey

Kick samples and Dip nets were the key method utilized. Kick sampling involves kicking an area of about 0.15m^2 of substrate in a designated riffle for 1.5 minutes. Dip net pulls under bank side vegetation and along the bank were used. The open water of the large ponds was sampled using plankton nets, and fish trawls.

For identification, a representative number of individuals of all taxa will be stored in 70% ethanol for subsequent examination in the laboratory.

Results

One hundred and seven (107) species of invertebrates were recorded in the study site. This was dominated by the Homoptera (plant bugs) and the Lepidoptera (butterflies and moths). Table 4-30 below provides a summary of the Orders collected. Table 4-31 and Table 4-32 show butterfly/moth and land snail results.

Table 4-30 – Summary of Invertebrates recorded

Order	*Number of species*
Homoptera	22
Hemiptera	10
Orthoptera	3
Dictyoptera	2
Hymenoptera	17
Coloeptera	21
Thysanoptera	1

Order	*Number of species*
Lepidoptera	20
Arachnida	11

Table 4-31 - Butterflies and moths (Lepidoptera) recorded

Order & Family	**Genus & Species**	**Common Name**	**DAFOR Rating**	**Comments**
Pieridae	*Eurema nise*	The Jamaican Sulphur, Cramer's Little sulphur	O	
	Phoebis sennae sennae	The Cloudless sulphur	O	
	Ascia monuste eubotea	Cabbage White Butterfly, Antillean Great white	O	not endemic
Heliconiidae	*Heliconius charitonius simulator*	Jamaican Zebra	O	endemic sbspecies
	Dryas iulia delia	Julia	F	Central America, Greater Antilles
	Dione vanillae	The Tropical silverspot	O	Greater Antilles, Bahamas, Central America
Nymphalidae	*Anartia jatrophae jamaicensis*	The Jamaican White Peacock	F	endemic subspecies
	Mestra dorcas	Jamaican Mestra, Dorcas	O/F?	endemic species
Hesperiidae	*Urbanus proteus*	The Common Tailed Skipper, Common Long	R	not endemic

Order & Family	Genus & Species	Common Name	DAFOR Rating	Comments
		Tailed skipper		
Lycaenidae	*Leptotes cassius theonus*	The Cassius Blue	O	Greater Antilles and Florida
Heliconiidae	*Heliconius charitonius simulator*	Jamaican Zebra	O	
	Dione vanillaeinsularis	The Tropical silverspot	A/F	Greater Antilles, Bahamas, Virgin Islands
Nymphalidae	*Mestra dorcas*	Jamaican Mestra, Dorcas	F	endemic species
Satyridae	*Calisto zangis*	The Jamaican Satyr	O	
Hesperiidae	*Urbanus proteus*	The Common Tailed Skipper	R	

Table 4-32 – Land snails recorded

Family	Genus & Species	DAFOR Rating	Comments
Pleurodontidae	*Pleurodonte lucerna*	F	endemic
	Dentellaria invalida	F	endemic
	Dentllaria valida	F	endemic
	Thelidomus aspera	F	endemic
Camenidae	*Zachrysia provisora*	D	introduced
Neocyclotidae	*Cyclochittya chittyi*	F	endemic
Sagdidae	*Sagda spei spei*	R	endemic

Family	Genus & Species	DAFOR Rating	Comments
Urocoptidae	*Urocoptis brevis*	R	endemic
	Urocoptis sp.	R	
	uk sp.	F	
Helicinidae	*Alcadia atrinolabris*	R	endemic
Helicinidae	*Alcadia hirsuta*	R	endemic
	Lucidella aureola	F	endemic
	Lucidella depressa	R	endemic
	Eutrochatella pulchella	F	endemic
	Hemitrochus graminicola	F	endemic
Annulariidae	*Parachondria fascia fascia*	R	endemic
Oleacinidae	*Varicella* sp.	R	endemic
Urocoptidae	*Apoma agnesianum*	O	endemic
	uk sp.	O	
Subulinidae	*Allopeas gracile*	R	introduced

Discussion

Because the habitat has been disturbed for decades the species found here are generalists, capable of surviving a large variety of habitats. No species requiring specific conservation measures were identified. However, many species play key roles in the environment and all measures should be employed to reduce habitat disturbance.

4.2.2.6 Freshwater Fauna

Method

Two sites (Site 1 and Site 2) (Figure 4-84) suitable for sampling were selected along the Little River. This comprised the only fresh water source along the proposed route of the project. The sites were chosen based on accessibility through the Urban Development Corporation property at Roaring River.

The aquatic resources, namely habitat quality, macroinvertebrate and fish communities, and riparian and in stream vegetation were assessed. A list of fauna and flora was generated through:

- Floral survey – vegetation in the river & riparian zone
- Faunal survey – macro invertebrates and fish species
- Habitat description - physical and biological
- General river substrate assessment and recording the physical conditions and water quality.

Habitat Assessments: Habitat assessments were carried out for 50 metre stretches of the river at each sample location. Photographs were taken, and visual assessments made of selected riparian and water quality characteristics.

Macroinvertebrate assemblages: At each site, qualitative sampling (using kick samples with aquatic bottom nets and general surveys under rocks, in vegetation, etc) were conducted. Samples were preserved in formalin and stored until sorted and identified. Identification of specimens was conducted to Family level – or species level where appropriate.

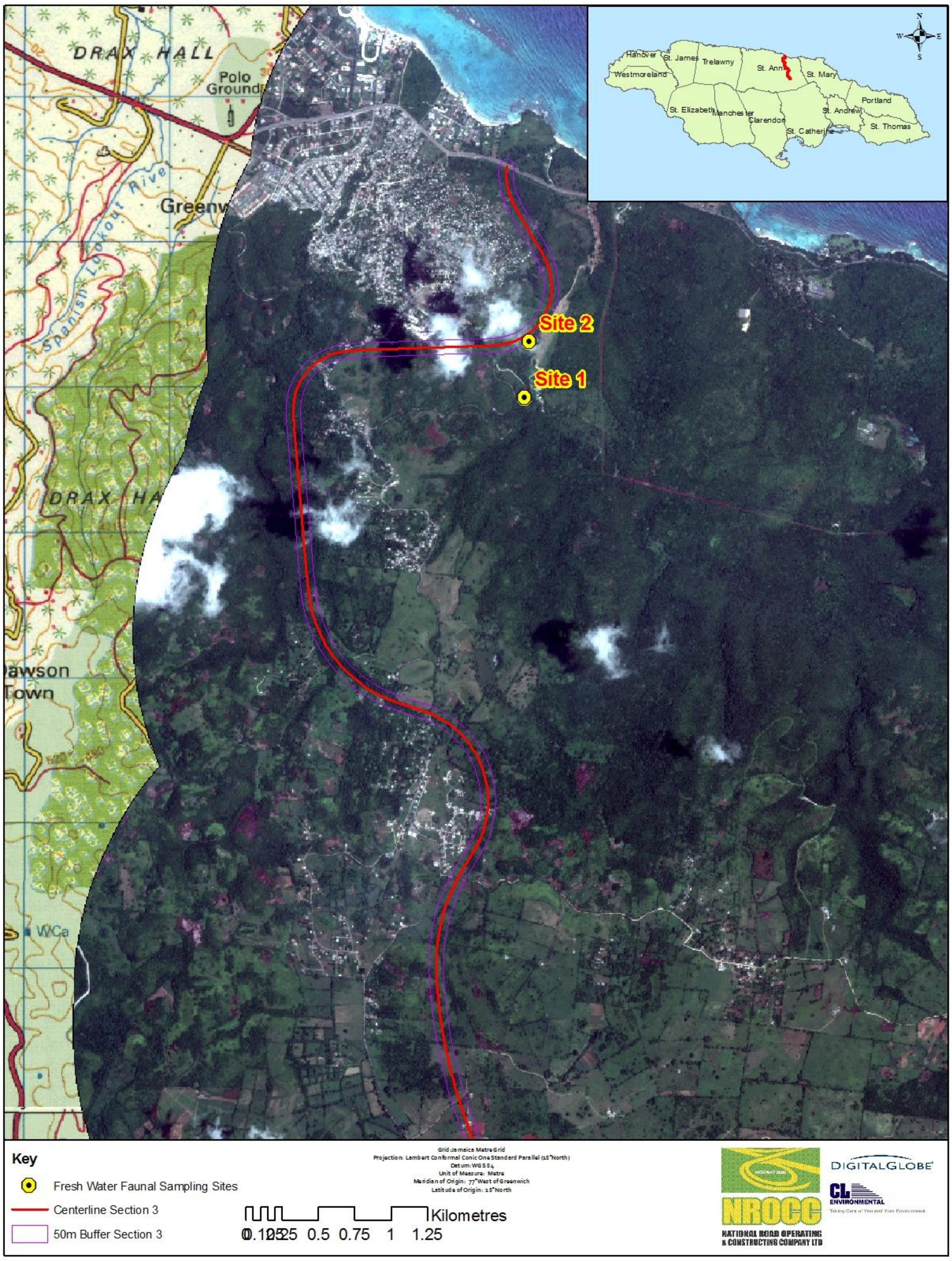

Figure 4-84 – Map showing freshwater faunal sampling sites along Little River

Site Description

The river is relatively small and rhithronic (i.e. large substrate size, relatively fast flow and steep gradients) throughout most of its length (See Plate 4-27 to Plate 4-29). While the river is not heavily populated along most of its reaches, there was evidence of solid waste disposal along many parts in the form of PEP Bottles and other plastic refuse, styrofoam containers, old tyres, etc.

Site 1 exhibited the following characteristics:

- Velocity, channel depth and riffle/pool regimes

The volume was low throughout most of the river, with the exception of the terminal stretches close to the coast. It appears to experience seasonal fluctuations in volume. Consequently the depth was shallow, and the river was confined to small disparate pools along most of its reaches.

- Channel alteration, Bank stability & vegetative protection
  - The channel was mostly unaltered with intact riparian vegetation which consisted of large trees and shrubs where the river ran through public and UDC properties.
  - There was little in-stream vegetation and little to no algae present.

- The substrate composition was generally limestone bedrock.

Site 2 was the last accessible point of above-ground water. The location was very similar to Site 1 in general characteristics. The river ran through a ravine, with taller overhanging vegetation; large trees were more prevalent than succulent plants at this point. The river disappears underground just beyond the site, and resurfaces further downstream closer to the coast on private property to which no access was available. The flow increases significantly at this point until its eventual termination at the coast.

Plate 4-27 - Photograph showing seasonal low flow at Little River (Site 1)

Plate 4-28 - Photograph showing riparian vegetation and canopy cover at Site 2

Plate 4-29 - Photograph showing dry riverbed typical of stretches of the Little River

Results

The full data collected are summarized in Table 4-33.

- The physico-chemical parameters collected showed values for pH and redox potential within normal ranges for the local conditions. The mean flow rate was obtained along stretches of the river which had not dried into small pools and is normal for a high gradient stream.
- The temperature is slightly elevated considering the level of shading from the canopy cover, but this is likely the result of the shallow depths as a result of seasonal fluctuations in water levels.
- The conductivity is higher than the normal range for a Jamaican river in relatively pristine condition. The causes are likely to be the result of nutrient inputs from low levels of domestic impacts, as well as hypersaline concentration of the water due to reduced quantity and flow during the dry season

- The biological composition of the river was normal for a high gradient stream with low to moderate impacts. Representatives from thirteen macroinvertebrate taxonomic groups were found, with gastropod (snails) dominating, followed by various insect groups, and crustaceans. No fish were collected; these appeared to be limited in range and abundance, as a result of the desiccation of long stretches of the river.
- The fauna were assigned scores which indicate sensitivity to organic pollution ranging from 1 (least sensitive) to 10 (most sensitive) based on Hyslop, 2002.[2] A large proportion of the total fauna had scores of 7 and higher, indicating that prior to the seasonal drought, the water quality conditions were relatively fair.

Table 4-33 – Physicochemical parameters and biological composition of Little River

	Site 1		*Site 2*	
PHYSICO-CHEMICAL COMPOSITION	Mean Values		Mean Values	
Temperature (˚C)	24.3		24.5	
pH	7.3		7	
Redox Potential	214.2		210.3	
Conductivity (microSiemens/cm)	624		695	
Dissolved Oxygen, D.O. (%)	116.7		114.3	
Absolute D.O. (mg/l)	9.6		9.3	
Width (m)	3.0-4.0		3.0-4.1	
Depth (m)	0.05-0.3		0.05-0.3	
Flow (cm/sec)	110			
BIOLOGICAL COMPOSITION		*(Biotic Index)*		*(Biotic Index)*
Crustacea				
Atyidae:				
Atya innocuous	x	*7*		
Xiphocaris elongaata	x	*7*	x	*7*
Grapsidae: *Sesarma sp.*	x	*10*		

[2] E. J. Hyslop, 2002. Provisional Biotic Index for Jamaican Rivers based on Benthic Macroinvertebrates. Unpublished Report.

	Site 1		Site 2	
Ephemeroptera				
Baetidae			x	*4*
Gastropoda				
Thiaridae:				
Melanoides tuberculata	x	*3*		
Thiara granifera	x	*3*	x	*3*
Hemiptera				
Corixidae	x	*5*	x	*5*
Gyrinidae (adult and larvae)	x	*3*	x	*3*
Odonata				
Coenagrionidae	x	*5*	x	*5*
Gomphidae: ***Progomphus integer***	x	*8*	x	*8*
Libellulidae	x	*7*		
Trichoptera				
Calamoceratidae: ***Phylloicus farri***	x	*8*	x	*8*

Conclusion

The Little River, based on limited sampling of the two accessible representative sites, appears to exhibit the normal physico-chemical characteristics expected of an upland stream. The fact that it flows through an area of limestone bedrock would predispose the stream to episodic intermittent above-ground flow, with much of the flow occurring underground. The vegetation cover is good and the parameters indicate that the river is in good condition. This is substantiated by the composition of the macroinvertebrate fauna which is indicative of a good quality stream. The absence of a significant fish component is normal for such a small intermittent stream. In short then the Little River exhibits the expected physico-chemical conditions and invertebrate fauna expected of an unpolluted intermittent limestone stream at elevation.

4.2.2.7 Bat Survey

All faunal assessments were conducted on selected sample sites representing the different vegetation types along or in the vicinity of the area demarcated for the proposed highway. During the assessment, trees, sinkholes and rock faces encountered in the area were searched for bats. In addition, locals (farmers, coal burners and residents) seen in the area were interviewed about the location of caves in the area or if they have seen "Rat Bats" in the area. At no time did the locals mention the presence of bats in the survey area.

It should be noted that the bat survey did not cover the entire area that the proposed highway will pass through and it is possible that there are caves along the route. It is recommended that, during the execution of the project, an environmental officer is present to monitor operations so if a cave is present along the alignment, measures are put in place to address the matter.

4.3 LAND USE

4.3.1 Previous

4.3.1.1 Beulah Park

In 1920 Geo L. Trewick owned the 148 acre property valued at £310, land use grazing. Mabel Moseley owned the 156 ¼ acre property valued at £550 in 1938. It was under pastures and pimento.

4.3.1.2 Blackheath

James Duncan was the owner of Blackheath in 1783 with 418 acres of land. A race course was located on the property at this time (See Plan). William Duncan owned Blackheath between the years 1815 and 1817. In 1815 the property had 21 enslaved persons and 18 heads of stock and in 1817 the total had risen to 36 enslaved and 30 heads of stock (Jamaica Almanac 1815, 1817).

Eight owners are recorded for 1822: William Duncan had 25 enslaved and 41 heads of stock; Joseph M. Dunn had 14 enslaved persons and 23 heads of stock, the estate of Joseph M. Dunn had 22 enslaved persons and 44 heads of stock, the estate of F. Duthie had 5 enslaved persons and no stock, John Fox Edwards owned 36enslaved persons and 4 heads of stock, Dorcas Evans was the owner of 6 enslaved persons, F. Ewers also owned 6 enslaved persons and Margaret Ewers owned 14 enslaved persons(Jamaica Almanac 1815, 1817).

By 1832 only five owners are recorded for Blackheath: William Freeman with 11 enslaved persons and 16 heads of stock, Arthur

Foulks had 54 enslaved persons and 123 heads of stock, Joan Frances had 14 enslaved persons, Margaret Fraser had 18 whilst Duncan McCallum owned 26. Robert G. Drew is recorded as the sole owner of 358 acres in 1840 (Jamaica Almanac 1815, 1817). By 1882 Jane Poulton owned 108 acres of which 1 acre was in ground provisions, 3 acres in Guinea grass, 12 acres in common pasture and pimento and 92 acres in wood and ruinate. Geo Trewick owned the 108 acre property between 1912 and 1938. In 1912 the estate was valued at £250 with the property utilized as cattle pen. The value was £420 in 1930 and 1938 respectively. Land usage in 1930 was cultivation and pimento and in 1938 pastures and citrus.

By 1957 the estate was purchased by Reynolds Jamaica Mines Ltd.

4.3.1.3 Mammee Bay (Taino Site)

In 1762 the Mammee Bay Estate belonged to Samuel Heming who was also the owner of Seville Estate (Crop Accounts 1762:218). Upon the death of Samuel Hemmings, Mary Hemmings became the administrator for Mammee Bay and Thicketts properties. She had intermarried with Thomas Wynn by 1767. For 1767 the properties produced: 197 hogsheads of sugar, 500 gallons of molasses, 65 puncheons of rum and 975 lbs of cotton (Crop Accounts Book 5, folio 1).

John Perry was the owner in 1810 possessing 126 enslaved persons and 34 heads of stock. Between the years 1815 and 1817 Perry and Andrews (receiver) were in possession of the estate. In 1815 there were 72 enslaved persons and 52 heads of stock. The estate shipped 43 ¾ hogsheads of sugar and 20 ½ puncheons of rum in 1816. Mathew Pybus was the overseer. In 1817 the enslaved numbered 94 and stock 56. Catherine Wordie was the owner in 1822 the estate possessing 75 enslaved persons and 120 heads of stock. Mary Young owned the estate in 1832 having 78 enslaved persons and 83 heads of stock (Jamaica Almanac 1811, 1815, 1817, 1832).

The property had 83 apprentices in 1837. John W. Davis was the owner of the property at this time. He owned a number of properties including Mammee Bay in 1840. The acreage for these holdings was 2016. By 1845 Mammee Bay was in the hands of McCullock and McNab. The extent of the estate was 476 acres (Jamaica Almanac 1838, 1840, 1845).

In 1881 the owner was Donald Mackintosh with C. W. Steer as manager and the estate consisted of 551 acres 100 of which was in guinea grass 200 in common pasture and pimento and 251 in wood and ruinate. Forty bags of pimento were produced (*Return of Properties* 1882). The owner in 1912 was Edward Pratt with E. C. Pratt in charge. The 551 acres was valued at £2,500. The land was in coconut cultivation and cattle pen. Edward Pratt also owned it in 1920 when the 551 acres was valued at £4,570 and was in coconut and common (*List of Properties* 1920:19). E. C. Pratt owned it between the years 1930-45. For the years 1930 and 1938 the estate was valued at £3,115 and in coconuts and commons. In 1945 there were 87 heads of cattle.

4.3.1.4 Lydford/Linford/Lynford

Lydford Penn made £408.14 from the sale of 3 horses, 10 horned cattle, 4 sheep and for pasturage in 1806. The overseer was Robert Marsh and William Marsh (deceased) was the owner (Account Produce 1807:145). In 1816 £737.5.10 was collected from the sale of cattle£502.10, horses £218.13.4, coffee £8 and interest £8.25

William Marsh owned Lydford in 1832 with 38 enslaved persons and 10 heads of stock. In 1837 there were 99 apprentices (Jamaica Almanac 1832, 1838).

By 1881 the 381 acre was recorded as the estate of Robert Marsh. Percy Fox owned Bradfield and Lydford in 1912 the acreage being 435 valued at £1,750. Grazing was the main use of the properties. In 1918-19 Lydford and Bradfield were still owned by Percy Fox with 1,119 acres in grass and common, other acreage was 97 and the number of cattle was 391 heads.

Lyford had grown to 1,189 ¼ acres by 1920 and this acreage remained until 1930. In 1920 the land was valued at £3,300 and in 1930 £3,789. Percy Fox continued as owner and the land was used for grazing and pimento cultivation. Two owners are recorded for 1938: F. R. Fox owned 570 ¼ acres valued at £2, 089 and he had pastures and pimento. Dr. E. L. Fox owned 618 3/4 acres valued at £2,000 and he also had pastures and pimento.

Sir Alfred DaCosta was the owner in 1944 having 665 acres which were in grass and common.

4.3.1.5 Bauxite

Bauxite is the raw material from which the metal aluminum is made. Bauxite ore occurs in red earth found in the limestone areas of Jamaica. The existence of red ferruginous earth in Jamaica was known from the late 19th century though its potential importance as an ore of the metal aluminum was not recognized at the time, commercial production of aluminum from bauxite beginning only in the late 1880s. It was not until the middle of the Second World War that exploitation of the mineral was first considered.

In Jamaica new interest in bauxite came about when a local planter, Sir Alfred DaCosta, sent soil from a section of a property he owned in St. Ann for analysis since it yielded poor crops. Back came the answer it was almost pure bauxite. A Canadian company began prospecting and proved the existence of significant deposits in the parishes of St. Ann, Manchester and St. Elizabeth. In November 1942 under wartime regulations, the government declared all bauxite in Jamaica the property of the Crown. Extensive exploration work was begun in 1943 leading to the first test shipment to North America that year. Because of the war, commercial exploitation was delayed, the first shipment being made in 1952.

Reynolds Metal Company of America bought Sir Alfred D'Costa's properties of Lydford and Crescent Park and was among the pioneers of bauxite exploitation in Jamaica. Reynolds Jamaica Mines Ltd sent the first regular export shipment of bauxite in 1952 and the industry develop rapidly from this start.

The ore was transported from the plant to port by means of an overhead bucket tramway (aerial ropeway) which was replaced by a conveyor belt-line (Plate 4-30).

Plate 4-30 – Section of conveyor belt line at Murpy Hill, St. Ann, 2010. (Source JNHT Files)

The company carried on large-scale farming on its 80,000 acres of property. The chief feature was the improvement of pasture lands and cattle strain; herds of beef cattle, built up with special breeds of Santa Gertrudis, Brahmins, Charollais and others. Pigs and poultry were also raised, and much attention was given to afforestation and the rehabilitation of mined–out areas, including research into their suitability for local food crops. Lydford Enterprises, an affiliated company operates a cold storage and meat processing plant and a livestock feed mixing plant (Wright and White 1969:91).

Sir Alfred DaCosta is honoured for the pivotal role he played in the development of Jamaica's Bauxite Industry. Reynolds put up a plaque to Sir Alfred north of Crescent Park house the former home of Sir Alfred.

4.3.1.6 Phoenix Park

The property was formerly called the Menaughe. Phoenix Park was originally a 1,450 acre cattle and pimento estate which in 1776 had 72 enslaved persons and 503 head of stock. Phoenix Park was originally owned by the Brownrigg family. The Georgian Great House was built about 1775 by the Hon. John Brownrigg, Judge of the Court of Vice Admiralty of Jamaica, who is said to have entertained the young Lt. Horatio Nelson later Admiral Lord Nelson here. Judge Brownrigg an Anglo- Irishman probably named the estate after Phoenix Park in

Dublin, Ireland, the country residence of the British Viceroys of Ireland.

The estate was owned in 1810 by J.T. Brownrigg with 72 enslaved persons and 568 heads of stock. In 1818, John Brownrigg 11's daughter married William Mitchell II (1787-1828), nephew of the Hon. William "King " Mitchell of Bushy Park Estate, Custos of St. Catherine and so Phoenix Park passed into the possession of the Mitchell family (Espeut forthcoming).

In 1817 the estate was owned by William Mitchell with 67 enslaved persons and 406 heads of stock; in 1822 with 78 enslaved persons and 456 heads of stock, in 1824 with 74 enslaved persons and 425 heads of stock and owned in 1831 by his heirs with 92 enslaved persons and 402 heads of stock. The estate had 77 apprentices in 1837 (Jamaica Almanac 1817, 1822, 1832, 1838).

The Mitchells were absentee owners. Phoenix Park was managed by their planting attorney Hamilton Brown (1776-1844) of Minard Estate and founder of Brown's Town. From about 1795 to 1808, the Great House was leased to the British War Department as Quarters for the officers commanding the British troops garrisoned at the nearby Moneague Barracks; 2 graves in the garden behind the Great House are of two naval officers who died there. From 1808 to 1827, Phoenix Park became the favourite country residence of William Montagu, 5th Duke of Manchester and Governor of Jamaica. The 2nd Earl of Belmore, Governor of Jamaica, used the house as his summer residence between the years 1829-1831(Ashmeade-Hawkins 2001, Espeut forthcoming).

In 1845 the Mitchell family sold the estate to Henry Braham, overseer since 1836 and who later succeeded Hamilton Brown as planting attorney. It passed to various members of the Braham family. John Richard Braham inherited Phoenix Park in the 1870s, and the estate later passed to his sister, Alice Smallwood Braham, who married Winchester Harris of Seville Estate. The Harrisses lived at Phoenix Park from the 1890s to about 1905 when they moved to the Seville Great house. Phoenix Park was leased in 1908 to Horace Alexander Fowler, who had married Agnes Braham, the daughter of John Richard Braham. In 1921, the Fowler and Harris families sold the estate to Sir John McKenzie Pringle (1834-1923) Custos of St. Mary who presented Phoenix Park and Shaw Park Estates his elder daughter Mrs. Flora Stuart. Mrs. Stuart sold out to a syndicate, the Jamaica Agricultural Development Company in 1937. They bought the estate to grow potatoes for the early English market. The major shareholder was Mrs. Robinson, who formerly had been married to the heir of the Whitbread brewing fortune in England, she lived in the Great House for many years. She is said to have seen several ghosts in the Great House, one of an old lady who haunts the rose garden, and one of a Redcoat officer who is said to have hanged himself in one of the bedrooms after his fiancée jilted him (Ashmeade-Hawkins 2001, Espeut forthcoming).

4.3.1.7 Cattle

In 1938 the 1,430 acre property was valued at £ 4,500 and was in pastures and pimento.

Sir Alfred DaCosta bought the estate in 1943 converting it from a beef cattle property to a dairy farm. In 1945 the property had 360 head of cattle (Handbook of Jamaica).He gave the estate to his daughter Nellie Rodwell who sold it to Kaiser Bauxite Company in 1964. Kaiser subsequently subdivided most of the 1,450 acre estate for land resettlement for small farmers, but the Great House and 25 acres of land surrounding it were bought by Mr. A. D. Scott the artist, who later leased the Great house to Reynolds Bauxite Company as a company residence for senior Canadian staff. In 1977, the Great House and 25 acres were sold to Winston L. Ashley.

The Great house is a fine example of Palladian architecture, modified with local vernacular features to form a Jamaican Georgian house. The two -storey central square block has storage rooms on the lower floor and the living quarters on the upper floor approached by a classical white-pillared portico and the traditional double-staircase; two trap-doors (one in the Entrance Hall and one in the Dining Room) lead to the basement below, and to basement below, and to an underground passage exiting some distance from the house providing an escape route in the event of a slave rebellion. The 17th century kitchen and servants quarters are in separate buildings and were connected to the house by a covered walkway. There is a breathtaking view from the small garden (Ashmeade-Hawkins 2001, Espeut forthcoming).

4.3.1.8 Retirement

In 1882 the acreage was 673 with 441 acres in Guinea grass, 136 acres in common pasture and pimento and 96 acres in wood and ruinate. Richmond Braham is recorded as owner. In 1912 the property was valued at £2,520, owned by John R. Braham and operated as a cattle pen. By 1920 the value had increased to £ 2,600 with land usage being grazing and banana cultivation. In 1930 grazing was the only land usage recorded and by 1938 citrus and grazing. In 1945 there were 641 acres in grass and common, other acreage was 132. The property had 190 heads of cattle.

4.3.1.9 Davis Town

In 1839 part of the Malvern Park lands were laid out into lots by desire of John W. Davis Esquire.

4.3.1.10 Annandale

A Taino site is located at Rose's Farm. In 1974 a jar with a skull and hatchet was found. The hatchet was reburied (Archaeology Jamaica- 74/3).

Annandale property was first owned by Dr. Alexander Johnston, M.D (1739-1787, a Scottish physician and planter, who named the plantation after the ancestral seat of the Johnston family in Dumfrieshire, Scotland. He arrived in Jamaica in about 1760, settled Annandale Estate and later purchased Murphy Hill the adjoining estate, these properties totalling over 2,300 acres on which he grew coffee and pimento and raised cattle, with the labour of over 275 enslaved persons (Ashmeade- Hawkins 1999: 97).

Alex Geddes owned Annandale and Murphy Hill in 1841. The manager was George Middleton and the properties made £3838.68.6 from the sale of stock, timber, pimento, coffee, rents, pasturage and mutton.

Sales were to neighbouring estate as well as far afield. Planters cattle were sold to Vale Royal and Friendship Estate Trelawny, Russell Hall St. Mary, Grays Inn, St George, West Prospect and Williamsfield St. Thomas Y Vale. Breeding Cattle were sold to Friendship Estate Trelawny, Up Park Pen St Ann and Agualta Vale, St Mary. Fat Cattle went to Phoenix Park Pen, St. Ann, Cape Clear Pen and various individuals. Mules were sold to Sevens Plantation in Clarendon and sheep to Prospect Pen. Money was also made from the rent of Annandale Mansion house, pasturage, rent of cottages and grounds (to the former enslaved). Timber was sold to Russell Estate and Drax Hall bought cedar, broadleaf, bully tree and 3 side roller blocks (Crop Accounts Book 85: 80).

In 1842 the estate made £3850 from the sale of stock, pimento, lumber, lime and coffee. Money was collected for pasturage, sale of old Negro house, rents for parts of dwelling house and Negro cottages (Crop Accounts Book 86:148).

In 1845 the properties of Annandale and Murphy Hill were sold to the Hon. Alexander Geddes who was a prominent planter in St. Ann. Alexander Geddes became attorney for several plantations in St. Ann and later Custos of St. Ann. In October 1864 he was brutally murdered at Murphy Hill Great house, where he was spending the night by an unknown assailant, in a crime that shocked the entire colony (Ashmeade- Hawkins 1999: 97).

Following the murder, the heirs of Geddes sold the estates to Thomas Francis Roxburgh in 1865, a Kingston merchant, whose descendants have continued in the ownership of the properties. T.E. Roxburgh owned Annandale and Murphy Hill in 1882. The total acreage was 2,320 of which 60 were in ground provisions, 912 acres were in Guinea grass, 547 acres in common pastures and pimento and 801 in wood and ruinate. The estate produced 400 bags of pimento in 1881.

Thomas L. Roxburgh owned the property between 1912 and 1945 and during this period the land was used for cattle rearing. The value of the property rose steadily from £6000 in 1912 to £7,984 in 190 then fell to £7,321 in 1938. In 1918 Thos. L Roxburgh C. M. G had 2,120 acres in grass and common, other acreage was 200, with 746 heads of cattle. By 1930 Mr. Roxburgh had become Sir Thomas L. Roxburgh. In 1944-45 the property was once again given in with Murphy Hill having acreage of 2,182 with 707 heads of cattle (Handbook of Jamaica 1918-19, 1944-45; List of Properties 1912, 1920, 1930).

Annandale House

The house is set on a hill about 1660 feet above sea level. The Georgian (Queen Anne style) manner on two floors was built between 1760 and 1765. The two-storey rectangular building of five bays is built of cut- stone later whitewashed and has a central fan-lighted entrance door and hipped cedar-shingled roof.

Plate 4-31 – Annandale House (Source: JNHT Photo file 1960)

On the ground floor there is a central hall running from north to south, leading to a stone terrace on the north with steps down to the lawn. To the right (east) of the hall is the imposing dining room full length of the house, with twin sets of cedar double-doors from the hall. To the left there is a room on the north -west now used as a bedroom but probably formerly a study or morning room, with a timber staircase to the upper floor on the south-west.

The upper floor contains a stairs hall, bedrooms and a large salon, with coved ceiling. At the south is a verandah, with rooms east and west and subsidiary stairs; this part was added to the original, according to Mrs. Roxburgh.

South of the main structure and symmetrical about the north-south central axis there is a detached kitchen structure on one floor, separated from the great house by a small barbecues.

Internally floors are boarded and walls plastered. Rooms have a traditional skirting, chair rail, and cornice, and first –rate joinery to doors, windows and panelled window reveals. It contains elegant mahogany woodwork of note is the staircase. The ceilings, generally plastered have been decorated with painted scrolls and other details (Tom Concannon, JNHT File 1968, Ashmeade- Hawkins 1999: 97).

4.3.1.11 Golden Grove

Edmund Duncan owned Golden Grove in 1787. In 1824 the 306 acre property was owned by James Burton.

GOLDEN GROVE (*St. Ann, settlement between Moneague and Claremont*). The village takes its name from the associated property. In the main square the road from Moneague forks, one branch going towards Claremont and Bamboo and the other towards Chalky Hill and Steer Town. Birthplace of Presbyterian minister the Rev. Henry Ward (b. 1879), missionary to Nigeria, Africa (1916-1928), who established the first basic school in Jamaica at Islington, St. Mary in 1938, and who co-founded Meadowbrook High School in Kingston in 1958.

4.3.1.12 Steerfield

A Taino village site is located here (Archaeology Jamaica 74-3).

4.3.1.13 Steer Town

Steer Town formed out of Roaring River Estate lands.

4.3.2 Existing

The proposed alignment of the North South Highway is surrounded by various land use. The land use within 3km of the proposed alignment was assessed. These include agricultural, commercial, industrial, mined out areas, residential, educational and recreational (Dunns River Falls). Other uses include, airstrip, caves, hydroelectric plant, burial grounds (behind homes or private property), forest estates power lines, wells/pump houses, springs, water pipelines, telecommunication modules and cellular towers.

Agriculturally, the study area has papaya farming and subsistence farming. Commercially, the study area has offices, restaurants and bars. There are two limestone quarries within the study area.

There are 27 settlements (residential areas) within the Social Impact Area (SIA) with the major towns being Moneague, Golden Grove and Claremont (Table 4-34).

Table 4-34 – Settlements within the SIA

Golden Spring	***Irons Mountain***
Dawson Town	Steerfield

Green Park	Crescent Park
Greenwich Park	Roadside
CLAREMONT	Epworth
Ewart Town	GOLDEN GROVE
Harmony Hall	Breezy Hill
Mammee Bay	Grierfield
Pilgrim	Phoenix Park
Beechamville	Orange Park
Ogle	Unity Valley
Chalky Hill	MONEAGUE
Davis Town	Walton
Steer Town	

Educationally there are 10 schools within the SIA, these listed in Table 4-35.

Table 4-35 – Schools within the SIA

Steer Town Primary & Jnr. High	***Epworth All Age***
Moneague Primary & Jnr. High	Brittonville All Age
Ferncourt High	Golden Grove All Age
Moneague College	Irons Mountain All Age
Chalky Hill All Age	Sandals Dunns River Day Care

Figure 4-85 illustrates land use within 3km of the proposed highway alignment.

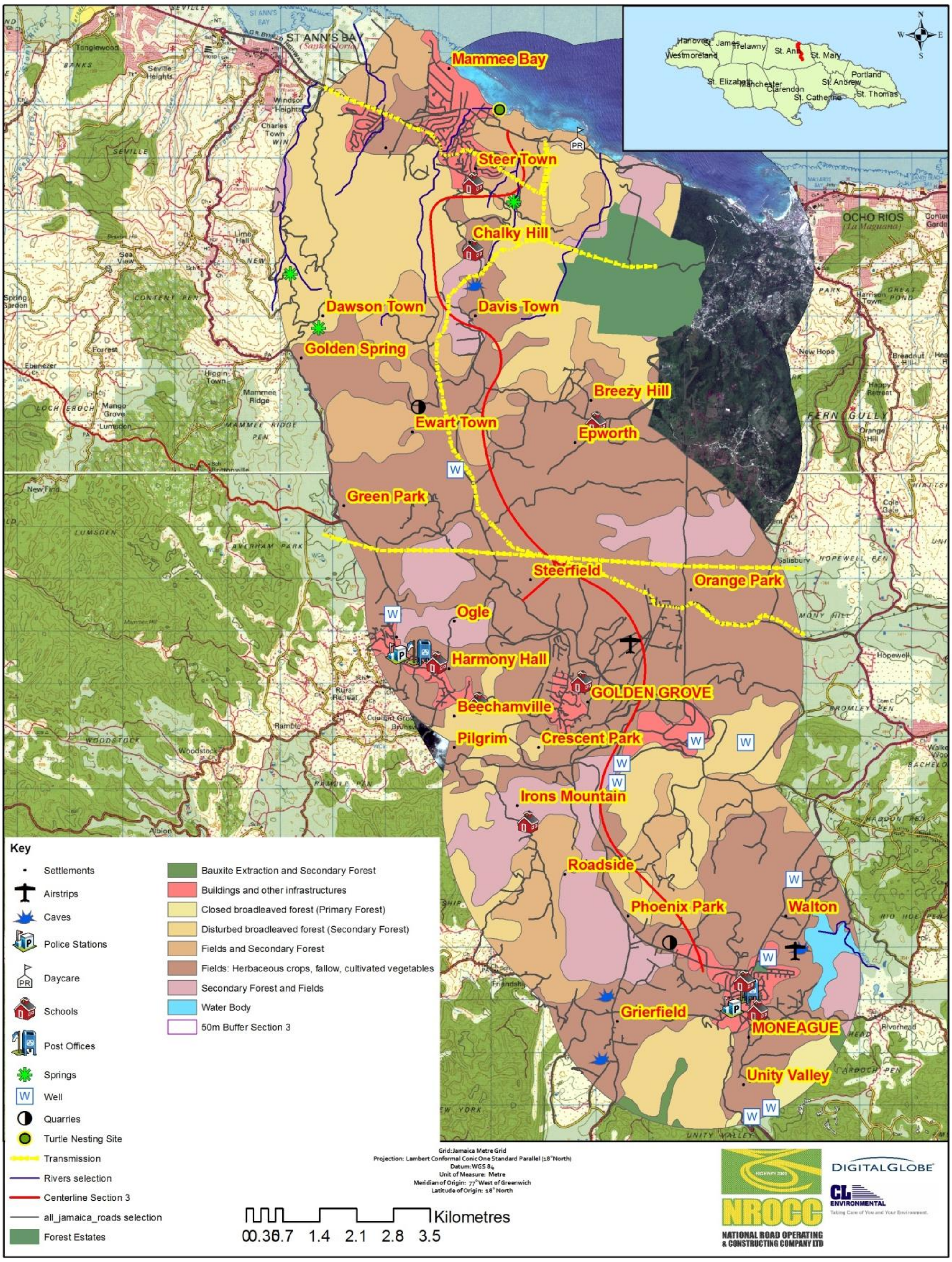

Figure 4-85 - Existing land use within 3km of the proposed Moneague to Ocho Rios alignment

4.4 STRUCTURES ALONG THE ALIGNMENT

A structure survey was conducted along the proposed highway alignment to determine the number and type of structures which would fall within the highway reserve. This study was conducted between July 4 - 5, 2012.

Approximately 64 structures will be impacted by the proposed highway alignment (Figure 4-86). Of these structures, approximately 25% are found in Zone 1 (49km+100 to 51km+000) and 28% in Zone 6 (66km+100 to 67km+000) (Table 4-36).

These vary from houses and other structures in proximity of and associated with households, such as fowl coups, pens, tanks, out houses and tanks. The size and conditions vary.

A detailed account of these structures can be found in the Structure Survey Report.

Table 4-36 – Zoning of impacted structure zones along the proposed alignment

Zone	Chainage along Highway Link*		No. of Impacted Structures
	Break Points	***Kilometres (km)***	
Zone 1	49km+100 to 51km+000	49,000 - 51,000	16
Zone 2	51km+100 to 52km+000	51,000 - 52,000	5
Zone 3	56km+100 to 61km+000	56,000 - 61,000	7
Zone 4	62km+100 to 63km+000	62,000 - 63,000	10
Zone 5	63km+100 to 65km+000	63,000 - 65,000	6
Zone 6	66km+100 to 67km+000	66,000 - 67,000	18
Zone 7	68km+100 to 69km+000	68,000 - 69,000	2
		Total:	**64**

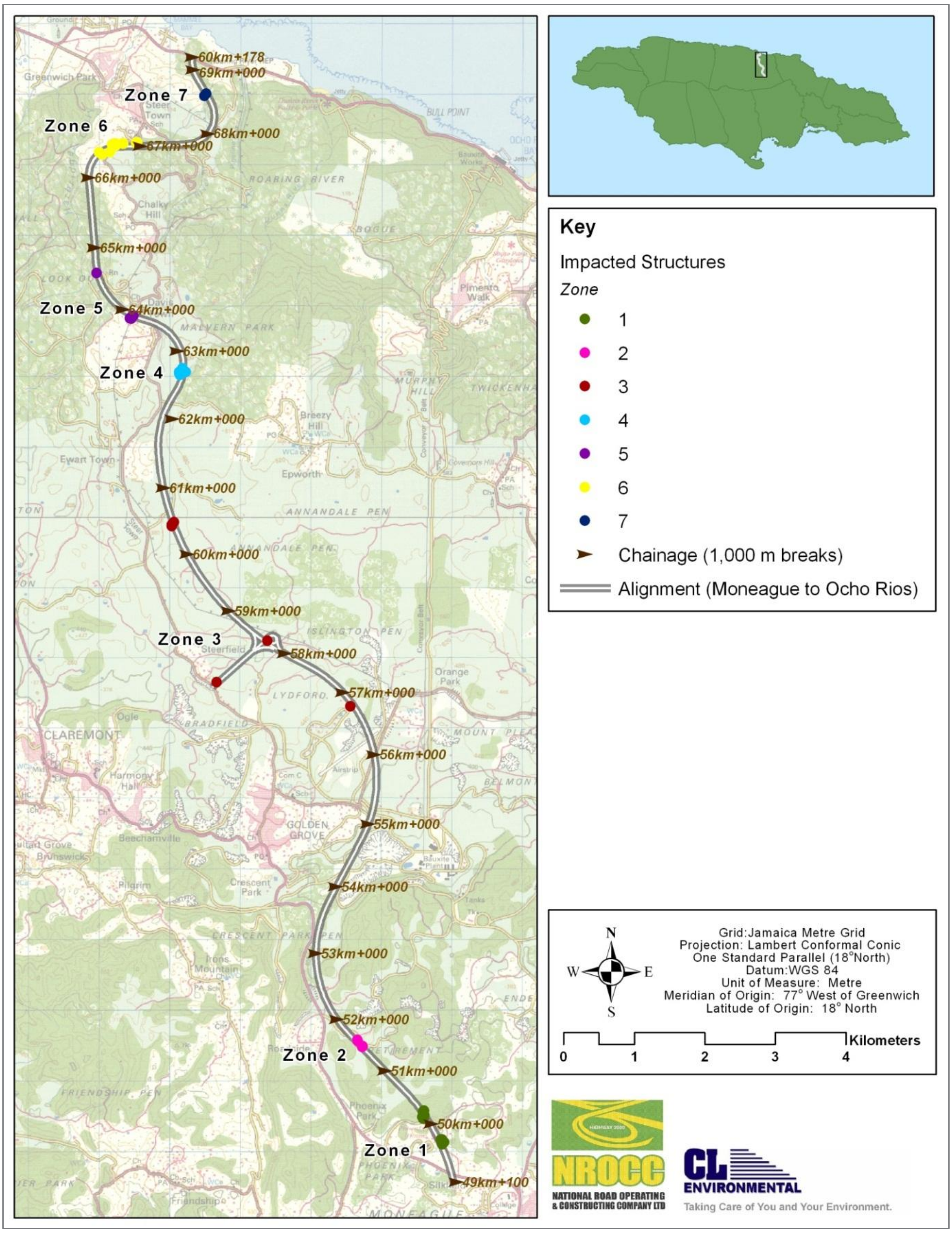

Figure 4-86 – Map showing locations of impacted structures

4.5 SOCIOECONOMICS

4.5.1 Introduction

The Social Impact Area (SIA) for this study was demarcated at approximately three (3) kilometres around the proposed Moneague to Ocho Rios Highway location. This is shown in Figure 4-87 below. By means of the socio-economic data, an understanding of the SIA population can be gleaned and used to develop an appreciation for the potential impacts of the proposed project.

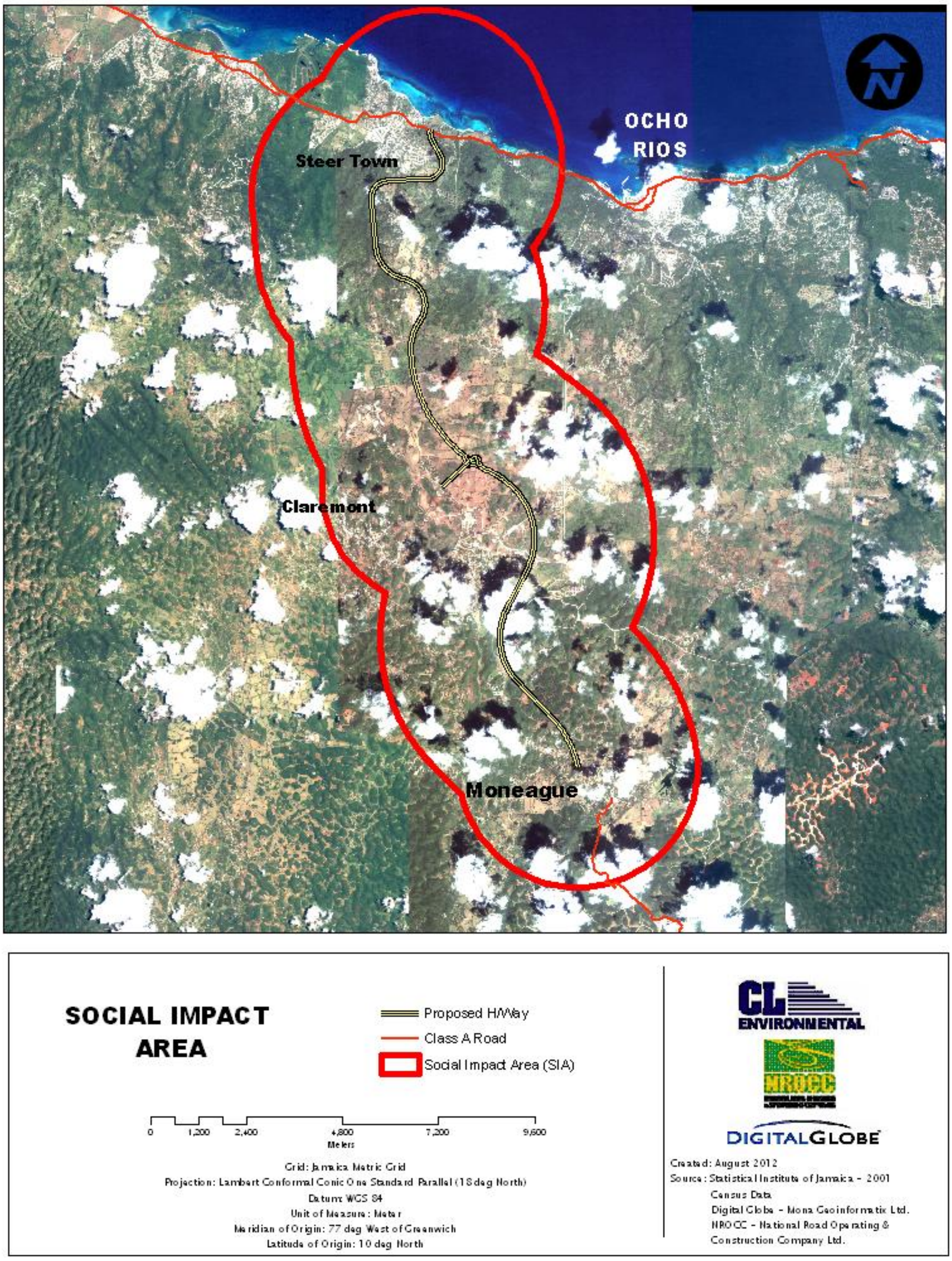

Figure 4-87 - Social Impact Area of the Proposed Moneague to Ocho Rios Highway

4.5.2 Methodology

Socio-economic data including but not limited to Population, Education, Fuel, Garbage Disposal, Housing and Sewage Disposal data were extrapolated from the 2001 population census database (Statistical Institute of Jamaica) for the SIA by enumeration district. In order to derive a visual representation of the data, Geographic Information Systems (GIS) methodologies were utilized to represent this tabular data spatially, that is, by means of a map.

In order to obtain information from the census data the following computations were made:

1. ***Population*** was calculated using the formula [$i2 = i1 (1 + p)^x$]; where i_1 = initial population, i_2 = final population, p = actual growth rate and x = number of years.

2. ***Population density*** – was derived by dividing the population by the land area. This is useful for determining the locations of greater concentrations of population.

3. ***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.

4. ***Male Sex Ratio*** – is 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.

5. ***Domestic Water Consumption*** – was calculated based on the assumption that water usage is 227.12 litres/capita/day

6. ***Wastewater Generation*** – at 80% of water consumption.

7. ***Domestic garbage generation*** was calculated at 4.11 kg/household/day or 1.5 Kg/person/day.

4.5.3 Demography

4.5.3.1 Population Growth Rate, Age & Sex Ratio

The growth rate for the Parish of St. Ann over the last inter-censal period (2001-2011) was 0.35 % per annum.

Based on the growth rates, at the time of this study the population of St. Ann was approximately 173,236 persons and is expected to reach 189,048 persons over the next twenty five years, if the current population growth rate remains the same.

The population of the SIA was approximately 21,464 persons and is expected to reach 23,423 persons over the next twenty five years, if the current population growth rate remains the same.

At the time of the STATIN 2001 Population Census, the age of the SIA population could be described as fairly youthful and mostly female, with the mass of the population concentrated between ages 0-44. This indicated a predominantly female labour force, possibly as a result of male migration in years 15-44 or a lower male birth rate (Figure 4-88).

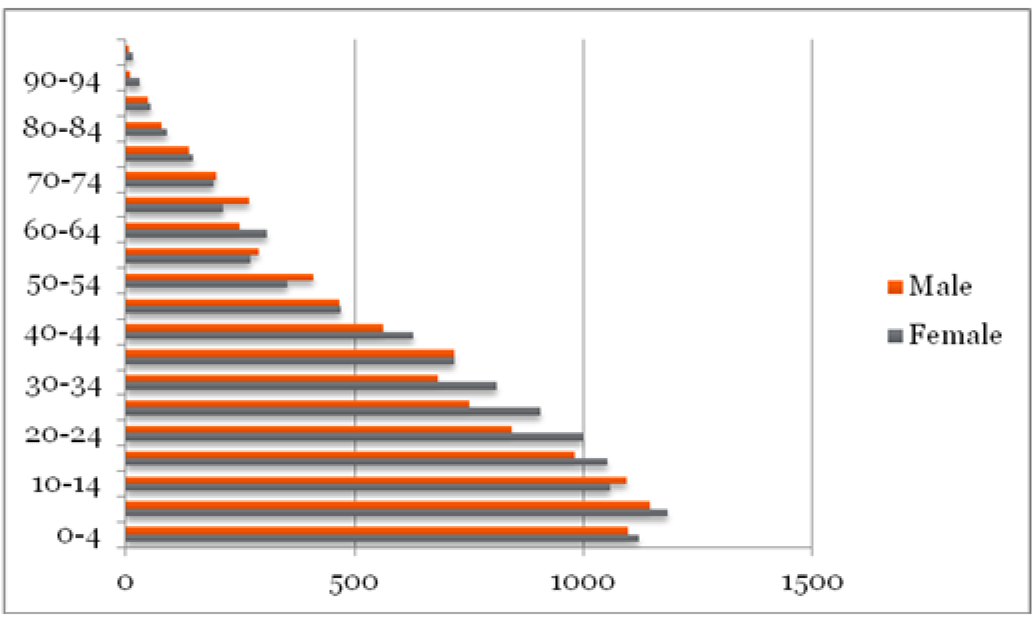

Figure 4-88 - Male/Female Populations

The sex ratio (males per one hundred females) in the SIA in 2001 was 94.57, approximately 5% lower than their female counterpart. The male population exceeded the females within the 10-14, 50-59 and the 65-74 segments of the population. This SIA sex ratio was lower than the national figure (Jamaica - 96.9) and also much lower than the regional (St. Ann) ratio of 101.4 males per hundred females.

Table 4-37 - SIA Male to Female Ratio

Age Cohort	*Female*	*Male*	*Male/Hundred Female*
0-4	1120	1097	97.94
5-9	1184	1147	96.90
10-14	1059	1095	103.38
15-19	1053	980	93.09
20-24	998	843	84.44
25-29	905	751	82.93
30-34	810	681	84.07
35-39	717	717	99.94
40-44	628	563	89.65
45-49	469	468	99.83
50-54	352	410	116.59
55-59	271	291	107.18
60-64	309	247	80.03
65-69	212	270	127.30
70-74	193	198	102.89
75-79	146	139	94.89
80-84	91	78	85.12
85-89	53	49	92.63
90-94	29	9	31.73
95+	15	6	38.55
	10615	**10039**	**94.57**

4.5.3.2 Dependency Ratio

Based on the STATIN 2001 Population Census, the total population within the SIA (considers the proportionate population of EDs that straddle the SIA) in 2001 was approximately 20, 655 persons. The 15-64 years age category accounted for approximately 60% of this population, with the age 0-14 years 33% and the age 65 and over category accounting for approximately 7%.

Table 4-38 shows the percentage composition of each age category to the population. This is compared at the national, regional and local level (at varying distances from the proposed highway). The data showed that the percentage contribution to the population for the 0-14 year's category in the SIA was similar to the regional (St. Ann) figure and slightly higher than the national figure. However, the 15-64 categories were slightly above the regional figures and similar to the national percentage. Whilst the local 65 & over category was slightly lower than the regional and national figures.

Table 4-38 - Age Categories as a Percentage of the Population (Source: STATIN Population Census 2001)

Age Categories	*Jamaica (%)*	*St. Ann (%)*	*SIA - 3km (%)*	*SIA - 2km (%)*	*SIA - 1km (%)*
0 - 14	32	33	33	32	32
15 - 64	60	59	60	60	61
65 & Over	8	8	7	7	7

The child dependency ratio for the SIA in 2001 was 326 per 1000 persons of labour force age; old age dependency ratio stood at 73 per 1000 persons of labour force age; and societal dependency a ratio of 399 per 1000 persons of labour force. This indicated that the youth (child dependency) was more dependent on the labour force for support when compared with the elderly.

Comparisons of the dependency ratios indicated that the child, aged and societal dependency ratios for the study area (SIA) were somewhat less than the regional and national figures (Table 4-39, Figure 4-89).

Table 4-39 - Comparison of Dependency Ratios (Popn per 1000)

Category	*Jamaica*	*St. Ann*	*SIA*
Child Dependency	539	333	326
Old Age Dependency	128	80	73
Societal Dependency	667	413	399

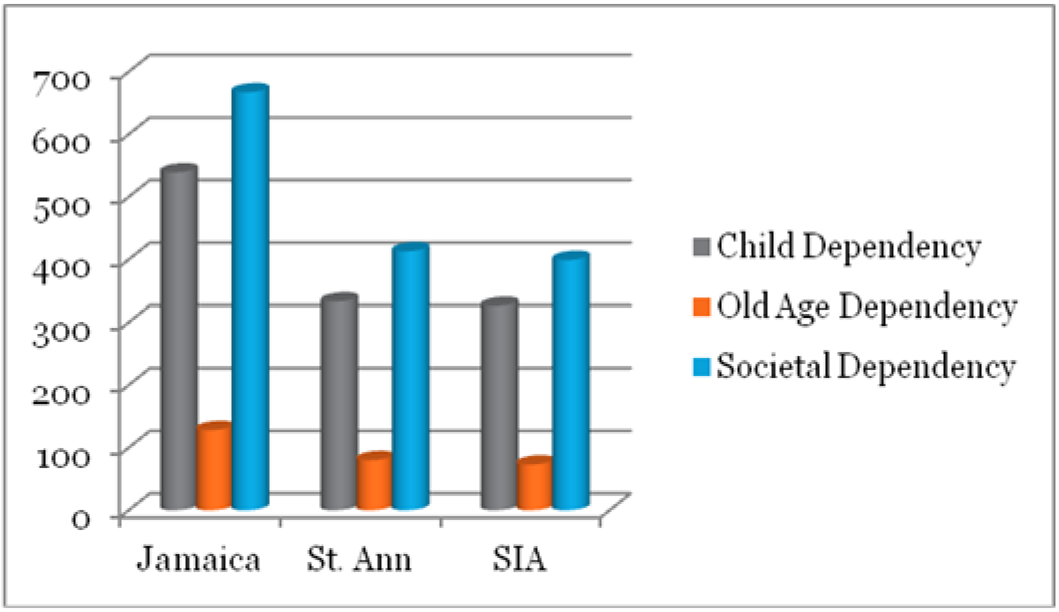

Figure 4-89 – Dependency Ratios

Overall, the societal dependency within the SIA represented less than half of the population (39%). The SIA's dependent population was noticeably lower than the regional and national figures and did not conform to national and regional norm, wherein the dependent population is usually larger than the working population.

Considering that the SIA's societal dependency is not high this could be indicative of a fairly substantial working population to support local area development.

4.5.3.3 Population Density

The SIA has a land area of approximately 14km² and a population of about 20,655 persons. The population density of the area is roughly 1475 persons per square kilometre. This is a slightly lower density than that of the parish of St. Ann and as expected a higher density than that of the national population density figure of 238 persons per square kilometre (Table 4-40). The SIA was not a very densely populated region and whilst it contained growth centres such as Claremont & Moneague the other settlements were mainly linear. The area is mainly characterized by agricultural tracts of land interspersed with small rural settlements.

Table 4-40 - Comparison of Population Densities

Category	*Jamaica*	*St. Ann*	*SIA*
Land Area (km2)	10991	112	14
Population	2607632	166704	20655
Population Density	238	1488	1475

Figure 4-90 shown below, demonstrates where the largest concentration of the SIA population is located. These areas have approximately 1268 to 2289 persons residing within the Enumeration Districts. For the most part the proposed highway bypasses the settlements within the SIA, except where it begins in Moneague, provides an off-ramp close to Claremont and then terminates adjacent to Steer Town.

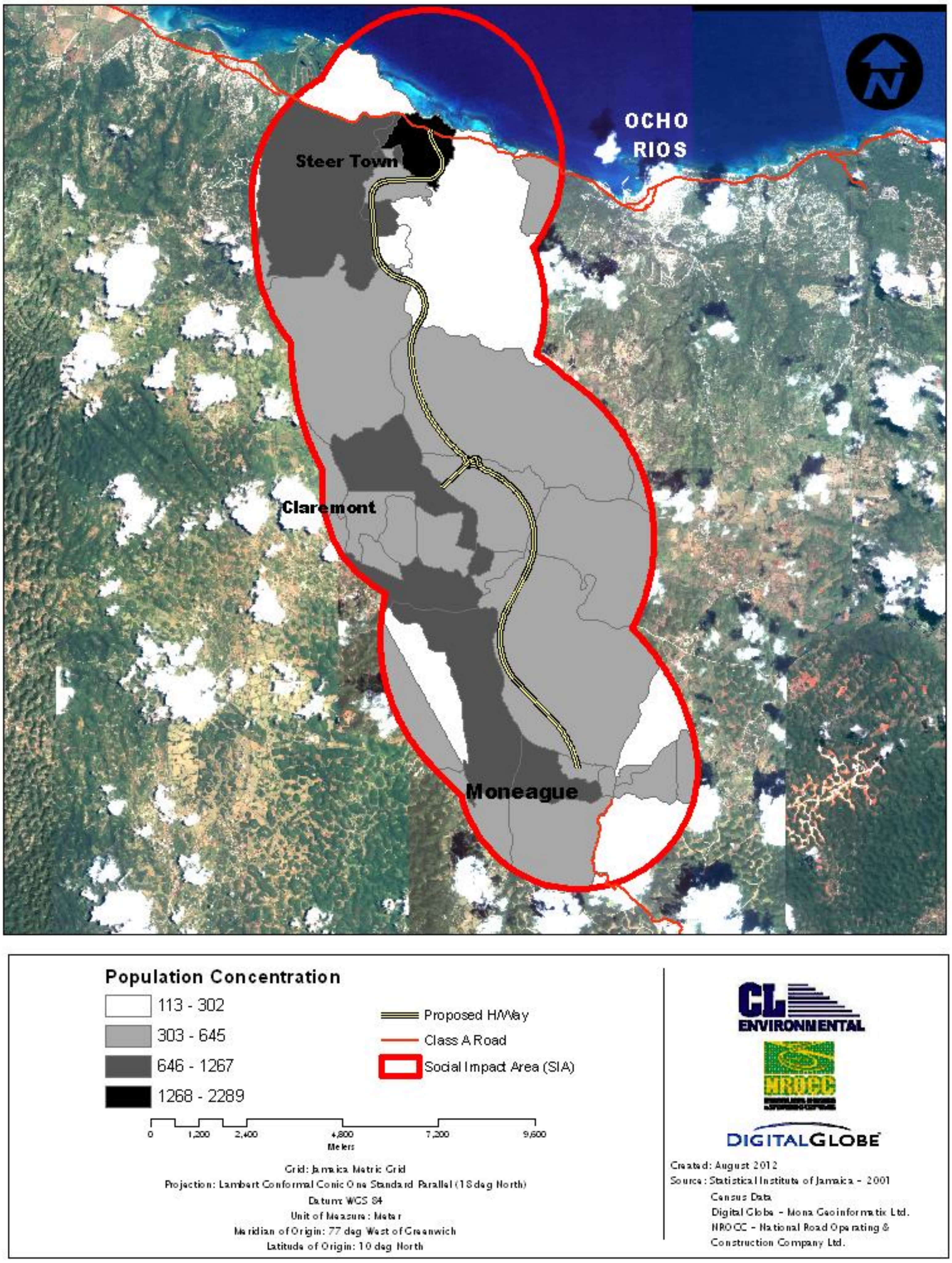

Figure 4-90 – Map showing Population Concentration

Since the 2001 STATIN Population Census, the SIA has seen the development of other settlements such as the Greenwich Estate development in the vicinity of the northern Steer Town limits. This development would no doubt have resulted in an overall increase in the SIA population density. Additionally, the construction of a proposed highway could result in increased population densities within the SIA as improvements in physical infrastructure normally attract additional residential, commercial and even industrial development.

4.5.4 Education

Consistent with the national and parish trends, educational attainment within the SIA population reflected a pre-dominantly primary and secondary level of schooling (Table 4-41, Figure 4-91). There are more All Age schools than there are High and Junior High schools serving the area. The statistics revealed that the percentage of All Age schools within the SIA were slightly higher than the regional and national figures and likewise the percentage of High Schools were slightly less than the regional and national percentages. The presence of the Moneague Community College might have contributed to a higher percentage of Tertiary educational attainment within the SIA when compared to the regional and national data.

Table 4-41 - Education Attainment as a % of the Population of persons 4 years and older

Category	*Jamaica*	*St. Ann*	*SIA*
Pre-Primary	4.7	4.7	4.6
Primary	31.2	33.3	36.4
Secondary	49.7	49.2	45.0
University	3.1	1.2	1.6
Other Tertiary	5.9	6.1	7.1
Other	2.8	3.0	3.3
Not Stated	1.7	1.3	1.1
None	0.9	1.0	0.8

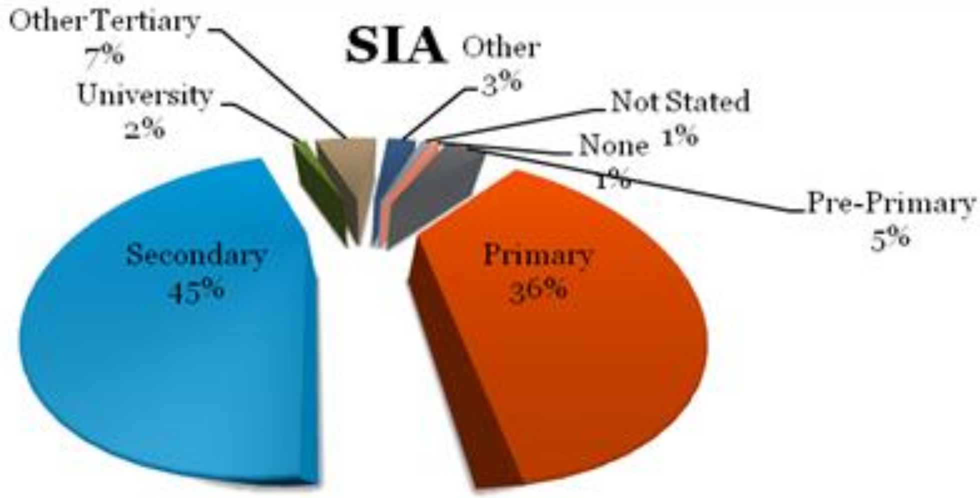

Figure 4-91 - Education Attainment as a % of the Population of persons 4 years and older

Figure 4-92 below, highlights where the highest degree of persons educated to the primary and secondary levels are located. Also, the location of the schools are shown. As the map indicates, the schools within the SIA area tend to be located close to the growth and developing centres (Moneague, Claremont, Steer Town). Table 4-42 lists the schools within the SIA.

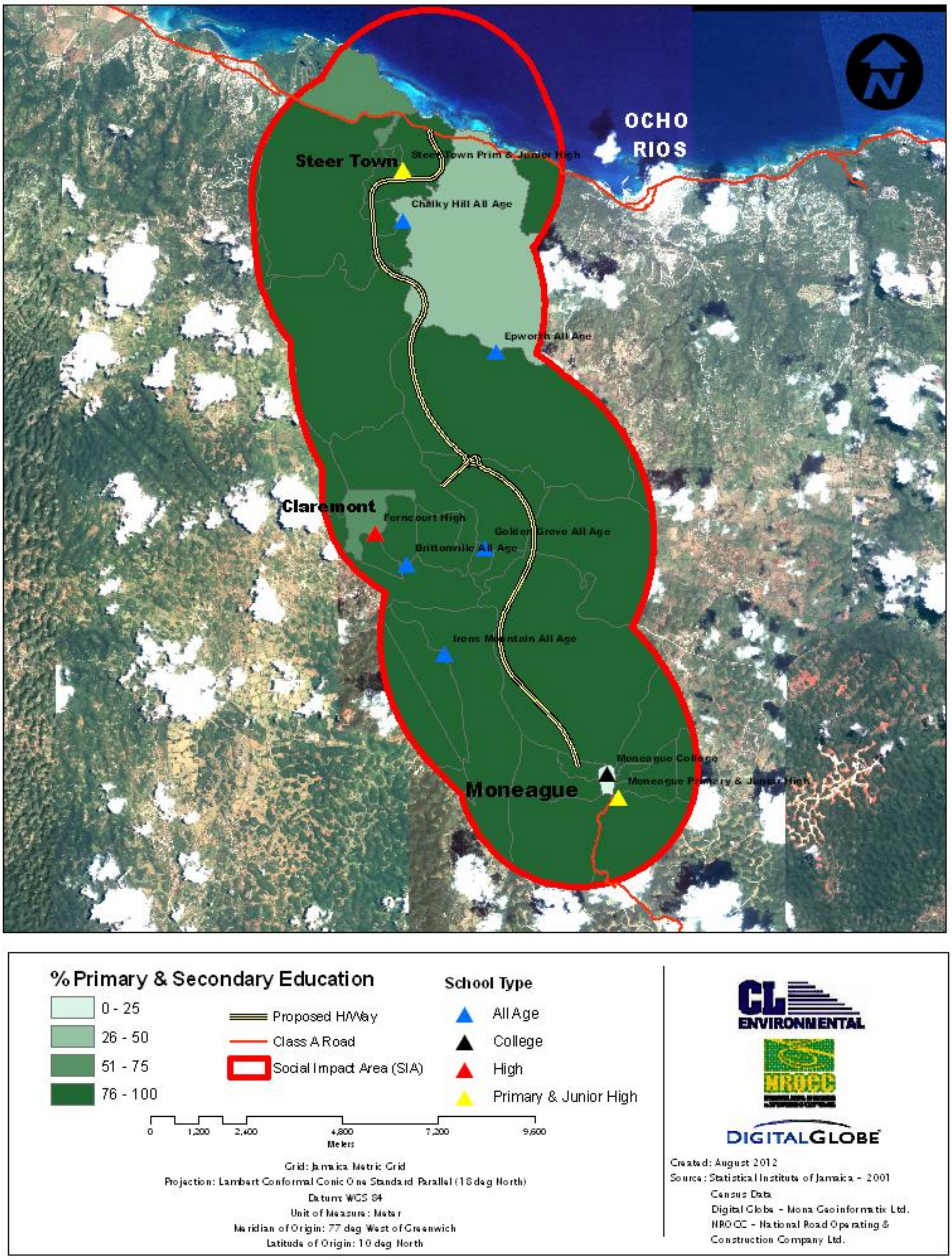

Figure 4-92 - Map showing Percent Primary & Secondary Education – Location of Schools

Table 4-42 - Schools Located within the SIA

Name	*Type*	*Parish*
Moneague	Primary & Junior High	St. Ann
Moneague	College	St. Ann
Irons Mountain	All Age	St. Ann
Brittonville	All Age	St. Ann
Golden Grove	All Age	St. Ann
Ferncourt	High	St. Ann
Epworth	All Age	St. Ann
Chalky Hill	All Age	St. Ann
Steer Town	Primary & Junior High	St. Ann

4.5.5 Housing

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. The definition states that:

1. A "housing unit is a building or buildings used for living purposes at the time of the census.
2. 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 6238 housing units, 6832 dwellings and 7031 households within the SIA in 2001. The average number of dwelling in each housing unit was 1.10 and the average household to each dwelling was 1.03. The average household size in the SIA was 2.94 persons per household (Table 4-43).

A comparison of the SIA and national and regional ratios indicate that the SIA in general had similar dwelling to housing unit and average household ratios. However, there was a lower household/dwelling ratio in the SIA than both the regional (parish) and national ratios.

Table 4-43 - Comparison of national, regional and local housing ratios (Source: STATIN Population Census 2001)

	Jamaica	*St. Ann*	*SIA*
Dwelling/Housing Unit	1.2	1.10	1.10
Households/Dwelling	1.03	1.03	1.03
Average Household Size	3.48	3.67	2.94

Approximately 95.87% of the housing units in the SIA were of the separate detached type, 2.15% were attached, 0.66% part of a commercial building, 0.06% categorized as other, 0.11% improvised housing, and 1.14% did not state.

The majority of the households in the SIA in 2001 used 1-3 rooms for sleeping (87%). Approximately 8% of the households occupied four rooms, 4% used five rooms and 1% did not report the number of rooms used for sleeping. Most of the households (36%) used two rooms for sleeping (Figure 4-93).

Along with other indicators such as the land tenure and infrastructural development, these statistics may be used to infer the overall economic status of the SIA. So far, the study area would seem to fall primarily within the lower-middle to middle income bracket.

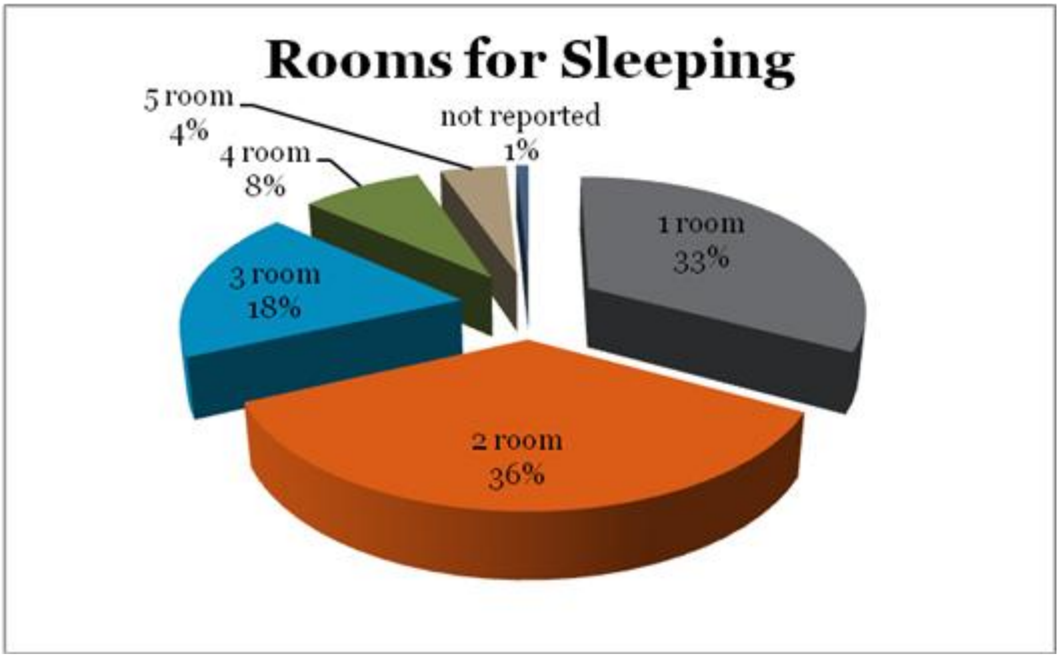

Figure 4-93 – Sleeping Rooms

4.5.6 Land Tenure

In 2001, 49.6% of the households in the SIA owned the land on which they lived. Approximately 2% leased the land on which they were, 15.8% rented, 19.5% lived rent free, 2.7% "squatted", 1.1% had other arrangements and 9.3% did not report the type of ownership arrangements they had (Table 4-44).

Table 4-44 - Comparison of Percentage household tenure; nationally, by parish and SIA

Category	*Jamaica*	*St. Ann*	*SIA*
Owned	37.5	51.5	49.6
Leased	5	2.0	2.0
Rented	14.8	16.6	15.8
Rent Free	17	16.8	19.5
Squatted	2.9	2.3	2.7
Other	0.9	0.6	1.1
Not Reported	21.9	10.2	9.3

There were a larger percentage of households in the SIA owning the land they lived on, renting and living rent free when compared to household tenure at the national level. Squatting in the SIA was seen to be higher than on the parish level although marginally less than the national average. Otherwise, there were lower or comparable percentages seen for all other land tenure categories when compared to the national and regional figures (Figure 4-94).

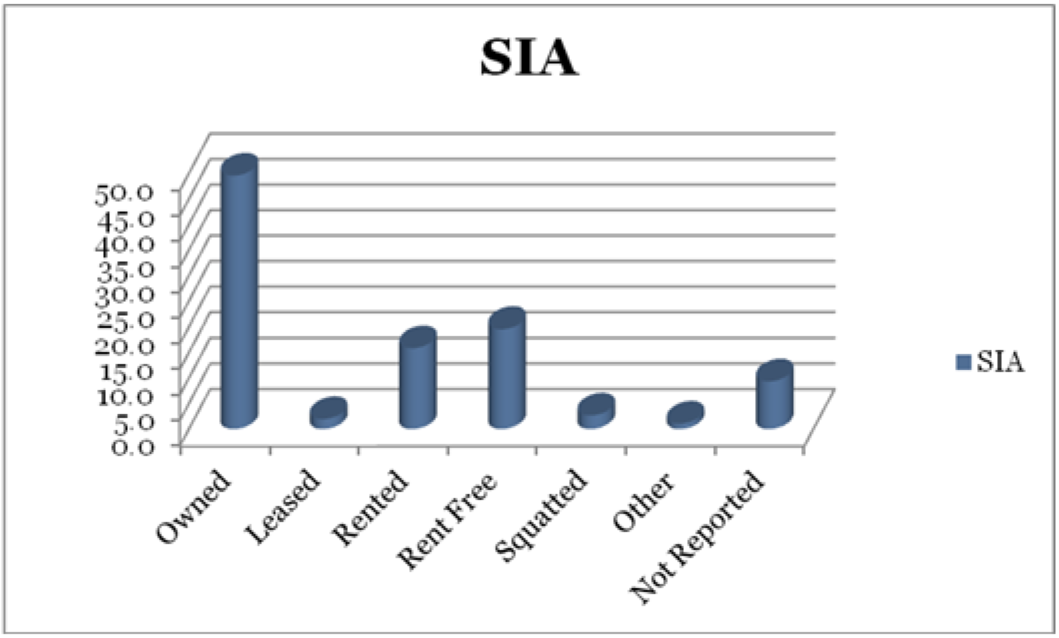

Figure 4-94 - Percent Household by Land Tenure

As shown in Figure 4-95, the proposed highway falls mostly within areas of the SIA that are recording between 25-50% of land ownership.

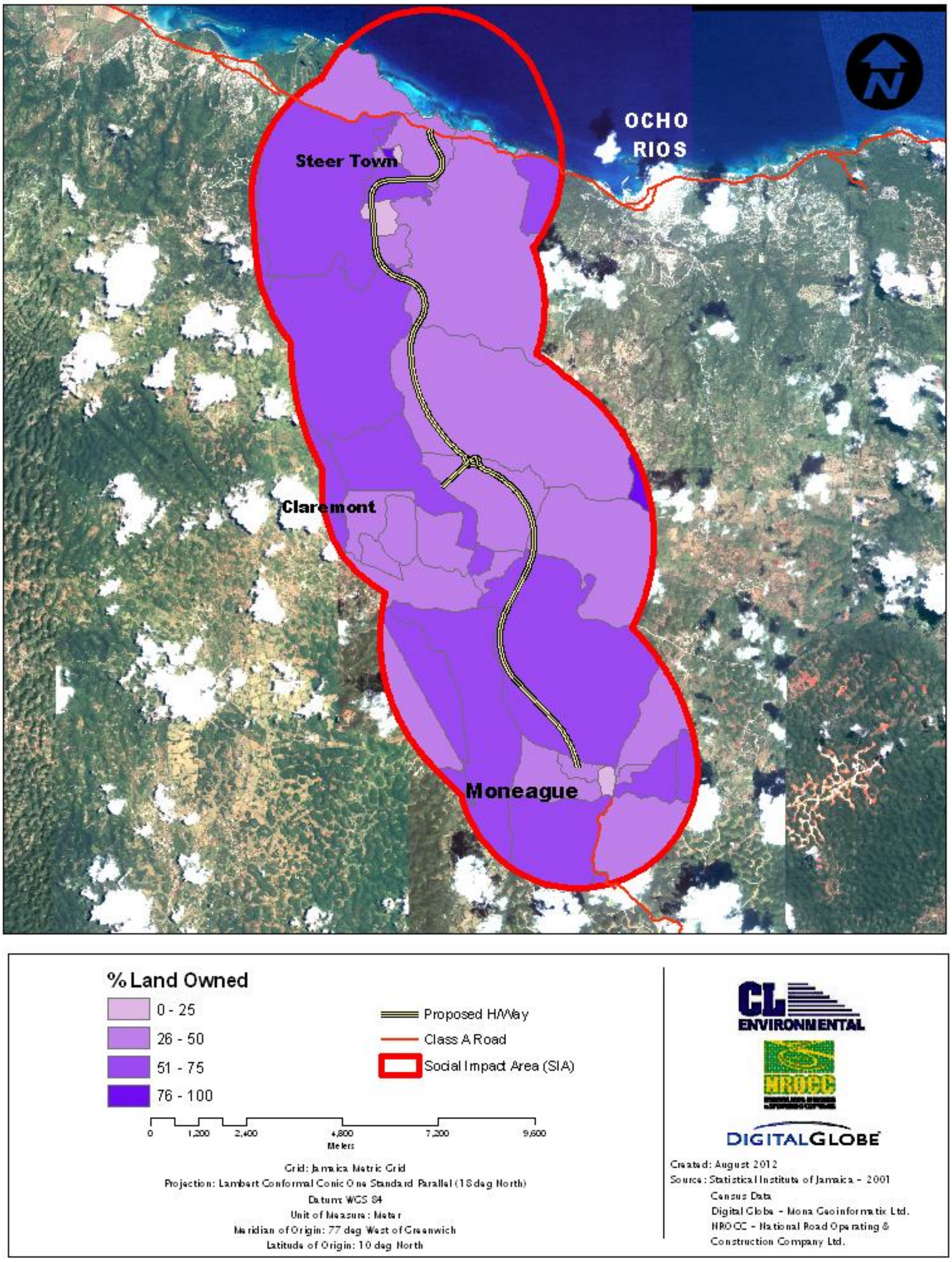

Figure 4-95 – Map showing Percent Land Ownership

4.5.7 Infrastructure

4.5.7.1 Lighting

There are a slightly greater percentage of households in Jamaica using electricity when compared with the regional and SIA households. This is consistent with a slightly greater number of households using kerosene at the regional and local level when compared with the national figure. Table 4-45 details the percentage of households using a particular category of lighting.

Table 4-45 - Percentage Households by Source of Lighting

Category	*Jamaica*	*St. Ann*	*SIA*
Electricity	87	85	84
Kerosene	10.6	12	13
Other	0.4	0	1
Not Reported	2	2	2

As shown in Figure 4-96, most SIA households (which accounts for 76% to 100%) utilize electricity as their main source of lighting. The proposed highway falls within the areas of high household electricity use.

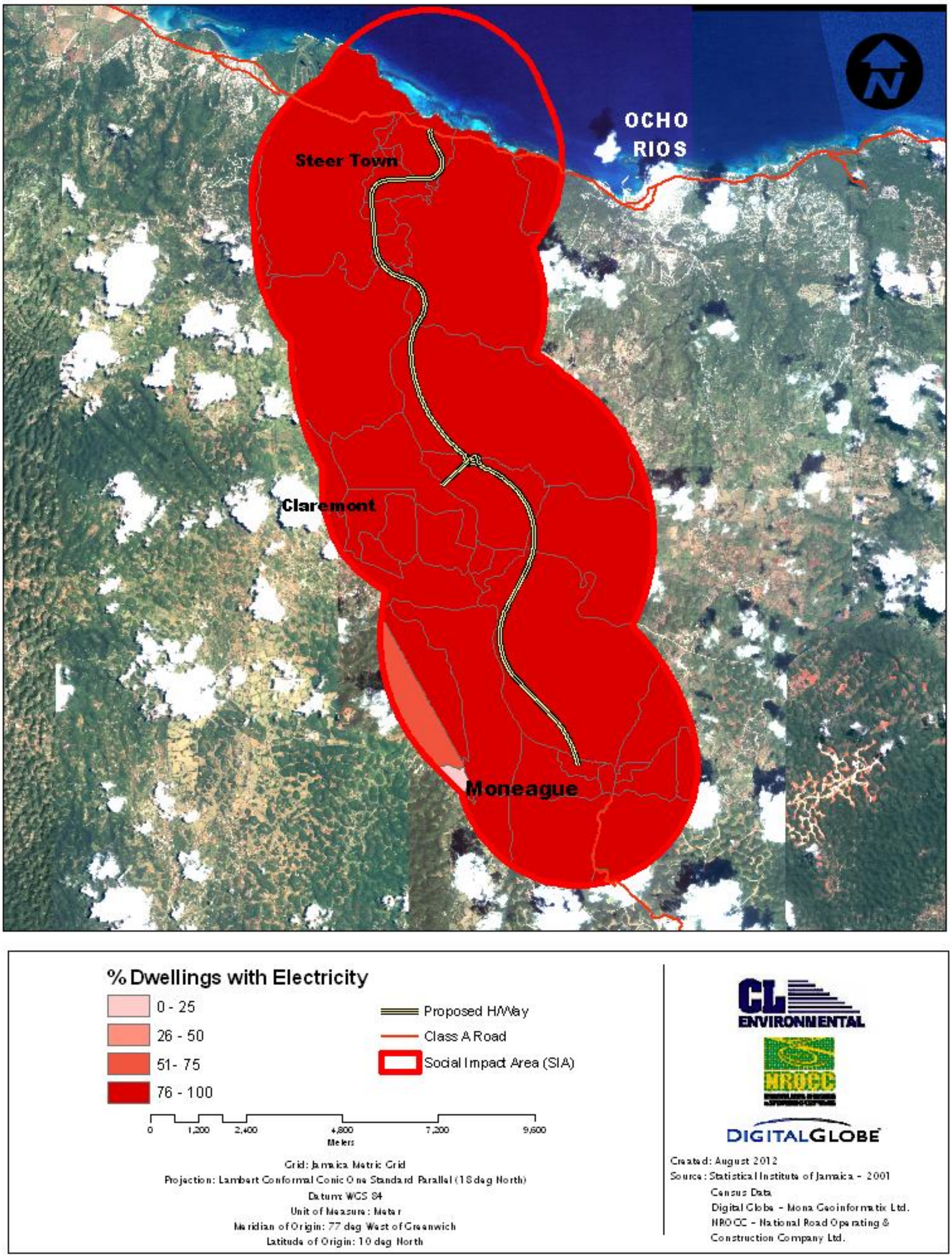

Figure 4-96 - Map showing Percentage Dwelling with Electricity

4.5.7.2 Telephone/Telecommunications

The study area is served with landlines provided by Cable and Wireless: LIME Jamaica Limited. Wireless communication (cellular) is provided by Cable and Wireless (LIME) and Digicel Jamaica Limited. A network to support internet connectivity is also provided by Cable and Wireless (LIME).

4.5.7.3 Domestic Water Supply

As seen in Table 4-46 the greater portion of SIA households (75%) receives its domestic water supply from the National Water Commission (NWC). This was more than both the regional and national figures of 53% & 73% respectively. On the other hand, households utilizing a private source of water supply (25%) were lower than the regional and national average. Water demand in the SIA is 4,691,163.6 liters per day.

Table 4-46 - Percentage of Households by Water Supply

	Category	*Jamaica*	*St. Ann*	*SIA*
Public Source	Piped in Dwelling	43.8	33	51
	Piped in Yard	16.3	8	15
	Stand Pipe	10.5	8	7
	Catchment	1.9	4	3
Private Source	Into Dwelling	6.3	10	6
	Catchment	9.9	25	11
	Spring/River	4.6	5	1
	Other	4.5	5	6
	Not Reported	2.2	2	2

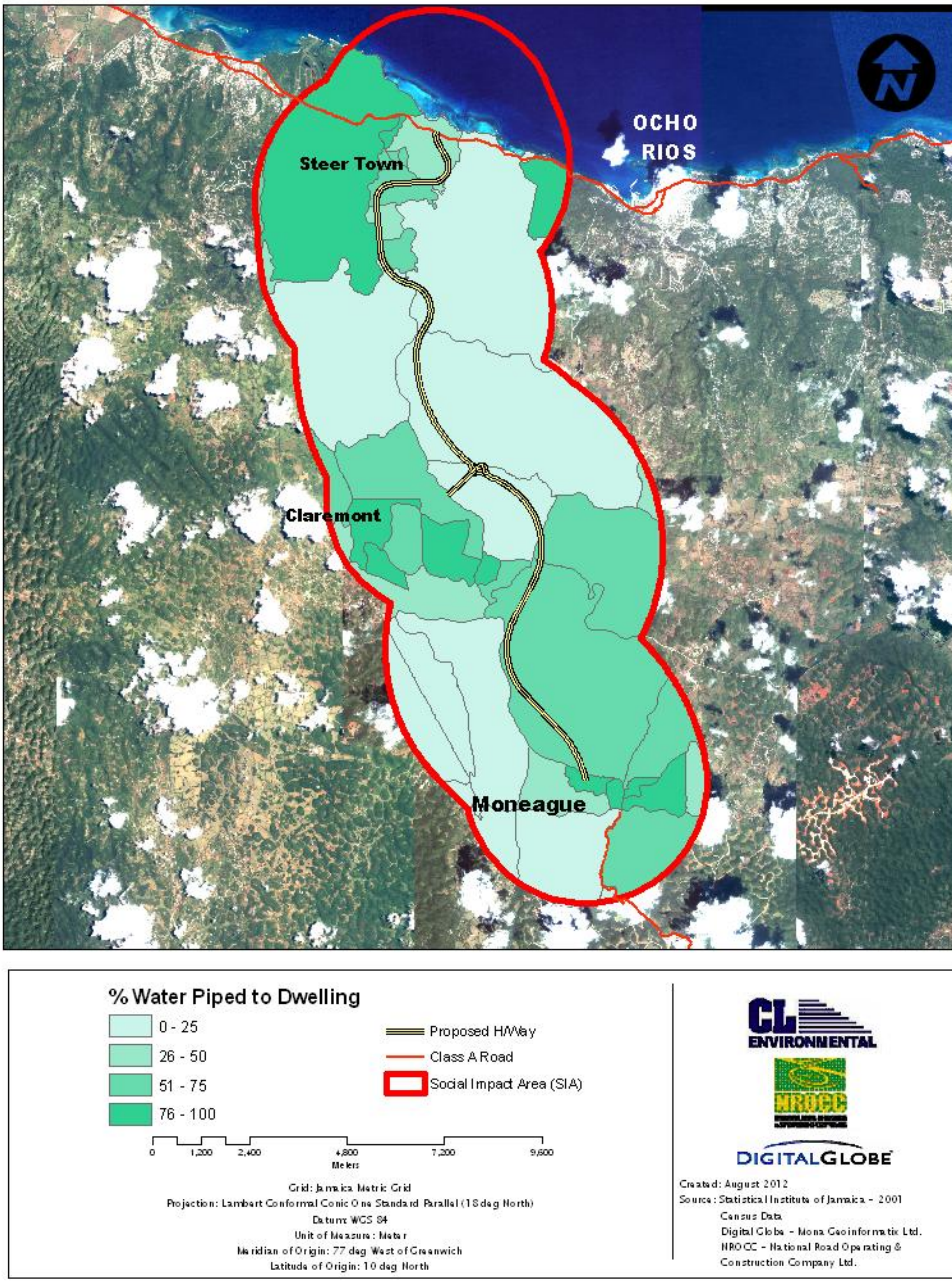

Figure 4-97 - Map showing Percent Water Piped to Dwelling

4.5.7.4 Wastewater Generation & Disposal

It is estimated that approximately 3,752,930.88 litres/day of wastewater is generated within the study area. A higher percentage of households used water closets within the SIA when compared to the regional and national data (Table 4-47, Figure 4-98). Conversely, a smaller percentage of SIA households utilize pit latrines when compared to the national and regional data for 2001. A higher percentage of households in the SIA did not report their method of sewage disposal, when compared to the national data, although there was a smaller amount of households that reported having 'no facility'.

Table 4-47 - Percentage Households by Method of Sewage Disposal (Source: STATIN Population Census 2001)

Disposal Method	*Jamaica*	*St. Ann*	*SIA*
Pit Latrine	37.9	41.6	33.5
Water Closet	58.2	52.2	61.3
Not Reported	1.4	3.8	3.1
No Facility	2.5	2.4	2.1

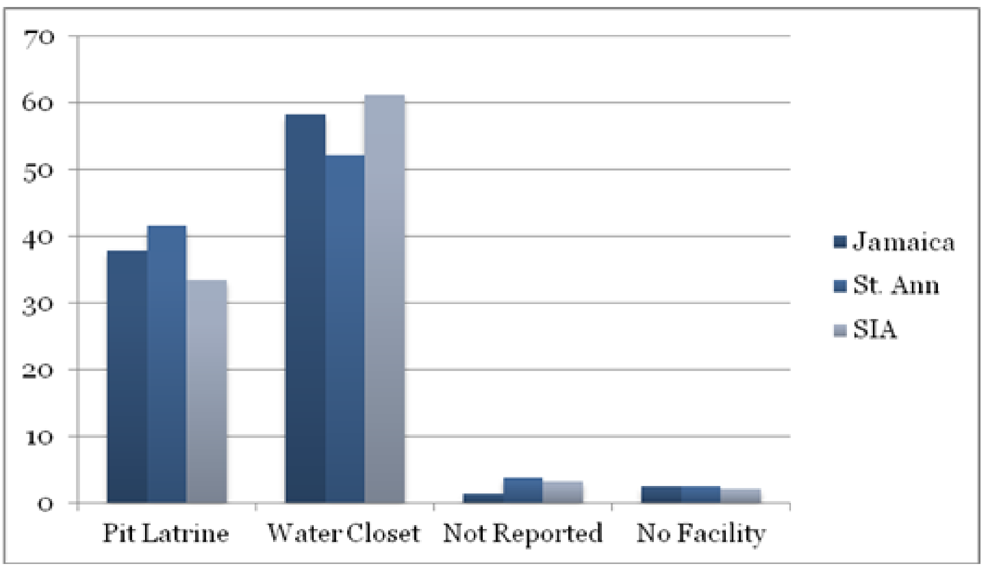

Figure 4-98 - Percentage Households by Method of Sewage Disposal (Source: STATIN Population Census 2001)

4.5.7.5 Solid Waste Generation & Disposal

The National Solid Waste Management Authority is responsible for domestic solid waste collection within the study area. Presently, collection is done twice per week. 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 28,897.41 kg of solid waste in 2001. Based on the population growth, it has been estimated that at the time of this study, approximately 32,196.42 kg of solid waste was being generated and it is expected that within the next twenty five years, if the population growth rate remains the same, the amount will be 35,135.17 kg.

The 2001 census data indicated that approximately 32.2% of the households in the parish of St. Ann had their garbage collected by public means (National Solid Waste Management Authority), with a higher percentage (44.2%) in the SIA. It also observed that the preferred method of disposal in the SIA (47.9%) was by burning (Table 4-48).

Table 4-48 - Percentage households by method of garbage disposal (Source: STATIN Population Census 2001)

Disposal Method	*Jamaica*	*St. Ann*	*SIA*
Public Collection	47.7	32.2	44.2
Private Collection	0.5	0.7	0.7
Burn	43	58.0	47.9
Bury	1.2	1.4	0.8
Dump	6	6.4	5.1
Other Method	0.3	0.4	0.1
Not Reported	1.3	1.0	1.1

Figure 4-99 demonstrates where burning of garbage is mostly utilized within the SIA. These areas tend to correspond to the more rural parts of the study area. Significant construction activities generating much solid waste within the more rural areas should ensure that private methods of garbage disposal are consistently employed.

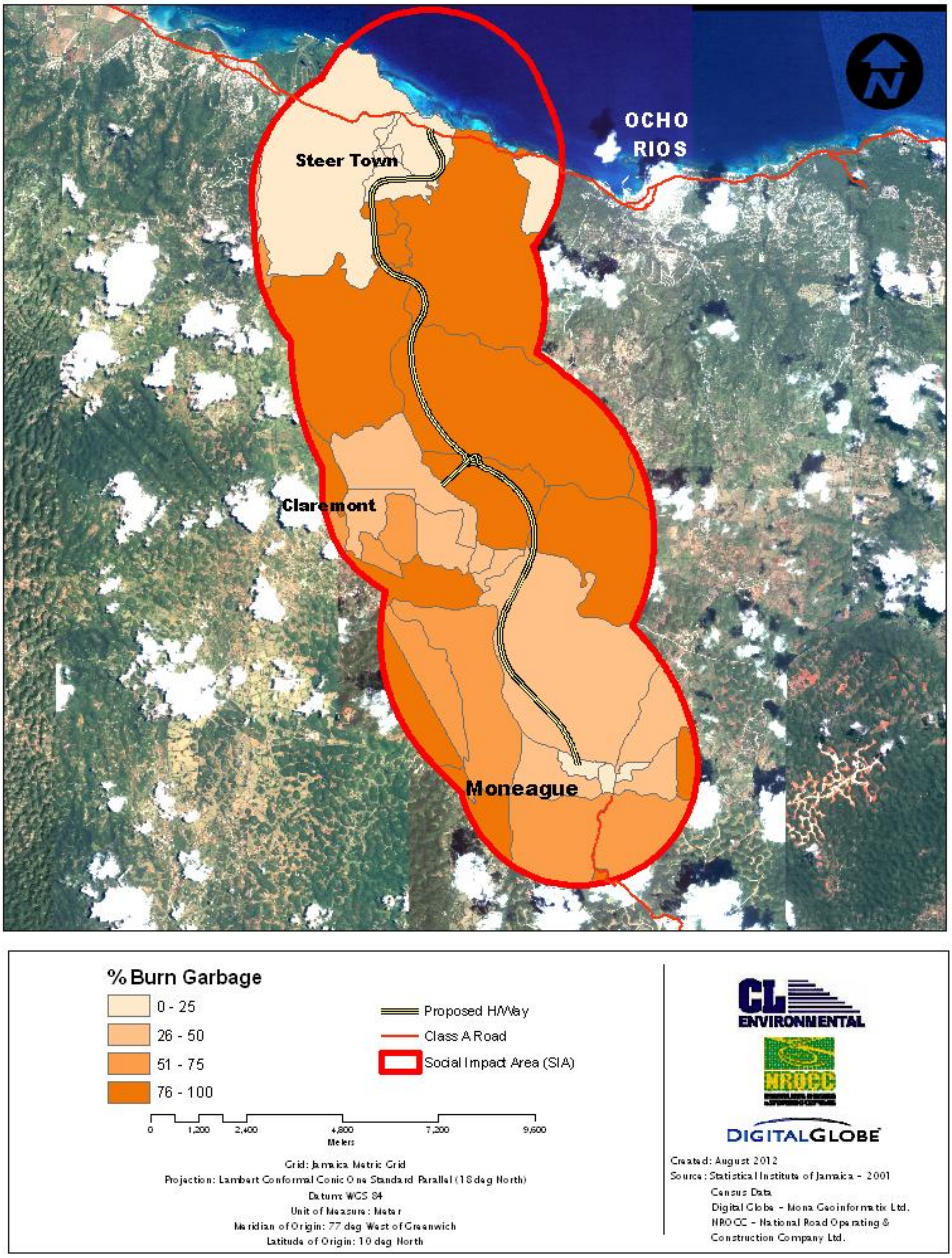

Figure 4-99 – Map showing Percentage Burning Garbage

4.5.8 Traffic

The construction of this phase (Moneague to Ocho Rios) will result in several benefits to commuters, these will include:

- Less congestion on the existing roads which traverse through Fern Gully;
- Safer driving conditions for motorists and pedestrians;
- The reduction of travelling time.
- More comfortable trips
- Providing an alternative route between Moneague and the North Coast Highway

Along the H2K Moneague to Ocho Rios alignment, there exist a number of access points including road intersections, vehicular accesses and pedestrian accesses. Residential and commercial properties are attributable to these access points. These access points are generally of poor geometry and pose challenges within the design of the highway. The implementation of the alignment divides some communities from their respective main towns which poses grave problems. Furthermore, the road widening and road structures (ramps, bridges) at specific chainages along the highway increase the inconvenience of affected communities. The design of the alignment should consider the preservation of vehicular access at current intersections and round-a-bouts. Pedestrians, who are less concerned with the rapid transit of the highway, may be directly and permanently inconvenienced by the 'un-crossable' barrier of the roadway, making journeys subsequently longer. The legally protected right of local residents is essentially a concept of a social right-of-way which protects the public rights if a proposed roadway conflicts with the right of the public to move freely along a particular route. However, during legal land acquisitions these rights are generally are surrendered by the land owners (2007). In the designing of vehicular access points, speed and safety with respect to pedestrian crossings must be primarily considered while costs are considered secondary.

4.5.9 Services

4.5.9.1 Health Services

There are no hospitals located within the SIA.

Three public health centres are located within the SIA:

- Moneague (Type II)
- Claremont (Type III)
- Steer Town (Type I)

One of the health centres located in the SIA are Type III (Claremont). 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 Type II health centre (Moneague) provides similar services, however this centres is serviced by a visiting Doctor and Nurse Practitioner.

4.5.9.2 Other Services

Fire Stations

There are no fire stations located within the SIA.

Police Stations

The following 2 police stations are found within the SIA

- Moneague
- Claremont

Post Offices

Two post offices are situated within the SIA in the following towns:

- Moneague
- Claremont

4.5.10 Community Perception

4.5.10.1 Introduction

On August 24th, 27th, 28th and 29th, 2012, One Hundred and Thirty Four (134) community questionnaires were administered within a three kilometre radius of the area proposed for the construction of a Toll Road from the unopened existing A1 Toll Road at the Moneague roundabout entry/exit to Mammee Bay. 47.8% respondents were female and 52.2% were male.

Of the One Hundred and Thirty four (134) respondents, age cohort distribution was as follows; 15.7% were age 18-25 years , 9.7% were age 26-33 years, 20.9 % were age 34-41 years, 20.1% were age 42 – 50 years, 15.7% were age 51-60 years and 17.9% were older than sixty years of age. 57.5% of respondents were employed, 30.6% unemployed and 11.9% of respondents were retired.

Eleven main communities were visited. These communities were Moneague, Golden Grove, Orange Park, Steerfield, Ewart Town, Epworth, Hermitage, Davis Town, Chalky Hill, Steer Town and Mammee Bay.

4.5.10.2 Results and Findings

Approximately 25.4% of all respondents had heard of the National Road Operating and Construction Company (NROCC) while 74.6% of respondents indicated they had never heard of NROCC. Based on interviewees' comments and responses, It was thought that some respondents may have mistaken NROCC with other international road construction companies but this could not be confirmed with the interviewee.

Respondents indicated that they heard of the company in the media and from other persons relaying experiences ("word of mouth"). As it related to respondents awareness of the proposed toll road construction, 59.7% of respondents were aware of the proposal and 40.3% of respondents were not aware.

On the issue of concerns and comments related to the project, there were a series of mixed opinions. In general respondents who thought the project would affect their lives commented on the potential ease or difficulty in commuting. Respondents expressed that the introduction of the toll road would significantly reduce the time it takes for them to travel and also result in an increase in public transportation in the communities as there are few public passenger vehicles on the short distance/local routes (Moneague to St. Ann's Bay/Ocho Rios). Individuals interviewed also indicated their expectation of having existing off roads in the vicinity of the proposed areas upgraded as well as an increase in employment in the respective communities for youth.

Concerns highlighted, related to the possibility making the existing roadway areas inaccessible as well as possible devaluation of property and loss of commercial business. Concern was also expressed about the possible increase in noise and dust pollution and safety of children. The possibility of relocation of homes and/or businesses was also expressed. Of concern was also the issue of potential flooding as a result of the road construction or modification in areas currently not affected by flooding. The need for lighting at the existing Moneague roundabout was mentioned as there have been many motor vehicle accidents since the construction of the roundabout. It was also expressed that the warning signs were too close to the roundabout and need to be repositioned further away from the roundabout to allow for adequate warning to motorists.

Percentages presented below for community respondents are for the total number of respondents.

Moneague

8.2% of respondents were interviewed in the Moneague area. The Moneague area comprised smaller communites. These were Phoenix Park, Friendship and Roadside/Retirement. 36.4% of the respondents indicated that they had heard of NROCC, while 64% indicated they did not. 63.6% of respondents stated they were aware of the proposed toll road construction. Regarding project concerns, 54.5% did not express any concern. Of the remaining 45.5% of respondents 18.2% were concerned about of the effect the possible road modifications to their property. These respondents were from the Phoenix Park Area of Moneague and 50% of the Phoenix Park respondents indicated that the road was proposed to encroach on their property. 18.2% of respondents expressed concern that there would be a reduction in their business. 9.1% expressed concern about noise pollution and safety risks for residents in the Moneague area. 54.5% of respondents did not think the project would affect their lives in any way. 27.3% anticipated a positive impact attributed to possible appreciation in land value and the possible increase in the number of motor vehicles passing through the community as well as the possibility of a rest stop being established. 18.2% anticipated a negative effect mainly due to noise pollution, safety risks to residents and a projected fall off in patrons of shops. 81.9% of interviewees anticipated an easier commute as they expected fewer heavy vehicles, less traffic, shorter travel time and better access to transportation. 18.2% of respondents did not comment.

Golden Grove

4.5% of respondents were interviewed in the Golden Grove area. 50 % of respondents had heard of NROCC while 50% indicated they did not. Of the total number of interviewees 50% was aware of the project. Regarding project concerns, 33.3% of all respondents expressed no concern about the project. 66.7% of respondents expressed some concern about the project. 16.7% of respondents expressed concern that more lighting is needed at the existing roundabout. 16.7% were concerned about the possible creation of a dust nuisance. While the remaining 33.3% expressed concern about noise pollution. 50% of respondents indicated an expectation for a positive impact on their lives. 16.7% indicated a possible negative impact on their lives and 33.3% were uncertain about whether the project would affect their lives in a positive or negative manner. 83.3% of respondents anticipated an easier commute as it was expected that travel time would be reduced, and road infrastructure would be good.

Orange Park

9.7% of respondents were interviewed in the Orange Park area. 8% of respondents from Orange Park indicated that they had heard of NROCC while 92% of interviewees were not aware of NROCC. 77% of respondents were aware of the proposed the toll road construction project. Regarding project concerns, 53.8% of respondents did not express any concern while 23.1% expressed concern and 23.1% were non-committal. Of the 23.1% of respondents expressing concern, 33.3% of respondents expressed concern regarding the safety of children; 33.3% were concerned about when the project was proposed to start and 33.4% expressed concerned about the area they may have to be relocated to and hoped the area would be good. 53.8% of respondents indicated their expectation of a positive impact from the project. Positive impact was associated with interviewees forecasting development of the community, especially regarding employment opportunities and improved road conditions. 30.8% of respondents were uncertain about whether the project would affect their lives in a positive or negative manner while 15.4% indicated that the project would affect their lives negatively specifically in the creation of a dust nuisance and the increased risk to children's safety. On the issue of the ease/difficulty in commuting with the introduction of the toll road, 84.6% of respondents indicated that they expected an easier commute. 7.7% expected a more difficult commute due to fewer vehicles travelling on the existing roadway and 7.7% were non-committal.

Steerfield

12.7% of respondents interviewed were from Steerfield. 88.2% of respondents had never heard of NROCC and 35.3% were not aware of the proposed toll road construction project. 64.7% of respondents were aware of the toll road project. Regarding project concerns, 82.4% of respondents expressed no concern; 11.8% of respondents were non-committal and 5.9% expressed concern specifically related to the existing public transportation problems being worsened as no taxis ply the route to St Ann's Bay from Steerfield. 17.6% of respondents were uncertain about the possible positive/negative impacts associated with the project. 11.8% of interviewees perceived a negative impact from the project as they anticipated a reduction in farm sales as well as a reduction in customers at shops as trucks would no longer use the route. 23.5% of respondents did not think the project would affect their lives while 47.1% of respondents anticipated a positive impact from the project mainly in the areas of better roads, less traffic, heavy duty vehicles will use toll road and more public transportation availability. Respondents also anticipated an easier commute.

Ewart Town

2.2% of respondents were interviewed in Ewart Town. 66.7% of respondents had heard of NROCC. 100% of respondents indicated that they were aware of the toll road construction project. Regarding project concerns, 66.7% of respondents did not express concern while 33.3% of respondents expressed concern relating to children crossing the busy roadway. 100% of respondents also indicated that they thought the project could have a positive impact on their lives as they anticipated road improvement, community development and an increase in the number of vehicles travelling along the existing roadway. As it related to the ease or difficulty in commuting, 100% of respondents anticipated that commuting would be easier due to shorter travel time and easier access to transportation. Of note asbestos roofing is still present in the Ewart Town. 33.3% of respondents have asbestos roofing.

Epworth

3.0% of respondents were interviewed in Epworth. 75% of respondents had heard of NROCC and 25% indicated they had never heard of a company called NROCC. 25% of respondents were not aware of the proposed toll road construction project and did not express any concerns. 75% of respondents expressed concerned about the project. Concerns related to the safety of the project and whether the existing road which was in disrepair would continue to be neglected of if it would be repaired. 100% of respondents anticipated a positive. 25% respectively anticipated benefit from sale of land, appreciation in property value and community development, increase in business opportunity and easier travelling. On the issue of ease or difficulty in commuting, all respondents indicated that commuting should be easier due to better road infrastructure and better traffic flow.

25% of respondents suggested that a good route to be considered for the toll road should be east of Epworth on idle/uninhabited land as the Steerfield/Davis Town area is populated and many persons would need to be relocated.

Hermitage

11.9 % of respondents were interviewed in Hermitage. 12.5% of respondents had heard of NROCC and 87.5% indicated they had never heard of a company called NROCC. 31.3% of respondents were not aware of the proposed toll road construction project. 12.5% of interviewees did not comment on project concerns. 50% of respondents indicated they did not have any project concerns. 31.3% of respondents indicated that they had concerns about the project. Respondents were concerned about the proximity of the road to their residence and possible relocation, devaluation of property, their dwelling being on lands identified as the road footprint and when the project was scheduled to start. 31.3% of interviewees expected the project to affect their lives positively, 12.5% anticipated a negative impact, 43.8% did not anticipate a positive or negative impact and 12.5% of respondents anticipated both positive and negative impacts. Respondents indicating positive impact anticipated community development, an opportunity to sell lands, employment opportunities, relocation to a good area and better transportation availability. Respondents indicating a negative impact anticipated being relocated to a substandard area and having the toll road close to their residence.

On the issue of ease or difficulty in commuting, 87.5% respondents indicated that commuting should be easier as shorter and faster travel is anticipated. Respondents also expected better transportation availability. 12.5% of interviewees were uncertain about whether their commute would be affected.

Davis Town

9.7% of respondents were interviewed in Davis Town. The Malvern Park Pen Housing Development is the main residential area in Davis Town. 38.5% of respondents had heard of NROCC and 61.5% indicated they had never heard of a company called NROCC. 30.8% of respondents were not aware of the proposed toll road construction project. 30.8% of respondents did not express any project concerns while 69.2% or respondents had concerns. 30.8 % of respondents' concerns included whether the road would pass through Davis Town and the exact location of the road footprint. 50% of these respondents (located in the Malvern Park Pen Housing Scheme) indicated that "Chinese surveyors" advised that the road footprint was to go through their property. Other concerns included noise and dust pollution, the need for existing drainage to be repaired and the impact the toll road would have on the domestic water supply. Regarding the perceived positive or negative impact associated with the project, 15.4% of respondents did not anticipate any impact, 23.1% anticipated both a positive and negative impact, 7.7% expected a negative impact and 53.8% of respondents expected a positive impact from the project. Respondents indicating a negative impact expected health issues to arise, specifically asthma, sinusitis and eczema. Noise and dust pollution was also expected. The concern about flooding if the road is constructed higher than the housing scheme was also an issue of concern. Being relocated without compensation was also an issue of concern. Loss of business due to vehicles using the toll road was also mentioned. Interviewees anticipating a positive effect from the project anticipated fair compensation in the event that relocation becomes reality, job creation, community development, fewer road accidents and easier travelling to Ocho Rios. On the issue of ease or difficulty in commuting, 61.5% of respondents indicated that commuting should be easier due to better traffic flow, better roads, and fewer accidents and less travelling time. 38.5% of respondents anticipated a more difficult commute as the toll road was expected to cause a reduction the number of vehicles using the existing route thereby making it harder to access transportation.

Chalky Hill

18.7% of respondents were interviewed in the Chalky Hill area. 32% respondents had heard of NROCC and 62% indicated they had never heard of the company. 44% of respondents knew about the toll road project. 80% of respondents did not have any project concerns while 20% expressed concern. Concerns expressed related to respondents not wanting to be relocated or wanted to know if relocation was mandatory for residents whose dwellings may fall within the road footprint. Concern was also raised about the construction of the road in the watershed area. 44% of respondents indicated a possible positive impact as employment opportunities may arise, heavy duty vehicles will be off the Chalky Hill main which lacks sidewalks. Additionally respondents anticipated a positive as the traffic risk to children was expected to be eliminated. 12% of respondents did not anticipate a positive or negative effect; 4% indicated a negative effect specifically related to the creation of a dust nuisance. 40% of respondents did not anticipate an effect from the project on their lives. On the issue of ease or difficulty commuting, 100% of respondents indicated that commuting will be easier as it is anticipated that there will be less traffic, travel time is expected to be reduced and more vehicles are expected to be on the roads. 4% of the respondents while indicating an easier commute also indicated a more difficult commute as it is expected that existing transportation will be diverted to the toll road.

Steer Town

10.4% of respondents were interviewed in the Steer Town area. 21.4% of those interviewed knew of NROCC while 78.6% were not aware of the company. 71.4% of respondents were aware of the toll road project. On the issue of project concerns, 57.1 % of respondents expressed no concerns about the project; 14.3% were non-committal and 28.6% indicated that they had concerns. Concerns related to the loss of business for the community as traffic would utilize the toll road and not travel through Steer Town. Respondents were also concerned about the potential employment possibilities for unemployed persons in the community. 57.1% of respondents indicated that they expected the project to have a positive effect on their lives. 28.6% of respondents anticipated no effect; 7.1% expected both a positive and negative effect and 7.2% of respondents were non-committal. Respondents anticipating a positive effect expected an appreciation of land value, fewer traffic accidents, increase in work opportunities, community development and commercial business opportunities. Interviewees expressing a negative effect anticipated the possibility of relocation from their present location. Regarding the ease of commuting, 92.9% of respondents indicated that commuting would be easier as the road infrastructure would be improved, travel time would be reduced and farm produce can be transported easily and quickly. 7.1% of interviewees were non-committal.

Mammee Bay

9.0% of respondents were interviewed in the Mammee Bay area. 8.3% of respondents had heard of NROCC while 91.7% of respondents did not hear of NROCC. 16.7% of interviewees were aware of the toll road project; the remaining 83.3% did not know of any of the project components.. On the issue of project concerns, 41.7 % of respondents expressed no concerns about the project. 41.7% also expressed project concern. Concerns related to the creation of a dust nuisance, residents anticipating an increase in traffic volume, the duration of the construction phase of the project and the proximity of the toll road to residences. 16.6% were non-committal. Regarding possible project impact 16.7% of interviewees thought the project would have a positive impact as the noise from the heavy duty vehicles presently experienced would be gone and commuting to Kingston would be easier. 0.0% of respondents indicated a negative impact while 66.7% of respondents thought the project would have no impact and 16.6% were non-committal. Regarding the ease of commuting, 75.0% of respondents expected an easier commute as shorter travel time is anticipated. 16.7% of respondents expressed that their commute would be more difficult as senior citizens would have difficulty crossing the street and the toll fee cannot be afforded. 8.3 % of respondents were noncommittal on the potential ease or difficulty in commuting.

4.6 CULTURAL AND HISTORICAL SETTING

A cultural and historical survey was conducted by the Jamaica National Heritage Trust (JNHT) and the composition of the assessment team was made up of archaeologist specialists from the Archaeology Division. Four main tasks were undertaken as follows:

(1) Desk-Based Assessment – This comprised researching relevant historical documentation (maps, plans, estate accounts, correspondents, titles, and deeds) and published and unpublished narratives, studies and data sets of the study area, adjoining areas and associated projects. Analysis of satellite images and aerial photographs was also undertaken.

(2) Oral History - Oral history research was conducted in order to bridge the data gap and to identify and describe additional resource material, to more exactly identify the location of sites and to generate

a more comprehensive cultural heritage bibliography. This information was used to create a comprehensive list of sites and other cultural heritage elements in the data gap areas that needed to be visited.

(3) Site Survey – This involved an archaeological field walk and windshield survey, artifacts sample collection and analysis, cultural heritage contexts interpretation and analysis and recording significant cultural assets to be affected.

(4) Recording and Analysis of Artifacts - All archaeological features, including artifacts, were recorded by means of sketches, digital photographs, GPS, survey, and field notes. Where artifact assemblages are identified, samples will be collected and recorded for analysis.

Preliminary analysis of artifacts was done to establish manufacture location and cultural association.

Individuals familiar with the site were interviewed and this information noted to add to the database on sites.

In all 3 sites have been noted for the area with 2 of these sites showing a Taíno presence. A total of 6 pieces of artifacts were collected from the surface of three sites namely Phoenix Park (2 Taino artifacts), Adstock (skeletal remains found in 1966) and Annandale (3 Taino artifacts found in 1974).

Detailed results of the assessment may be found in the accompanying Archaeological Impact Assessment report.

5.0 AESTHETICS

The highway is not expected to have a negative visual impact on the surroundings.

6.0 IDENTIFICATION OF POTENTIAL IMPACTS

Table 6-1 – Impact matrix for site preparation and construction phases

ACTIVITY /IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
	Pos	Neg	Long	Short	Direct	Indirect	Major	Minor	Wide	Local	Large	Small
1. Site Preparation												
Vegetation clearance		x	x		x			x		x		x
Fauna (removal of habitats)		x	x			x		x		x		x
Excavation works		x		x	x			x		x		x
Increased infiltration/runoff and flooding hazard		x		x		x		x		x		x
Soil erosion		x		x	x			x		x		x
Solid waste generation		x		x	x			x		x		x
Foundation dewatering		x		x	x			x		x		x
Piling/building Foundation		x		x	x			x		x		x
Air quality		x		x	x			x		x		x
Noise		x		x	x			x		x		x
Water quality		x		x		x		x		x		x
Land use		x	x		x			x		x		x
2. Material Transport												
Dusting & spillage		x		x	x			x		x		x
Traffic congestion, road wear		x		x	x			x		x		x
3. Material Storage												
Dusting		x		x	x			x		x		x
Suspended solid runoff		x		x	x			x		x		x
4. Construction Works												
Noise		x		x	x			x		x		x
Water demand and supply		x		x		x		x		x		x
Refueling 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
Landscaping	x		x		x			x		x		x
Fauna (replacement of habitat)	x		x			x		x		x		x
5. Construction Crew												
Sewage/wastewater		x		x	x			x		x		x

ACTIVITY /IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
	Pos	Neg	Long	Short	Direct	Indirect	Major	Minor	Wide	Local	Large	Small
generation												
Solid waste management		x		x	x			x		x		x
Emergency response		x		x	x			x		x		x
6. Socioeconomics												
Employment	x			x	x		x			x	x	
Traffic flow and access roads		x		x	x			x		x		x
Businesses (established)		x		x		x		x		x		x
Community fragmentation		x	x		x			x		x	x	
7. Cultural and Historical												
Historic sites		x	x		x			x		x		x

Table 6-2 - Impact matrix for operation phase

ACTIVITY/ IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
	Pos	Neg	Long	Short	Direct	Indirect	Major	Minor	Wide	Local	Large	Small
1. Plant Maintenance												
Polluted run-off from wash-down activities		x	x		x			x		x		x
2.Storm Water/Drainage												
Increased flow, siltation and flooding hazard		x	x			x		x		x		x
Water quality		x	x			x		x		x		x
Ponding		x	x			x		x		x		x
3. Landscaping												
Vegetation maintenance	x		x		x			x		x		x
Fauna (increased access to wildlife)		x	x			x		x		x		x
5. Air Quality												
Increased pollutants in air shed		x	x		x		x			x	x	
6. Noise												
Increased noise pollution		x	x			x		x		x		x
7. Health and Safety												
Increased air emissions exposure		x	x		x			x		x		x
Increased noise exposure		x	x		x			x		x		x
Increased potential for accidents		x	x			x		x		x		x
8. Spills and Waste Disposal												

ACTIVITY/ IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
	Pos	Neg	Long	Short	Direct	Indirect	Major	Minor	Wide	Local	Large	Small
Increased potential for oil spills		x	x			x		x		x		x
Improper oily water disposal		x	x			x		x		x		x
Improper solid waste disposal		x	x			x		x		x		x
Improper black & grey water disposal		x	x			x		x		x		x
9. Occupational Health												
Increased noise exposure		x	x		x			x		x		x
Increase exposure to air pollutants		x	x		x			x		x		x
Increased accident potentials		x	x		x			x		x		x
10. Socioeconomics												
Employment	x		x			x	x			x	x	
Traffic and access roads	x		x		x		x		x		x	
Stable electricity supply	x		x			x	x			x	x	
Increased worker productivity	x		x		x		x			x	x	
Economic growth nationally	x		x		x			x	x		x	
Water demand and supply		x	x			x		x		x		x
Community fragmentation		x	x		x			x		x	x	

6.1 SITE CLEARANCE AND PREPARATION

6.1.1 Soil Removal and Rock Blasting

Blasting is expected to be concentrated between Moneague to Golden Grove and Davis Town to Steer Town. The main concerns are:

- Fragments of rocks 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.
- A second concern is vibrations caused by blasting will impact on structures within close proximity to the blast sites.

6.1.2 Soil Erosion and Siltation

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 drainage. Areas where bare ground is exposed tend to erode faster than areas inhabited by plants as they help percolate rainwater into the substrate below and into underground aquifers. The substrate of the elevated areas was comprised mainly of limestone rock, which readily succumbs to weathering over time by rainfall and flowing water. Therefore, there could also be a resulting shift in the level of the water table as a result of plant removal.

Soil erosion and siltation of watercourses could have a negative impact on the flow regime and water quality within the study area. This could lead to minor negative impacts during the construction phase such as declined water quality and water transparency, along with severe negative impacts such as flow impairment and localised upstream/downstream flooding (arising from the overtopping of the river/gully banks). It is imperative, therefore, that proper soil/construction material management practices be implemented during site clearance, site preparation and the construction phase of the project.

6.1.3 Water Resources

Water resources include sinkholes and wells. Sinkholes are natural holes in the ground caused by the erosion of water, usually occurring in regions of limestone formation, which facilitates in the recharging of aquifers through which surface runoff. Throughout the length of the proposed alignment, the topography includes various depressions in which sinkholes occur. A safety buffer of 50m and 100m was established within reason around the Moneague alignment of Highway 2000. Figure 6-1 shows that five (5) of these sinkholes can be located directly under the highway alignment reservation, ten (10) are situated within the 50m buffer whereas 13 were identified as being contained within the 100m buffer as shown below.

Table 6-3 Sinkholes intersected by H2K alignment

Location	*Sinkholes Identified*
Traversed by alignment	5
Within 50m buffer	10
Within 100m buffer	13
Total	**28**

Figure 6-2 indicates several wells, both pumping and non-pumping, within close proximity of the proposed H2K Moneague alignment. This map should be used as a guide to avoid the covering and/or destruction of these wells. Implementing the abovementioned 50m and 100m buffer area, no wells were determined to be affected by the construction of the proposed H2K North-South alignment. These wells are owned and operated by both private and government entities. The 100m buffer of the alignment, being a 4-lane highway, will not cover these wells nor may lead to their destruction and/or contamination.

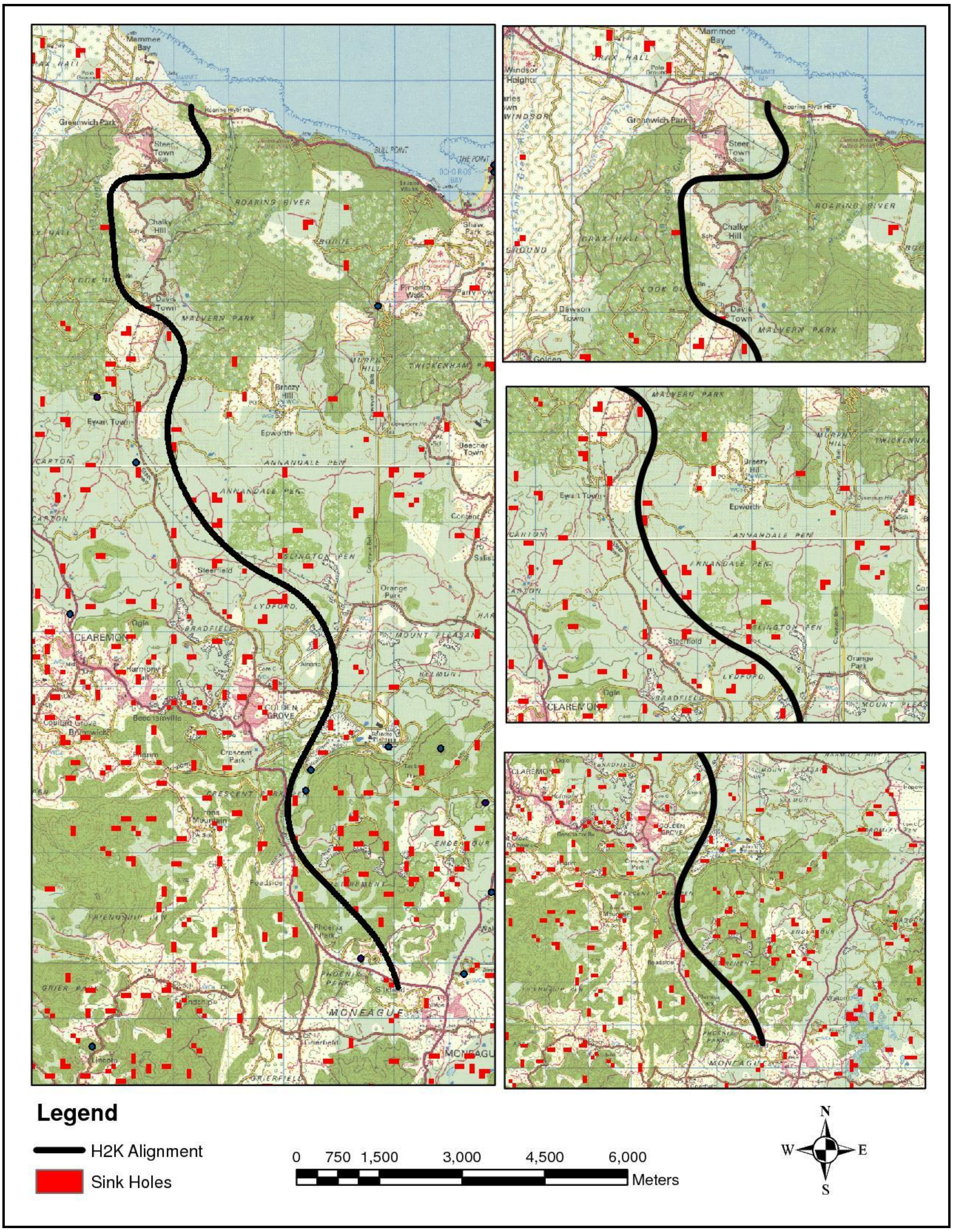

Figure 6-1 Sinkholes identified along H2K Moneague alignment

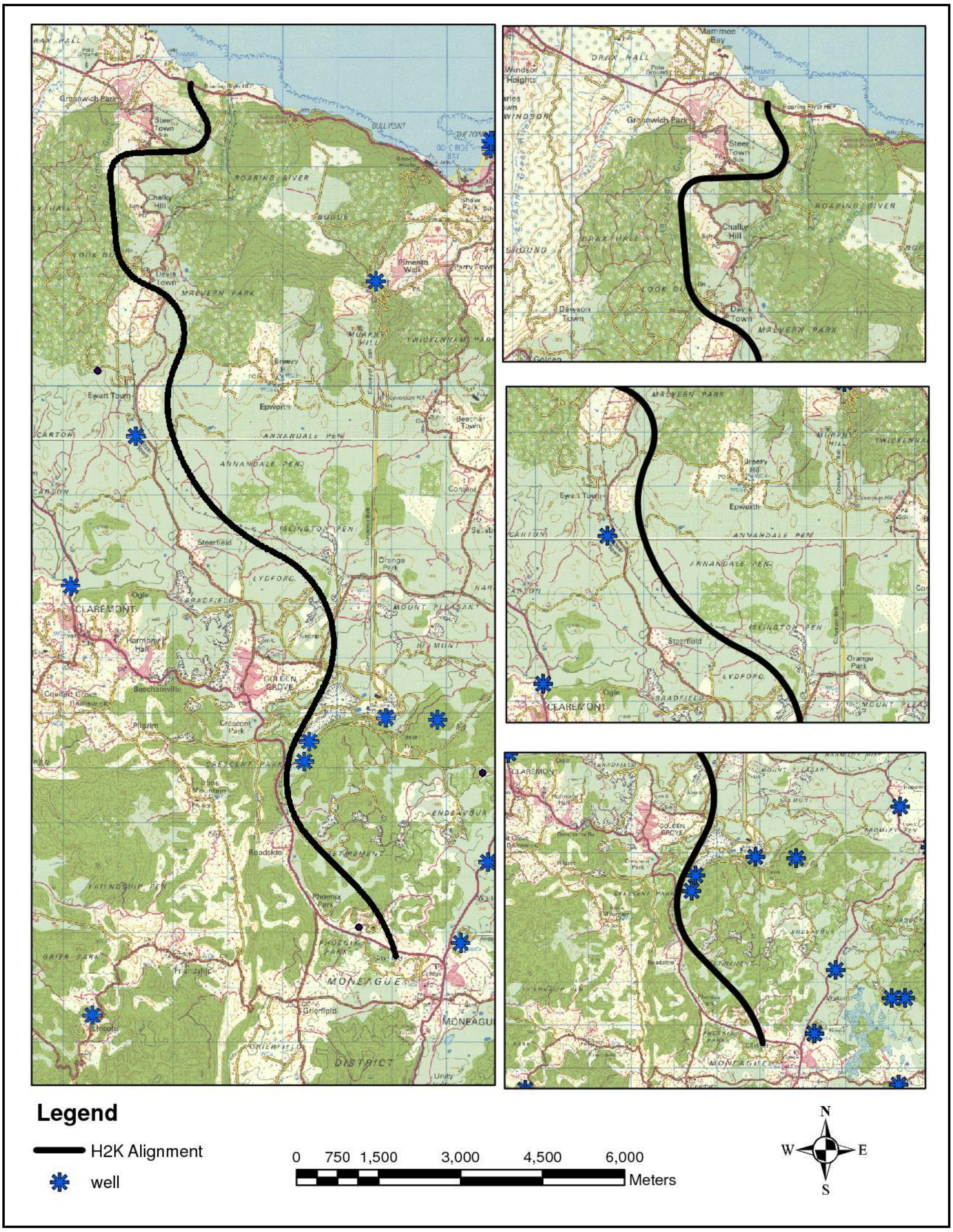

Figure 6-2 Wells identified within the vicinity of the H2K alignment

6.1.4 Flora and Fauna

6.1.4.1 Vegetation and Habitat Removal/Disturbance

The vegetation communities present within the study area exhibited various levels of anthropogenic influence and as such, would be affected by any development in various ways. The overall assessment of the study site revealed that the vegetation in each locale sampled was disturbed; however, roadside vegetation had the highest level of endemism and as such, care should be taken in carrying out the development in these areas. The impacts and possible mitigations for the development are outlined below. As with any development, the options of not to build and the use of alternative routes should always be considered.

Perceived Impacts to the Pastureland Areas:

The vegetation located in the pastureland areas exhibited signs of human modification (with several agricultural and residential developments), which would indicate that the natural ecological habitat was already degraded in these locations. Therefore, the vegetation here should be the least affected by the highway development.

Perceived Impacts to the Roadside Vegetation and Modified Woodlands:

Habitat fragmentation and the loss of endemic species are the two main ecological threats posed by the planned roadway development, especially on the highland areas during construction and operational phases. Other impacts include: increased surface runoff of rainwater and sediment; the encouragement of urban sprawl; and increased human intrusion.

Habitat Fragmentation

Habitat fragmentation is the process whereby a large, continuous area of habitat is both reduced in area and divided into two or more fragments by roads, fields, towns and many other 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". Edge effect refers to the variation in the observed microenvironment at the fragment edge. Differences in microclimate factors such as light, temperature, wind and humidity may each significantly impact species composition and vigour within the fragment.

Fragmentation normally occurs during circumstances of severe habitat loss where, for example, large areas of natural vegetation may be cleared for agricultural or residential developments. However, it may also occur when the area of disturbance is reduced to a minor degree: such as roadway developments similar to this project. Comparatively, the clearance needed for a roadway is much less than that needed for agriculture; nonetheless, the thoroughfare may induce the following habitat destructive issues:

- Roadways may act as physical barriers to the passive movement of spores and seeds across a landscape.
- Highways may also restrict the movement of animal species that often act as pollen and seed vectors for many plants.
- Roadways help to divide once continuous populations into smaller, more isolated, contiguous populations due to restrictions on the movement of spores and seeds. This restriction may precipitate further population decline due to inbreeding depression, genetic drift and other issues common to small population size.
- Fragments may also experience the increased incidence of fire due primarily to the increased penetration of wind, reduced humidity, higher temperatures and the accumulation of drying wood from dying or dead trees expected at fragment-edges (Primack, 2006). Commuters along highways may also dispose of flammable debris along the corridor, further contributing to this risk.
- Fragmentation may also lead to increased vulnerability of the fragment to invasion by alien and native invasive species as well as diseases.

Accidental or intentional removal of important plant species

Over 200 plant species were encountered during the field excursion, including several fern and orchid species. Ten were endemic. Therefore, the area could be considered species rich with an indigenous component – important to the local environment and the natural history of the country.

Human Encroachment, Urban Sprawl and Control of Invasive Species

The study site, although disturbed, is species rich and possesses a relatively high tree density. Therefore, minimising the impact on the flora during the construction phase of the development is important. This impact may continue also into the operation phase of the project. Furthermore, as in any land modification project, the clearing of natural vegetation allows the intrusion of invasive plant and animal species into the development site and more importantly, into watershed and protected areas.

Increased soil/substrate erosion

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 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.

Storage and transportation of raw materials

Plant growth and health can be significantly affected by dust, grime and toxic emissions. Leaching from storage areas can disturb the pH balance in the soil and result in plant loss.

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.

6.1.4.2 Fauna

The proposed highway will have an impact on the natural ecosystem and resulting fauna. These impacts are outlined below.

1. Fragmentation of the ecosystem

This will affect some wildlife which has to negotiate, tolerate or cope with the natural barriers (Southerland, 1994). In this project the wildlife which could be affected includes reptiles (snakes, lizards), amphibians, mammal and invertebrates (land snails and insects).

- Erode genetic diversity and increase inbreeding.
- Loss of interior or area-sensitive species.

- Increase abundance of weed species.
- Increase mortality of animals who try to cross the highway.

2. Degradation of the natural habitat

- Excessive vegetation removal for the construction of the road.
- Natural characteristics of the land are eliminated within the paved area and adjacent roadsides.
- The replacement of forest trees with grasses and shrubs have negative impacts on forest specialist species.
- Reducing the habitat for forest specialist species including eliminating nesting.
- Introduction of exotic species as a result of the construction of the highway.
- Create habitat for non-forest specialist species. For example roadway with the grass or shrub vegetation provide habitat for these species.
- The highway including service roads used in the construction have created easy access to pristine areas which will lead to habitat degradation.
- Cumulative impacts where the highway development is provided as a stimulus to secondary development and ultimately local economic enhancement. This will cause an indirect loss of the natural habitat.

3. Noise

- Noise from construction of the highway will scare away some of the wildlife. For example birds and other wildlife that communicate by auditory signals may be at a disadvantage near roads.

6.1.5 Noise Pollution

Site clearance for the proposed development necessitates the use of heavy equipment to carry out the job. These equipment include bulldozers, backhoes, jackhammers 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 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.

Construction noise on a highway project can result in short-term impacts of varying duration and magnitude. The construction noise levels are a function of the scale of the project, the phase of the construction, the condition of the equipment and its operating cycles, the number of pieces of construction equipment operating concurrently. To gain a general insight into potential construction noise impacts that may result from the project, the typical noise levels associated with various types of construction equipment are identified in Table 6-4. The noisiest periods of highway construction are typically the ground clearing and earthwork phases.

Table 6-4 – Typical construction equipment noise levels

Type of Equipment	***Typical Sound Level at 50 ft. (dBA Leq.)***
Dump Truck	88
Portable Air Compressor	81
Concrete Mixer (Truck)	85
Jackhammer	88
Scraper	88
Bulldozer	87
Paver	89
Generator	76
Piledriver	101
Rock Drill	98
Pump	76
Pneumatic Tools	85
Backhoe	85

Adapted from - Route 101A Widening and Improvements, City of Nashua Hillsborough County, New Hampshire; McFarland-Johnson, Inc. May 30, 2007

6.1.6 Air Quality

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.

6.1.7 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.

6.1.8 Wastewater Generation and Disposal

With every construction campsite comes the need to provide construction workers with showers and sanitary conveniences. The disposal of the wastewater generated at the construction campsite has the potential to have a minor negative impact on groundwater.

6.1.9 Storage of Raw Material and Equipment

Raw materials, for example sand and marl, used in the construction of the proposed development will be stored onsite. There will be a potential for them to become air or waterborne. Stored fuels and the repair of construction equipment has the potential to leak hydraulic fuels, oils etc.

Plant growth and health can be significantly affected by dust, grime and toxic emissions. Leaching from storage areas can disturb the pH balance in the soil and result in plant loss. Owing to the fact that the main substrate type (especially in elevated areas) was porous limestone rock, any chemical/material spills may quickly reach the underlying water table.

6.1.10 Transportation of Raw Material and Equipment

The transportation and use of heavy equipment and trucks is required during construction. Trucks will transport raw materials and heavy equipment. This has the potential to directly impact traffic flow along local roads.

6.1.11 Affected Structures

Approximate 64 structures will be impacted due to them falling in the highway reserve. This will necessitate then being removed or relocated to facilitate the construction of the North-South Highway Link – Moneague to Ocho Rios.

6.1.12 Emergency Response

Construction of the proposed highway has the potential for accidental injury. There may be either minor or major accidents.

6.1.13 Workers Safety

Construction of the highway and its infrastructure may entail workers being suspended in the process. This has the potential for increase construction accidents. Additionally, there may be some blasting in preparing the site for the construction of the new highway.

6.1.14 Traffic Management

The construction of the new highway alignment may necessitate the re-routing of some vehicular and pedestrian traffic and introducing traffic delays thereby increasing in travel time. The re-routing of vehicular traffic has the potential to lead to increase fares.

Negative impacts on traffic are expected during the construction stages, and these include:

- disruptions in traffic
- reduced level of service due to increased large/construction vehicle on the roads.

6.1.15 Travel Costs

There is the potential negative impact on the cost of travel within the construction area as there is the possibility of traffic being diverted resulting in increased travel distance which will translate into increased costs to the travelling public.

6.1.16 Employment

There is the potential for increase employment during the pre clearance construction phase. It is anticipated that approximately 1,000 persons will be employed directly. Based on data from the U.S. Department of Transportation and the Federal Highway Administration there are approximately 2.5 indirect jobs and 1.8 induced jobs created for every direct job created. Therefore, it is anticipated that approximately 2,500 indirect and 1,800 induced jobs will be created by the proposed project.

Indirect jobs are are those held by workers in industries that supply highway construction manufacturers with materials and by offsite construction industry workers such as administrative, clerical, and managerial workers. Supplying industry jobs include those supported in stone and clay mining and quarrying, petroleum refining, lumber, steel, concrete, and cement products, as well as in miscellaneous professional services.

Induced jobs are jobs supported throughout the economy when highway construction industry employees spend their wages. Expenditures by these workers on various goods and services stimulate demand for additional employees in these industries, resulting in jobs being supported throughout the general economy.

6.1.17 Cultural and Historical

The proposed alignment has the potential to negatively impact a number of culturally and historically significant structures during site clearance activities. These include Taino sites (Phoenix Park, Adstock and Annandale), Lydford Park/Beulah Park (Protocol House), historic cut stone bridge at Davis Town, cut stone ruins of sugar works, aqueduct and water wheel located closer to Mammee Bay. In some areas however, there appears to be no significant direct cultural heritage or archaeological impacts.

6.2 OPERATION

6.2.1 Climate Change and Flooding

Impacts of the highway implementation may include:

- The climate change impacts identified within the context of the Highway include increase runoffs caused by more intense storms.
- Several areas contiguous to the alignment presently experience flooding as a result of the rivers/gullies that cross the alignment. The highway construction will interrupt the natural storm flow pattern and further exacerbate the flooding problems being experienced. The areas surrounding Moneague, Chalky Hill and Golden Grove are particularly vulnerable as these areas are densely populated areas.

6.2.2 Water Resources

Impacts of the highway implementation may include:

- Sinkholes within close proximity to the highway may become plugged. Consequently, the recharge area for the aquifers will decrease in size, affecting the productivity of wells located nearby.
- Recharge paths for surface run-off may be traversed by the alignment, decreasing the volume of run-off reaching the sinkholes.
- Surface run-off will become contamination due to oil spills. This problem may be more prone in areas where fuel stations are located.

6.2.3 Natural Hazards

Impacts of the highway implementation may include the following:

- The sections of the highway which traverses the mountainous environs north of Phoenix Park, north of Chalky Hill and south of Steer Town were determined most vulnerable to landslides.
- Approximately 1km of the alignment which traverses east to west through the mountains south of Steer Town is determined to have high vulnerability of landslides.
- 2.25km of the highway is determined to have slight to moderate vulnerability in the region of Crescent Park Pen.
- Slope failure will be of low risk on Section 1 (between Moneague and Malvern Park) apart from local rock falls induced by heavy rain or earthquakes and during construction. A greater risk exists on Section 2 (Between Malvern Park and Mammee Bay) which traverses chalky limestones of variable resistance to rain or seismic events.

- There is low risk of flooding for Section 1 (between Moneague and Malvern Park), but higher risk for Section 2 (Between Malvern Park and Mammee Bay) which crosses several active gully systems.

6.2.4 Noise

The predicted noise impact from the operation of the North South Link (Moneague to Ocho Rios) was determined by using SoundPlan 7.1 noise modelling software and estimated traffic data from the North South Highway Link Modelling and Traffic Forecast Report (November 2008) done by Steer Davies and Gleave (SDG).

The locations at which the baseline noise readings were taken were digitized as receivers so as to determine the noise at those locations when the highway is in operation and ultimately to see the change in the noise climate there. The environmental conditions in the model were set at 87% relative humidity, 27^{o}C temperature and pressure of 1010.00 mbar.

Comparison with NEPA Guidelines

Stations 1, 2 and 5 will be non -compliant with the NEPA day time guidelines (Table 6-5) and Figure 6-3. Whilst non–compliant, the baseline noise level at Stations 5 was already exceeding the NEPA day time guidelines.

Stations 1, 2, 5 and 6 will be non-compliant with the NEPA night time guidelines (Table 6-5) and Figure 6-4. Whilst non-compliant, the baseline noise levels at Stations 5 and 6 were already exceeding NEPA night time guidelines.

Table 6-5 – Comparision of predicted noise levels with NEPA guidelines

STATION			DAY TIME (7 am. – 10 pm.) (dBA)			NIGHT TIME (10 pm. – 7 am.) (dBA)		
No.	**Location**	**Category**	**Baseline**	**Predicted noise from highway**	**NEPA Std.**	**Baseline**	**Predicted noise from highway**	**NEPA Std.**
1	Moneague	Residential	48.7	**61.0**	55	49.0	**60.6**	50
2	Golden Grove	Residential	51.8	**55.6**	55	47.4	**55.2**	50
3	Lydford	Residential	58.2	42.5	55	57.1	42.1	50
4	Annandale Farms	Commercial	56.2	58.8	65	53.5	58.6	60
5	Steer Town All Age School	Silent	55.4	**54.3**	45	49.6	**53.6**	40
6	Roaring River Community	Residential	52.3	54.0	55	50.5	**53.6**	50

NB: Noise levels in red exceeded the NEPA guidelines

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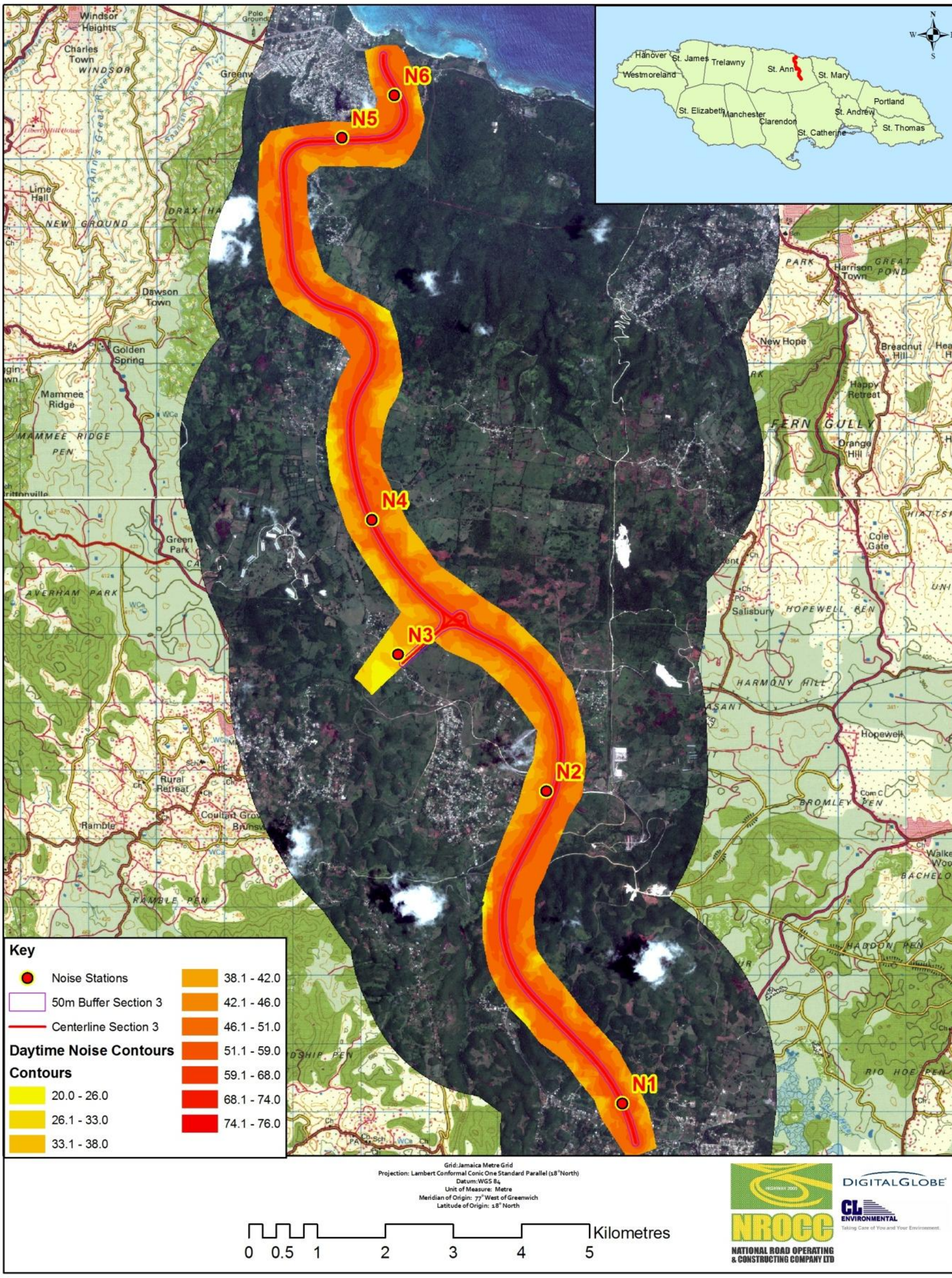

Figure 6-3 – Modelled Day Time noise levels along the proposed alignment

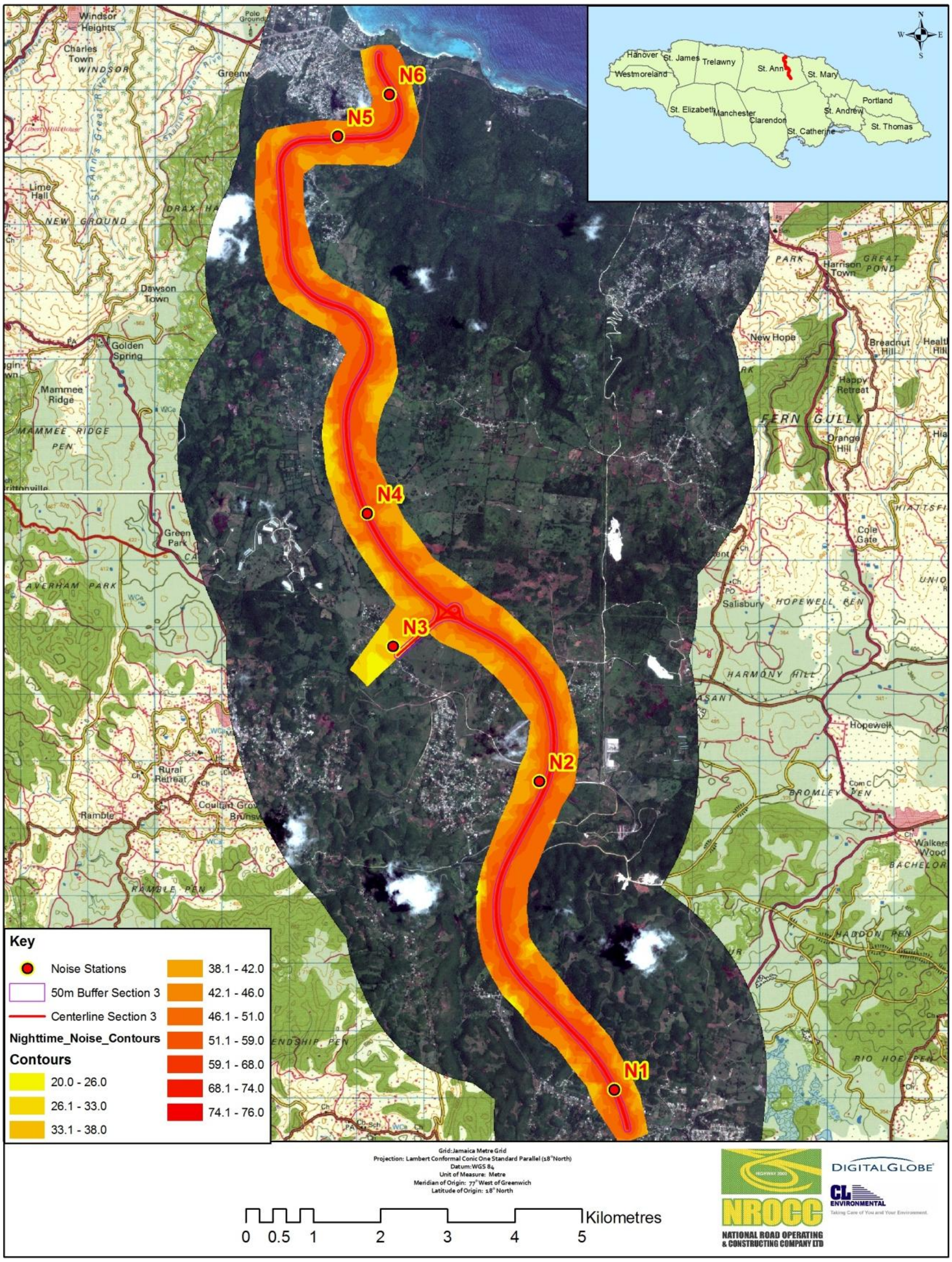

Figure 6-4 – Modelled Night Time noise levels along the proposed alignment

6.2.5 Occupational Noise

There are no data for worker noise exposure for highway in Jamaica. However, it is accepted internationally that toll booth workers are exposed to varying noise levels and there is a potential for them to be exposed to noise levels detrimental to their health.

Employees working at toll booth are exposed to the extended and continuous traffic noise. Sustained noise levels of this nature may cause hearing loss, induce fatigue or stress, and reduce worker's productivity. The annoyance and discomfort related to the continuous noise exposure may create an unpleasant working condition and may affect the hospitality of the toll tellers and their attitude toward customers (S. Nadya, S. Z. Dawal, T.M.Y.S Tuan Ya, M.Hamidi).

6.2.6 Emergency Response

There is a potential for the highway to be impacted by natural or man-made disasters such as earthquakes, floods, fires and accidents.

6.2.7 Traffic

Negative impacts on traffic are expected during the construction stages, they will include:

- Disruptions in traffic especially in the areas surrounding Moneague, Golden Grove, Steer Town and Davis Town; as well as reduced level of service due to increased large/construction vehicle on the roads;
- Damage to existing roads due to the increase number of heavy vehicles transporting construction material;
- Increased risk of accidents or damage to vehicles due to objects falling from a truck.

The increased residential developments taking place in the parish of St. Ann are increasing traffic congestion in Ocho Rios. Fern Gully is one of the main transit route for trips from Kingston to the north coast and vice versa. The construction of this phase (Moneague to Ocho Rios) will result several benefits to commuters, these will include:

- Less congestion on the existing roads which traverse through Fern Gully and the town of Ocho Rios;
- Safer driving conditions for motorists and pedestrians;
- The reduction of travelling time.

The Moneague leg of the highway is expected to attract motorists which subsequently will generate significant volumes of traffic. The expected traffic impacts are as follows:

1. This phase of the highway will provide additional access points which will enable commuters from Claremount, Golden Grove and further areas to access the highway going northbound, reducing time and expenses.

2. Similarly, for commuters from Moneague and beyond, the Moneague connection will provide an alternative to going through the Ocho Rios town congestion when travelling to the North coast from the south; the existing highway A3 will also be reduced significantly.

Along the H2K Moneague alignment, there exist a number of access points including road intersections, vehicular accesses and pedestrian accesses. Residential and commercial properties are attributable to these high numbers of access points. These access points are generally of poor geometry and pose challenges within the design of the highway. The implementation of the alignment divides some communities from their respective main towns which poses grave problems. Furthermore, the road widening and road structures (ramps, bridges) at specific chainages along the highway increase the inconvenience of affected communities.

6.2.8 Employment

There is the potential for increase employment during the operation phase. It is anticipated that approximately 400 persons will be employed directly. It is anticipated that approximately 1,000 indirect and 720 induced jobs will be created by the proposed project.

7.0 CUMULATIVE IMPACTS

7.1 NOISE

The operation of the proposed highway will result in an increase in the existing noise level (cumulative) (Table 7-1).

The cumulative noise impact takes into account all the existing background noise sources. Noise from the new noise source (the proposed highway) is then added to the existing noise levels to determine what if any impact this new development would have on the surrounding community.

7.1.1 Comparison with NEPA Guidelines- 2011

Only Station 4 would be compliant with the NEPA day time guidelines and all stations would be non-compliant with the night time guidelines when the cumulative noise levels are calculated (Table 7-1).

However, it should be noted that the NEPA Guidelines were being exceeded at the non-compliant locations prior to the addition of the proposed project except for Stations 1, 2, 4 and 6 (day time) and Stations 1, 2 and 4 (night time).

Table 7-1 – Comparison of the cumulative noise impact with NEPA noise guidelines

STATION			***DAY TIME (7 am. – 10 pm.) (dBA)***			***NIGHT TIME (10 pm. – 7 am.) (dBA)***		
No.	***Location***	***Category***	***Baseline***	***Cumulative***	***NEPA Std.***	***Baseline***	***Cumulative***	***NEPA Std.***
1	Moneague	Residential	48.7	**61.2**	55	49.0	**60.9**	50
2	Golden Grove	Residential	51.8	**57.1**	55	47.4	**55.9**	50
3	Lydford	Residential	58.2	**58.3**	55	57.1	**57.2**	50
4	Annandale Farms	Commercial	56.2	60.7	65	53.5	**59.8**	60
5	Steer Town All Age School	Silent	55.4	**57.9**	45	49.6	**55.1**	40
6	Roaring River Community	Residential	52.3	**56.2**	55	50.5	**55.3**	50

NB: Noise levels in red exceeded the NEPA guidelines

7.2 AIR QUALITY

With the anticipated increase in vehicular traffic it is expected that the level of particulate, NO_x and SO_2 will increase. However, the impact is expected to be minor.

7.3 STORM WATER RUNOFF

7.3.1 Runoff Impact

The following impacts are expected when the highway is constructed:

1. The peak flows will increase by 0.56 – 0.99 % from the current scenarios (Table 7-2).
2. The most significant impacts that the roads will have on drainage within the catchments is the cutting off of small and minor drains that cross the highway alignment. This will result in localized flooding in especially in flood prone areas. There are numerous tributaries which also cross the proposed alignment and will need culvert openings as shown in Figure 7-1. Numerous areas identified as flood prone areas by the Office of Disaster and Emergency Management (ODPEM) are within close proximity to the alignment.

Table 7-2 – Increase in peak flows

Hydrology	*Units*	*Location*	
		Harbridges Gully	**Little River**
Catchment area	HA	1130	385
Return period	Years	100	100
Tc	min	12	10
Peak runoff			
Existing Condition	m^3/sec	146.4	116.0
Existing Condition plus Highway	m^3/sec	147.8	116.6
Difference		0.99%	0.56%
Future Flows (fully developed catchment with highway)	m^3/sec	172.7	130.2

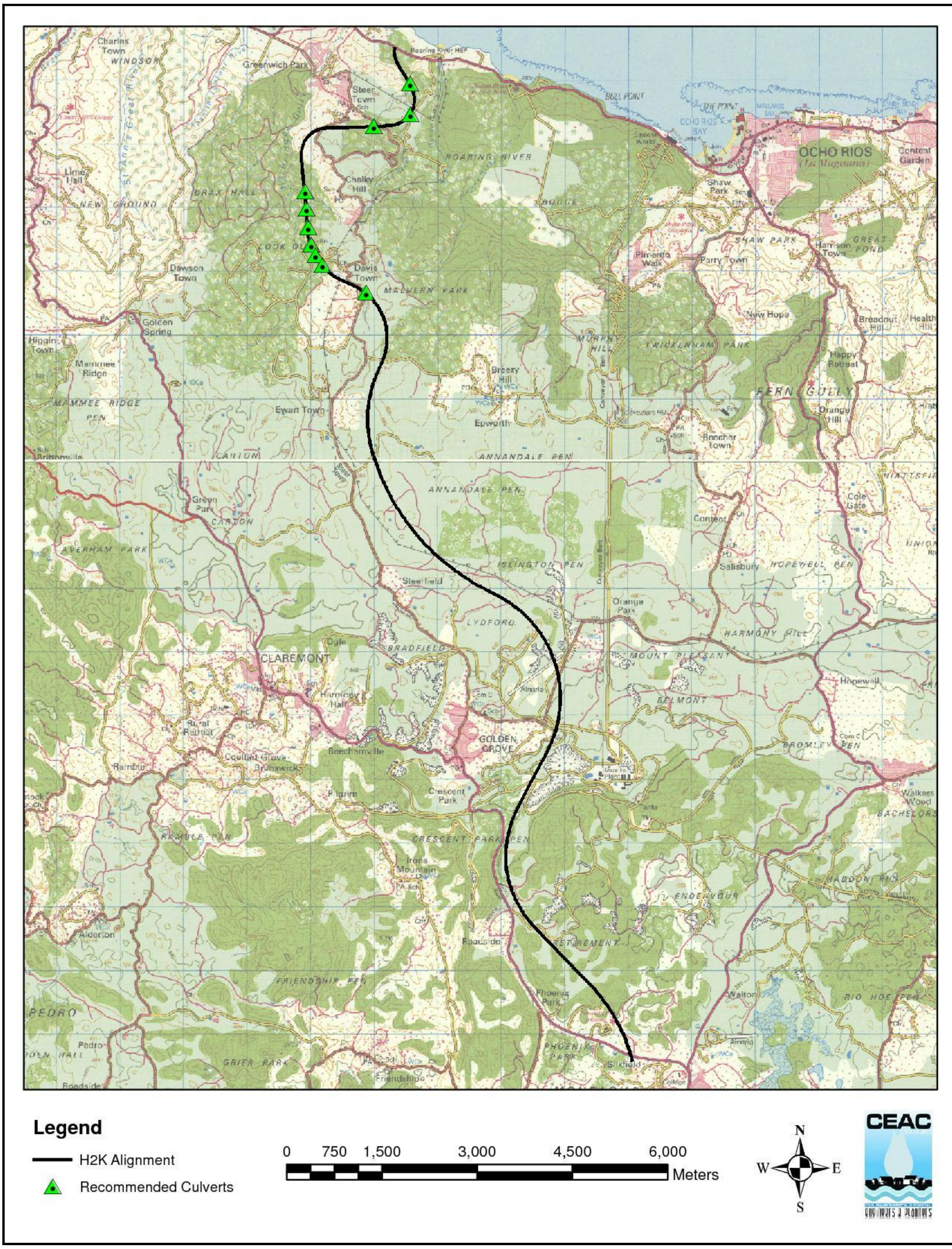

Figure 7-1 – Map showing the proposed culvert openings and bridges along the alignment

8.0 ANALYSIS OF ALTERNATIVES

The following alternatives have been identified and are discussed in further detail below:

- The "No-Action" Alternative
- The H2K alignment as proposed
- The H2K alignment with relocated sections

8.1 THE "NO-ACTION" ALTERNATIVE

The following Positive impacts are anticipated:

- Destruction of natural habitats will be avoided from the cutting and filling operations required during construction.

The following Negative impacts are anticipated:

- Continued delays may be experienced in Ocho Rios town during morning and evening peak hours;
- High maintenance and fuel costs for motorists using the existing roads in poor condition;
- Loss of potential employment opportunities for communities near to alignment.

8.2 THE H2K ALIGNMENT AS PROPOSED

The following Positive impacts are anticipated:

- The construction of this alternative will reduce the travel times, from urban centres and residential settlements in St. Ann and other northern parishes, to and from Kingston;
- Reduced maintenance and fuel costs associated with better quality roads;
- Job opportunities will be created during the construction phase as well as the post-construction phase. It will give local residents the prospect of earning an income to better sustain their families;
- Improved travelling conditions during commute.

The following Negative impacts are possible:

- Destruction of habitats especially in the hills between Moneague and Steer Town which is due to the extensive clearing, cutting and filling operations required during construction;
- Relocation of residents whose properties fall within the alignment and the associated project limits;
- Possible contamination of water groundwater as there are several sinkholes and wells in close proximity the proposed alignment.

8.3 RELOCATE H2K ALIGNMENT

Relocating the alignment will have more or less the same socioeconomic issues while environmental and engineering issues may vary due to geology and hydrological issues.

9.0 MITIGATION

9.1 SITE CLEARANCE AND CONSTRUCTION

9.1.1 Soil Removal and Blasting

i. To prevent caving-ins and the development of unstable/unpredictable rock fissures (on and off the site), blasting will be used in instances where it is deemed unavoidable. Alternative methods such as bulldozing and jack hammering will be the preferred options, with blasting practices being the last resort option. These blasting practices will be kept to a minimum and will involve directional, controlled blasts, using mats where possible. The following procedures are also recommended to mitigate or minimize the potential for dangers including:

- Conducting preblast crack surveys which documents the existing status of structures (homes and residences) within of the alignment 500m.
- Executing preblast tests to monitor effects, measure attenuation characteristics and minimize vibration impacts. Predictions are evaluated using actual data and adjustments are made during the blasting program. This is monitored using instruments placed at the nearest structure in every direction.
- Implementing rockfall catchment fences. These mechanisms help to contain fragmented pieces of stones (flyrock) from impacting nearby settlements. An illustration of such mechanisms is shown below.

Plate 9-1 - Rockfall catchment fences being implemented

9.1.2 Soil Erosion and Siltation

i. Under no circumstance will sand, marl or silt be allowed to collect within the river to the extent that they impair surface water flow and provide the opportunity for overtopping and flooding.
ii. Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin to prevent them from being eroded and washed away.
iii. Provision of catch or diversion drains to divert surface flows from unsloped catchments around disturbed area prior to major works.
iv. Installation of silt fences.
v. Installation of coffer dams where necessary.
vi. If possible, trees with trunks of DBH 20 cm and greater should be left intact. Remove trees only as would be necessary. Hence a proper procedure should be developed as to site preparation prior to project initiation.

9.1.3 Water Resources (Sinkholes and Wells)

Sinkholes and wells work accordingly as an underground water network. To ensure this network does not become contaminated or destroyed, special mitigation steps such as those listed below may be taken:

1. Specifically, a water resources risk management plan should be created for the recharge area, identified with the high concentrations of sinkholes and the wells to be affected. This occurs primarily in the regions along the alignment from

Moneague to Chalky Hill. This should be done in conjunction with Water resources Authority's approval of the measures to mitigate against adverse pollution during both the construction and operational phases.

2. In keeping with the recommendation for a water resource risk management plan, a dedicated mapping exercise should be undertaken to identify all vulnerable sinkholes.
3. A drainage and vegetated buffer area should be installed around and within the sinkhole drainage area to improve runoff water quality by filtration and adsorption of contaminants before direct discharge to sinkholes.
4. Culverts and proper drainage should be implemented wherever the alignment crosses the surface run-off paths for the sinkholes to ensure the recharge area is not disturbed.
5. The developers should consider installing a combination of wetland detention basins, oil separators or interceptor within the drainage system which will facilitate the filtering of the local water system from toxic contaminants. An example of an oil separator is shown below:

Plate 9-2 Filling station forecourt separator

9.1.4 Flora

9.1.4.1 Habitat Fragmentation

1. Limit rights-of-passage to areas already showing noticeable signs of habitat degradation. For example, areas with open fields, pastureland, low endemism and areas of agricultural or isolated residential development.
2. Incorporate at regular intervals engineering solutions that would help minimise habitat fragmentation such as tunnels and/or bridges especially at higher elevations. These structures would help reduce population isolation by providing links between potentially fragmented habitats (Primack, 2006; Smith & Smith, 2006) and minimise the impact of vegetation removal. Comparatively, highway developments that do not incorporate these features may result in higher incidences of population isolation, complete vegetation removal within the swath of the rights-of-way, as well as further habitat degradation from engineered land modifications, designed to suitably grade the highway.
3. It is understood, however, that fencing may be a necessary feature of this development in order to limit the disposal of solid waste into the plant communities as well as restrict the encroachment of humans and livestock.

9.1.4.2 Accidental or intentional removal of important plant species

1. The removal of endemic species should be avoided.
2. If removal is necessary, a nursery 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 forest or used for landscaping and other aesthetic purposes.
3. The development should be fenced to impede human and livestock access to the adjacent vegetation through which the highway runs.

9.1.4.3 Human Encroachment, Urban Sprawl and Control of Invasive Species

1. A proper plan should be developed concerning transportation routes and storage for equipment and material.

2. The proposed post construction or operation road network should be kept simple as well as used throughout the preparation and construction phases of the project.
3. Fencing of exposed points to human and ruminant entry should reduce their intrusion.
4. Proper planning regarding access points to the construction site should be established.
5. Further planning will be required for the establishment of development zones within nearby lands, villages and towns. These zones should direct controlled or prohibited development of nearby areas.

9.1.4.4 Increased soil/substrate erosion

1. If possible, trees with trunks of DBH 20 cm and greater should be left intact.
2. Remove trees only as necessary. A site preparation plan should be developed prior to project initiation.

9.1.4.5 Storage and transportation of raw materials

1. A central area should be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of paints and chemicals into the sediment.
2. In terms of transporting equipment, the paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.

9.1.4.6 Increased human and invasive species access

1. A buffer area should be established and maintained between the project area and the surrounding limestone forest. Fencing will most likely be necessary.
2. Fencing of exposed points to human and ruminant entry should reduce their intrusion.
3. Proper planning regarding access points to the construction site should be established.
4. Further policy planning will be required for the establishment of development zones within nearby lands, villages and towns. The zones should direct controlled or prohibited development of nearby areas.

9.1.5 Fauna

9.1.5.1 Preserve sensitive communities and ecosystem

1. Protect unique or sensitive environments: For example the "Gully forest" should be maintained since there are several species which would be found in good forest are found there.
2. Remove as little vegetation as possible to protect the watersheds for the rivers in Ocho Rios.

9.1.5.2 Maintain natural habitat structure and ecosystem

1. In areas where some of the natural vegetation will have to be remove for the project and then restored. Vegetation that is native to the general area should be used in the restoration. The introduction of non- native species should be avoided.
2. Limit spread of exotic species

9.1.5.3 Monitor for biodiversity impacts

1. Protect rare and ecological important species: During the assessment no caves were encountered which serve as habitat for fauna such as Bats, Jamaica Boa and the Jamaica Coney. A monitoring programme and mitigative measures should be put in place to identify these sensitive habitats if encountered during the construction phase (vegetation removal, earth moving and road building) of the project.
2. Protect endemic and migratory species

9.1.5.4 Noise pollution

1. The noise from the construction of the road will scare away the birds. However, there are no studies definitively identifying traffic noise as the critical variable affecting birds with regard to stress and physiological effects near roadways and highways (Robert and Arthur, 2007).

9.1.6 Community Fragmentation

Construct bridges or other access features to ensure that communities that had access to either other areas or within the community is not impeding.

9.1.7 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.

9.1.8 Air Quality

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.
ii. Minimize cleared areas to those that are needed to be used.
iii. Cover or wet construction materials such as marl to prevent a dust nuisance.
iv. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.

9.1.9 Solid Waste Generation

i. Skips and bins should be strategically placed within the campsite and construction site.
ii. The skips and bins at the construction campsite should be adequately designed and covered to prevent access by vermin and minimise odour.
iii. The skips and bins at both the construction 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.

9.1.10 Wastewater Generation and Disposal

i. 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.
ii. Showers should be provided for the workers.

9.1.11 Storage of Raw Material and Equipment

i. A central area should be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of chemicals into the sediment.
i. Raw materials that generate dust should be covered or wet frequently to prevent them from becoming air or waterborne.
ii. Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin to prevent them from being eroded and washed away.
iii. Raw material should be placed on hardstands surrounded by berms.
iv. Equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental surface runoff.
v. Bulk storage of fuels and oils should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored. In addition, these containers should be surrounded by berms to contain the volume being stored in case of accidental spillage.

9.1.12 Transportation of Raw Material and Equipment

i. Paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.
ii. Adequate and appropriate road signs should be erected to warn road users of the construction activities. For example reduced speed near the construction site.
iii. Raw materials such as marl and sand should be adequately covered within the trucks to prevent any escaping into the air and along the roadway.
iv. The trucks should be parked on the proposed site until they are off loaded.
v. Heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage.
vi. The use of flagmen should be employed to regulate traffic flow.

9.1.13 Emergency Response

i. A lead person should be identified and appointed to be responsible for emergencies occurring on the site. This person should be clearly identified to he construction workers.

ii. The construction management team should have onsite first aid kits and arrange for a local nurse and/or doctor to be on call for the construction site.
iii. Make prior arrangements with local health care facilities such as health centres or the hospitals to accommodate any eventualities.
iv. Material Safety Data Sheets (MSDS) should be store onsite.

9.1.14 Workers Safety

i. The provision of lifelines, personal safety nets or safety belts and scaffolding for the construction workers.
ii. Adequate communication with workers and signage should be put in place to alert/inform workers of the time, location of such blasting and instructions.

9.1.15 Traffic Management

During Construction the following should be enforced:

i. Delivery trucks should operate ideally during off peak hours.
ii. Loading of trucks as per NWA axel load guidelines.
iii. Traffic diversion routes must be identified and constructed as necessary.
iv. Adequate caution signage as per NWA guidelines and the use of flagmen where necessary.
v. Trucks must be properly covered and loaded so as to not let loose material fall during transport.

9.1.16 Cultural and Historical

i. Further archaeological evaluations should be undertaken in order to ascertain the magnitude of Taíno sites.
ii. The recording of impacted structures should be undertaken prior to destruction.
iii. Monitoring should be conducted during clearing and excavation stages in areas where historic artefacts were discovered.
iv. Ensure the preservation of the historic and cultural sites.

9.2 OPERATION

9.2.1 Natural Hazards

The following general mitigation means should be considered:

i. Ensure that the new structures can withstand hurricane, flood and earthquake impacts.
ii. Ensure that the new structures are designed to withstand a 50 – 100 year flood event.
iii. Road integrity inspections should be conducted every two (2) years by qualified personnel.

9.2.1.1 Earthquake Hazard

i. To minimize earthquake impact it is recommend that the highway and bridges should be designed and constructed to withstand moderate to large earthquakes.
ii. An emergency response plan to address natural and man-made disaster and possible evacuation is required by NEPA and should be developed in close consultation with the Office of Disaster Preparedness and Emergency Management (ODPEM).

9.2.1.2 Climate Change and Extreme Rainfall

i. In light of the predicted increase in rainfall intensities from regional and global climate models, and given the observed increases in intensities locally as well, it is recommended that the recent re-analysis of 24-hour rainfall extremes for intensities be sourced from the Meteorological Service and utilized for hydrological investigations models. The following are the minimum recommended parameters of the hydrological analysis:
    - The estimates of extremes should be suitably factored to account for the likely climate change effects of increased intensities. A 100 year planning horizon should be utilized;
    - The 100 year return period rainfall event under wet antecedent conditions should be considered;
    - Partial build out of the catchments where developable lands and land use modification for arable lands to farms should be considered in order to contemplate the increase in run-off from potential drainage areas;
    - Verification of hydrological model with WRA stream gauge data was possible, in light of disparities between hydrological model predictions.

ii. Flood plain mapping from previous storms and flood plain analysis should be conducted to identify the existing areas which are prone to flooding for all five major rivers. Suitable drainage mitigation measures should be installed to ensure that the alignment does not exacerbate existing conditions for the 100 year return period, with increased intensities due to climate change.
iii. In light of no hydraulic report being submitted a detailed hydraulic report that meets and exceeds the requirements of the National Works Agency should be prepared and submitted for review by the Engineers.
iv. Consider the use of use detention ponds or retarding basins which aid in the reduction of the peak flows in the drains crossing the highway (Plate 9-3). In addition, a weir may be constructed to further alter the flow characteristics (Plate 9-4).

Plate 9-3 - Detention ponds used to reduce peak flows

Plate 9-4 - Example of weir which may be used in conjunction with a detention pond

v. Levees are implemented to impede the collection of water. Levees are embankments composed of soil and earthen material such as sandbags that are used to prevent flooding controlling the rate of runoff.

Plate 9-5 - Levee implemented in New Orleans during storm Gustav

vi. Create larger openings in relation to drainage and culverts to allow a greater volume of water to flow or escape.

9.2.1.3 Landslides

A slope stability study should be undertaken in areas slated to have deep cuts or high fills. Such a study should be based upon geophysical data from boreholes, etc. on the in situ material and material sources likely to be used. Additionally, a detailed soil investigation and slope stability study should be undertaken in the areas believed to be most susceptible to landslides. Suitable mitigation measures should be defined for the proposed cuts and fills.

Landslide mitigation measures should be considered and incorporated in the designs. These measures might include:

i. The introduction of reinforcement elements such as metal soil nails (Plate 9-6) 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 9-6 - Installation of metal soil nails at edge of slope

ii. 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.

Plate 9-7 - Bench trail cut on face of steep slope

iii. 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 as seen below:

Plate 9-8 Gabion walls erected along face of steep slope

iv. Constructing rockfall protection mesh systems, for example catch fences, rockfall drapery or rockfall netting, which are made from high-tensile steel wire.

Plate 9-9 - Rockfall netting used to protect trains from falling rocks

v. 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.

Plate 9-10 - Geogrids being placed on face of slope

9.2.2 Debris Flow

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 (Plate 9-11). 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.

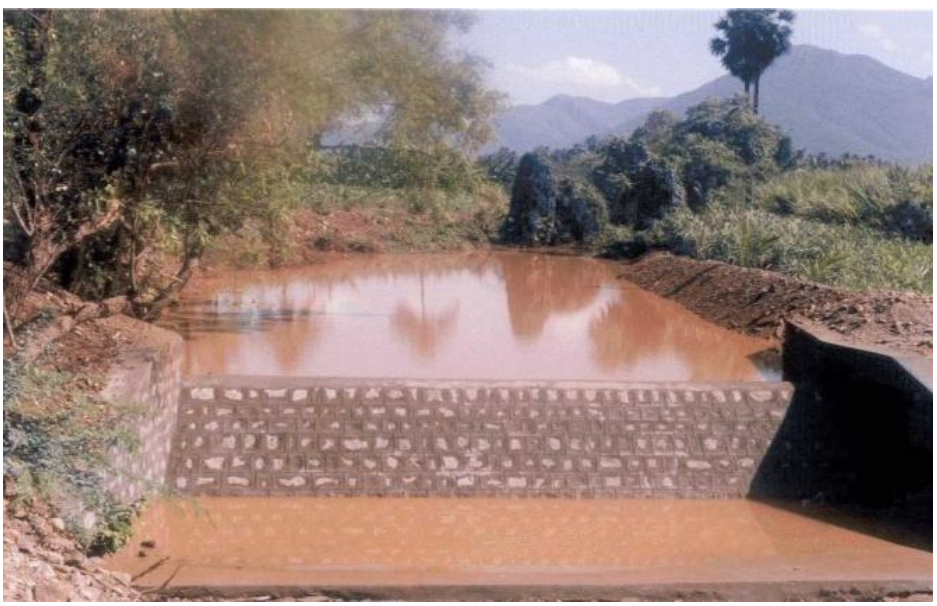

Plate 9-11 - An example of a check dam being used

ii. Sedimentation basins, debris racks (for small culverts or openings) upstream of culverts that can be schedule for maintenance cleaning.

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.

9.2.3 Runoff

A detailed study should be conducted to include historical flooding of areas along the alignment. Following this, a detailed flood plain map should therefore be created for the pre and post construction scenarios for both the present and future conditions. This will enable the designers to locate appropriately sized culverts in the correct locations to eliminate any flooding problems that the highway may cause. Given the observed climate change trends, it is recommended that the design runoffs for the future scenario be used to implement all drainage infrastructures.

9.2.4 Emergency Response

i. Alternate route or routes should be identified beforehand.
ii. Adequate and clearly defined signs should be erected and public announcements will be made if there is a need to use the alternate route(s).

9.2.5 Noise

i. Conduct annual noise assessment to determine if the traffic from the highway is having negative impact on the environment.
ii. Where necessary, noise mitigative structures should be put in place such as noise barriers, etc.

9.2.6 Traffic

Along the H2K Moneague alignment, there exist a number of access points including road intersections, vehicular accesses and pedestrian accesses. Residential and commercial properties are attributable to these high numbers of access points. These access points are generally of poor geometry and pose challenges within the design of the highway. The implementation of the alignment divides some communities from their respective main towns which poses grave problems. Furthermore, the road widening and road structures (ramps, bridges) at specific chainages along the highway increase the inconvenience of affected communities.

The design of the alignment should consider the preservation of vehicular access at current intersections and round-a-bouts. Pedestrians, who are less concerned with the rapid transit of the highway, may be directly and permanently inconvenienced by the 'un-crossable' barrier of the roadway, making journeys subsequently longer. The legally protected right of local residents is essentially a concept of a social right-of-way which protects the public rights if a proposed roadway conflicts with the right of the public to move freely along a particular route. However, during legal land acquisitions these rights are generally are surrendered by the land owners (2007). In the designing of vehicular access points, speed and safety with respect to pedestrian crossings must be primarily considered while costs are considered secondary.

10.0 ENVIRONMENTAL MANAGEMENT AND MONITORING PROGRAMME

It is recommended that several parameters be monitored before during and after the project implementation to record any negative construction impacts and propose corrective or mitigative measures. The suggested parameters include the following:

1. Water quality to include but not be limited to:
    a. pH
    b. electrical conductivity
    c. turbidity
    d. BOD
    e. Total Suspended solids (TSS)
    f. Grease and Oils
2. Noise
3. Dust
4. Traffic

10.1 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.
  NROCC's project engineer / construction site supervisor should monitor the construction work hours. NEPA should conduct spot checks to ensure that the hours are being followed.

  It is not anticipated that this exercise will incur additional costs.

- Daily monitoring to ensure that the activity is not creating a dust nuisance. NROCC'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 dusts. NEPA should conduct spot checks to ensure that this stipulation is followed.
It is anticipated that the particulate measurements will cost approximately J$55,000 per sampling occasion.

- Background readings should be taken of all water quality parameters prior to construction. Readings should be conducted monthly, prior to construction, upstream and downstream of the anticipated impact zone.

- 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 the Developer may perform this exercise.

  No additional cost is anticipated for 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 Developer may perform this exercise.

  No additional cost is anticipated for this exercise.

- Traffic should be monitored during preconstruction at each location for one week to assess alternate routes.

10.2CONSTRUCTION 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 and the St. Ann Parish Council.
  Person(s) appointed by NWA may perform this exercise.

  No additional cost is anticipated for 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. The parameters that should be monitored are salinity, dissolved oxygen, nitrates, phosphates, turbidity, total suspended solids, faecal and total coliforms.
  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.

  This is estimated to cost approximately J$ 75,000 per 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.
  NROCC's project engineer / construction site supervisor should monitor the construction work hours. NEPA should conduct spot checks to ensure that the hours are being followed.

  The monitoring of the construction work hours is not expected to incur any costs. The noise survey is estimated to cost approximately J$100,000.

- 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.
  NROCC's project engineer / construction 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.

  It is anticipated that the particulate measurements will cost approximately J$55,000.

- Undertake daily inspections of trucks carrying raw material 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 the Developer may perform this exercise.

  No additional cost is anticipated for this exercise.

- Conduct daily inspections to ensure that trucks carrying raw materials and heavy equipment are parked at the designated area on the proposed site so as to prevent traffic congestion along existing roads.
  Person(s) appointed by the Developer may perform this exercise.

  No additional cost is anticipated for this exercise.

- 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.
  Person(s) employed by the Developer may perform this exercise.

  No additional cost is anticipated for this exercise.

- 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.
  Person(s) appointed by the Developer may perform this exercise.

  No additional cost is anticipated for this exercise.

- 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.
  Person(s) appointed by the Developer may perform this exercise.

  No additional cost is anticipated for this exercise.

- Monitor and approve the suppliers and sources of local materials. Inspection of the quarry should be conducted to ensure that they are legal. Copies of these licences should be kept on file.
  Person(s) appointed by Developer may perform this exercise.

  No additional cost is anticipated for 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 the Developer may perform this exercise.

  No additional cost is anticipated for this exercise.

- Traffic should be monitored during construction to ensure approved traffic management plans at critical areas are being followed. NEPA and NROCC 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 NROCC 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. The St. Ann Chamber of Commerce could be used as the watchdog to ensure that this is achieved.
  Person(s) appointed by the Developer may perform this exercise.

  No additional cost is anticipated for this exercise.

10.3OPERATIONAL 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. NROCC/WRA or their appointed person should conduct these inspections.

- The integrity of the road structures should be conducted every two (2) years.
  This should be done by a qualified person. NWA or their appointed person should conduct these inspections.

  No additional cost is anticipated for this exercise.

- Semi annual checks on the asphaltic decking to ensure that it is not breaking up and not contributing pollution to the environment from surface runoff.
  This should be done by a qualified person. NWA or their appointed person should conduct these inspections.

No additional cost is anticipated for this exercise.

- During operation noise monitoring should be conducted annually.
- Water quality monitoring should be done at least monthly after construction. If three to six 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 and approved monitoring plan.

Table 10-1 - Summary of the key recommended Environmental Monitoring Parameters

Parameter	***Phase***	***Monitoring Frequency***	***Reporting Frequency (month)***	***Reporting Agency***
Water Quality	*Pre-construction*	monthly	3	WRA/EHU
	Construction	fortnightly	1	WRA/EHU
	Post-construction	monthly	1	WRA/EHU
Dust	*Pre-construction*	monthly	1	NEPA
	Construction	monthly	1	NEPA
Noise	*Pre-construction*	monthly	3	NEPA
	Construction	monthly	1	NEPA
	Post-construction	yearly	12	NEPA
Traffic	*Construction*	daily	1	NWA

11.0 REPORTING REQUIREMENTS

11.1NOISE ASSESSMENT

11.1.1 Ambient

A report shall be prepared by the Contracted Party three months after operation of the Highway and then annually thereafter. 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 highway.

The report shall be submitted to Developer or his designate within two 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 for a minimum of three years.

11.1.2 Occupational

A report shall be prepared by the Contracted Party three months after operation of the Highway and then annually thereafter. This report shall include the following data:

i. Dates, times and occupational category tested.
ii. Test Method used.
iii. Copies of instrument calibration certificates.
iv. Noise level measurements in decibels measured on the A scale (Leq), Lmin, Lmax and peak.

v. Noise levels measured to be compared with Occupational Safety and Health Administration (OSHA) Hearing Conservation and Permissible Exposure Limit (PEL), American Conference of Industrial Hygienists (ACGIH) recommended levels
vi. Evaluation of data, discussions and statement giving a professional opinion of the noise impact on the employee.

The report shall be submitted to Developer or his designate within two 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 for a minimum of three years.

11.2 AIR EMISSIONS

A report shall be prepared by a Contracted Party three months after operation of the Highway and then annually thereafter. 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 highway.

The report shall be submitted to Developer 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.

11.3WATER 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 Developer or his designate within two weeks of the monitoring being completed.

The Developer 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.

Reports will be maintained on file at the plant for a minimum of three years.

12.0 REFERENCES

Adams, C. D. 1972. Flowering plants of Jamaica. University of the West Indies, Mona, Jamaica.

Agrocon Ltd. 1994. *Development proposal for the Roaring River, Malvern Park, & Belmont properties*. Jamaica: Urban Development Cooperation.

Agrocon Ltd. 1998. *Project implementation plan for the Roaring River, Malvern Park, & Belmont properties*. Jamaica: Urban Development Cooperation.

Asprey, G. F. & R. G. Robbins. 1953. The Vegetation of Jamaica. *Ecological monographs*. 23:4, pp. 359-412.

Barker, G.; 1968. Soil and Land-Use Surveys No. 24 Jamaica, Parish of St. Ann. The Imperial College of Tropical Agriculture.

Caribbean Disaster Mitigation Project (CDMP) 2001. Seismic Hazard Maps: Jamaica. OAS.

Downer, Audrey, and Robert Sutton. Birds of Jamaica. Cambridge: Cambridge University Press, 1990.

Dunham, R.J. 1962. Classification of carbonate rocks according to depositional texture. A.A.P.G. Memoir 1, 108-121.

Fenton, Allison. 1981. Mineral Resources of Jamaica. In *Bulletin No. 8*. Kingston: Geological Survey Division, Ministry of Mining and Energy.

Grossman, D. H., S. Iremonger & D. M. Muchoney. 1991. Jamaica: a rapid ecological assessment. Arlington, Virginia: The Nature Conservancy.

Johnson, F. 1979. *Roaring River & Malvern Park: land use proposals*. Jamaica: Urban Development Cooperation.

Lyew-Ayee, Jr. P. & Ahmad, R. 2012. Natural Hazards Atlas of Jamaica. University of the West Indies Press, 150 pages.

Miller, Waite and Harlan – 2001 country assessment, US Army corps of Engineers.

Mitchell, S. F. 2004. Lithostratigraphy and palaeogeography of the White Limestone Group. In The mid-Cainozoic White Limestone Group of Jamaica, edited by S. K. Donovan: Cainozoic Research.

O'Hara, M. O. , and R. Bryce. 1983. A Geotechnical Classification of Jamaican Rocks. In *Bulletin No. 10*. Kingston: Geological Survey Division, Ministry of Mining and Energy.

Parker, T. 2003. Manual of dendrology: Jamaica. GOJ: Forestry Department, Min. of Agriculture.

Primack, R. B. 2006. Essentials of conservation biology. 4th Ed. Sunderland, MA: Sinauer Ass.

Raffaele, J. A Guide to the Birds of the West Indies. Princeton University Press, 1998.

Robert, J Dooling, and N Popper Arthur. The effects of highway noise on birds. Rockville: Environmental BioAcoustics LLC, 2007.

Robinson, E., 1967. Submarine slides in White Limestone Group, Jamaica: *Bull. Amer. Assoc. Petrol. Geol.*, vol. 51, pp. 569-578.

Robinson, E. & Khan, S.A. 2012. Geology and Physical Features Associated with the Caymanas to Linstead Leg of the North South Highway. Report to CL Environmental Ltd. April, 2012.

Robinson, E. & Mitchell, S.F. 1999. Middle Eocene to Oligocene stratigraphy and palaeogeography in Jamaica: a window on the Nicaragua Rise. Contributions to Geology, UWI Mona 4, 47 pages.

Smith, T. M. & R. L. Smith. 2006. Elements of ecology. 6th Ed. San Francisco, CA: Pearson Education Inc.

Southerland, Mark. Evaluation of Ecological impacts from Highway Development. Rockville: Dynamic Corporation, 1994.

UNDP/FAO, 1972 Technical Report 4, Groundwater Surveys in Two areas of the Interior, Summary of Findings of Hydrologic Reconnaissance on Moneague Area.

Vernon, K. C. 1958. Soils and Land Use Surveys Jamaica, Parish of St. Catherine. Trinidad: The Imperial College of Tropical Agriculture.

Water Resources Authority, 2005. Hydrological Assessment, Moneague Lake, Post Hurricane Dennis and Emily, WRA HBIX – 9, August 2005

Water Resources Authority, 2008. Preliminary investigation of the April 2008 Flooding of Ocho Rios and environs, May 12, 2008.

Wunderle, J M. “Census methods for Caribbean land birds.” Gen. tech, 1994: S0-98.

Zans, V.A. et al. 1963. Synopsis of the geology of Jamaica, Geological Survey of Jamaica Bulletin 4; 1-72.

13.0 APPENDICES

Appendix 1 - Terms of Reference

The Terms of Reference for conducting the EIA are based on the Generic Terms of Reference (TOR) provided by NEPA for the Construction of Roads, Railways, Cables and Bridges and the Minimum Standard Requirements for TOR's for EIA's prepared by NEPA. The TOR's have been modified to include project-specific conditions and are now being submitted to NEPA for approval.

Task 1: Description of the Project

Provide a comprehensive description of the project, noting areas to be reserved for construction and verges. The description of the project will give the total length of the alignment, the width of the right-of-way, width of verges, drainage requirements, bridges and crossings and the location of toll plazas. This will also include an account of activities and features, which will introduce risks or generate impacts (negative and positive) on the environment. This may include secondary activities such as fuel dispensing stations, concrete batching plants and camp sites with the various auxiliary activities. This will 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, and post construction plans. For projects to be done on a phased basis it is expected that all phases be clearly defined, the relevant time schedules provided, and phased maps, diagrams and appropriate visual aids are included.

A description will also be given of:

i) The impact that the modification of the current use of the roads will have on the road network adjacent to the project
ii) Methods and location of construction surplus material disposal
iii) Any changes to associated water diversion management system
iv) Total quality management of modifications, vehicular traffic, equipment, waste etc
v) The proposed off-site facilities such as construction camps and infrastructure service
vi) Proposed decommissioning and abandonment of works and/or facilities
vii) Possible source of suitable material for road fill and the likely impacts the quarry operation will have on the physical, biological and socio-economic environment.
viii) Public Health and Safety
ix) Workers Health and Welfare

Task #2 Description of the Environment

Baseline data will be generated in order to give an overall evaluation of the existing environmental conditions, values and functions of the area, as follows:

i) Physical environment
ii) Biological environment
iii) Socio-economic and Cultural

Baseline data will include:

Physical
i) Detailed geotechnical studies of the areas that will have the slopes modified and propose recommendation to address these, with emphasis on the existing and long term storm water runoff requirements. Emphasis must also be placed on the geological faults in the vicinity of the highway in addition to any other geological structure (s) vis-à-vis fracture plains and orientation of bedding. S on, or in close proximity
ii) Identification of old landslides on or in close proximity to the highway route.
iii) Reference will be made to future development of lands. Special emphasis should be placed on storm water run-off and drainage patterns. Any slope stability issues that could arise will be thoroughly explored.
iv) Water quality and quantity of any existing rivers, ponds, or streams in the vicinity of the development, and particularly to be crossed by the highway. Quality Indicators should include but not necessarily be limited to suspended solids, turbidity, oil and grease.
v) Climatic conditions and air quality in the area of influence including particulate matter, NOx, SOx, wind speed and direction, precipitation, relative humidity and ambient temperatures
vi) Noise levels of undeveloped site and the ambient noise in the area of influence.
vii) Obvious sources of pollution existing and extent of contamination
viii) Availability of solid waste management facilities.
ix) Availability of public sanitary facilities (rest stops) along the corridor
x) Identify and assess the impact of the project on potential wells, ground water pre, during and post construction phases and its associated effect on water supplies to the adjacent communities.
xi) Assess the potential impact on the air quality during construction and operation to include baseline air quality information
xii) Assess the potential residual air quality impact.
xiii) A section will be included called "Issues of Natural Hazard and Geotechnical Stability".
xiv) Proximity of Raw material to haulage route and stockpile area
xv) Proximity of the corridor to established residential settlements

Drainage and Stormwater Issues:

An assessment of Storm Water Drainage should be conducted. The EIA Report will cover but not be limited to:

i) Drainage for the site during construction to include mitigation for erosion and sediment control.
ii) Drainage for the site during operation, to include mitigation for erosion and sediment control.
iii) Drainage control for crossings of rivers and/or gullies, to include impacts that drainage control features could have on aesthetics, water quality and sedimentation of rivers and/or gullies.
iv) Assessment of the impact of draining the site on adjacent communities and on future developments including mitigation measures. This should be calculated and designed to the storm runoff without causing flooding of these development. Underpasses for the highway should be designed to accommodate the volume and velocity of storm water post construction.
v) Assessment of drainage channels for debris flow associated with up gradient land use as well as impacts related to climate change.
vi) Assess the use of detention ponds to regulate peak flow.
vii) Identify and clearly map locations of sinkholes based on Water Resources Data base, to ensure that where necessary, these are not traversed by the highway alignment.
viii) Identify other effects of storm water such as the input of oil and grease into the aquatic environment.

Biological

Present a detailed description of the flora and fauna (terrestrial and aquatic) of the area, with special emphasis on rare, endemic, protected or endangered species. Migratory species will also be considered. Information will be presented on existing vegetation, proposed vegetation loss and resulting loss and/or fragmentation of habitat for fauna. Generally, species dependence, niche specificity, community structure and diversity will be considered.

A description will be given of:

i) Different ecosystem types including cave and sinkholes and their species, if present
ii) Nocturnal species within the project site. Attention should be paid to the species of tree dwelling bats *(Ariteus flavescens)* inhabiting areas in close proximity to the proposed alignment.
iii) Habitat of flora
iv) Biological diversity importance of the area
v) Invasive and economically important species
vi) Mitigation measures to avoid or minimize negative impacts on wildlife, wildlife habitat, and vegetation communities/ecosystems.

Socioeconomic & Cultural

A Socioeconomic Analysis will be prepared and will include present and projected population; present and proposed land use; planned development activities, issues relating to squatting and resettlement, community structure, employment, distribution of income, goods and services; recreation; public health and safety; community health, health facilities and medical services; cultural peculiarities, aspirations and attitudes should be explored. The historical importance of the area should also be examined, augmented by consultation with the Jamaica National Heritage Trust (JNHT). While this analysis is being conducted, an assessment of public perception of the proposed development will be conducted. This assessment may vary with community structure and may take multiple forms such as public meetings, interviews with key stakeholders or the distribution of interview instruments (questionnaires).

The following will also be identified:

i) Private land acquisition needs
ii) Tenure issues during pre-application consultations and how they will address them
iii) Local economic benefits and cost overall and on an individual community basis
iv) Implications of the project during the construction phase for resident commuter travel and travel times; accommodation for construction workers; access to and delivery of health, educational and social services and emergency support to local communities
v) Correlation between highway upgrade and possible traffic issues for the adjoining communities
vi) Impact on future transit opportunities
vii) Economic impact of the construction phase on local economic benefit on the project and in the adjacent communities, road closures, delays and detours a well as quality of experience for visitors (tourists).
viii) Implications during the construction and operation phase on: - Emergency support to local communities - Resident commuter travel and travel time - Access to and delivery of health and other social amenities.
ix) Social rights of ways and pedestrian crossings

Task #3: Legal and Regulatory considerations

Outline the pertinent regulations and standards governing environmental quality, safety and health, protection of sensitive areas, protection of endangered species, siting and land use control at the national and local levels. The examination of the legislation should include at minimum, legislation such as the NRCA Act, the Public Health Act, the Town and Country Planning Act, the Toll Roads Act, the Main Roads Act, and the appropriate international convention/protocol/treaty where applicable.

Task #4 Identification of Potential Impacts

Identify the major physical, environmental, biological and social issues of concern and indicate their relative importance to the development project. Identify potential impacts as they relate to, (but are not restricted by) the following:
i. flooding potential and change in drainage pattern
ii. Blasting/blast vibrations and other such activities on human settlements adjacent to the highway corridor.
iii. landscape impacts of excavation and construction
iv. loss of and damage to geological and palaeontological features
v. landscape impacts of excavation and construction
vi. slope stability
vii. loss of species and natural features
viii. habitat loss and/or fragmentation
ix. biodiversity/ecosystem functions
x. pollution of potable, surface or ground water
xi. air pollution
xii. socio-economic and cultural impacts
xiii. maintenance of any alternative routes identified
xiv. impact on private and commercial property owners and recreational facilities
xv. impact of flooding, loss of natural features, excavation and construction on the historic landscape, architecture and archaeology of the site
xvi. risk assessment and hazard management (slope stability, flooding, debris torrents and seismic activity
xvii. technological hazards o noise o solid waste disposal
xviii. soil and change in land use

The following will be addressed:

i) A detailed emergency and remediation plan to be implemented if water bodies or land become contaminated as well as if irrigation and domestic water supply are disrupted due to the project (to be addressed in mitigation measures).
ii) Emergency Response and Safety Plan for workers protection.
iii) Mitigation measures for erosion and sediment control management for each construction section.
iv) Aesthetics/scenic values of the highway alignment; include an evaluation of opportunities to provide viewpoints or scenic lay-by along the corridor.
v) Access to, from and across the highway- including bicycle/pedestrian access requirements for corridor communities; a description of how emergency access requirements (fire, police, ambulance) will be addressed during construction.
vi) Traffic management and road safety; consider the risk of forest fire impacts on safety in use of the highway as well as animals intruding onto the highway.
vii) Impact of highway on the future viability of the railway line which runs from Spanish Town to Ewarton.

viii) Identification of any known contamination sites that would be disturbed as a result of project-related actions, and propose mitigation measures to deal with any contamination of material.
ix) Effects of the environment on the project (in particular, identify and describe any potential geotechnical and weather related factors on the Project, and proposed mitigation measures.
x) Cumulative environmental impacts- identify and describe any residual environmental impacts that are likely to result from the project in combination with other projects or activities that have been or likely to be carried out. The assessment will identify relevant 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.

Task #5 Mitigation

Prepare guidelines for avoiding, as far as possible, (e.g. restoration and rehabilitation) any adverse impacts due to proposed usage of the corridor and utilizing of existing environmental attributes for optimum development. Quantify and assign financial and economic values to mitigating methods. Guidelines should include the issues of restoration and rehabilitation.

Task #6 Environmental Management and Monitoring Plan

Design a plan for the management of the natural, historical and archaeological environments of the project to monitor implementation of mitigatory or compensatory measures and project impacts during construction and occupation/operation of the highway. An Environmental Management Plan and Historic Preservation Plan (if necessary) for the long term operations of the site will also be prepared. An outline Environmental Monitoring Programme (EMP) for the construction phase will be prepared, indicating the parameters to be monitored, and the recommended frequency of monitoring. A detailed version of the EMP will be submitted to NEPA for approval after the granting of the permit and prior to the commencement of the development. At the minimum the monitoring programme and report should include:

i. Introduction outlining the need for a monitoring programme and the relevant specific provisions of the permit license(s) granted.
ii. The activity being monitored and the parameters chosen to effectively carry out the exercise.
iii. The methodology to be employed and the frequency of monitoring.
iv. 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.
v. Frequency of reporting to NEPA The Monitoring report should also include, at minimum:
vi. Raw data collected. Tables and graphs are to be used where appropriate

vii. Discussion of results with respect to the development in progress, highlighting any parameter(s) which exceeds the expected standard(s).
viii. Recommendations
ix. Appendices of data and photographs if necessary. Consideration will be given to the development of a Resettlement Action Plan.
x. During construction and occupation/operation of the highway, health impact assessment on the toll booth operators for the effect of emission
xi. A system to be developed to address public complaint

Task #7 Project Alternatives

Examine alternatives to the project including the no-action alternative. This examination of project alternatives will incorporate the use history of the overall area in which the site is located and previous uses of the area itself.

Task #8 Public Participation/Consultation Programme

A Public Presentation on the findings of the EIA will be conducted to inform, solicit and discuss comments from the public, on the proposed project. Considering the geographical scope of the project at least two consultations are recommended. All Findings will be presented in the EIA report and will reflect the headings in the body of the TORs. Information and data presented will be supported by references. Ten hard copies and an electronic copy of the report will be submitted to NEPA. The report will include an appendix with items such as maps, site plans, the study team, Terms of Reference, photographs, and other relevant information. Key Stakeholders to be consulted will be identified and the mechanisms for consultation and disclosure of the project, from the project design to the operational phase will be given. All Findings will be presented in the EIA report and will reflect the headings in the body of the TORs. Information and data presented will be supported by references. Ten hard copies and an electronic copy of the report will be submitted to NEPA. The report will include an appendix with items such as maps, site plans, the study team, Terms of Reference, photographs, and other relevant information.

WATER RESOURCES AUTHORITY

ESTABLISHED BY THE WATER RESOURCES ACT, 1995

HOPE GARDENS, P.O. BOX 91, KINGSTON 7, JAMAICA
TEL: (876) 927-0077, 927-0293, 927-0189, 927-0302
FAX: (876) 977-0179, 702-3937

REF: DR 8-26 August 7, 2012

National Environment and Planning Agency
10 Caledonia Avenue
Kingston 5.

AUG 08 2012
REGISTRY

Attention: Mrs. Levonne Newsome

Dear Sir,

Re: Environmental Permit Application for Road Construction Moneague to Ocho Rios, St. Ann. Reference No.:2012-06017-EP000109.

Comments on Terms of Reference (TOR) for the Environmental Impact Assessment (EIA) for the Road Construction from Moneague to Ocho Rios, St. Ann.

General Comment: This alignment of the highway is located in the Rio Bueno- White River Watershed Management Unit of the Dry Harbour Mountain Hydrologic Basin. This is a very productive aquifer system which acts as recharge for springs/ rivers north of the site. The TOR appears to encompass most of the major issues relating to the construction of the Moneague to Ocho Rios alignment/ section of the Highway.

The WRA's comments are detailed below and are discussed as outlined in the document provided:

Task 2: Description of the Environment

The location of sinkholes and surface water features within a 5km buffer of the highway alignment should be documented and mapped.

Task 4: Identification of Potential Impacts

Any potential risk of groundwater and surface water contamination due to the construction of the highway and runoff from the highway post construction should be included.

Jamaica's Hydrologic Agency

Attention: Mrs. Levonne Newsome

August 7, 2012

2

Task 5: Drainage Assessment

Drainage for the highway should be designed with consideration of the possibility of further development north of the highway. The drainage should therefore be designed to convey the storm runoff without causing flooding impacts to these potential future developments.

Sincerely,
Water Resources Authority

....
Angella Graham (Ms)
Chief Hydrologist
For Managing Director

MINISTRY OF SCIENCE, TECHNOLOGY, ENERGY AND MINING

MINES AND GEOLOGY DIVISION

ANY REPLY OR SUBSEQUENT REFERENCE TO THIS COMMUNICATION SHOULD BE ADDRESSED TO THE COMMISSIONER OF MINES NOT TO ANY OFFICER BY NAME AND THE FOLLOWING REFERENCE QUOTED:-

HOPE GARDENS
P.O. BOX 141
KINGSTON 6, JAMAICA, W.I.
PHONE: (876) 927-1936-40
FAX: (876) 977-1204
E-MAIL: commissioner@mgd.gov.jm
WEBSITE: www.mgd.gov.jm

July 27, 2012

The Chief Executive Officer
National Environment and Planning Agency
10&11 Caledonia Avenue
Kingston 5.

ENVIRONMENT & PLANNING AGENCY
AUG 07 2012
REGISTRY

Attention: Levonne Newsome

Re: Road Construction: Moneague to Ocho Rios, St. Ann

By: NRDCC, Ref#2012-06017-EP00109

The Mines and Geology Division has reviewed the above captioned Environmental Permit Application (EPA) and has the following comments:

1. Information In Project Document At Variance With Map Information

The project information provided in the document SECTION 3: MONEAGUE TO OCHO RIOS, concerning chainage on the highway route, is in conflict with the information shown on the Google map containing the route for the three areas highlighted in the document. The project information as presented describes: Moneague to Lydford (km 49+200 to km 58+000); Lydford to Davis Town (km 58+000 to km 64+600); Davis Town to Mammee Bay (km 64+000 to km 69+000). However, the Google map with the highway route shows chainage at Lydford to Davis Town at km 55+000 to km 60+500; Davis Town to Mammee Bay at km 60+500 to km 66+26.

2. Geotechnical Study

A geotechnical appraisal of the highway route is highly recommended. Special attention is to be given to areas along the route where deep excavation will be made close to geological faults, as well as developing plans to stabilize these areas that could prove problematic

3. Highway Alignment At km 59,000 To km 61,000 (Map Information)

The highway route traverses east of Ewart Town, west of Malvern Park near to the Roaring River Catchment area and then passes over the community of Davis Town via an overpass. It is uncertain why this route has been chosen, as it may be more economically feasible to maintain the route east of Ewart Town at km 59+000, then taking a north-north westerly alignment and connecting it at km 61+500 passing west of Davis Town and by-passing the community.

In addition, this proposed route would be further away from the Roaring River watershed which is part of the Dunn's River Catchment; an environmentally sensitive area.

4. Highway Construction Passing Through Special Exclusive Prospecting Licence

The proposed highway passes through land that is designated by the Commissioner of Mines for a Special Exclusive Prospecting Licence (SEPL558). It is observed that the alignment of the route was laid out to avoid or minimise the number of bauxite ore bodies and rehabilitated mined out bauxite areas that the highway will pass through; our review indicates however that the alignment traverses some of the ore bodies and mined out areas. This suggests therefore that a small number of bauxite ore bodies will become sterilized by the highway construction. This is nevertheless expected to be a small amount.

The Environmental Impact Assessment should pay some attention to this area, particularly those lands that may have been restored following bauxite mining, which would not have been compacted but were left to consolidate under its own weight. Further information could be obtained from the Mines and Geology Division and the Jamaica Bauxite Institute.

5. Limestone Quarries

Limestone aggregate may be required as material for the highway. An application for licence is to be made to the Mines and Geology Division for approval to quarry material for such purposes. With respect to licensed quarries which are in close proximity to highway alignment, there are two quarries beside the Old Reynolds Bauxite Plant and two (2) quarries at Lydford.

The Mines and Geology Division however has no objection to the construction of the Moneague to Ocho Rios Highway however we recommend that the above be followed.

Yours truly,

for Norman Harris
For Commissioner of Mines

AUG 07 2012
REGISTRY

Appendix 2 – Study Team

• Dale Webber, PhD.	Flora
• Carlton Campbell, M. Phil., CIEC	Noise, Air and Socio-economics
• Matthew Lee, M.Sc.	Water and Air Quality
• Professor Edward Robinson	Geology
• Dr Shakira Khan-Butterfield	Geology
• Dr Eric Garraway	Fauna
• Dr Catherine Murphy	Entomology
• Dr Eric Hyslop	Freshwater Faunal Survey
• Dr Philip Rose	Flora
• Damion Whyte, M. Phil.	Avifuana
• Tanya Hay, BSc., PM	Socioeconomics
• Janette Manning, M.Phil.	Socioeconomics
• Tamia Harker, BSc.	Structure Survey
• Rachel D'Silva, BSc.	Structure Survey
• Kristoffer Lue, BSc.	Structure Survey
• Zahra Ennis, BSc.	Structure Survey
• Kimani Kitson-Walters, BSc.	Structure Survey
• Christopher Haughton	Structure Survey
• Glen Patrick	Field Technician
• Errol Harrison	Field Technician

<u>CEAC Solutions Ltd.</u>

• Christopher Burgess M.Sc. Eng., PE	Landslide and Review
• Carlnenus Johnson	Hydrology and Traffic Impact
• Kristoffer Freeman	Landslide Susceptibility, Hydrology and Debris flow
• Marc Henry	GIS Technician (Hydrology and Landslide)

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 – Calibration Certification (Hydrolab DS-5)

HACH®
Hydromet

Certificate of Instrument Performance

Agency Name: CL ENVIRONMENTAL

Certification for Job# 672064

Part/Model Number: DATASONDE 5	Serial Number: 100100048757

RECEIVED CONDITION: *(One must be checked)*	X	Within Tolerance
		Within Tolerance but Limited *(*see service report)*
		Out of Tolerance *(*see service report)*
RETURNED CONDITION: *(One must be checked)*	X	Within Tolerance
		Within Tolerance but Limited *(*see service report)*

Test Equipment Used, (ID#): ASTM – N.I.S.T traceable glass thermometer (Thermo-Fisher Scientific, Serial ***1781)*** and a Cole-Parmer "*PolyStat*" Constant Temperature Circulator

Environmental Conditions:

Actual Temperature	Instrument Reading	Error
10 °C	10.03°C	.03°C
20 °C	20.02°C	.02°C
30 °C	30.00°C	.00°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: David W Simonis   Title: Instrument Service Technician

Certification Date: 02-28-2012

5600 Lindbergh Drive • Loveland, CO 80538
(800) 227-4224 / FAX (970) 461-3924

Doc# 19773-01
Rev. 3

Appendix 5 – Calibration Certification (Quest QC -10)

3M Occupational Health and Environmental Safety Division

3M

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 — Date Received: 7/17/2012

Customer ID: — Date Issued: 7/20/2012

Model: QC-10 CALIBRATOR — 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#1336.01

Appendix 6 – Flora Survey Results

Species	Common Name	Site Occurring	Habit
Abrus precatorius	Crab Eyes, Red Bead Vine, Wild Liquorice	13	Epiphytes & Climbers
Antigonon leptopus	Coralita	11	
Centrosema virginianum		1, 3, 5, 6, 7, 9, 13	
Cissus sicyoides	Snake Withe, Pudding With	10	
Dioscorea sp.		1, 9	
Encyclia cochleata	Cockleshell Orchid	9	
*Hylocereus triangularis**	God Okra	9, 10	
Ionopsis satyrioides		3, 6, 9	
Ipomoea sp.		1, 5, 6, 7, 9, 10, 11, 12	
Ipomoea triloba		1, 2, 6, 7, 9, 10	
Merremia umbellata		10	
Mikania micrantha	Guaco	1, 2, 9, 11	
Momordica balsamina	Cerasee	4, 13	
Mucuna pruriens	Cowitch	1, 9	
Oncidium luridum (syn. *Trichocentrum undulatum*)	Brown Gal	2, 9	
*Oncidium tetrapetalum**	Pimento Orchid	9	
Passiflora sp.		10, 12, 13	
Phaseolus vulgaris	Red Peas	13	
Philodendron scandens	Wicker Vine	9, 10, 13	
Piper pellicida	Rat Ears	9	
Smilax domingensis		1	
Tillandsia juncea		1	
Tillandsia spp.		1, 2, 3, 4, 9	
Tournefortia volubilis	Chigger Nut	12	
Urechites lutea	Nightshade	6	
Adiantum sp.	Maiden Hair Fern	3, 10, 11	Ferns
Anemia adiantifolia		3	
Nephrolepsis rivularis		2	
Nephrolepsis sp.		1, 2, 3, 4, 5, 7, 9, 10, 11	
Polypodium phyllitidis (syn. *Campyloneurum phyllitidis*)	Cow tongue fern	2, 3, 4, 5, 9, 10, 12	

Species	Common Name	Site Occurring	Habit
Agapanthus africanus		7, 8	Herbs
Ambrosia peruviana	Wormwood, Wild Tansy	1, 5, 6, 9, 10, 11	
Arundo donax	Giant Reed	3, 5, 6	
Asclepias curassavica	Red Top, Redhead	13	
Asparagus sp.		3, 4, 11	
Asystasia gangetica		1	
Bidens pilosa	Spanish Needle	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13	
Bletia purpurea		3, 6	
Bromelia pinguin	Ping-wing	9	
Bryophyllum pinnatum	Leaf-of-Life	3, 4, 7, 8, 9, 10, 12, 13	
Canna sp.	Canna Lily	7	
Cenchrus echinatus		12	
Chromalaena sp.		2, 6, 9, 10, 11	
Clitoria sp.		5, 6, 7, 9, 13	
Colocasia esculenta	Dasheen	9, 13	
Commelina diffusa	Water Grass	1, 9, 10, 13	
Conyza canadensis	Canada Fleabane	2, 4, 5, 7, 12	
Cyperus sp.		1, 4	
Desmodium adscendens		1, 3, 5, 7, 8, 9, 10, 13	
Desmodium sp.		10, 12, 13	
Emilia javanica	Cupid's Shaving Brush	2, 7	
Emilia sonchifolia		2, 7	
Emilia sp.		4	
Euphorbia cyathophora		1, 13	
Euphorbia heterophylla		1, 2, 3, 4, 6, 10, 13	
Euphorbia prostrata	Milkweed	1, 5, 10	
Hedychium sp.		7	
Heliconia sp.		7	
Heliotropium angiospermum	Dog's Tail	1, 13	
Heliotropium indicum	Scorpion Weed, Wild Clary	13	
Hippobroma longiflora	Madam Fate	3	
Hohenbergia sp.		1, 3, 4, 9, 13	
Hydrocotyle umbellata		1	
Lactuca sp.		3, 6	

Species	Common Name	Site Occurring	Habit
Lemna minor	Duckweed	9	
Leonotis nepetifolia	Christmas Candlestick, Bald Bush	1, 3, 11	
Lippia stoechadifolia		3, 5, 6, 13	
Lippia strigulosa		3, 5, 6, 13	
*Lobelia viridifolia**		2, 4, 10, 11	
Mimosa pudica	Shame-o-lady, Shame Weed	7, 8, 13	
Mirabilis jalapa	Four o'clock, Marvel of Peru	10	
Musa sapientum	Banana	1, 9, 10, 11, 13	
Oeceoclades maculata	Monk Orchid, Ground Orchid	9	
Panicum maximum	Guinea Grass	3, 5, 7, 10, 12, 13	
Paspalum sp.		2, 7, 9	
Pilea microphylla var. *trianthemoides*	Artillery Plant	3	
Plectranthus blumei	Joseph's Coat	2, 7	
Pluchea odorata	Bitter Tobacco	11	
Plumbago sp.		13	
Priva lappulacea	Clammy Bur	3, 4, 7	
Rhipsalis baccifera	Currant Cactus, Mistletoe	2, 4, 9	
Rhoeo spathacea	Oyster Plant, Moses-in-the-Bulrushes	11	
Rhynchospora nervosa	Star Grass	1, 3, 13	
Rivinia humilis	Bloodberry	1, 2, 4	
Saccharum officinarum	Sugar Cane	13	
Sansevieria sp.		11	
Setaria sp.		6	
Stachytarpheta jamaicensis	Vervine	1, 2, 4, 6, 9, 13	
Stenotaphrum secundatum	Crab Grass, Pimento Grass	13	
Strelitzia reginae	Bird of Paradise	7	
Syngonium auritum	Five finger	10, 13	
Trifolium dubium	Shamrock	4	
Trimezia martinicensis	Wild Scallion, Walking Iris	1, 7, 9	
Vernonia sp.		2, 13	
Wedelia trilobata	Creeping Ox-eye, Marigold	1, 3, 6, 7, 8, 13	
Zea mays	Maize, Indian Corn	1	

Species	Common Name	Site Occurring	Habit
Zoysia tenuifolia		5	
Usnea sp.		1, 3, 7, 9	Lichens
Abutilon sp.		12	Shrubby Herbs
Begonia sp.		1, 7	
Borreria verticillata	Wild Scabious	1, 2, 3, 5, 6, 7, 9, 10, 11, 13	
Cassia ligustrina		2, 12	
Cassia occidentalis	Dandelion, Wild Coffee, Stinking Weed, Piss-a-bed	13	
Catharanthus roseus	Periwinkle	7, 13	
Croton sp.		1, 7, 11	
Hyptis verticillata	John Charles	10	
Miconia sp.	Melastome	1, 2, 3, 9, 10, 11	
Pavonia rosea	Conger Watchman	9	
Peperomia sp.		4, 9	
Pilea grandiflora	Maroon Bush	10	
Ruellia sp.		12	
Turnera ulmifolia	Ram-goat Dashalong	11, 13	
Urena lobata	Ballard Bush, Bur Mallow	1	
Agave sp.		11	Shrubs
Allamanda cathartica	Yellow Allamanda	2, 3, 5, 6, 7, 9, 10, 11, 12, 13	
Bocconia frutescens	John Crow Bush	2, 6, 9	
Bougainvillea sp.		7	
Capparis ferruginea	Mustard Shrub	6	
Cestrum nocturnum	Jasmine	6	
Chromalaena odorata	Christmas Bush	2, 6, 9, 10, 11, 13	
Clidemia hirta	Soap Bush	1	
Colubrina asiatica	Hoop Withe	12	
Cordia bifurcata§		12	
*Cordia bullata**		9, 13	
Dasmanthus virgatus		12	
Datura candida	Angel's Trumpet	2, 10	
Dracaena sp.		1	
Drejerella guttata	Shrimp Plant	7	
Galphimia gracilis	Shower of Gold	3	
Hibiscus rosa-sinensis	Hibiscus, Shoe Black	1	
Ixora coccinea		1	

Species	Common Name	Site Occurring	Habit
Lantana camara	Wild Sage, White Sage	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 13	
*Lantana jamaicensis**		2, 10, 11, 13	
Malpighia fucata		2, 3	
Miconia albicans	Georgia White Man, Whiteback	1	
Moghania strobilifera	Wild Hops	5, 7	
*Oryctanthus occidentalis**	Godbush, Scorn-the-Earth	9	
Piper amalago var. *amalago*		6	
Piper amalago var. *nigrinodum**	Black Jointer	9, 12, 13	
*Piper fadyenii**		10	
Piper sp.	Piper	2, 3, 6, 9, 10, 13	
Pisonia aculeata	Cockspur	2, 6, 7, 11, 13	
Pithecellobium unguis-cati	Privet, Bread-and-Cheese	7, 11	
Psychotria brachiata		1, 9	
Randia aculeata	Indigo Berry, Box Briar, Ink Berry	1, 2, 10	
Ricinus communis	Oil Nut, Castor Oil Nut	11	
Rosa sp.		6	
Rubus jamaicensis	Bramble	9	
*Rytidophyllum tomentosum**	Search-me-Heart	3, 5, 9, 10, 11	
Sida acuta	Broomweed	2, 4, 5, 7, 8, 9, 10, 11, 12, 13	
Sida sp.		2, 4, 5, 7, 8, 9, 10, 11, 12, 13	
Solanum erianthum	Wild Susumber	9, 11, 13	
Solanum turvum	Susumber, Gully Bean, Turkey Berry	9, 11, 13	
Tecoma stans		1	
Thunbergia alata	Black-eyed Susan	1, 2, 4, 13	
Tournefortia sp.		1	
Acacia tortuosa	Wild Poponax	9, 13	Trees
Adenanthera pavonina	Red Bead Tree	2, 3, 9	
Albizia lebbeck	Woman's Tongue Tree	7, 11	
Annona reticulata	Custard Apple	7	
Annona squamosa	Sweetsop, Sugar Apple	7	
Araucaria exelsa	Norfolk Island Pine	7	
Artocarpus altilis	Breadfruit	1, 11	

Species	Common Name	Site Occurring	Habit
Bambusa multiplex?		7	
Bambusa vulgaris	Bamboo	1, 11, 13	
Bauhinia divaricata	Bullhoof	3	
Blighia sapida	Ackee	1, 7, 11	
Bursera simarouba	Red Birch	13	
Caesalpinia bonduc	Grey Nicker/Nickal	11	
Caesalpinia pulcherrima	Pride of Barbados	1	
Carica papaya	Papaw, Papaya	2, 7, 11	
Cassia emarginata	Senna Tree	4, 7, 10, 11, 13	
Catalpa longissima	Yokewood, French Oak	6	
Cecropia peltata	Trumpet Tree	1, 2, 3, 7, 9, 10, 11, 12, 13	
Ceiba pentandra	Silk Cotton Tree	8, 9	
Chrysophyllum cainito	Star Apple	6, 7	
Citharexylum fruticosum	Yellow Fiddlewood	5, 6	
Citrus paradisi	Grapefruit	10	
Citrus spp.	Orange	1, 2, 7	
Clusia sp.		2, 3, 9, 12	
Coccoloba sp.		6	
Cocus nucifera	Coconut	1, 2, 11, 13	
Comocladia pinnatifolia	Maiden Plum	1, 2, 3, 5, 6, 7, 8, 9, 11, 12, 13	
Cordia sebestena	Scarlet Cordia, Red Cordia	2, 5	
Cupania glabra	Wild Ackee	1, 11, 13	
Cycas circinalis		2	
Delonix regia	Poinciana	7, 9, 11, 12, 13	
Dendropanax arboreus	Angelica Tree, Galipee	2, 3, 6, 9	
Eugenia sp.		9	
Fagara martinicensis	Prickly Yellow, Yellow Hercules	1, 2, 9, 13	
Fagara sp.		1	
Ficus americana	Jamaican Cherry Fig	3, 9, 13	
Ficus sp.	Fig	1, 2, 3, 4, 5, 6, 9, 10, 11	
Gliricidia sepium	Quick Stick	8	
Guazuma ulmifolia	Bastard Cedar	12, 13	
Haematoxylum campechianum	Logwood	1, 3, 8, 13	
Leucaena leucocephala	Lead Tree	10, 11, 12	

Species	Common Name	Site Occurring	Habit
Maclura tinctoria	Fustic Tree	13	
Malpighia punicifolia	West Indian Cherry, Barbados Cherry	1	
Malpighia sp.		3, 9	
Mangifera indica	Mango	11	
Mussaenda sp.		1	
Nectandra antillana	Long-leaved Sweetwood, Yellow Sweetwood	2, 3, 4, 5, 6, 9, 10, 12	
Nectandra sp.		9, 13	
Petitia domingensis		2, 6	
Pimento dioica	Pimento, Allspice	7, 13	
Piscidia piscipula	Dogwood	1, 3, 4, 13	
Podocarpus sp.		7	
Psidium cattleianum	Strawberry Guava	1	
Psidium guajava	Guava	5, 7, 13	
*Roystonea altissima**	Mountain Cabbage	1, 3	
Samanea saman	Guango	4, 7, 8, 13	
Simarouba glauca	Bitter Damson	13	
Solanum sp.		1	
Spathodea campanulata	African Tulip Tree	5, 8, 9, 10, 11, 12, 13	
Tabebuia sp.	Poui	7, 8, 9	
Terminalia catappa	West Indian Almond	1, 2, 5, 9, 11, 12, 13	
Theobroma cacao	Cocoa	1, 9	
Ziziphus mauritiana	Coolie Plum, Crab Apple, Jujube	9	

* Endemic
§ Rare

Appendix 7 - The birds identified during the survey of the area for the proposed highway from Moneague to Ocho Rios. The DAFOR (Dominant ≥ 20; Abundant 15 – 19; Frequent 10 – 14; Odd 5-9; Rare <4) scale used to rank the birds.

Proper Name	***Scientific Name***	***Status***	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 8**
American Kestrel	*Falco sparverius*	*Resident*	R		O		O			R
American Redstart	*Setophaga ruticilla*	Migrant						R		O
Antillean Nighthawk	*Chordeiles gundlachii*	Migrant								F
Bananaquit	*Coereba flaveola*	*Resident*	O	R	O	O	F	F	O	F
Black Swift	*Cypseloides niger*	*Resident*					F			A
Black-Crowned Night Heron	Nycticorax nycticorax	Resident								
Black-faced Grassquit	Tiaris bicolor	*Resident*			O					
Black-Whiskered Vireo	*Vireo altiloquus*	*Resident*		O	O			O		O
Caribbean Dove	*Leptotila jamaicensis*	*Resident*	R			O			R	R
Cattle Egret	Bubulcus ibis	*Resident*	R	R	F					A
Chestnut-bellied Cuckoo	***Hyetornis pluvialis***	**Endemic**						R		
Common Barn Owl	*Tyto alba*	Resident		R						R
Common Ground Dove	*Columbina passerina*	*Resident*	O	R	O	R			R	O
Gray Kingbird	*Tyrannus dominicensis*	*Resident*		O						O
Greater Antillean Bullfinch	*Loxigilla violacea*	*Resident*					R			R
Greater Antillean Grackle	*Quiscalus niger*	*Resident*	R	R						A
Jamaica Tody	***Todus todus***	***Endemic***				**R**		**O**		**R**
Jamaican Crow	***Corvus jamaicensis***	***Endemic***		**O**	**F**	**O**	**F**	**O**	**O**	**O**
Jamaican Elania	***Myiopagis cotta***	***Endemic***	**R**							**R**
Jamaican Euphonia	***Euphonia Jamaica***	***Endemic***				**R**		**R**		**F**
Jamaican Lizard-cuckoo	***Saurothera vetula***	**Endemic**		**R**			**R**			**R**
Jamaican Mango	***Anthracothorax mango***	***Endemic***					**R**	**R**		

Proper Name	Scientific Name	Status	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Jamaican Oriole	***Icterus leucopteryx***	***Endemic***		**R**	**R**		**R**	**R**	**O**	
Jamaican Pewee	***Contopus pallidus***	***Endemic***				**R**				
Jamaican Vireo	***Vireo modestus***	***Endemic***			**R**	**O**		**O**		**R**
Jamaican Woodpecker	***Melanerpes radiolatus***	***Endemic***	**R**		**O**	**O**	**O**	**O**	**R**	**O**
Loggerhead Kingbird	*Tyrannus caudifasciatus*	*Resident*	F	O	F		R		O	
Nothern Mockingbird	*Mimus polyglottos*	*Resident*	O	R	O	O	O	O	O	O
Olive-throated Parakeet	*Aratinga nana*	*Resident*	O	F	R			O	**O**	
Orange Quit	***Euneornis campestris***	**Endemic**						R		
Prairie Warbler	*Dendroica discolor*	*Migrant*		R						R
Red-billed Streamertail	***Trochilus polytmus***	***Endemic***	**R**	**R**	**O**	**R**		**O**	**O**	
Red-tailed Hawk	*Buteo jamaicensis*	*Resident*					R			R
Ruddy Quail Dove	*Geotrygon montana*	*Resident*						R		R
Sad Flycatcher	***Myiarchus barbirostris***	***Endemic***		**R**			**O**			**R**
Smooth-billed Ani	*Crotophaga ani*	Resident	R			O	O	O		O
Stolid Flycacther	*Myiarchus stolidus*	*Resident*			R					R
Stripe-headed Tanager	*Spindalis zena*	*Resident*					R			R
Turkey Vulture	*Carthartes aura*	*Resident*	O	R	A					F
Vervain Hummingbird	*Mellisuga minima*	*Resident*	R	O	O		R		R	O
White Crowned Pigeon	*Columba leucocephala*	*Resident*	O		R	R		O		O
White-chinned Thrush	***Turdus aurantius***	***Endemic***	**R**		**R**			**O**		**F**
White-Winged Dove	*Zenaida asiatica*	*Resident*	R		O		R			O
Yellow-faced Grassquit	*Tiaris olivacea*	*Resident*	R	O	O	O	F	R	O	F
Yellow-shouldered Grassquit	***Loxipasser anoxanthus***	***Endemic***	**O**	**O**	**O**	**R**		**R**		**O**
Zenaida Dove	*Zenaida aurita*	*Resident*			R		O			O