ENVIRONMENTAL IMPACT ASSESSMENT

Proposed Highway 2000 North South Link – Caymanas to Linstead

CL ENVIRONMENTAL

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ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED HIGHWAY 2000 NORTH SOUTH LINK – CAYMANAS TO LINSTEAD

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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/m³	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 Caymanas Estate area (east of the parish-capital, Spanish Town) and is to connect with the existing highway and parochial road networks via an enhanced interchange provision. The highway will then travel west-northwest over the hills in this region, through Waterloo Valley and south of Cross Pen and crosses the Rio Cobre River in the vicinity of Content/Dam Head; from where it climbs towards Giblatore and Lime Walk on the St. Johns Red Hills. The highway later descends and heads north, from Wakefield, towards Linstead and the Linstead bypass, where it terminates.

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 (Caymanas to Linstead) 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 ≈27.92 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 furthering this objective, a North South Link, Spanish Town to Ocho Rios, is being developed.

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 Description

The Highway is being constructed in two main phases. Phase 1 covers a 72km distance from Kingston to Williamsfield. Phase 2 of the project is now being implemented and l comprise two corridors: an 86km section from Williamsfield to Montego Bay and a spur from Caymanas to Ocho Rios.

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: CAYMANAS TO LINSTEAD

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

Alignment

The Caymanas to Linstead (Section1) segment of Highway 2000 requires the construction of a two lane, dual carriageway, with a design speed of 80 km/h.

Ferry to Waterloo Valley, via Caymanas (km 0+000 to 9+000)

The alignment through Caymanas is shown on **Error! Reference source not found.** (SK-SEC1-003, rev 1). The alignment will begin at the Highway 2000 interchange at Ferry. A new underpass will be required at km 1+200 for the Dyke Road connection. This interchange may be excluded from the project.

A new cloverleaf interchange will be constructed at the intersection of the NS Highway and the Mandela Highway, complete with a new underpass at km 2+000. The alignment will utilize the existing Rio Cobre Bridge, as well as westbound on ramp from Mandela Highway. The existing Mandela Highway Underpass will need to be demolished.

A partial cloverleaf interchange will be constructed along the Parochial Road, complete with an underpass at km 3+100, and traffic signals on the Parochial Road at the ramp terminals, if required. This road will be the primary access to Caymanas.

A Collector-Distributor Road system may be required along both sides of the highway from the Ferry Interchange to the Caymanas Interchange, due to the close proximity of the interchanges. If the CD Road is required, additional structures will be required along both sides of the highway along this entire length, including the Rio Cobre River crossing.

The NS Highway will cross over two local roads at km 3+800 and km 4+100; underpasses will be required at these locations. The NS Highway will then start to climb into the hills in the vicinity of km 5+000 with maximum 8% gradient, and will cross over the Caymanas Bay Road in a high fill. An Underpass will be required at km 6+000 to accommodate the local road. A major cut will be required to accommodate the profile until it meets existing grade around km 7+000.

The highway will generally follow the existing topography from km 7+000 to 9+000, with a crossing of Waterloo Road at km 8+600 (underpass or overpass).

Waterloo Valley to Content (km 9+000 to 13+500)

The alignment generally continues through rolling topography through an undeveloped area from km 9+000 to km 10+500. From km 10+000 to 13+500, the alignment is parallel to, and east of, the existing local road to Content, with a crossing of the local road to Bamboo at km 12+400 (underpass).

An interchange will be constructed at km 12+700 adjacent to the Rio Cobre River, complete with a 2 lane Link Road to the existing A1 Road, north of the Angels Shopping Centre. Two river bridges will be required on the Link Road to cross the Rio Cobre River and the irrigation channel.

A new roundabout will also be required at the A1 Road to provide adequate access to the NS Highway.

A Toll Plaza may be constructed east of the interchange in the vicinity of km 11 to km 12 along the tangent section of the highway. This will be confirmed in the Outline Design.

From the interchange to Content (km 12+700 to 13+500), the road will pass through the existing housing development along the Rio Cobre River.

Content to Wakefield (km 13+500 to 23+000)

The highway will cross the Rio Cobre River at km 13+900, approximately 150m upstream of the Dam Head. The estimated span of the river crossing is 100m.

Once the highway crosses the river, it starts a rapid ascent into the mountains along the west side of the Gorge, with maximum gradient of 8%, and maximum cut and fill of 30m. The topography changes from elevation 60 at km 14+000, to elevation 320 at km 18+500, and back down to elevation 110 at km 23+000 (Wakefield).

The highway generally runs parallel to the Rio Cobre River from km 14+000 to 20+500, crossing over the A1 at 14+200, and over the railway at km 15+100. There are no other road crossings until the crossing of the Giblatore – Bog Walk Road at km 20+300.

The highway traverses along the side of the mountain from km 20+500 to km 23+000, with grades up to 7%.

Wakefield to Linstead (km 23+000 to 29+700)

The highway generally passes through sugar cane fields and orange groves from km 23+000 to 26+000, with field connectors at km 23+700, km 24+500, km 25+000 and km 25+600, and local road crossings at km 23+900 and km 26+000. The highway will be constructed 3 m to 5m above the existing ground to ensure positive drainage, and to facilitate the field connector crossings under the highway.

The highway passes through an area of low density housing from km 26+000 to km 28+000, with field connectors at km 26+900 and 27+200. The highway crosses over the Rio Cobre River at km 28+100, and over the Linstead Main Road / railway/Constant Spring Road at km 28+300.

The highway will then traverse through undeveloped lands west of the Linstead Bypass where it will again cross over Constant Spring Road at km 29+300, and over the Linstead Bypass at km 29+400, before connecting to the existing Treadways Roundabout at km 29+700 from the west side of Byndloss Hardware. Alternatively an interchange will be constructed at the Linstead Bypass and the roundabout will be removed.

Crossings

Twenty eight (28) crossings have been identified along the highway and the Angels Link Road, and will be facilitated by overpasses and underpasses. These crossings include rivers, local roads, railway and field connectors. The crossing at km 28+300 includes the Linstead Main Road, the JRC railway and Constant Spring Road.

Toll Plaza and Equipment

A Toll Plaza is proposed between km 4+800 and km 5+500, along the tangent prior to the ascent into the hills north of the Caymanas Golf Course.

Alternatively, the Toll Plaza could be located along the tangent between km 11 and km 12, in advance of the Angels Interchange.

The location of the Toll Plaza will be confirmed during the Outline Design.

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.

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. The steps are broken down as per below.

- Road bed construction work will take 18 months to complete.
- It will take approximately six months to finish the pavement.

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

PHYSICAL ENVIRONMENT

Meteorology and Climate

- Temperature values over the assessment at all locations ranged from a low of 17.2^{o}C at Cambria Farms to a high of 32.3 ^{o}C at Caymanas Bay.
- Relative humidity values ranged from a low of 81.9% at Caymanas Bay to a high of 99% at both Caymanas Bay and Cambria Farms.

- Wind speed ranged from a low of 0 m/s to a high of 8.9 m/s at Cambria Farms.
- There was some measurable precipitation during the assessment ranging from 2.3mm – 21.8mm.
- Barometric pressure ranged from a low of 973.7 millibar at Caymanas Bay to a high of 1029 millibar at Cambria Farms.

Soils and Geology

- It was documented that the proposed Caymanas alignment traverses fourteen (14) identified soils. Thirteen (13) of the traversed soils possess slight to moderate erosive properties. Bonygate Stony Loam is however the most predominant soil group within the middle third of the alignment, between Giblatore and Waterloo Valley, in the mountaineous regions. This soil group has a very high susceptibility to erosion. Most of the other soils are very slow to moderate draining soils while Bonnygate Stony Loam, St. Ann Clay Loam and Union Hill Stony Clay are rapidly free draining soils.
- Between Linstead and Bog Walk, in the region named the Linstead basin of St. Thomas in the Vale, the proposed route traverses an area of undulating topography with a soil cover of variable thickness underlain by the White Limestone. Approximately thirty percent of the route follows or crosses alluvium associated with the drainage system.
- The southern edge of the Vale is bounded by the steep escarpment associated with the Bog Walk Fault System and this forms the northern edge of the limestone plateau to the south. South of Giblatore the limestone is dissected by gullies draining into sinkholes and surface storm drainage exiting into the Rio Cobre gorge.
- The proposed route traverses Limestones. The geological structure is dominated by block faulting of otherwise gently southward dipping units of the White Limestone. The southern edge of the Linstead Basin is bounded by the extensive Bog Walk Fault zone. Other minor faults within the limestone plateau traverse the proposed highway route at several points.
- The Bog Walk Fault zone is dominantly a multiple set of strike-slip faults that have caused extensive brecciation of the southern scarp of the Linstead Basin and the northern margin of the plateau. As noted above the zone is reported to include slivers of Cretaceous volcanic rocks. In this respect the fault zone resembles the one

that has been encountered at the southern end of the Mount Rosser Bypass section of the highway. The Bog Walk Fault zone is part of the major Above Rocks-Rio Minho Fault system that extends across the entire island and is structurally an integral part of the northern boundary fault complex of the Caribbean Plate.

- The northern segment of the highway descends the slope south of Bog Walk and is oriented parallel with a fault breccia zone which extends east west along the northern facing slope. This area consists of extensive completed faulting resulting in very soft rubbly material of several of the limestone formations. This area should be of high priority when considering slope stability. The northern segment (on the basin floor) does not appear to be transected by faults and so tectonic instability should not be an issue here.
- The proximity of the highway alignment just east of the Cretaceous units (in the Giblatore area) should be noted as these units are most likely to be much more susceptible to erosion and slope failure.

Topography

- The topography of the project area comprises of both gently sloping areas, in the northern end of the alignment, and a mountainous section, in the middle third of the alignment with sharp increases/decreases in elevations. The southern tip of the alignment is on relatively flat lands.

Hydrology

- Throughout the length of the proposed alignment, the topography includes various depressions in which sinkholes occur. A safety buffer of 50m was established within reason around the Caymanas alignment of Highway 2000. Eighteen (18) of these sinkholes can be located directly under the highway alignment reservation whereas ten (10) are within the 50m buffer. Implementing the abovementioned 50m buffer area, eleven (11) 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 alignment being a 4-lane highway will easily cover these wells and furthermore may lead to their destruction and/or contamination.
- 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 465.9 km^2, extending from Mannings Hill in the east to Thetford mountains in the west and Guys Hill in the north to Christian Pen in the south. The catchment is approximately 30.9 km long at its longest and 29.8 km wide.

- Four of these rivers cross the alignment within a 4 km radius of Linstead Town while the fifth (Rio Cobre) traverses the alignment in the Angels area. These rivers are known to have large flood plains and tend to swell rapidly and overtop their banks during extreme weather.

Quarries

- The report concluded that common fill materials will be sourced primarily from excavations. However since the cut areas are expected to be in weak limestone, the sub-base, base, concrete and pavement aggregates will have to be sourced from quarries in May Pen or St Thomas.
- The closest quarries to the project are located at distances varying from 3 km to 30 km in proximity to the highway alignment. Most 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.

Hazards

- The Bog Walk Fault zone consists of a broad belt of mainly limestones that have been extensively brecciated. The brecciation will result in potentially unstable slopes being exposed during and after construction of the highway, so the potential for landslides is high. If the highway route also intersects slivers of volcaniclastic rocks (Cretaceous units), presently just west of the proposed route in the Giblatore area this potential will become even higher. Active landslides have been encountered along, or in the vicinity of, the proposed highway route.
- 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° - 30°. The dominant slopes along the alignment are between 0 to 5 degrees. The segment of the alignment which traverses north of Lime Walk and west of Bog Walk comprises of the steepest slopes, varying from 0 to 30 degrees.

- 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.
- The Caymanas 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 Lime Walk and south of Bog Walk. The hilly environs in close proximity to Lime Walk runs parallel to the proposed alignment and extends from 1.3km southeast of Wakefield to 1.2km southwest of Bog Walk and 1.02km north of Lime Walk. Other susceptible regions identified include those near to Crescent and Content where the highway will intersect the Rio Cobre. In addition, the steep terrain of the Caymanas Bay creates moderate susceptibility to landslides in the surrounding areas.

Ambient Particulates (PM 2.5 & PM 10)

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

Ambient Noise Climate

- Two stations (5 and 9) 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 Stations 3, 8 and 9.

BIOLOGICAL ENVIRONMENT

Flora

- The planned road construction is, therefore, slated to impact several land use types namely, agricultural, residential and semi-industrial areas as well as pre-disturbed natural habitats. The terrain to be encountered is also variable in substrate, slope and aspect. Because of these factors, a decision was made that the vegetation within study area should be assessed under two broad categories, "lowland" and "highland" areas.
- There were two main lowland areas: one located southerly, to the east of Central Village and the other, adjacent to the large town of Linstead in the north. The vegetation in these areas showed severe anthropogenic influence, evidenced by large-scale orange and sugar cane cultivation, as well as several hectares of pastureland. Some isolated dwellings and settlements were also encountered, especially within the northern lowland areas thus influencing the characteristics of the nearby flora with the persistence of garden ornamentals and fruit trees.
- In general, the highland areas appeared significantly less disturbed than the lowland areas. Nonetheless, man's influence on the environment could be seen with the occurrence of a few village-settlements and isolated dwellings. These were usually associated with subsistence agriculture of several fruit trees (such as Ackee, Breadfruit, Star-apple and Allspice), including some pastureland. There were two main "highland" areas to be impacted by the highway development, namely those areas between Caymanas Bay and Content (easterly) and between Dam Head and near Lime Hill (westerly).
- The vegetation here transitioned into lands occupied by dwellings and subsistence agriculture. Anthropogenic influence on species composition was exhibited with the increased presence of fruit trees and ornamental trees.
- The vegetation communities present within the study area exhibited various levels of anthropogenic influence and as such would be affected by a development such as this in various ways. The overall assessment of the study site is that the vegetation in each locale sampled was disturbed but the upper regions of the St. Johns Red Hills show the least disturbance as well as the highest endemism and as such care should be taken in carrying out the development in these areas.

Fauna

- Thirty five species of birds were identified in the Gully forest while 41 was observed in the Caymanas Hills; the other sites had much lower diversity. A number of endemic species were forest dependent, however they do not require primary forests and do thrive even is secondary forests.
- The only amphibian observed was *Rhinella marina*. Ten species of Reptiles, belonging to 5 genera were recorded. These populations here appear to be an extension of the population recorded for the adjoining Red Hills area. The Arthropod fauna is also improvised, with a maximum of 13 land snails and 10 arthropod species recorded for any area.
- Since none of the species recorded are known to be endangered or needing any special conservation measures, standard good environmental practice should be adequate to conserve these species.
- This area has been the subject of significant human activity, very intense in many cases; consequently all the species observed are generalist capable in surviving in a wide variety of habitats. The species diversity is comparatively low.

LAND USE

- The proposed alignment of the North South Highway is surrounded by various land use. These include agricultural, commercial, industrial, residential, educational and recreational. Other uses include motor rally route, airstrip, caves, burial grounds (behind homes or private property), power lines, wells/pump houses, water pipelines, telecommunication modules and cellular towers.
- Agriculturally, the study area has sugar cane, citrus and apple farming (Caymanas and Tru Juice). Commercially, the study area has offices, restaurants, bars, two markets (Bog Walk and Linstead), stalls, garages, block making facilities and factories such as the Tru Juice and Nestle Factory. There are eight quarries within the study area, five of which are limestone, two marl and the other sand.
- There are also health facilities which include the Linstead Hospital and health centres such as Giblatore, Bog Walk and Linstead.

- There are 60 settlements (residential areas) within the (Social Impact Area (SIA)) with the major towns being Spanish Town, Bog Walk and Linstead.

STRUCTURES ALONG THE ALIGNMENT

- Approximately 220 structures will be impacted by the proposed highway alignment. Of these structures, approximately 52% are found between Crescent and Content. These vary from stalls, houses, church, wells/pump house, shops, cell tower, farms, pens, used car lot and unfinished structures.

SOCIOECONOMICS

- The age of the SIA population could be described as fairly youthful and mostly female, with the majority of the population concentrated between ages 0-49. Since the SIA also has a substantial mature population, this contributes to an established labour force to support the population. However the fact that it is largely female could indicate either a high female birth rate or a high rate of male emigration from the SIA.
- The SIA has a land area of approximately 30km^2 and a population of about 220,555 persons. The population density of the area is roughly 7,350 persons per square kilometre. This is a far greater density than that of the parish of St. Catherine and also considerably higher than the national population density figure of 238 persons per square kilometre.
- A comparison of the SIA and national and regional ratios indicate that the SIA in general had lower dwelling to housing unit and average household ratios. However, there was a higher household/dwelling ratio in the SIA than both the regional (parish) and national ratios.
- There were a smaller percentage of households in the SIA owning the land they lived on than those renting and living rent free compared to the national and regional setting. Otherwise, there were higher or comparable percentages seen for all other land tenure categories when compared to the national and regional figures.
- Most SIA households (which accounts for 75% to 100%) utilize electricity as their main source of lighting. For the most part the

proposed highway falls within the areas of high household electricity use.

- St. Catherine and the study area are 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) and Flow.
- The greater portion of SIA households (86%) receives its domestic water supply from the National Water Commission (NWC). This was more than both the regional and national figures of 79% & 73% respectively. Conversely, households utilizing a private source of water supply (14%) were lower than the regional and national average. Water demand in the SIA is 66,648,364 litres per day.
- It is estimated that approximately 53,318,691 litres/day of wastewater is generated within the study area and is expected to increase to 102,032,479 litres/day over the next twenty five years.
- The National Solid Waste Management Authority is responsible for domestic solid waste collection within the study area. Presently, collection is done twice per week. The waste is transported to the Riverton landfill located in Kingston. Solid waste collection for commercial and industrial facilities is done by arrangements by these entities with private contractors.
- The increased residential developments taking place in the south central parts of St. Catherine are increasing congestion in Spanish Town. Spanish Town is the main transit route for trips from Kingston to the north coast and vice versa.
- The construction of phase 1 (Caymanas to Linstead) will result in several benefits to commuters and these will include:
  - less congestion on the existing roads through Spanish Town
  - Safer driving conditions for motorists and pedestrians
  - reduced travelling time
- There is one hospital located within the SIA. Linstead Hospital is a public hospital belonging to the Southeast Health Region. Accident and emergency care, medical care, minor surgery, mental health, out-patient clinic, pharmacy, ambulance and obstetrics are the major services provided and it is open on a 24 hour basis for all services except pharmacy and X-ray.
- Spanish Town, a Southeast Health Region Type B hospital is not located within the 3 km of the proposed alignment, but is situated on the southern outskirts of the SIA. Inpatient and outpatient

services in at least the five basic specialties (general surgery, general medicine, obstetrics and gynaecology, paediatrics and anaesthetics) are offered here. X-ray and laboratory services are usually available to serve hospital patients as well as those from Primary Health Care and the local private sector.

- Four public health centres are located within the SIA:
  - Bog Walk Health Centre – Type II
  - Giblatore Health Centre
  - Christian Pen Health Centre - Type III
  - Linstead Health Centre - Type III

- There is one fire station located within the SIA – Vanity Fair, Linstead. This station is located at the northern end of the proposed highway. Currently, this station has one fire engine with a water capacity of ≈ 6,365 litres (1,400 imperial gallons). There is also a fire station worth mentioning located in the south western end of the general study area in Spanish Town, about 3 km south of the proposed alignment.
- Four police stations are found within the SIA (Bog Walk, Caymanas Park, Ferry and Linstead).
- Three post offices are situated within the SIA (Bog Walk, Linstead and Gregory Park-Portmore)

- Approximately forty three percent (43.2%) of all respondents had heard of the National Road Operating and Constructing Company (NROCC). It was observed that more males knew of NROCC than females. Of the 43.2% of respondents who had heard of NROCC, 46.3% had heard only of the company's name but were unaware of the company's services.
- 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 37.4% of respondents were aware of the proposal and 62.6% 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 bypass and/or the toll road would significantly reduce the time it takes for them to travel. Individuals

interviewed also indicated their expectation of having existing off roads in the vicinity of the proposed areas upgraded.

- Concerns highlighted, related to the possibility of high toll fees, as well as making currently accessible areas inaccessible. 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.

Aesthetics

- All towns, with the exception of Green Acres and Big Pasture will be able to see the proposed highway alignment. Less than 10% of the proposed road alignment will be seen by persons situated in Bog Walk, Giblatore, Gregory Park, Linstead and Spring Vale.
- On the other hand, in the case of Gregory Park, the visible areas are over 2 km away from the observation point and are located directly north of the Giblatore point at the start of the alignment and northwest in proximity of Caymanas.
- Visible sections of the proposed road from Spanish Town and Angels (collectively constituting a large percentage of population in the study area) are similar with 11% and 12% of road visible respectively. On the other hand, the town of Caymanas, situated east of Angels, will be able to see as much as 16% of the proposed alignment, with these visible areas restricted to the first the start of the proposal alignment, east and north of Caymanas.

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	• 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
Vegetation/Habitat Disturbance	• 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 • If removal is necessary, a nursery should be established for maintenance and propagation of endemic and naturally occurring plants • 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

Impact	Mitigation
	established • Further planning required to establish development zones within nearby lands, villages and towns to prohibit development of nearby areas
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 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

Impact	Mitigation
	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 for the construction workers. • Adequate communication with workers and signage should be put in place to

Impact	Mitigation
	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.
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 Rio Cobre water canal.

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. • 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 • 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). • 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.
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.
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 Caymanas Estate area (east of the parish-capital, Spanish Town) and is to connect with the existing highway and parochial road networks via an enhanced interchange provision. The highway will then travel west-northwest over the hills in this region, through Waterloo Valley and south of Cross Pen and crosses the Rio Cobre River in the vicinity of Content/Dam Head; from where it climbs towards Giblatore and Lime Walk on the St. Johns Red Hills. The highway later descends and heads north, from Wakefield, towards Linstead and the Linstead bypass, where it terminates (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 (Caymanas to Linstead) 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 ≈27.92 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 furthering this objective, a North South Link, Spanish Town to Ocho Rios, is being developed.

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.

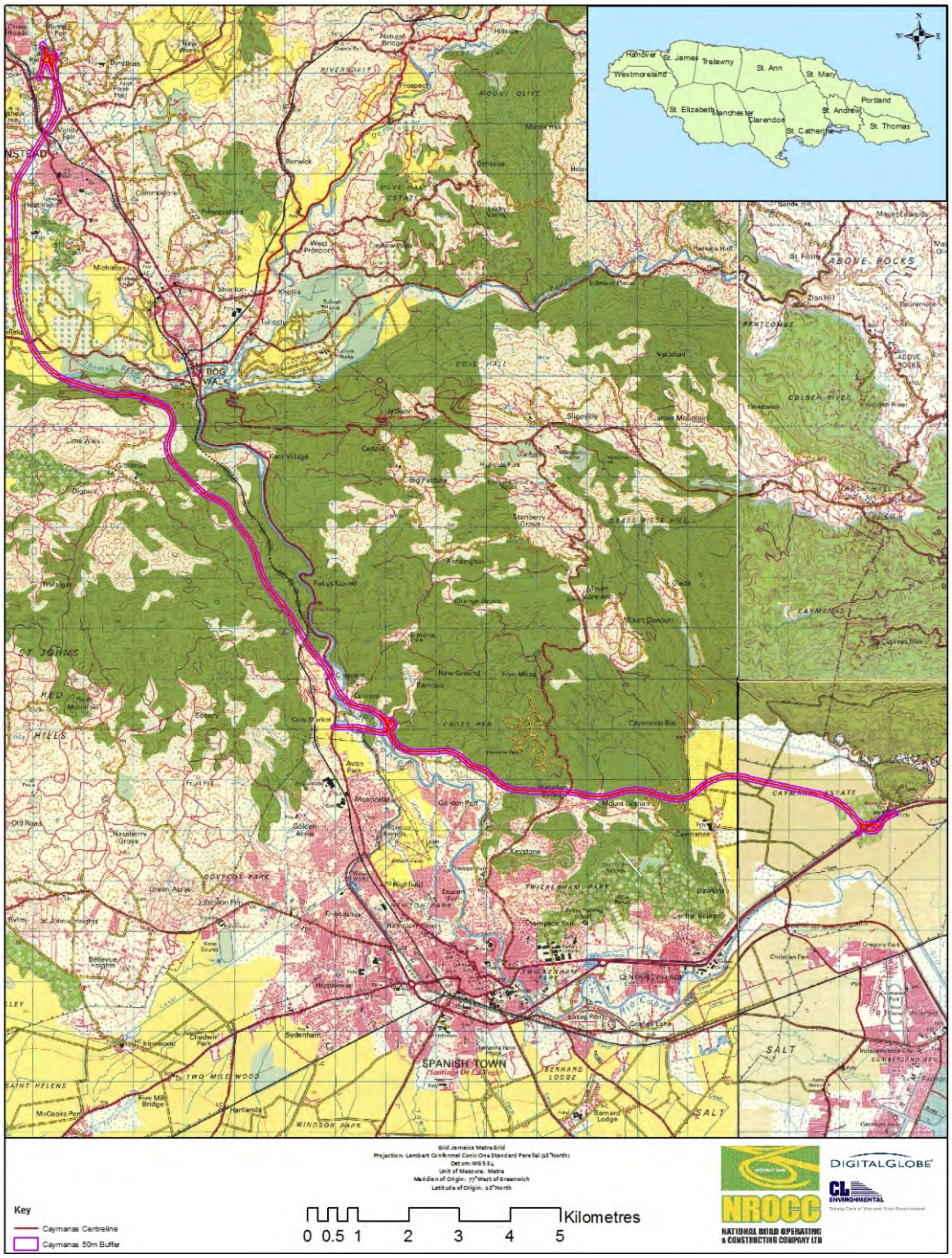


Figure 2-1 - Map of planned North-South highway development from Caymanas to Linstead, St. Catherine

2.2 PROPOSED PROJECT

2.2.1 Alignment, Crossings and Toll Plaza

2.2.1.1 Alignment

The Caymanas to Linstead (Section1) segment of Highway 2000 requires the construction of a two lane, dual carriageway, with a design speed of 80 km/h.

Ferry to Waterloo Valley, via Caymanas (km 0+000 to 9+000)

The alignment through Caymanas is shown on Figure 2-2 (SK-SEC1-003, rev 1). The alignment begins at the Highway 2000 interchange at Ferry. A new underpass will be required at km 1+200 for the Dyke Road connection. This interchange may be excluded from the project.

A new cloverleaf interchange will be constructed at the intersection of the NS Highway and the Mandela Highway, complete with a new underpass at km 2+000. The alignment will utilize the existing Rio Cobre Bridge, as well as westbound on ramp from Mandela Highway. The existing Mandela Highway Underpass will need to be demolished.

A partial cloverleaf interchange will be constructed along the Parochial Road, complete with an underpass at km 3+100, and traffic signals on the Parochial Road at the ramp terminals, if required. This road will be the primary access to Caymanas.

A Collector-Distributor Road system may be required along both sides of the highway from the Ferry Interchange to the Caymanas Interchange, due to the close proximity of the interchanges. If the CD Road is required, additional structures will be required along both sides of the highway along this entire length, including the Rio Cobre River crossing.

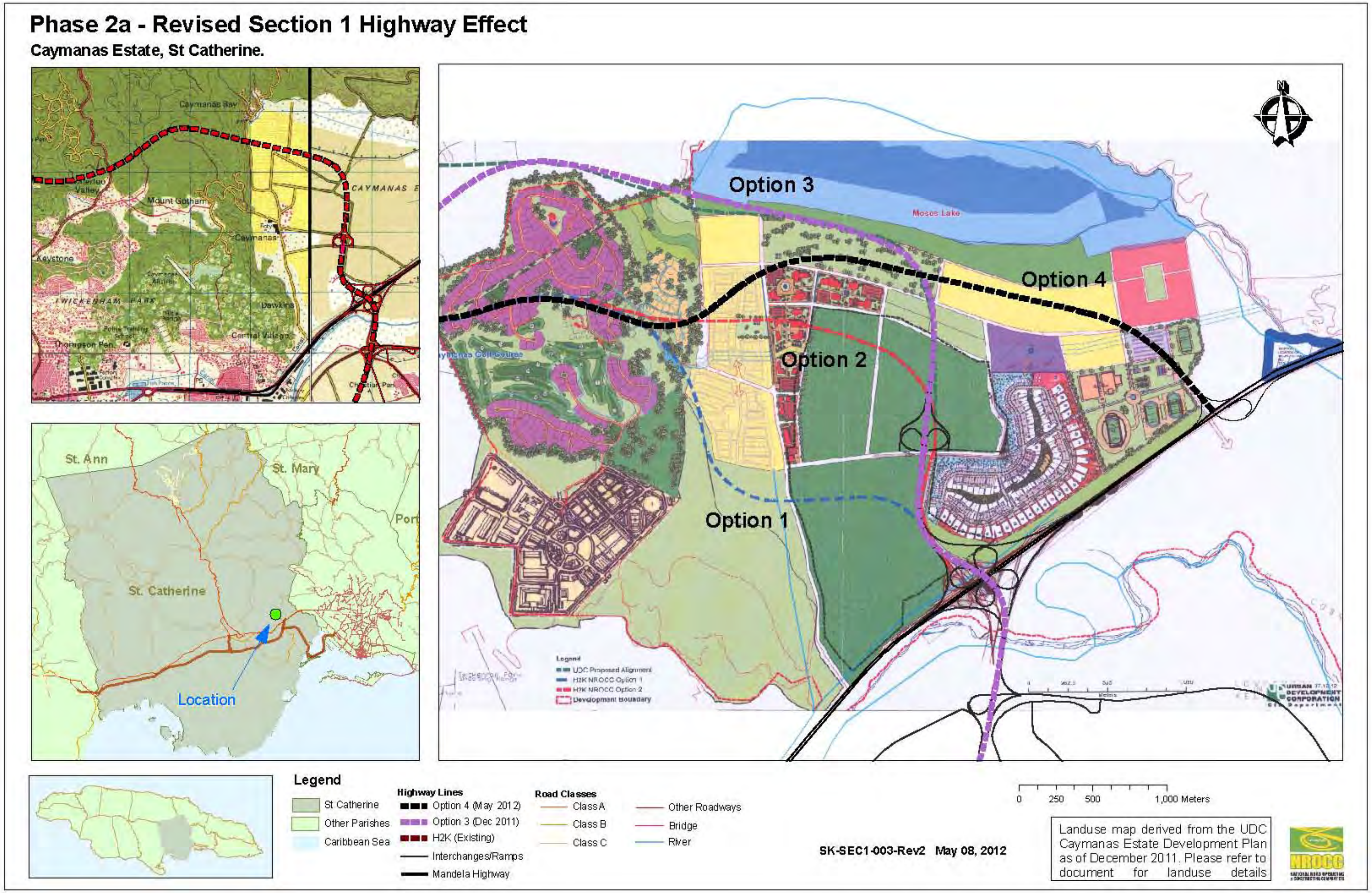


Figure 2-2 - The Caymanas to Linstead highway alignment through the Caymanas Estate (Option 4)

The NS Highway will cross over two local roads at km 3+800 and km 4+100; underpasses will be required at these locations. The NS Highway will then start to climb into the hills in the vicinity of km 5+000 with maximum 8% gradient, and will cross over the Caymanas Bay Road in a high fill. An Underpass will be required at km 6+000 to accommodate the local road. A major cut will be required to accommodate the profile until it meets existing grade around km 7+000.

The highway will generally follow the existing topography from km 7+000 to 9+000, with a crossing of Waterloo Road at km 8+600 (underpass or overpass).

Waterloo Valley to Content (km 9+000 to 13+500)

The alignment generally continues through rolling topography through an undeveloped area from km 9+000 to km 10+500. From km 10+000 to 13+500, the alignment is parallel to, and east of, the existing local road to Content, with a crossing of the local road to Bamboo at km 12+400 (underpass).

An interchange will be constructed at km 12+700 adjacent to the Rio Cobre River, complete with a 2 lane Link Road to the existing A1 Road, north of the Angels Shopping Centre. Two river bridges will be required on the Link Road to cross the Rio Cobre River and the irrigation channel. A new roundabout will also be required at the A1 Road to provide adequate access to the NS Highway.

A Toll Plaza may be constructed east of the interchange in the vicinity of km 11 to km 12 along the tangent section of the highway. This will be confirmed in the Outline Design.

From the interchange to Content (km 12+700 to 13+500), the road will pass through the existing housing development along the Rio Cobre River.

Content to Wakefield (km 13+500 to 23+000)

The highway will cross the Rio Cobre River at km 13+900, approximately 150m upstream of the Dam Head. The estimated span of the river crossing is 100m.

Once the highway crosses the river, it starts a rapid ascent into the mountains along the west side of the Gorge, with maximum gradient of 8%, and maximum cut and fill of 30m. The topography changes from elevation 60 at km 14+000, to elevation 320 at km 18+500, and back down to elevation 110 at km 23+000 (Wakefield).

The highway generally runs parallel to the Rio Cobre River from km 14+000 to 20+500, crossing over the A1 at 14+200, and over the railway at km 15+100. There are no other road crossings until the crossing of the Giblatore – Bog Walk Road at km 20+300.

The highway traverses along the side of the mountain from km 20+500 to km 23+000, with grades up to 7%.

Wakefield to Linstead (km 23+000 to 29+700)

The highway generally passes through sugar cane fields and orange groves from km 23+000 to 26+000, with field connectors at km 23+700, km 24+500, km 25+000 and km 25+600, and local road crossings at km 23+900 and km 26+000. The highway will be constructed 3 m to 5m above the existing ground to ensure positive drainage, and to facilitate the field connector crossings under the highway.

The highway passes through an area of low density housing from km 26+000 to km 28+000, with field connectors at km 26+900 and 27+200. The highway crosses over the Rio Cobre River at km 28+100, and over the Linstead Main Road / railway/Constant Spring Road at km 28+300.

The highway will then traverse through undeveloped lands west of the Linstead Bypass where it will again cross over Constant Spring Road at km 29+300, and over the Linstead Bypass at km 29+400, before connecting to the existing Treadways Roundabout at km 29+700 from the west side of Byndloss Hardware. Alternatively an interchange will be constructed at the Linstead Bypass and the roundabout will be removed.

2.2.2 Crossings

Twenty eight (28) crossings have been identified along the highway and the Angels Link Road, and will be facilitated by overpasses and underpasses. These crossings include rivers, local roads, railway and field connectors. The crossing at km 28+300 includes the Linstead Main Road, the JRC railway and Constant Spring Road. The structure at Dyke Road may be excluded from the project.

Table 2.1 shows the types and locations of crossings and structures along Section 1.

Table 2.1 - Types and Locations of Crossings and Structures along Section 1

Chainage	Local Name	Overpass / Underpass	Bridge Type
1+200	Dyke Road (Interchange)	Underpass	Local Road
1+600	Rio Cobre River	Underpass	River
2+100	Mandela Hwy (Interchange)	Underpass	Local Road
3+100	Caymanas Parochial Rd (Interchange)	Underpass	Local Road
3+800	Caymanas Local Road	Underpass	Local Road
4+100	Caymanas Local Road	Underpass	Local Road
6+000	Caymanas Bay Road	Underpass	Local Road
8+600	Spanish Town - Waterloo Road	Underpass or Overpass	Local Road
12+400	Bamboo Road	Underpass	Local Road
12+700	Angels Link Road (Interchange)	Underpass	Local Road
	2 lane Bridge on the Link Road over the Rio Cobre River	Underpass	River
	2 lane Bridge on the Link Road over the irrigation channel	Underpass	River
13+900	Rio Cobre River (Dam Head)	Underpass	River
14+200	A1 Road	Underpass	Local Road
15+100	JRC	Underpass	Rail
20+300	Giblatore – Bog Walk Road	Overpass	Local Road
23+700	Wakefield 1	Overpass or Underpass	Field Connector
23+900	Bog Walk - Wakefield Road	Overpass or Underpass	Local Road
24+500	Wakefield 2	Overpass or Underpass	Field Connector
25+000	Wakefield 3	Overpass or Underpass	Field Connector
25+600	Wakefield 4	Overpass or Underpass	Field Connector
26+000	Wakefield - Heathfield Road	Overpass or Underpass	Local Road
26+900	Heathfield 1	Overpass or Underpass	Field Connector
27+200	Heathfield 2	Overpass or Underpass	Field Connector
28+100	Rio Cobre River	Underpass	River
28+300	Linstead Main Road/Rail/Constant Spring Road 1	Underpass	Local Road/Rail
29+300	Constant Spring Road 2	Underpass	Local Road
29+400	Linstead Bypass	Underpass	Local Road
29+700	Treadways Roundabout	At-grade crossing	Mt. Rosser Bypass connection

2.2.3 Toll Plaza and Equipment

A Toll Plaza is proposed between km 4+800 and km 5+500, along the tangent prior to the ascent into the hills north of the Caymanas Golf Course.

Alternatively, the Toll Plaza could be located along the tangent between km 11 and km 12, in advance of the Angels Interchange.

The location of the Toll Plaza will be confirmed during the Outline Design.

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
- Sub base 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
- Sub base 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 2-3 below.

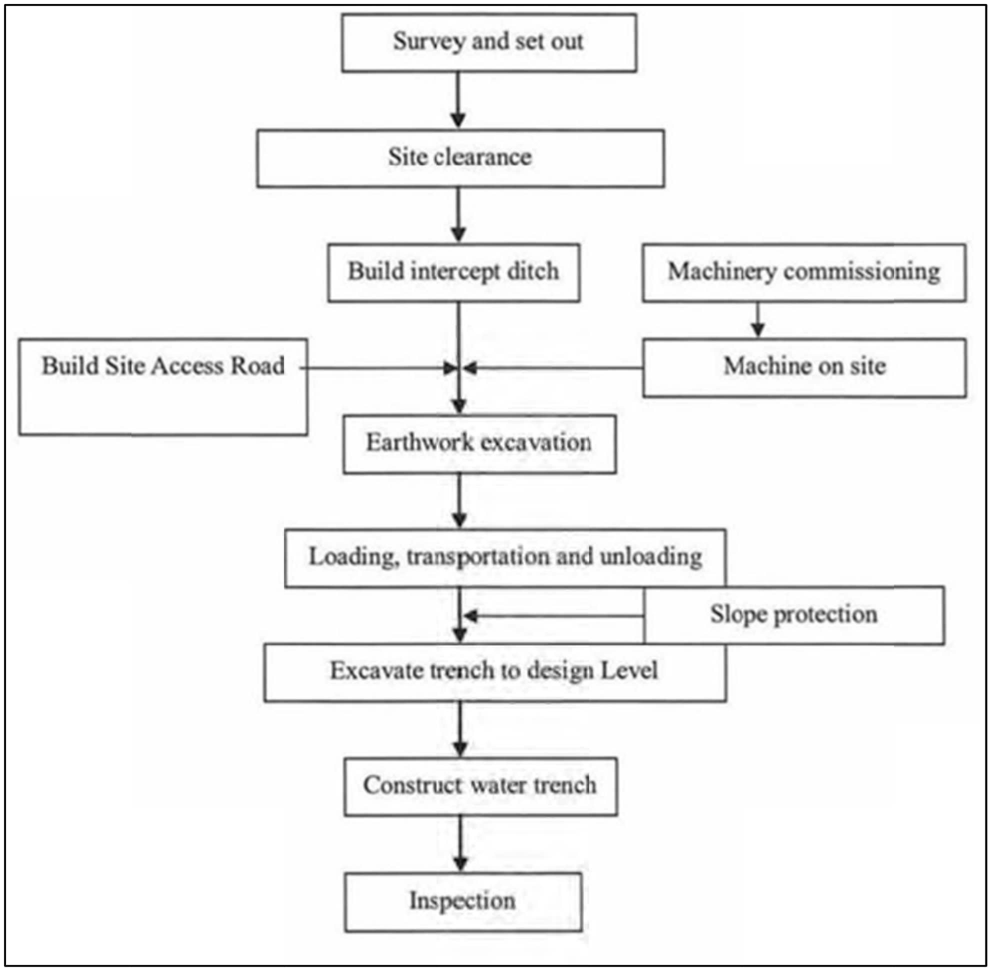


Figure 2-3 - Roadbed construction procedure (source CHEC)

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 2-4).

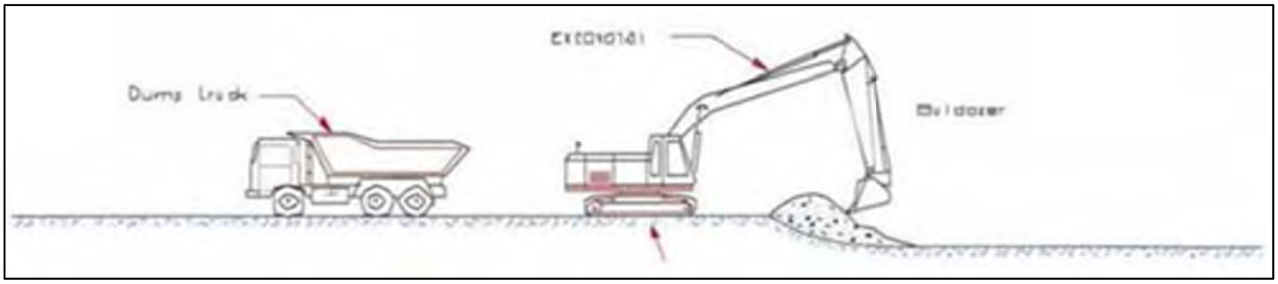


Figure 2-4 - Earthwork excavation (source CHEC)

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 2-5).

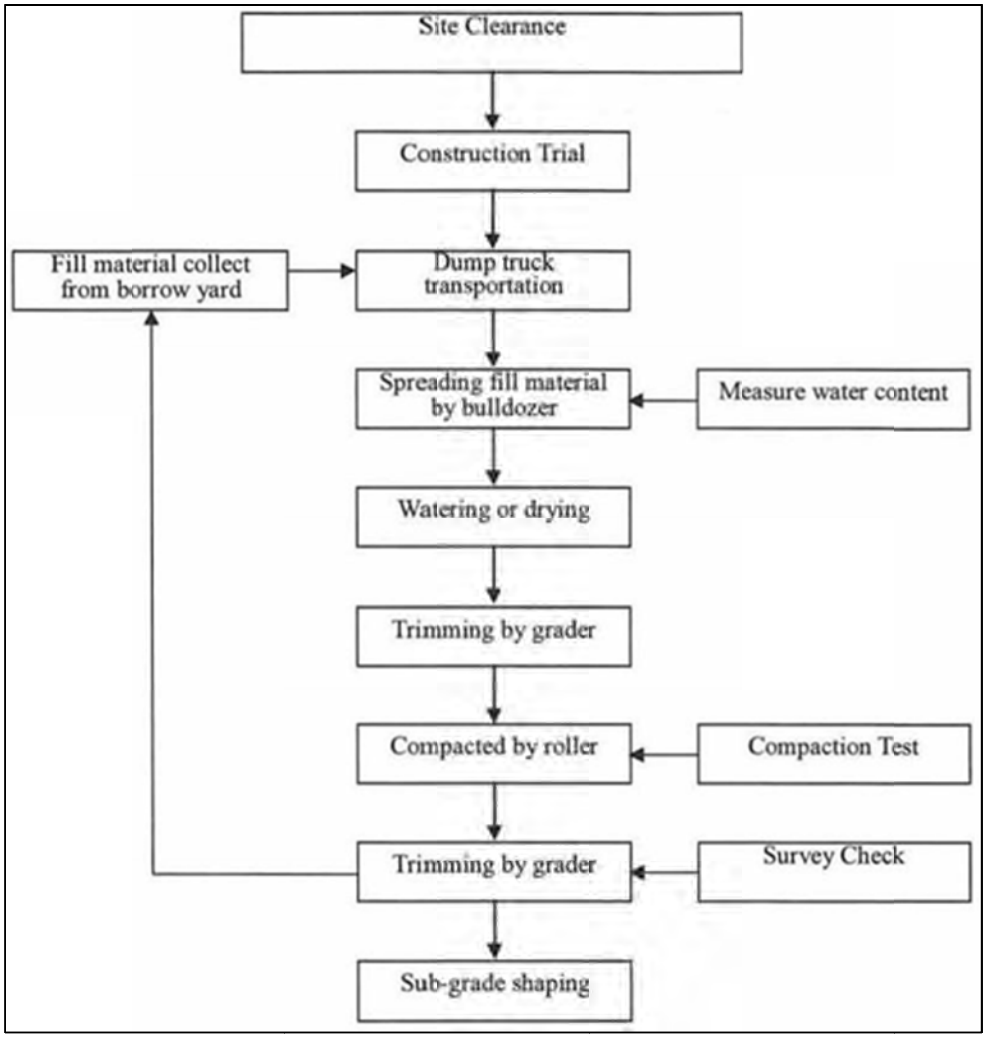


Figure 2-5 - Construction procedure for roadbed filling (source CHEC)

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 2-6).

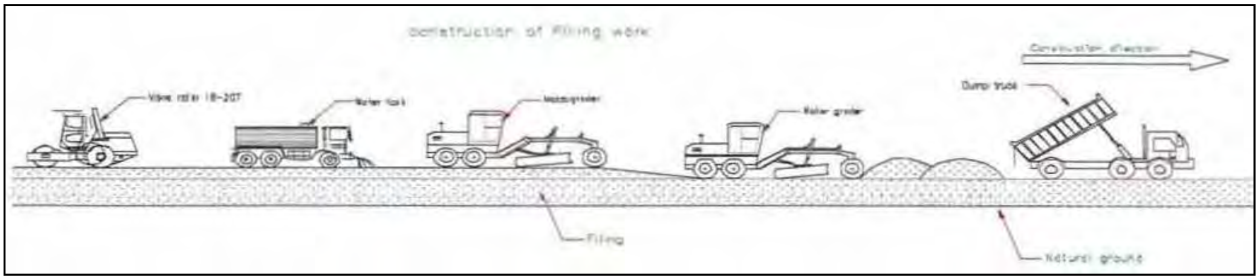


Figure 2-6 - The steps for transporting, spreading and compacting fill material (source CHEC)

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 2-7).

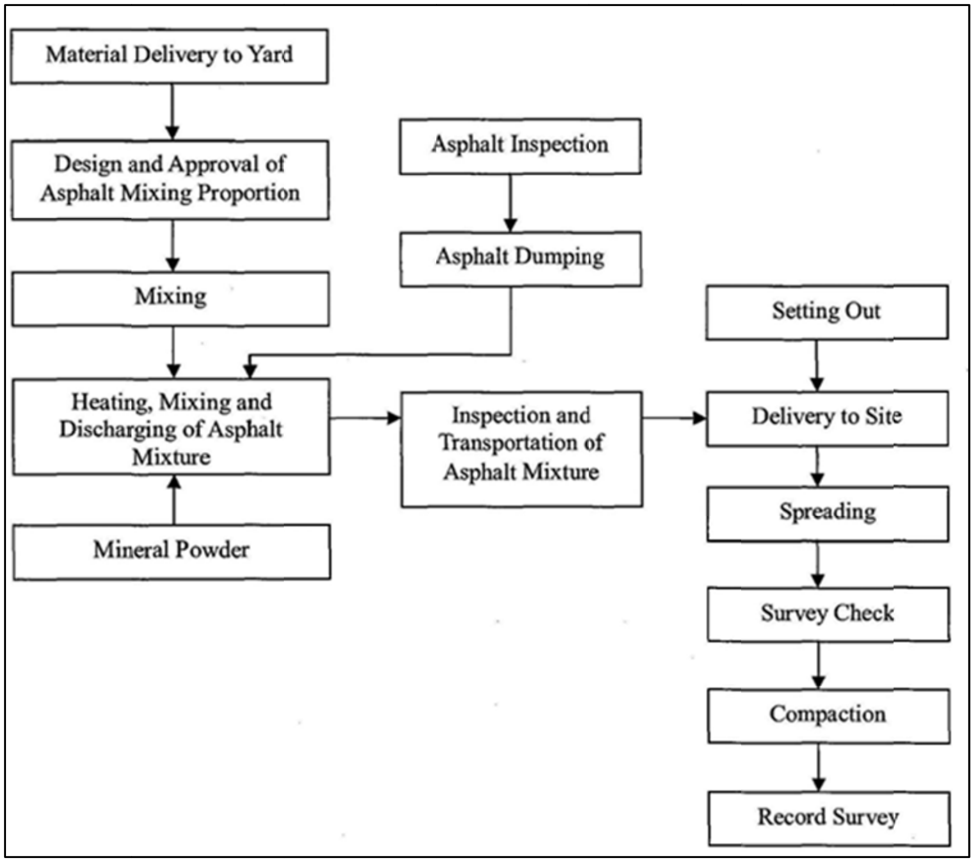


Figure 2-7 - Pavement Construction Schematic (source CHEC)

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 spreaded by 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 spreaded 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 2-8).

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.

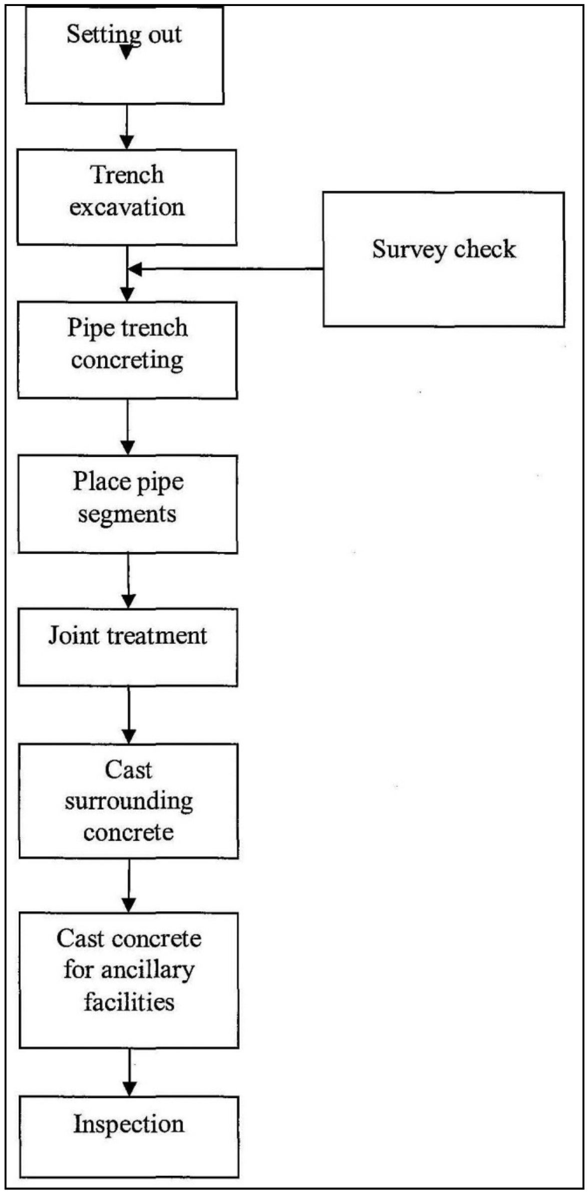


Figure 2-8 - Culvert Construction Procedure (source CHEC)

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 (Stations N1, N4, and N7) over the seventy two (72) hours (Friday March 9th – Monday March 12th, 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 - Photo showing weather station at N7 – Cambria Farms property

Table 4.1 - Locations of weather stations in JAD2001

Station #	Location	JAD 2001	
		Northing (m)	Easting (m)
N1	Caymanas Bay	653912.99	759070.26
N4	Content	654881.88	752467.18
N7	Cambria Farms	662384.24	745719.85

Results

Station 1 – Caymanas Bay

Average temperature was 24.5 °C and ranged from a low of 18.8 °C to a high of 32.3 °C.

Average relative humidity was 81.9% and ranged from a low of 50% to a high of 99%.

Average wind speed was 0.1 m/s and ranged from a low of 0 m/s to a high of 4.9 m/s.

Dominant wind direction was from the south southeast.

Measurable precipitation during the assessment was 2.3mm. Barometric pressure ranged from a low of 973.7 millibar to 1017.1 millibar over the noise assessment.

Station 4 – Content

Average temperature was 23.8 °C and ranged from a low of 19.8 °C to a high of 32.1 °C.

Average relative humidity was 83.9% and ranged from a low of 52% to a high of 97%.

Average wind speed was 0.5 m/s and ranged from a low of 0 m/s to a high of 5.8 m/s.

Dominant wind direction was from the north northwest.

Measurable precipitation during the noise assessment was 21.8mm. Barometric pressure ranged from a low of 1014.7 millibar to 1018.7 millibar over the noise assessment.

Station 7 – Cambria Farms

Average temperature was 23.4 °C and ranged from a low of 17.2 °C to a high of 30.6 °C.

Average relative humidity was 83.9% and ranged from a low of 56% to a high of 99%.

Average wind speed was 0.7 m/s and ranged from a low of 0 m/s to a high of 8.9 m/s.

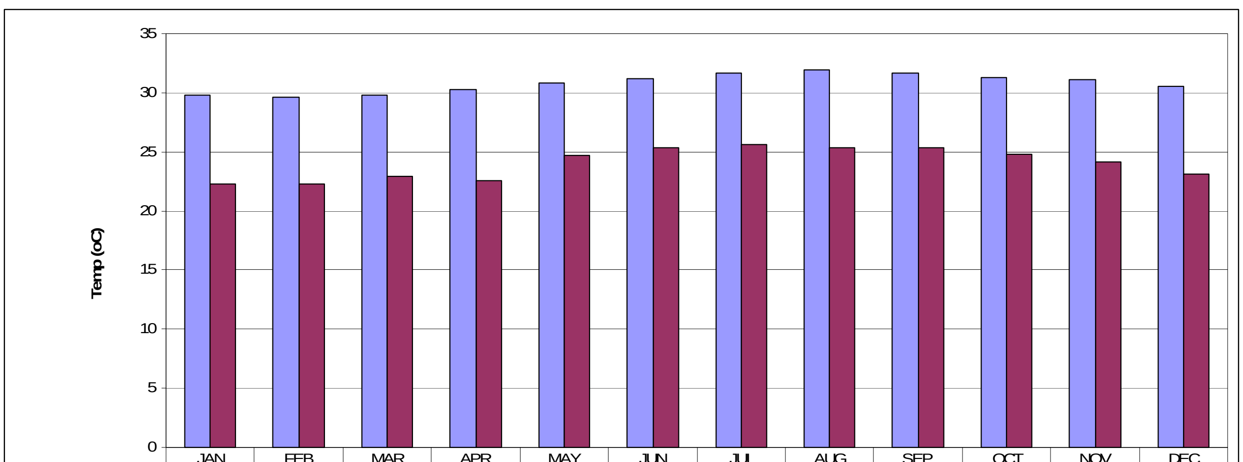
Dominant wind direction was from the north.

Measurable precipitation during the noise assessment was 10.9 mm. Barometric pressure ranged from a low of 1024.8 millibar to 1029 millibar over the noise assessment.

4.1.1.2 Monthly Trends at Norman Manley International Airport

Temperature

The mean monthly temperatures are lowest in January (22.3°C) and February (22.3°C) and highest between July and September (31.7 – 31.9°C). The minimum temperature ranges from 22.3 °C to 25.6 °C with highest temperatures in July and August and the maximum daily temperature ranges from 29.6 °C to 31.9 °C. The relatively narrow range in temperature reflects the moderating influence of the sea (Figure 4-1).



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max Temp. (C)	29.8	29.6	29.8	30.3	30.8	31.2	31.7	31.9	31.7	31.3	31.1	30.5
Min Temp. (C)	22.3	22.3	22.9	22.6	24.7	25.3	25.6	25.3	25.3	24.8	24.1	23.1

Figure 4-1 - Mean monthly temperatures for Norman Manley International Airport

Humidity

The mean monthly relative humidity ranges between 60 and 80 percent. Relative humidity is lower in the afternoons (Figure 4-2).

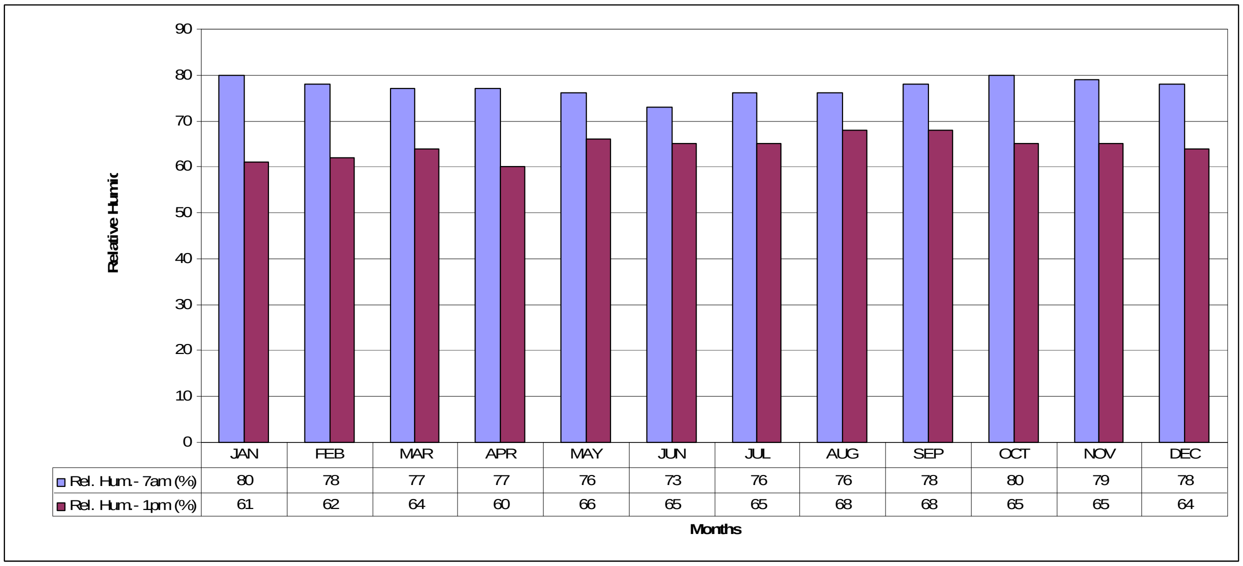


Figure 4-2 - Mean monthly relative humidity for Norman Manley International Airport

Rainfall

The annual mean rainfall is 62.1 mm. The data indicates that there are two rainy seasons in the year; these times are the May to June period and the August to October period where the highest intensities occur (Figure 4-3 and Figure 4-4). October has the highest average monthly rainfall (167 mm) and days with rain (10 days).

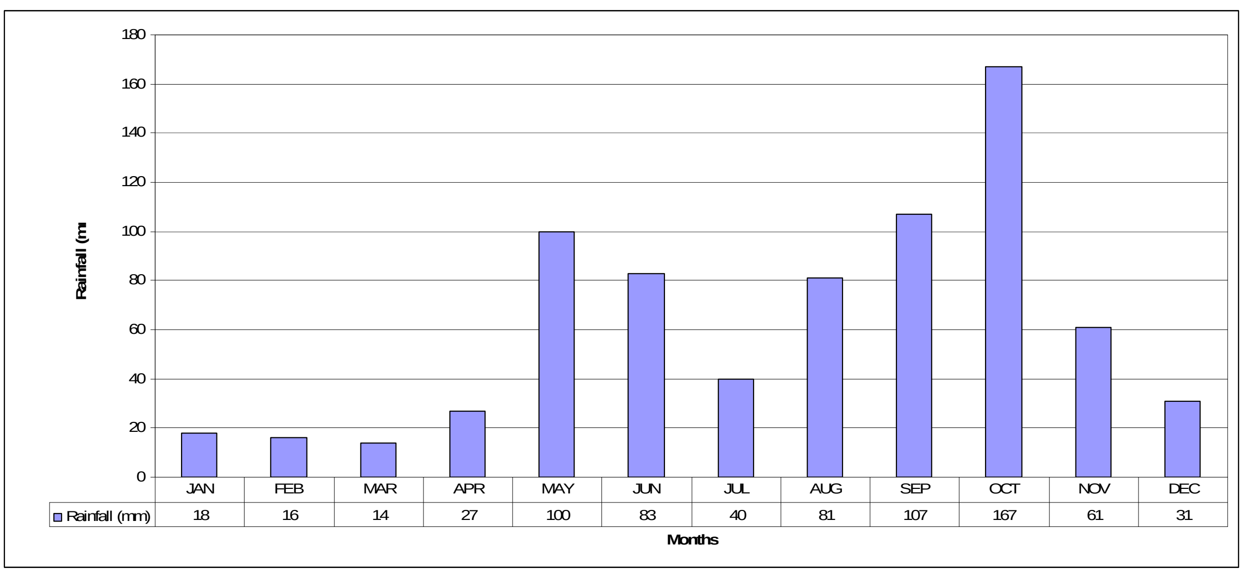


Figure 4-3 - Mean monthly rainfall data for Norman Manley International Airport

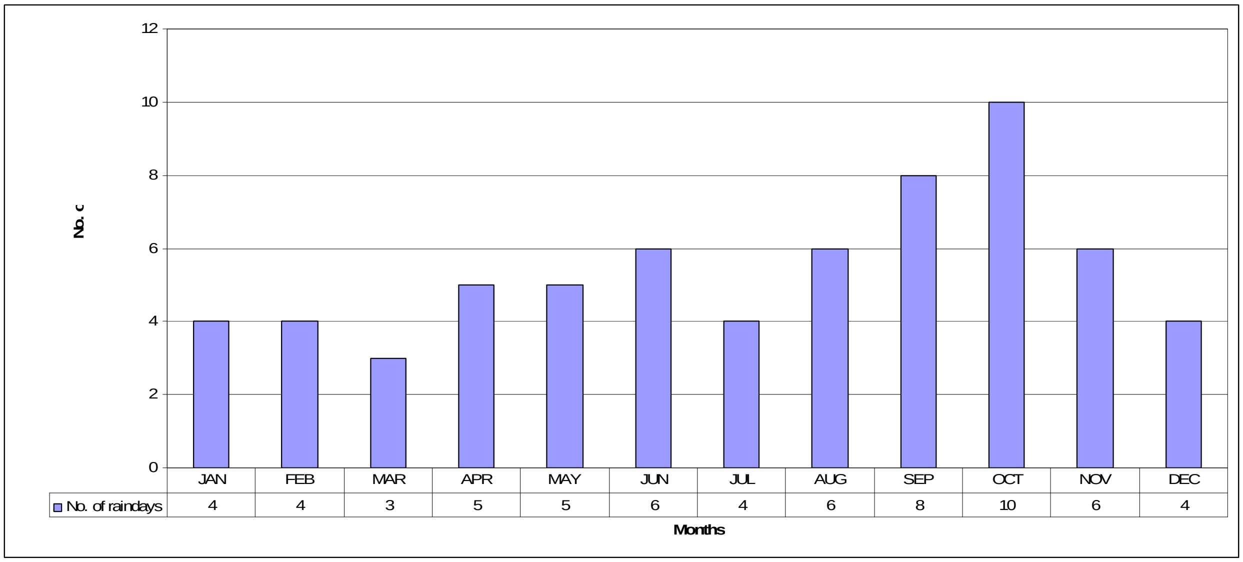


Figure 4-4 - Mean number of rain days for Norman Manley International Airport

Wind

The dominant winds over Jamaica are the northeast trade winds. Figure 4-5 shows an annual wind rose for the Norman Manley International Airport (NMIA) from January 1999 through December 2004. The predominant wind direction is from the east southeast with average wind speeds of 7.70 m/s. These are the prevailing sea-breeze directions and reflect the effects of the mountains that lie along an east west axis. The mountains deflect the dominant north-easterly trade winds and provide the easterly component to the winds.

A monthly analysis of wind direction and speeds indicated that monthly the winds generally blew to the west with wind speeds ranging from 6.32 to 10.97 m/s with the highest wind speeds occurring in the months June to August (10.97, 9.57 and 9.22 m/s respectively).

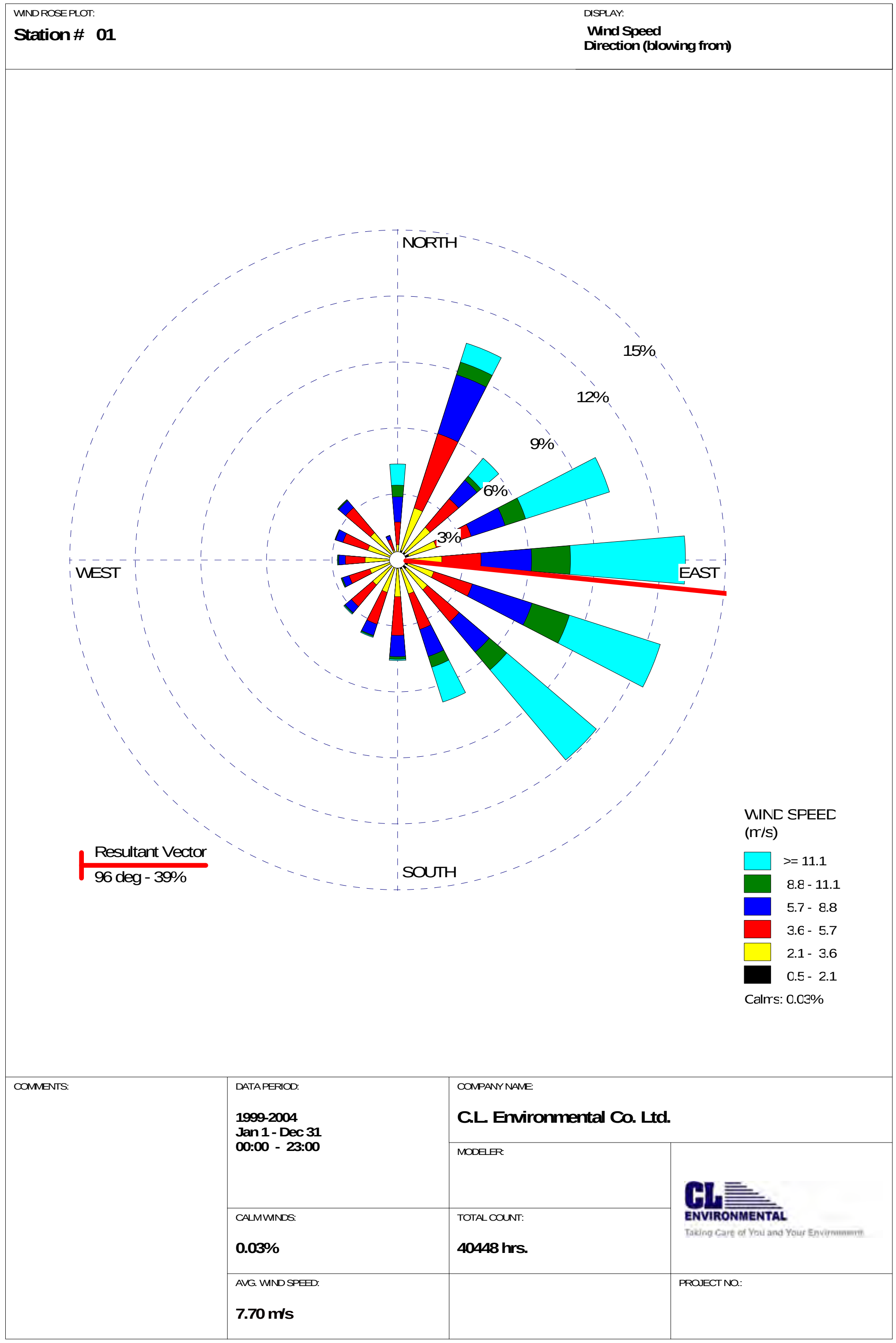


Figure 4-5 - Annual wind rose for Norman Manley International Airport (1999-2004)

4.1.2 Soils and Geology

4.1.2.1 Soils

The proposed H2K alignment was superimposed on the soils map of Jamaica (Figure 4-6). It was documented that the proposed Caymanas alignment traverses fourteen (14) identified soils shown inTable 4.2. Thirteen (13) of the traversed soils possess slight to moderate erosive properties. Bonygate Stony Loam is however the most predominant soil group within the middle third of the alignment, between Giblatore and Waterloo Valley, in the mountaineous regions. This soil group has a very high susceptibility to erosion. Most of the other soils are very slow to moderate draining soils while Bonnygate Stony Loam, St. Ann Clay Loam and Union Hill Stony Clay are rapidly free draining soils.

Table 4.2 - Outline of soil properties obtained from the Soil and Land use Surveys

Soil Type	***Erosion Hazard***	***Drainage through Soil***
Bonnygate Stony loam	High if developed	Extremely Rapid
Carron Hall Clay	Slight to Moderate	Moderate
Caymanas Clay loam	Slight	--
Caymanas Sandy loam	Slight	--
Ferry Silty clay	Slight	Slow in Subsoil
Lagoon Peaty loam	Slight	--
Linstead Clay loam	Moderate	Moderate
Pennants Clay loam	Moderate	Almost none
Rosehall Clay	Slight	Very Slow
St. Ann Clay loam	Moderate to high	Extremely Rapid
Sydenham Sandy loam	Slight	--
Sydenham Clay	Slight	--
Union Hill Stony clay	Moderate to high	Fairly Rapid
Wallens Silty clay loam	Slight	Almost none

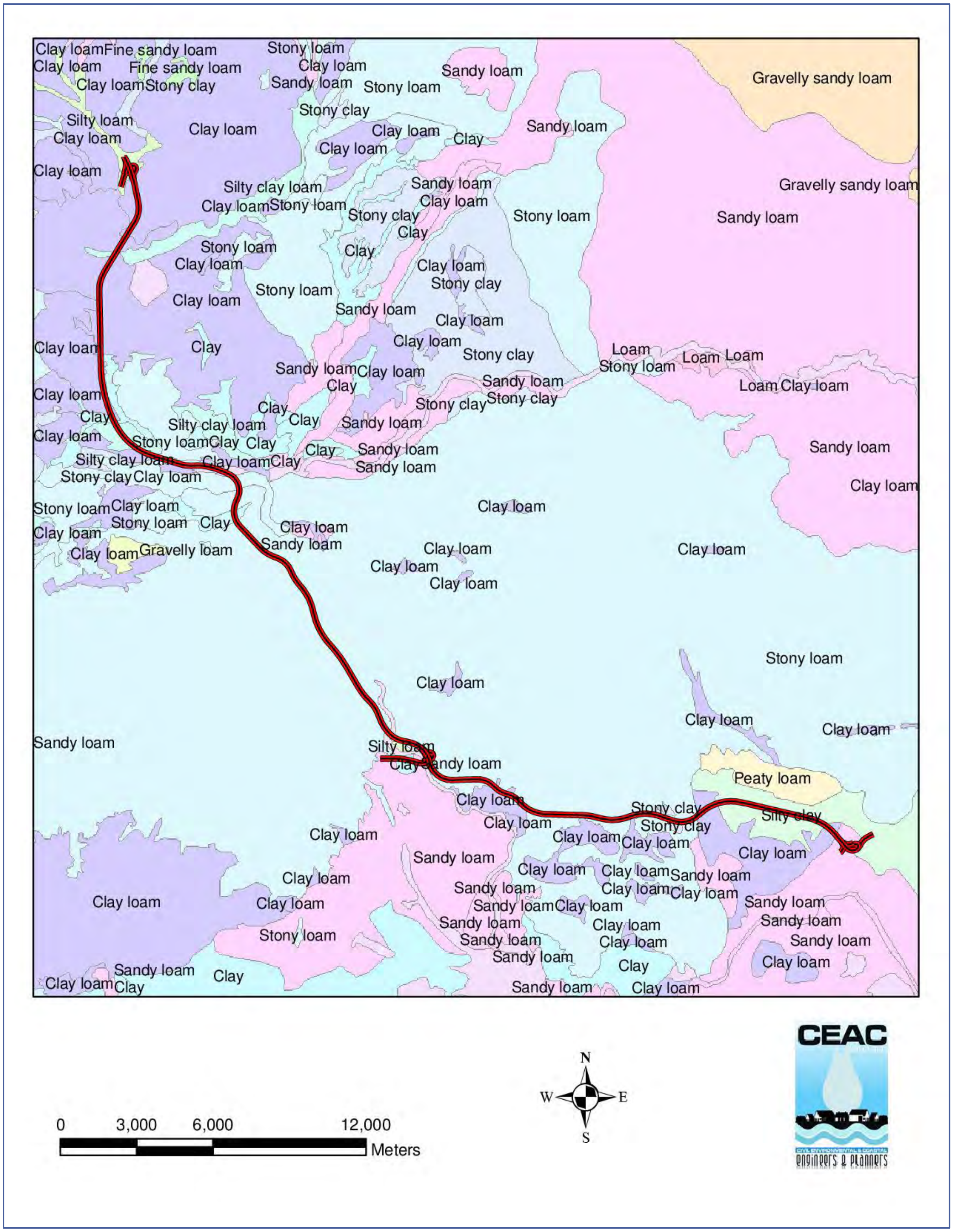


Figure 4-6 - Proposed road alignment superimposed on soils map of Jamaica

Descriptions of soil types are as follows:

1. **Bonny Gate Stony Loam** and **St. Ann Clay** are found on the limestones south of Bog Walk. The Bonny Gate Stony Loam is typically a thin brown or reddish soil (thickness typically less than 8 inches) 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 also forms in thin layers over bedrock but depth of soil may also exceed 60 inches in some locations. Surface drainage is good and soil permeability is described as very good to excessive.
2. **Rose Hall Clay** is a recent alluvium formed mainly from inland basin deposits and their soils, and is found in topographically flat areas. Surface drainage is very poor and permeability poor and decreases to very poor below 14 inches (36 cm). This clay has been identified in study area around Bog Walk (Figure 13).
3. **The Wallens Silty Clay Loam**, also found in the Bog Walk area, is formed from recent alluvium deposited by the Magno River and develops typically flat areas (5-10 ° slopes), primarily on flood plains. Permeability good to a depth of 11 inches (29 cm). External drainage is good however internal drainage is impeded with depth; fair to 27 inches (11 cm) poor below.
4. **Caymanas Sandy Loam** is found mainly on the flood plains of the Rio Cobre and is a recent alluvium formed from the mixed alluvium of the Rio Cobre. Within the study area it is located in the Kent Village area (Figure 12) and at Caymanas. The topography is typically flat, with slopes of 5- 10°. In places depth of soil may exceed 60 inches. It has poor external drainage but very good internal drainage and permeability is very good to excessive.
5. **Pennants Clay** (33) - located in the Wakefield area this soil is developed extensively on gentle slopes, typically flat areas (2-10 ° slopes), It is typically developed over gravelly or conglomerate parent material and possesses good surface drainage but high water retention and impeded drainage of its

subsoil with slow permeability below 10 inches (25 cm). This soils typically has a thickness of 36-60 inches (91-152cm) and the main management issues for this soil are related primarily to erosional hazards

6. **The Linstead Clay Loam** (61) is the major soil type between Linstead and Wakefield. It is a compact soil formed from recent gravels and basin deposits and has a thickness of 36-60 inches (91-152cm). It develops typically over flat areas (5-10 ° slopes) and has permeability good to a depth of 18 inches (45 cm). External drainage is good however internal drainage is impeded with depth; poor below 18 inches.
7. **Sterling Silt Loam** (14) occurs at the northern most end of the proposed highway route. They are formed from recent alluvium from interior basin deposits, limestones and hornfels. It is developed primarily on flat areas (2-5° slopes) and has poor internal and external drainage. Permeability is usually good to the first 5 inches but very poor below
8. **Linstead Clay & Union Hill Stony Clay** (61/75) - this is the major soil type in the basin between Linstead and Bog Walk. It is a mix of the Linstead Clay (described above) and the Union Hill Stoney Clay. The latter is typically found on the steeper areas (10-30° slopes) formed over hard limestone, from which it is formed. It has poor permeability and depth of soil is typically between 16-36 inches (40-90cm).

4.1.2.2 Geology

The Marine Geology Unit of the Department of Geography and Geology, University of the West Indies, undertook an environmental geological assessment of that section of the North-South Highway Construction Programme extending from Linstead in the north to Caymanas Estate and the Mandela Highway in the south. A previous investigation assessed the geological features associated with Alignment 1 of the proposed highway route extending from the southern border of the Linstead Basin, at Bog Walk, southward to the planned junction of the highway with Highway 2000, west of Spanish Town. This section describes the geological and hydrological features associated with the revised alignment for the Bog Walk Gorge bypass leg of the North-South Highway which extends from northern boundary of the Linstead Basin, just north of the town of Linstead, south and then westward to the planned junction with the Mandela Highway.

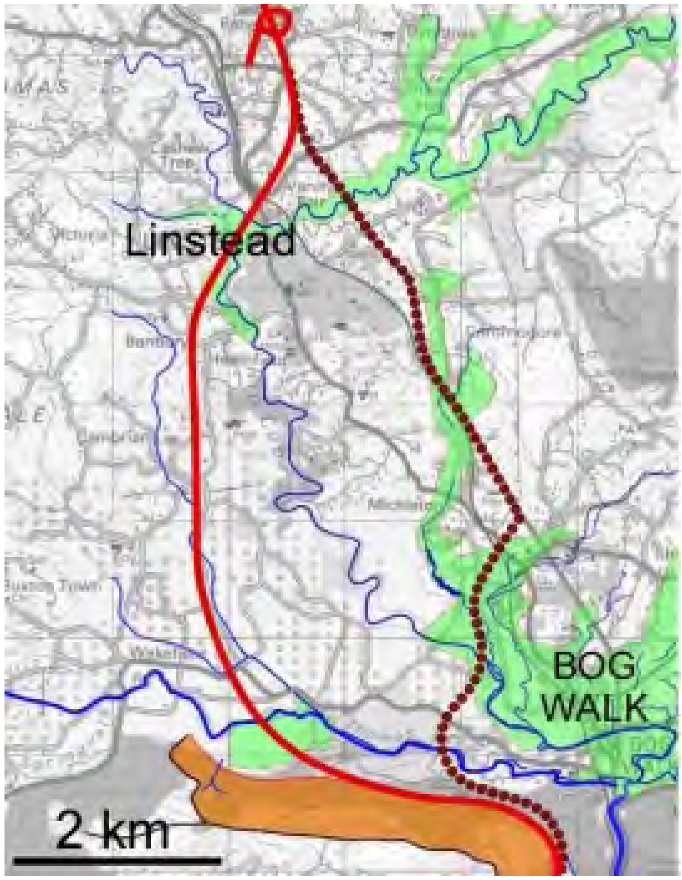
Methodology

Geological mapping was undertaken along roads and footpaths in the area from Caymanas Estates north to Linstead. Emphasis was placed on the areas where the proposed road will traverse the scarps and fault zones. Representative samples of all lithological units encountered were collected and remain on file at the Marine Geology Unit. 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) limestone 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.

Main Physical Features

The physical features along the proposed highway alignment are conveniently divided into four sections. Between Linstead and Bog Walk, in the region named the Linstead basin of St. Thomas in the Vale, the proposed route traverses an area of undulating topography with a soil cover of variable thickness underlain by the White Limestone. Approximately thirty percent of the route follows or crosses alluvium associated with the drainage system (Figure 4-7 and see section 4.1.4).

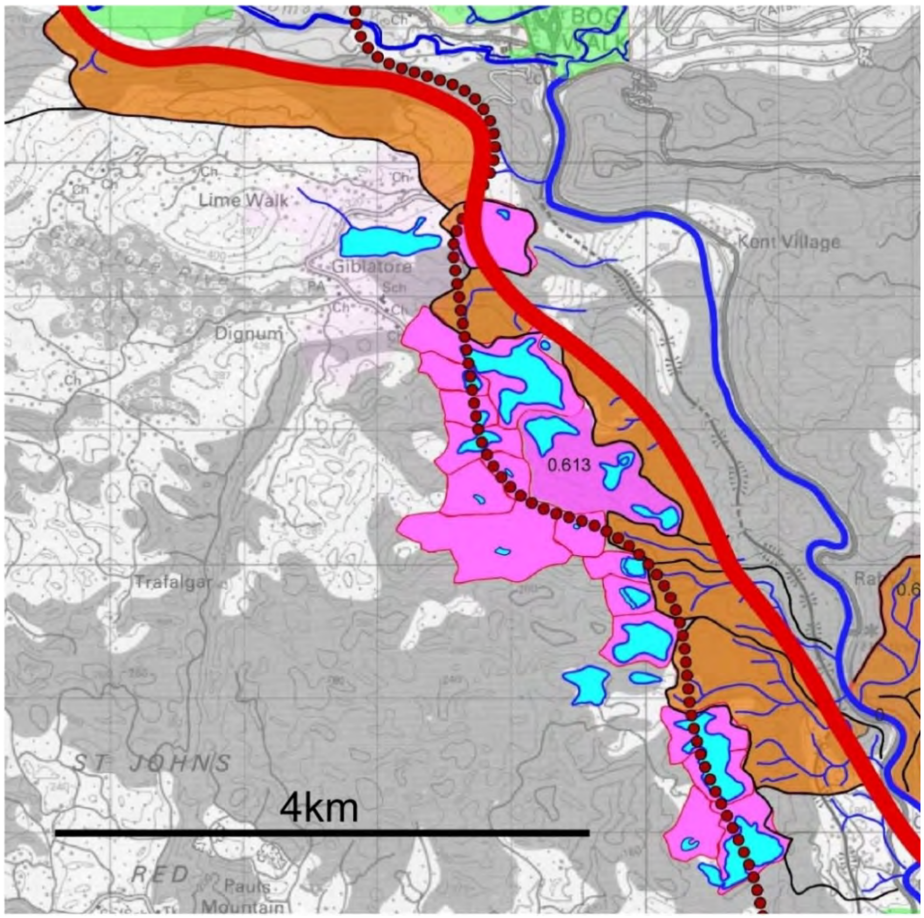


Key:

- line of dark red circles, previous proposed alignment
- thick red line, present proposed alignment
- thin blue lines indicate gully courses, normally dry
- thick blue lines, rivers
- green areas, alluvium as drawn on the 1:50,000 scale geological maps of the Mines and Geology Division
- brown areas topography with potential surface runoff towards the highway alignment during extreme precipitation events
- black lines indicate boundaries of gully catchments
- pink shading, areas of internal drainage
- light blue shading indicates lowest parts of internal drainage zones
- numbers on the shaded areas of indicate catchment sizes in square kilometres

Figure 4-7 - Proposed highway section from Linstead to Bog Walk

The southern edge of the Vale is bounded by the steep escarpment associated with the Bog Walk Fault System and this forms the northern edge of the limestone plateau to the south (Figure 4-8). South of Giblatore the limestone is dissected by gullies draining into sinkholes and surface storm drainage exiting into the Rio Cobre gorge. The proposed alignment of the highway in this part of the section, lies more to the east than the originally proposed alignment. This would bring the highway closer to the gorge, away from the sinkhole topography and across the region of storm gullies. The slopes are relatively steep down to the Rio Cobre and there is evidence of landslips within the limestone. This is particularly evident towards the northern part of this section, overlooking Kent Village, which is probably the site of the large landslide that blocked the river for many days after the 1692 earthquake. Over the southern part of this section the proposed route the highway traverses numerous gullies.

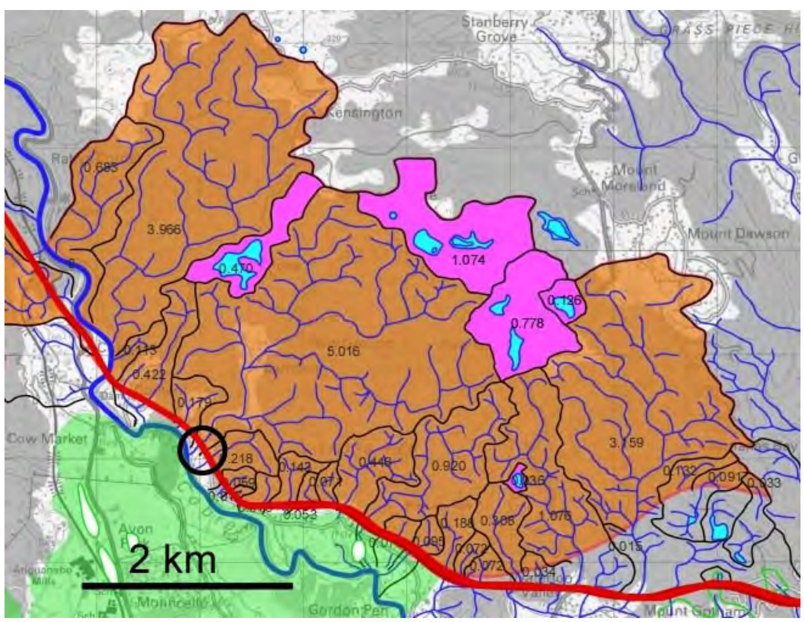


Key:

- line of dark red circles, previous proposed alignment
- thick red line, present proposed alignment
- thin blue lines indicate gully courses, normally dry
- thick blue lines, rivers
- green areas, alluvium as drawn on the 1:50,000 scale geological maps of the Mines and Geology Division
- brown areas topography with potential surface runoff towards the highway alignment during extreme precipitation events
- black lines indicate boundaries of gully catchments
- pink shading, areas of internal drainage
- light blue shading indicates lowest parts of internal drainage zones
- numbers on the shaded areas of indicate catchment sizes in square kilometres

Figure 4-8 - Bog Walk gorge bypass section of the proposed highway

After crossing the Rio Cobre the route skirts the southern flank of the limestone hills north of Central Village (Figure 4-9). In this region the karst limestone is dissected by extensive gullies (brown areas on Figure 4-9). Although the main flow of water is subsurface, there is the potential for considerable surface runoff resulting from extreme precipitation events.

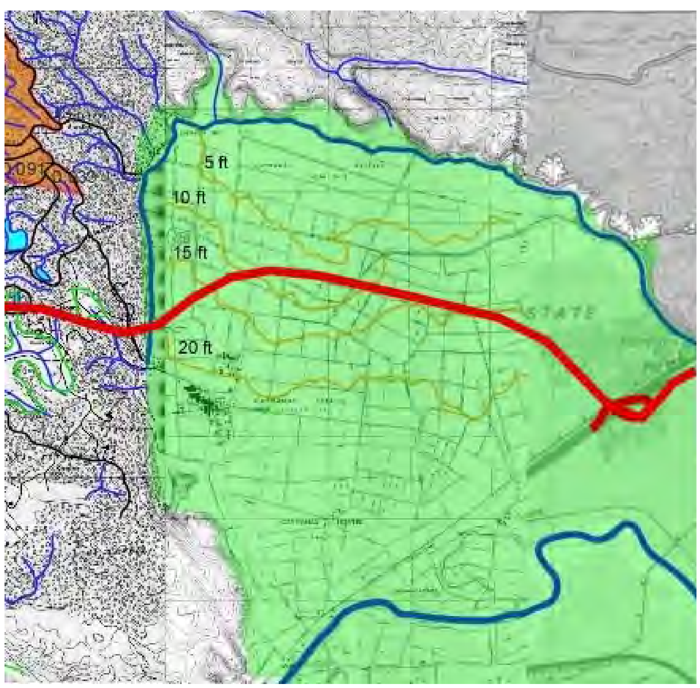


Key:

- thick red line, present proposed alignment
- thin blue lines indicate gully courses, normally dry
- thick blue lines, rivers
- green areas, alluvium as drawn on the 1:50,000 scale geological maps of the Mines and Geology Division
- brown areas topography with potential surface runoff towards the highway alignment during extreme precipitation events
- black lines indicate boundaries of gully catchments
- pink shading, areas of internal drainage
- light blue shading indicates lowest parts of internal drainage zones
- numbers on the shaded areas of indicate catchment sizes in square kilometres
- black circles indicate highway gully crossings with largest catchment areas

Figure 4-9 - Section of the proposed highway between the Rio Cobre dam and Caymanas Estate

After descending the steep slopes at the edge of the limestone hills, the stretch of proposed alignment through the Caymanas Estate to the Mandela Highway lies over the eastern part of the Rio Cobre alluvial fan. The river is now deeply incised into the fan sediments but the highest topographic expression of the fan more or less coincides with the present course of the river (see contours in feet on Figure 4-10). Thus the proposed route climbs from north to south gently upwards to the crest of the fan where it crosses the Rio Cobre and the regional surface drainage is away from the Rio Cobre northwards towards the Fresh River, bounding the northern edge of the Caymanas Estate.



Key:

- thick red line, present proposed alignment
- thin blue lines indicate gully courses, normally dry
- thick blue lines, rivers
- green areas, alluvium as drawn on the 1:50,000 scale geological maps of the Mines and Geology Division
- brown areas topography with potential surface runoff towards the highway alignment during extreme precipitation events
- black lines indicate boundaries of gully catchments
- pink shading, areas of internal drainage
- light blue shading indicates lowest parts of internal drainage zones

Figure 4-10 - Caymanas Estate section of the proposed highway

Geological Descriptions

- Geological investigations undertaken identified four limestones of the White Limestone Group, an undifferentiated fault breccia zone and recent alluvium in the Caymanas and Bog Walk areas (Figure 4-7). The geological succession includes the following main units from youngest to oldest:
  - Alluvium- Thick soils and clays of the Linstead Basin; Sands, silts and clays of the Rio Cobre Alluvial fan
  - Limestones of the White Limestone Group. These include the Troy/Claremont, Somerset, Walderston and Newport formations of the published literature.
  - Volcaniclastic Rocks of Cretaceous age

The proposed route traverses Limestones. The geological structure is dominated by block faulting of otherwise gently southward dipping units of the White Limestone. The southern edge of the Linstead Basin is bounded by the extensive Bog Walk Fault zone. Other minor faults within the limestone plateau traverse the proposed highway route at several points. The Bog Walk Fault zone is dominantly a multiple set of strike-slip faults that have caused extensive brecciation of the southern scarp of the Linstead Basin and the northern margin of the plateau. As noted above the zone is reported to include slivers of Cretaceous volcanic rocks. In this respect the fault zone resembles the one that has been encountered at the southern end of the Mount Rosser Bypass section of the highway. The Bog Walk Fault zone is part of the major Above Rocks-Rio Minho Fault system that extends across the entire island and is structurally an integral part of the northern boundary fault complex of the Caribbean Plate.

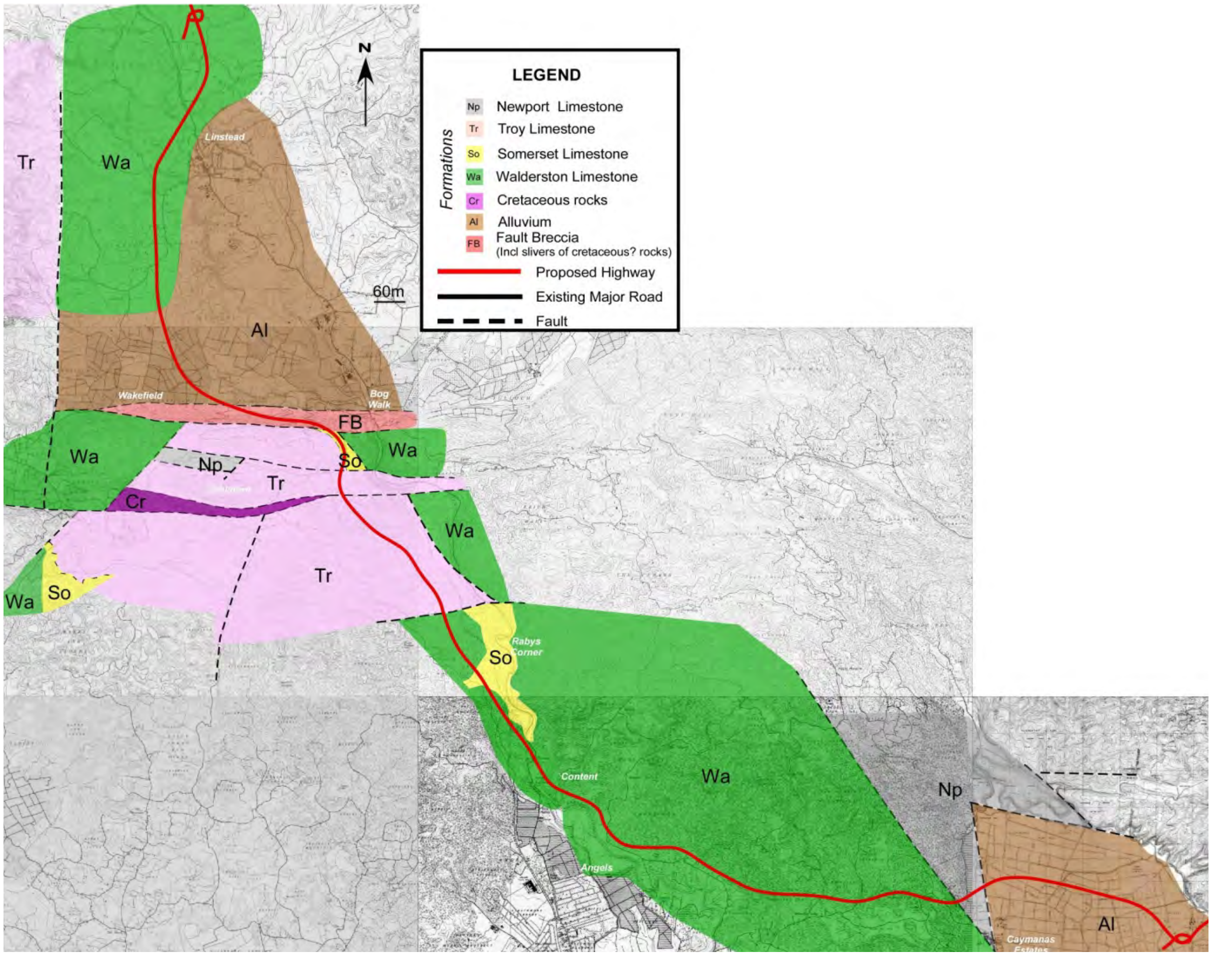


Figure 4-11 - Geological Map of the Caymanas Estate to Linstead area (based on the 1:12500 topological sheet series). Seven mappable units have been identified in the area; four formations of the White Limestone Group; an undifferentiated brecciated unit within the fault zone and alluvium fill in the Bog Walk and Caymanas Areas.

The geology of the Caymanas to Linstead leg of the North-South Highway is discussed in 3 sections; Section 1 covers the area from the district of Giblatore (south of Bog Walk) to Linstead. Section 2 covers the area from Giblatore south to Cresent and section 3 describes the area

Section 1

Section 1 traverses the area south of Bog Walk (district of Giblatore) north to Linstead. The northern segment of the highway descends the slope south of Bog Walk and is oriented parallel with a fault breccia zone which extends east west along the northern facing slope. This area consists of extensive completed faulting resulting in very soft rubbly material of several of the limestone formations. This area should be of high priority when considering slope stability. The Walderston Formation dominates the northern sections of this section of the route and is described below. The alluvium deposits identified in the basin are described in section 4.1.2.1. Faults (southern end of this section) and resulting brecciated units are of the greatest concern. The northern segment (on the basin floor) does not appear to be transected by faults and so tectonic instability should not be an issue here.

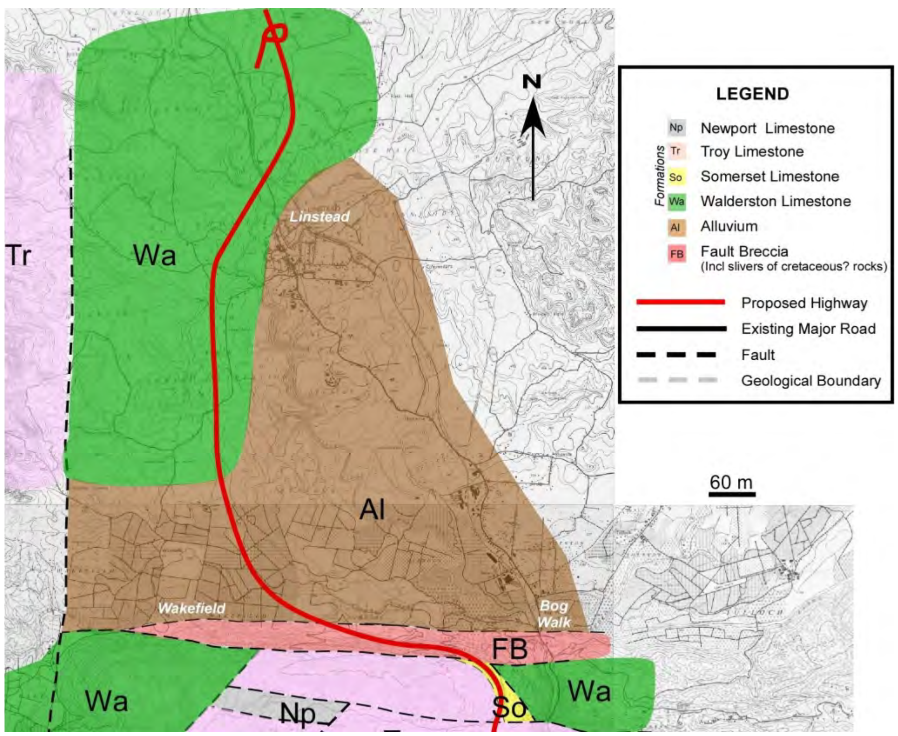


Figure 4-12 - Enlarged segment (Section 1) of geological map highlighting lithologies dominant along the northern section of the proposed highway route

Section 2

Section 2 traverses the District of Giblatore south to the community of Crescent. The segment of the highway traverses the limestone plateau and crosses the Walderston, Somerset and Troy Formations. The Walderston and Somerset formations, outcropping along the south eastern section of this segment are relatively soft limestone and may be susceptible to landslips particularly in faulted areas. The Troy formation is a dense compact limestone which is not typically susceptible to land slips. It is characteristic of well developed Sink Hole and subterranean caverns. The proximity of the highway alignment just east of the Cretaceous units (in the Giblatore area) should be noted as these units are most likely to be much more susceptible to erosion and slope failure.

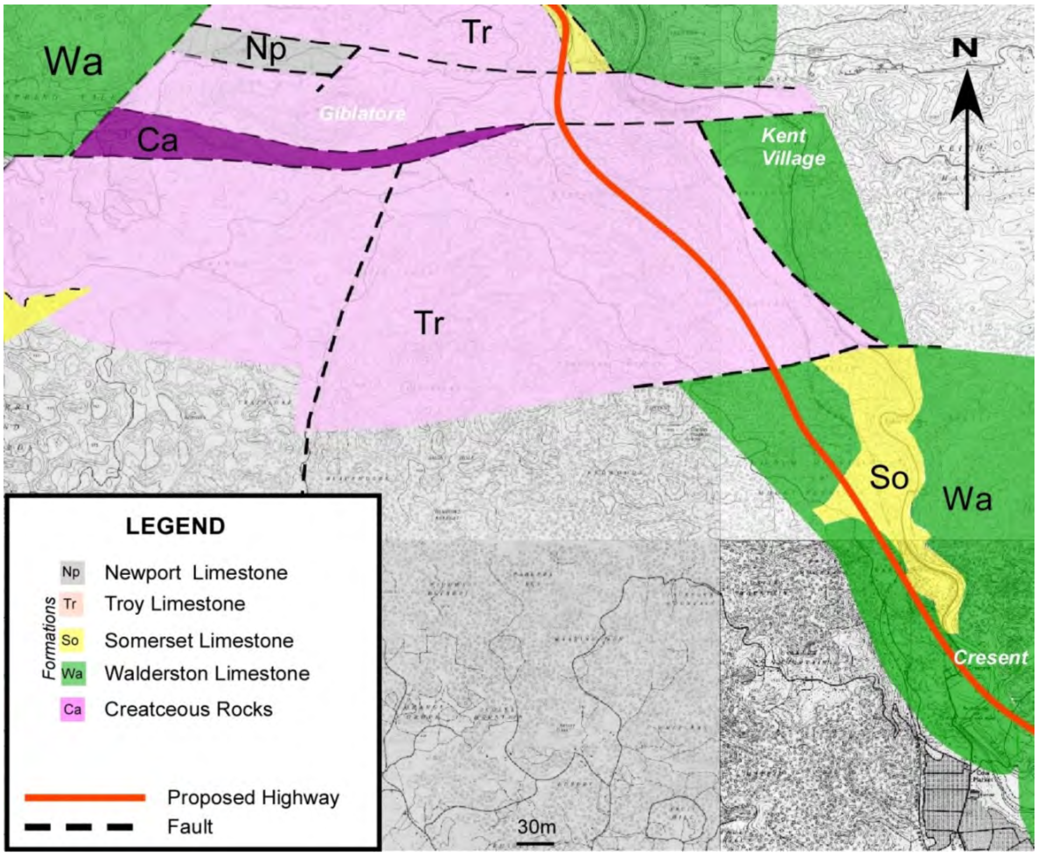


Figure 4-13 - Enlarged segment (Section 2) of geological map highlighting lithologies dominant along the middle section of the proposed highway route

Section 3

Section 3 traverses the community of Crescent east to Caymans Estates. The south eastern segment of the route is dominated by Walderston and Newport formations of the White Limestone Group. The Newport Limestone is compact and moderately well bedded and should offer sound foundations. However the Walderston limestone although forming large tower karsts in some areas is comparatively soft and landslides have been identified within the unit. The alluvium identified here is dominated by the Caymans Sandy loam properties of which are outlined in section 4.1.2.1.

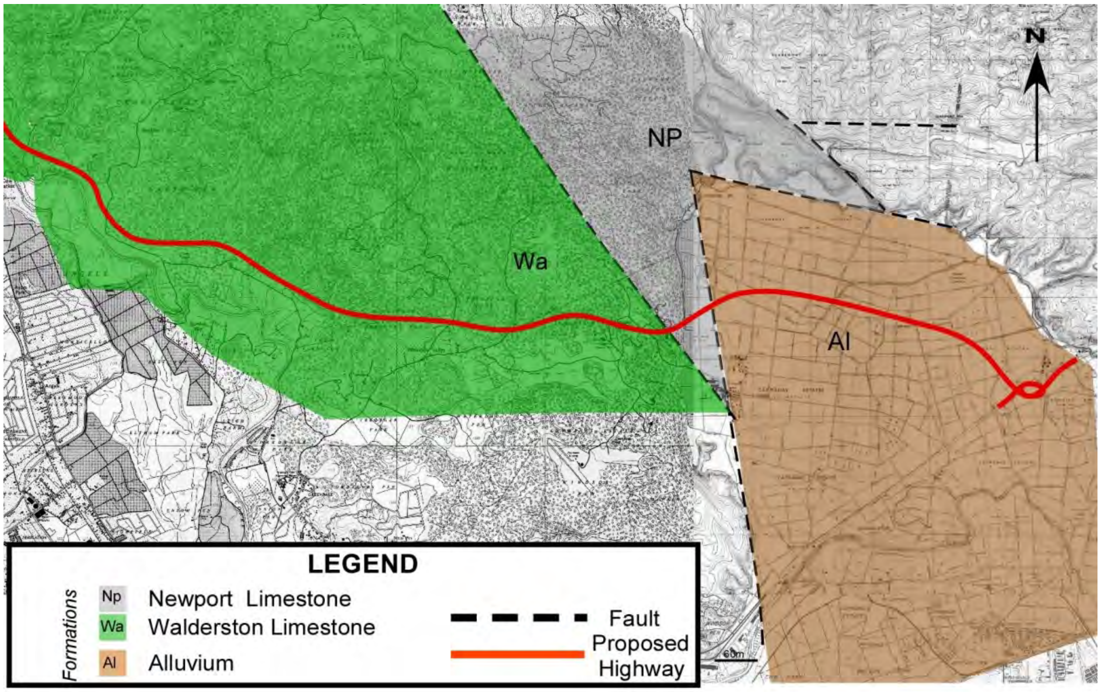


Figure 4-14 - Enlarged segment (Section 3) of geological map highlighting lithologies dominant along the south eastern section of the proposed highway route

Lithological Units

The following are descriptions of the lithologocal units identified in the Caymans to Linstead area of St. Catherine. Detailed descriptions and illustrations of these Units have been described in MGU's previous report. Summaries are given below:-

- **Troy/ Claremont Formation** - 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. 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).

- **Walderston/Browns Town Formation** – 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. Pink grainstones were commonly identified in the study area however the formation appears rubbly in areas adjacent to faults. Karstic development was identified However this 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).
- **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).
- **Newport Formation** – Limestones in this formation ranges from soft chalky and rubbly types to hard compact recrystallised limestones. Textures identified include pale coloured wackestones and carbonate mudstones. Exposures are typically thickly bedded or unbedded (Mitchell pers com.). Karstic drainage patterns are usually well developed with sink holes and depressions feeding underground drainage systems (O'Hara and Bryce, 1983). Industrial uses for this formation are varied. The soft rubbly types are best for landfill material and hard compact recrystallised types are good for aggregate, road metal, rip rap and dimension stone (Fenton, 1981).
- **Fault Breccia** – The brecciated outcrops identified in the fault zone (Figure 4-12), located on the slopes south of Bog walk, consists of very weathered, soft outcrops which can be broken by hand; several land slips were identified in this unit. Also identified were heavily jointed outcrops with loose blocks of scree deposits produced by the faults in the area (Plate 4.2).
- **Alluvium (Recent Deposits)**-The alluvium identified mainly in the Bog Walk to Linstead area and at Caymanas

estates the extent of which is indicated on the geological map (Figure 4-14) is described in greater detail in section 4.1.2.1.

Plate 4.2 - Outcrop view of the breaciated limestone that defines the fault zone south of Bog Walk. These are fracture bits of Newport and Troy/Claremont Limestones. Outcrops are fissile and are highly fractured and jointed

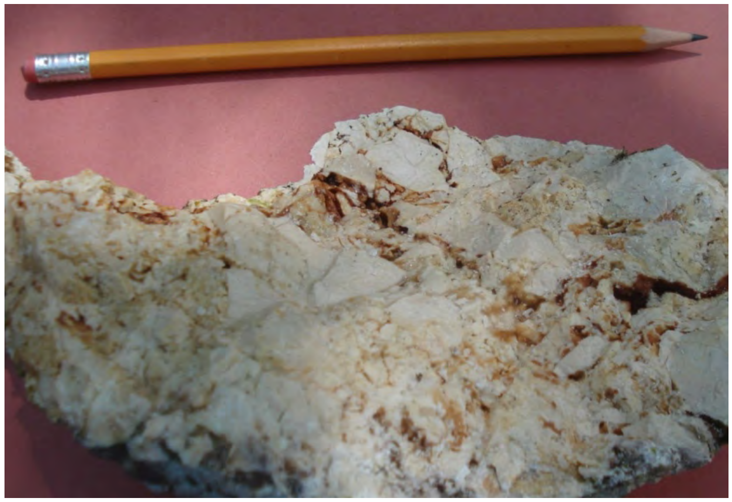


Plate 4.3 - Hand specimen example of the brecciated limestone identified within the Bog Walk Fault zone

Geotechnical Properties and Industrial Uses

Table 4.3 outlines geotechnical properties described by the Geology Survey Division for the five 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). Dimension stone is natural stone that has been quarried for production of blocks, slabs or shapes that have required dimension (Fenton, 1987).

Table 4.3 - 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	Aggregate, road metal, dimension stone, terrazzo tile chips and rip rap

Formation Names	Permeability	Bearing capacity	Possible Uses
		cavities for major structures: first 1-2m often "case hardened".	
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
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.
Newport 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".	Compact limestones-Road metal. Landfill, fillers (whitening) and chemical uses. Soft and rubbly limestone- Landfill

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, in the middle third of the alignment with sharp increases/decreases in elevations. The southern tip of the alignment is on relatively flat lands. The southern section of the alignment lies in the vicinity of Caymanas Estate, east of the central Spanish Town area, at approximately 14m above Mean Sea Level (MSL). As the highway progresses through the mountainous regions of Caymanas Bay to where it traverses the Rio Cobre in Content, the elevations range from 22m to 197m while slopes varies between 2º and 24º. Here the highway crosses the Rio Cobre south of Crescent where it continues in a north westerly direction trough the karst Limestone Mountains towards Giblatore. Elevations in this mountainous section vary between 80 and 345 metres above Mean Sea Level while varying between 1º and 31º. The terrain drops off sharply from elevations of 96 to 133m on entering the Wakefield area, west of Bog Walk before increasing gently towards Ewarton.

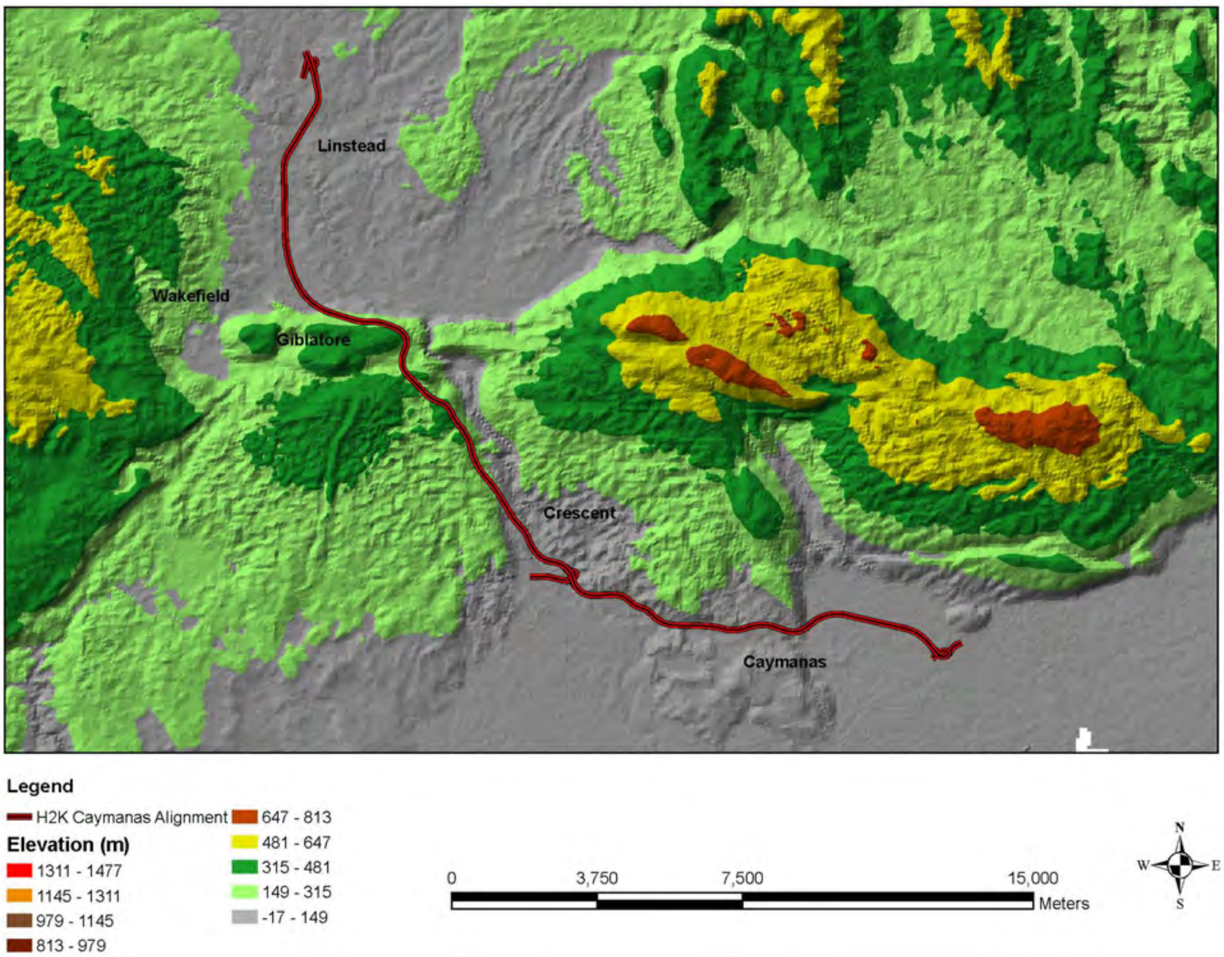


Figure 4-15 - H2K Caymanas alignment superimposed on a digital terrain map of Jamaica

4.1.4 Hydrology

4.1.4.1 Water Sources and Recharge Areas

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 was established within reason around the Caymanas alignment of Highway 2000. Eighteen (18) of these sinkholes can be located directly under the highway alignment reservation whereas ten (10) are within the 50m buffer as shown in Table 4.4and Figure 4-16 below.

Table 4.4 - Sinkholes intersected by H2K alignment

Location	*Sinkholes Identified*
Traversed by alignment	18
Within50m buffer	10
Total	**28**

Figure 4-17 indicates several wells, both pumping and non-pumping, within close proximity of the proposed H2K Caymanas alignment. This map should be used as a guide to avoid the covering and/or destruction of these wells. Implementing the abovementioned 50m buffer area, eleven (11) wells were determined to be affected by the construction of the proposed H2K North-South alignment as summarized in Table 4.5. These wells are owned and operated by both private and government entities. The alignment being a 4-lane highway will easily cover these wells and furthermore may lead to their destruction and/or contamination.

Table 4.5 - Summarizing the wells affected by the proposed H2K Caymanas alignment

Location	*Owner*
Portmore 1 (Test Hole 1)	National Water Commission
Belmore 2	Sugar Company of Jamaica
Cross Pen	United Estates
McConnell CH	National Water Commission
Belmore 3	Sugar Company of Jamaica
Watson Grove 3	National Irrigation Commission
Banbury 4 (Linstead 1)	Windalco

Central Village (White Marl)	National Water Commission
Content (Exp.) H	National Water Commission
Cross Pen Exp. III (well F)	National Water Commission
Content (well H)	National Water Commission

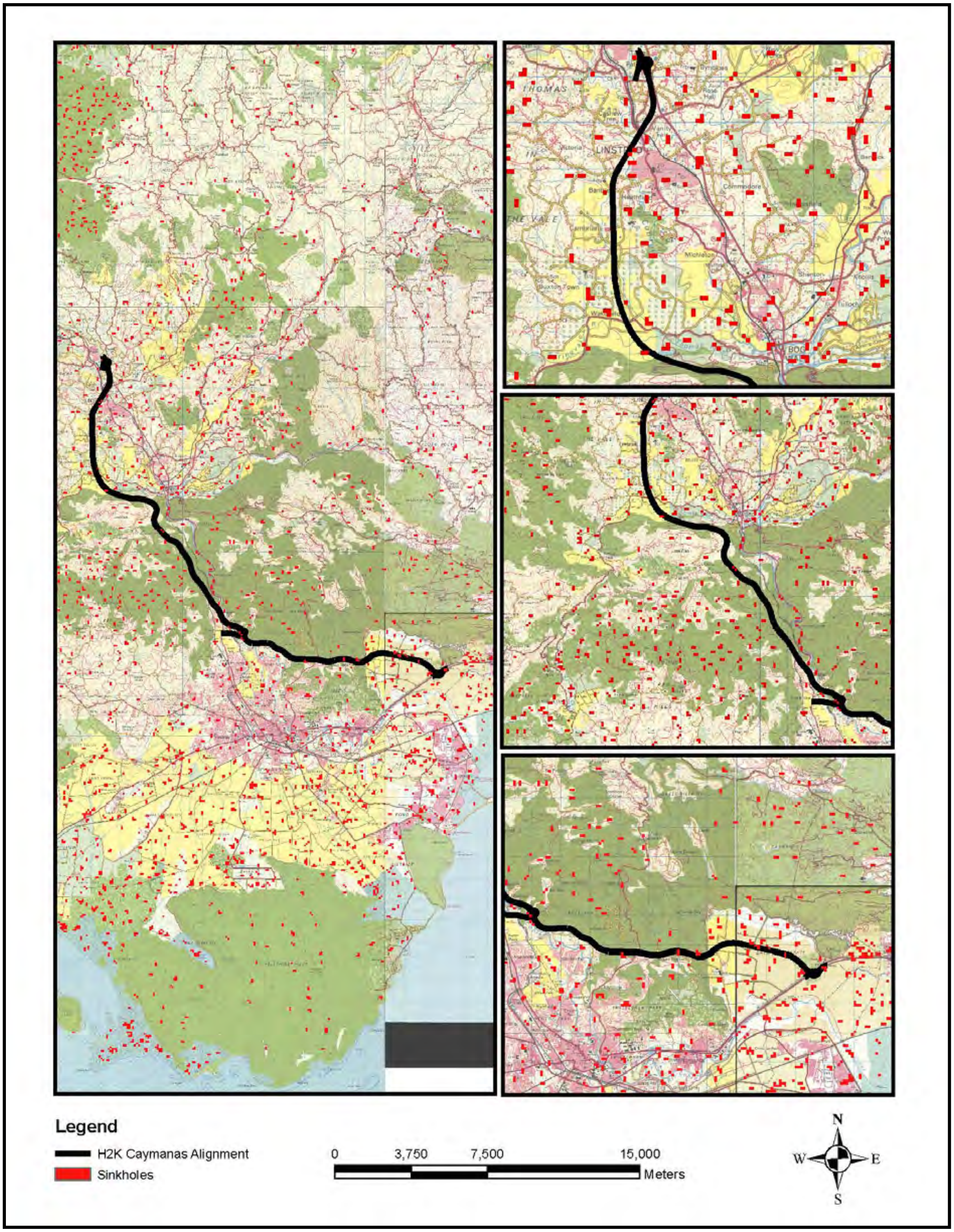


Figure 4-16 - Sinkholes identified along H2K Caymanas alignment

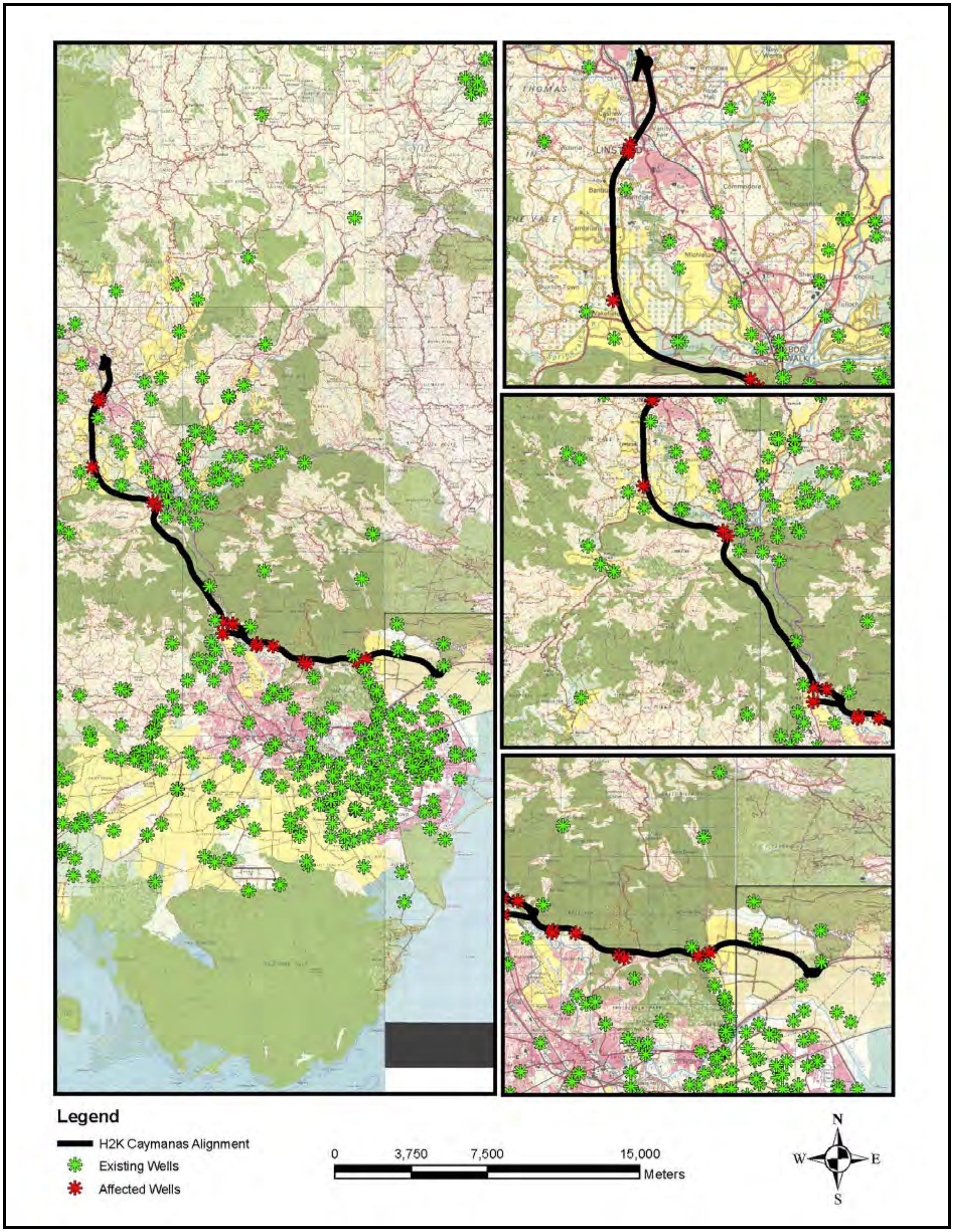


Figure 4-17 - Wells identified within the vicinity of the H2K alignment

4.1.4.2 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 (ArcHydro) 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 4-18. 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 465.9 km^2, extending from Mannings Hill in the east to Thetford mountains in the west and Guys Hill in the north to Christian Pen in the south. The catchment is approximately 30.9 km long at its longest and 29.8 km wide.

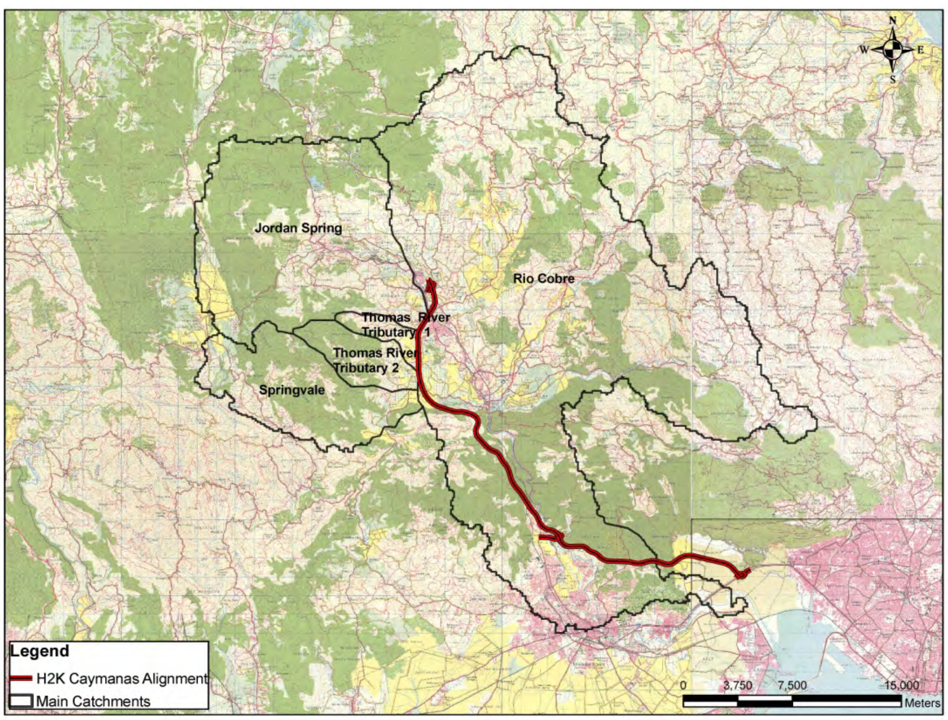


Figure 4-18 - Overall catchment area associated with H2K road alignment

Rivers

Based on the sub-catchments and streams identified, the proposed alignment crosses five rivers (Table 4.6). Four of these rivers cross the alignment within a 4 km radius of Linstead Town while the fifth (Rio Cobre) traverses the alignment in the Angels area (Figure 4-19 and Figure 4-20). These rivers are known to have large flood plains and tend to swell rapidly and overtop their banks during extreme weather.

Table 4.6 - Summary of rivers and associated catchment area that cross the proposed alignment

Nr	River	Crosses Alignment	Catchment Area (km^2)
1	Jordan Spring	0.85km NW of Linstead Town	87.67
2	Thomas River Tributary 1	2.17km West of Michleton Halt	4.06
3	Thomas River Tributary 2	1.42km SE of Buxton Town	5.34
4	Springvale River	1.55km SE of Buxton Town	40.07
5	Rio Cobre	0.53 NW of Content	461.4

TheH2K Caymanas alignment ends at Ferry where Fresh River traverses the existing road. The alignment does not cross the river itself but does impact the overall catchment area of this water source.

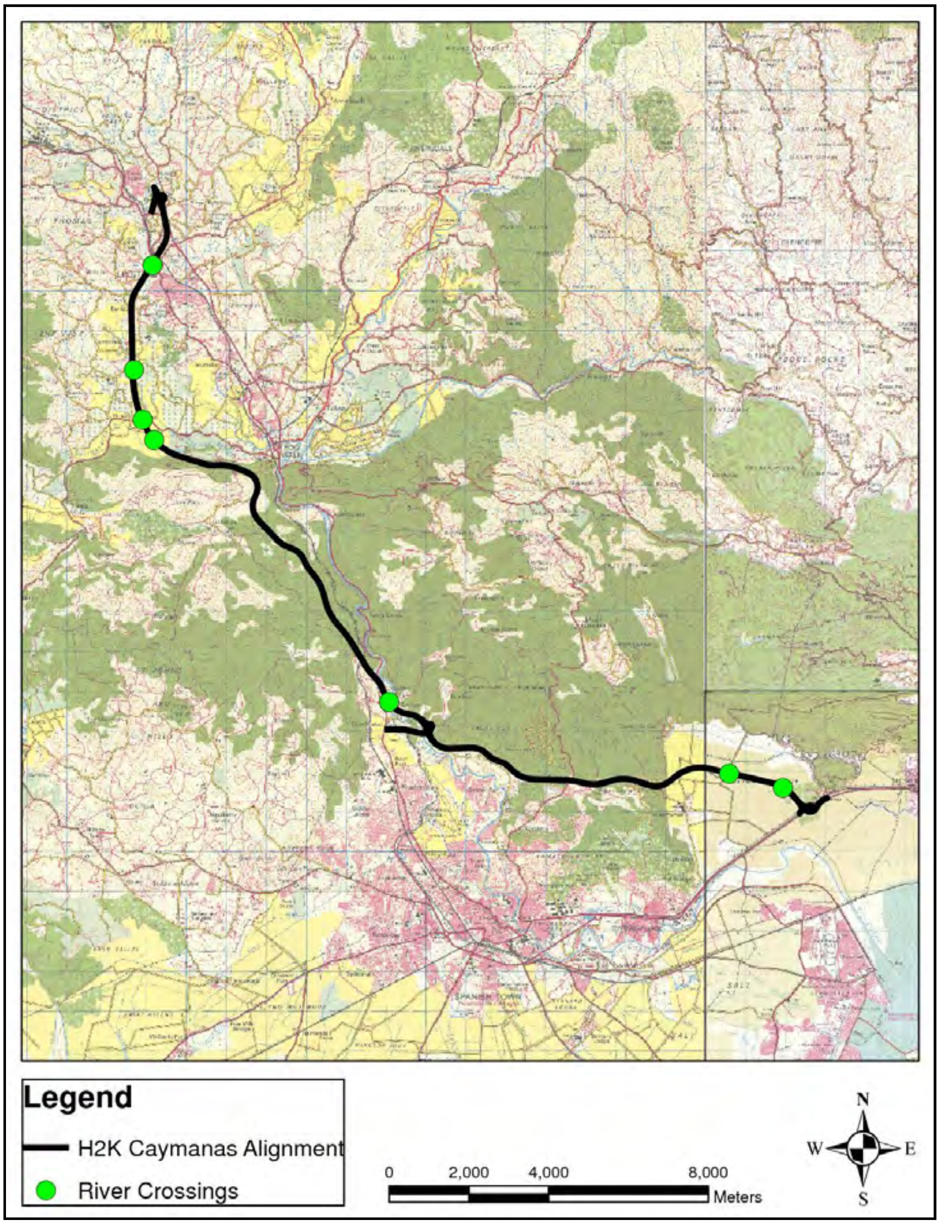


Figure 4-19 - Showing the major rivers which cross the proposed H2K alignment

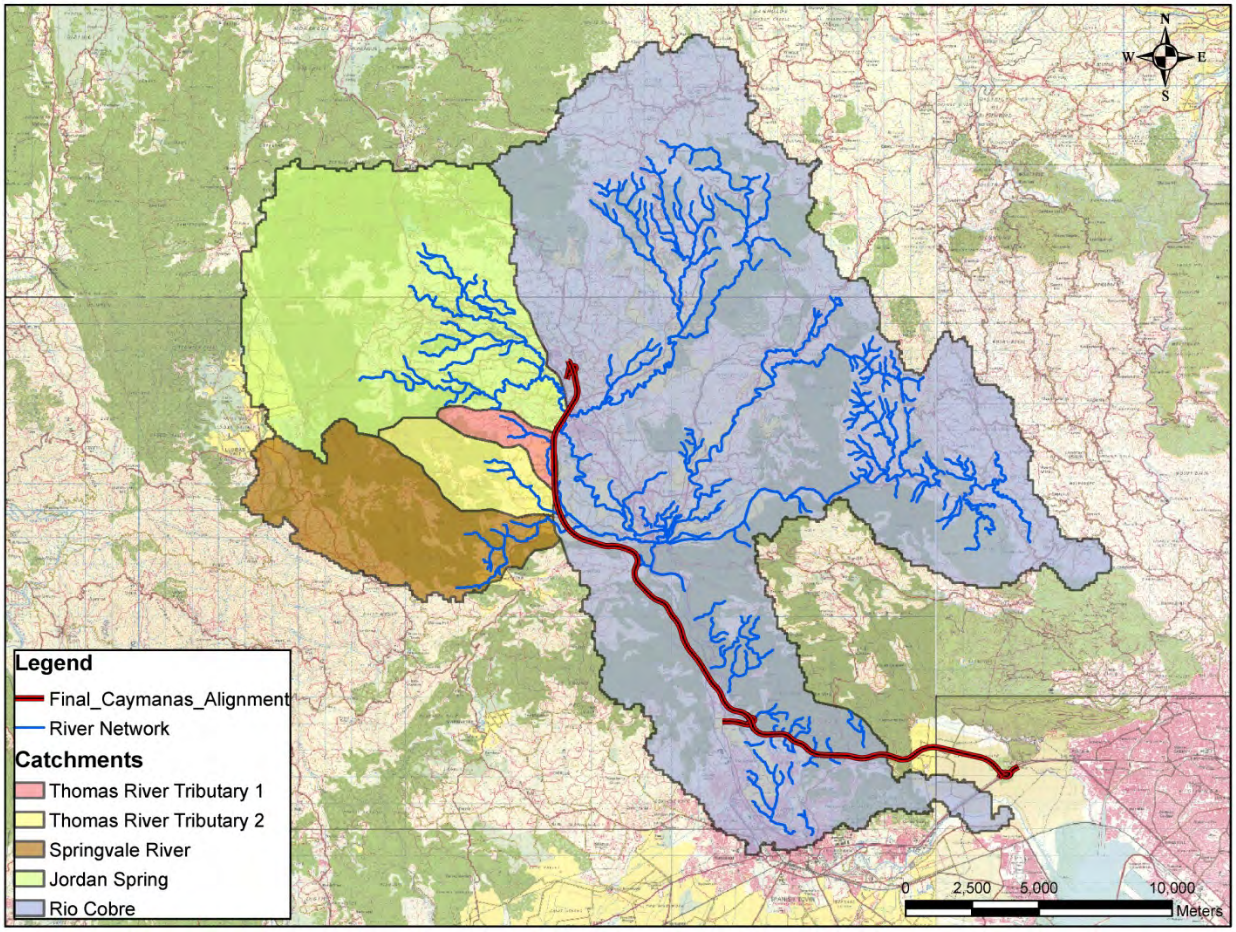


Figure 4-20 - Locations of the flowpaths of major rivers and gullies within each catchment

Jordan Spring

Jordan Spring starts in the north western area of Linstead, more specifically St. Thomas. It crosses the alignment in the vicinity of the Spanish Town Rd, Linstead which is a known flood prone area. Just north-west of the alignment, the Jordan Spring intersects and collects flow from the Byndloss Gully. Furthermore, south-east of the alignment the spring joins the Rio Magno Gully at the same location where Rio Cobre begins. The catchments associated with the spring crossing the alignment is approximately 8,767.20 hectares.

Plate 4.4 - Jordan Spring upstream of H2K alignment crossing

Thomas River

Main Stream (Thomas River Tributary 1) - The Thomas River crosses the alignment from west to east through a sugar cane plantation in the Wakefield vicinity. The total catchment area of this river is approximately 406.09 hectares. The catchment extends as far north as Guys Hill and is bounded on the east by Riversdale. This segment of the Thomas River which crosses the proposed alignment originates in the regions of Victoria, west of Linstead and continues in a south easterly direction until it discharges into the Rio Cobre.

Tributary (Thomas River Tributary 2) - One tributary associated with the Thomas River crosses the Highway 2000 alignment in the Wakefield area, close to the Barry 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 the Thomas River encompass and area of approximately 533.8 hectares. This segment of the Thomas River is one of two main tributaries which cross the proposed alignment.

Plate 4.5 - Main stream of Thomas River where it intersects with proposed alignment

Plate 4.6 - A tributary of Thomas River where it intersects with proposed alignment

Springvale River

The Springvale River, a second tributary associated with Thomas River, originates north of Buxton Town and flows south-east. It intersects the Thomas River while flowing in a southerly direction east of the alignment in the general Wakefield area. The overall catchment area of the Springvale River before it crosses the alignment is approximately 4,006.64 hectares.

Plate 4.7 - Dry riverbed of the Springvale River in absence of a rainfall event.

Rio Cobre

The Rio Cobre originates north of the alignment and flows south-east. It collects flows from the rivers aforementioned in the Bog Walk area and eventually discharges these flows into the sea. Having the largest area, the catchment associated with the Rio Cobre measures 46,140 hectares.

Plate 4.8 - Rio Cobre Dam situated downstream of the proposed alignment crossing

Fresh River

The Fresh River commences from the foothills of Caymanas Bay and continues to flow and discharge into the harbour of Hunts Bay. This river presently traverses Mandela Highway where it eventually discharges into Hunts Bay. The proposed H2K Caymanas alignment ends before it crosses the river along Nelson Mandela Highway but traverses two (2) associated tributaries and is located within the Fresh River catchment (Figure 4-21). Within the plains of Caymanas Estate, the alignment will traverse two tributaries which currently discharge into the Fresh River. These tributaries, spanning 2.45 km and 1.26 km in length, runs through the cultivated lands of Caymanas Estate where sugar cane is farmed. This indicates that appropriate evaluation of the hydrological nature should be conducted and necessary culverts be put in place to facilitate the free flow of runoff into the Fresh River. The overall catchment area of the Fresh River before it crosses the Nelson Mandela Highway is approximately 5298.4 hectares.

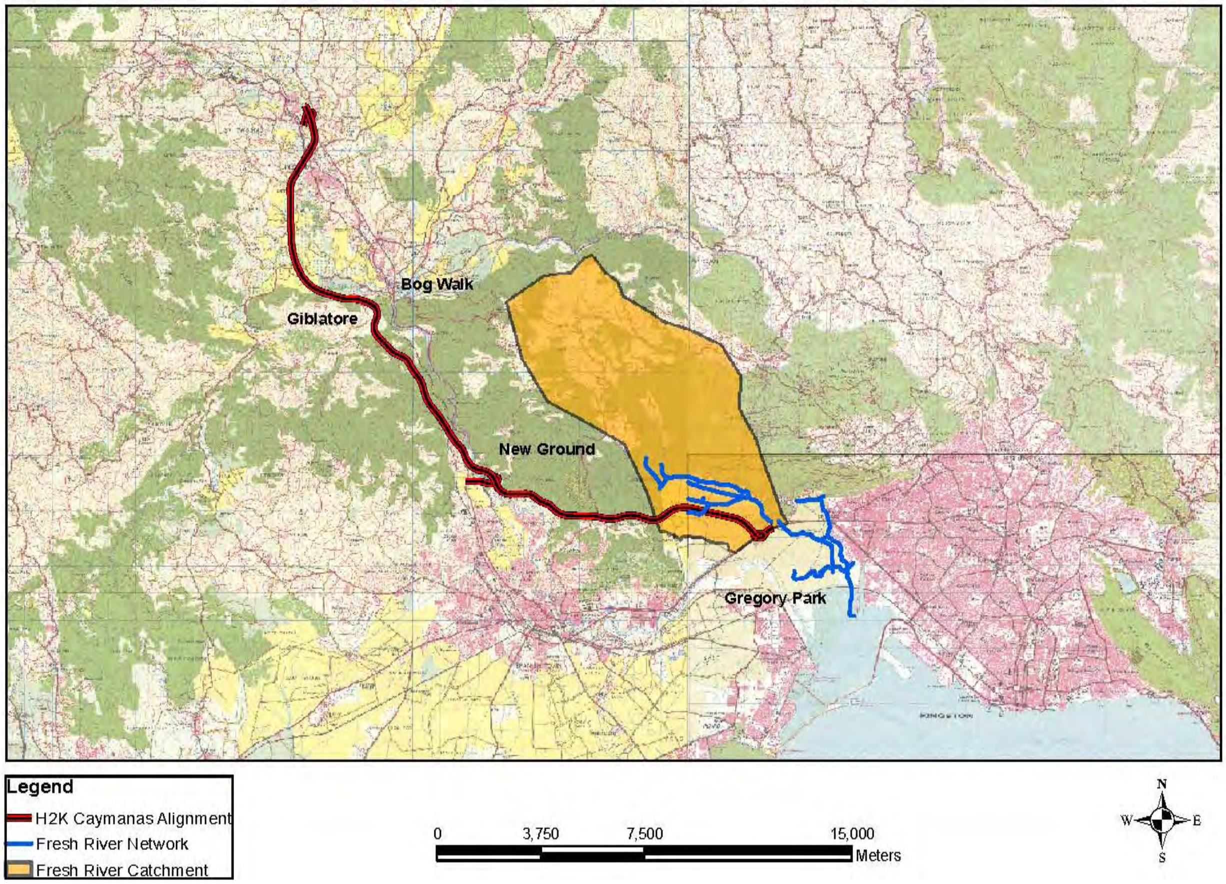


Figure 4-21 - Proposed H2K alignment superimposed on the Fresh River catchment

Anecdotal Information

In order to identify the impacts the highway implementation may have on the surroundings, it was necessary to visit the areas where the alignment cross major streams, especially in developed and known flood prone areas to collect anecdotal information.

A total of twelve (12) effective interviews were conducted with residents with an average age of 40 years and living in the areas an average of 28 years. Interviews were conducted as follows:

- Three (3) near to the Jordan Spring crossing;
- Six (6) in Wakefield near to both tributaries of the Thomas River and the Springvale River crossings;
- Three (3) in the Content area of St. Catherine near to the Rio Cobre crossing.

The interviews recalled 4 storms including Gilbert (1988), Ivan (2004), Dean (2007) and Gustav (2008). The resulting average observations are summarized in Table 4.7 and represented in Figure 4-22.

The three (3) interviewees at the Jordan Spring intersection reported flooding whenever it rains heavily. Hurricanes Ivan, Gustav and Gilbert were all reported to have caused flood levels reaching up to the underside of the existing bridge on the alignment. These levels equate to approximately 4 metres above the riverbanks. As a result, the bridge is sometimes impassable and houses nearby experience flooding. In addition, the torrential rainfall of June 2002 generated flood levels of 1.5m above the ground. It was also noted that the intersection of Jordan Spring with Rio Magno Gully experiences backflow up Jordan spring when produces heavy rains occur.

Similarly, the first tributary of the Thomas River (Thomas River Tributary 1) is reported to generate flood levels of up to 1.5 metres above ground level in the sugar cane fields close to Wakefield. The segment closer to the Barry Main Road (Thomas River Tributary 2), however, experience flooding of up to 1.2 metres above the river banks, causing floods throughout the citrus orchard and sugar cane fields during the October rains in 2010. Debris such as mud and brushes can be found flowing downstream.

Residents reported observing flood levels of up to 1.2 m close to the Springvale River intersection with the alignment during hurricanes Ivan, Dean and Gustav. As a result, portions of the sugar cane and citrus crops were destroyed. The flooding waters typically have debris flow such as broken tree branches.

All three interviewees along Rio Cobre near the alignment recollected flood levels during hurricanes Ivan, Dean and Gustav of up to 1.2m while the 2002 June rains and had flood levels of up to 1.8m above the banks. It was also noted that the Dam was forced open by the waters causing the water levels to rise and the water overflowed into the adjacent canal. During this particular flood, debris such as trees, animals and old household items could be seen flowing downstream.

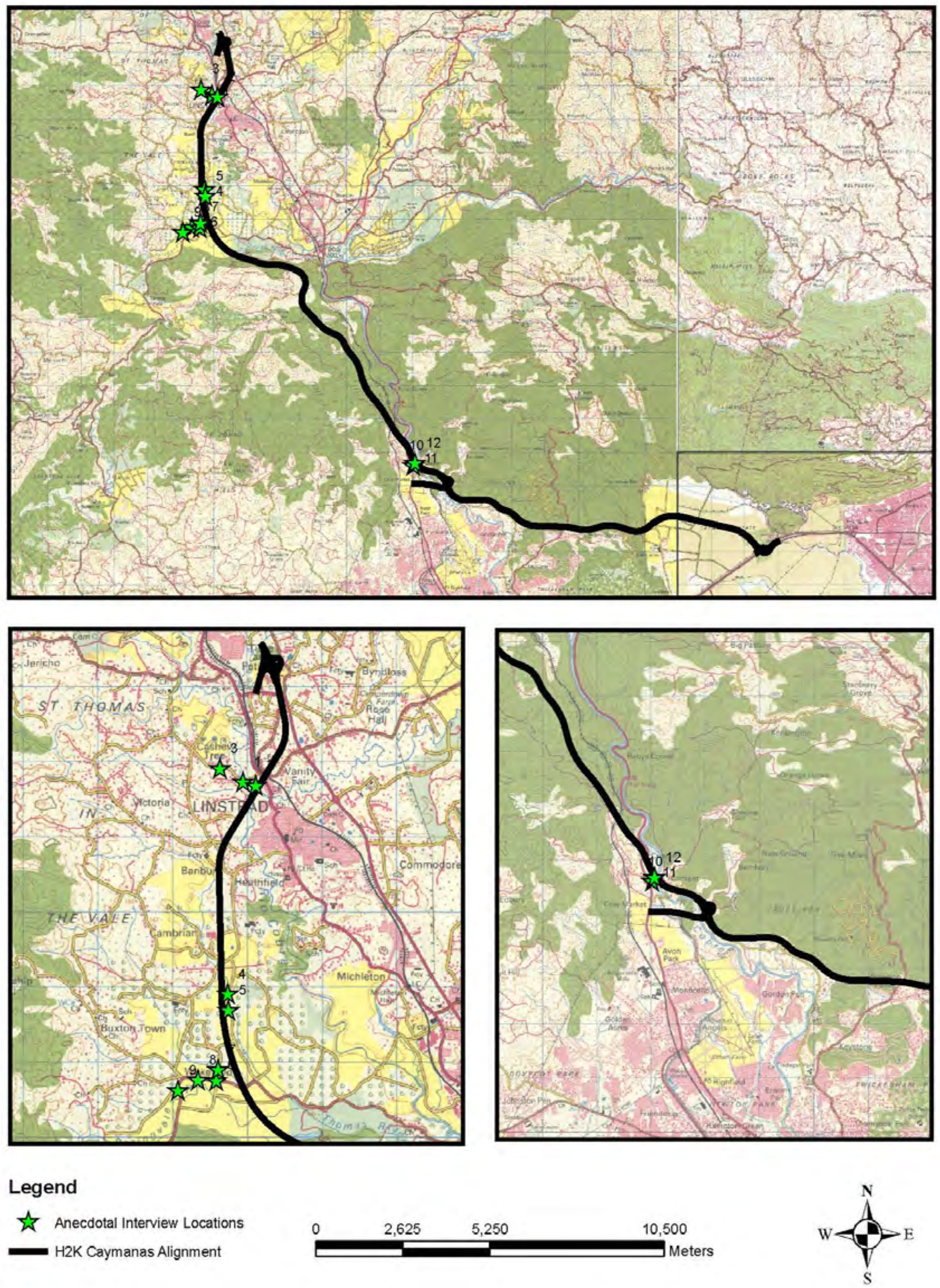


Figure 4-22 - Interview locations conducted along the H2K Caymanas alignment at river crossings

Table 4.7 - Summary of anecdotal information collected along H2K proposed alignment

River	ID	Name	Age (years)	Time lived in area (years)	Storm(s)	Year(s)	Flood depths (m)	Location	Debris Flow	Comments
Jordan Spring	1	Clive Walker	36	29	Ivan Dean Gustav	2004 2007 2008	0.5	Linstead	Bamboo, trees	Water levels reach underside of bridge
	2a	Glenmore Edwards	33	16	Dean Gustav	2007 2008	1	Linstead	Bamboo, trees, zinc	Banana, Plantain crops destroyed
	2b	Glenmore Edwards	33	16	October Rains	2010	0.5	Linstead	mud, brushes	Banana, Plantain crops destroyed (See Plate 4.9)
	3a	Clinton Brown	39	35	Ivan Dean Gustav	2004 2007 2008	0.5	Linstead	tree branches, household items	Intersection with Rio Magno Gully causes the Spring back up and overflow its banks
	3b	Clinton Brown	39	35	June Floods	2002	1.5	Linstead	tree branches, mud	Houses adjacent to banking experience flooding
Thomas River Tributary 1	4	Linton Edwards	64	64	Gilbert Dean Gustav	1988 2007 2008	1.2	Wakefield	brushes, logs, mud	Young citrus and sugar cane crops flood
	5	Jason Allen	45	38	Ivan Gustav	2004 2008	1.5	Wakefield	brushes, mud	Crops experience flooding
Thomas River Tributary 2	6a	Scott Newman	40	35	Ivan Dean Gustav	2004 2007 2008	1	Wakefield	mud, brushes	Depressions on the Barry main road produced by heavy farming equipment.
	6b	Scott Newman	40	35	October Rains	2010	0.5	Wakefield	mud, brushes	Water levels covers private road on plantation owners property
	7	Clifton Davis	52	45	Gilbert Dean Gustav	1988 2007 2008	1.2	Wakefield	Bamboo, trees	Citrus orchard and sugar cane crops flood
Springvale River	8	Burru Cox	28	17	Dean Gustav	2007 2008	1.2	Wakefield	mud, plastic bottles	Barry main road experience flooding (See Plate 4.10)
	9	Chevan	22	12	Ivan	2004	0.8	Wakefield	bamboo, mud,	Crops experience flooding

River	ID	Name	Age (years)	Time lived in area (years)	Storm(s)	Year(s)	Flood depths (m)	Location	Debris Flow	Comments
		Gordon			Dean	2007			logs	(See Plate 4.11)
Rio Cobre	10	Judith Boxx	46	12	June Floods	2002	1.5	Rio Cobre Dam	trees, household items	Dam destroyed; water levels reach height of dam wall
	11a	Norval Cunningham	32	13	Dean Gustav	2007 2008	1.2	Rio Cobre Dam	bamboo, trees	Water overflows the bank.
	11b	Norval Cunningham	32	13	June Floods	2002	1.8	Rio Cobre Dam	trees, animals, vehicles	Water levels reach height of dam wall and overflows into canal
	12a	Winston Curtis	39	36	Ivan Dean Gustav	2004 2007 2008	1.2	Rio Cobre Dam	bamboo, trees, animals	Banana crops on adjacent property destroyed
	12b	Winston Curtis	39	36	June Floods	2002	1.5	Rio Cobre Dam	trees, plastic bottles	Dam destroyed; Water levels reach height of dam wall and overflows into canal (SeePlate 4.13)

Plate 4.9 - Farmer Glenmore Edwards identifies the flood levels caused by Jordan Spring during torrential rainfall almost 20ft above the river bed.

Plate 4.10 - Resident Burru Cox illustrates the typical flood levels within the cane fields near Springvale River during heavy rainfall events.

Plate 4.11 - Resident Chevan Gordon identifies the flood levels produce by heavy rainfall events near Springvale River.

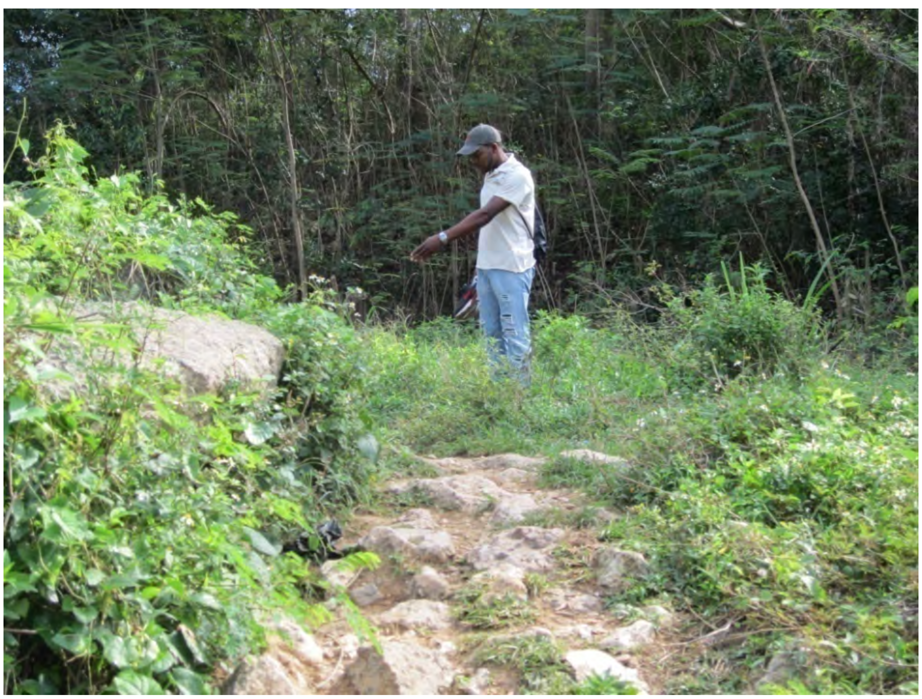


Plate 4.12 - Resident Norval Cunningham illustrates that water levels generated during the June 2002 floods.

Plate 4.13 - Flood levels of the Rio Cobre during the June 2002 floods.

Flood Prone Areas along Alignment

A 2007 study[2] conducted for NROCC highlighted several flood prone areas extending from of Bog Walk to the northern termination point. It was reported that flooding was due mainly to ponding and overflowing of the Rio Cobre. See Plate 4.14 which shows the Rio Cobre in spate in a 2008 photo and Plate 4.15 which shows the Jordan Spring north of the proposed alignment.

Plate 4.14 - 2008 Photo of the Rio Cobre in spate east of the existing road alignment in Bog Walk

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[2] Improvement and Widening of A1 Highway Bogwalk to Linstead & Moneague to Golden Grove, Dessau International in conjunction with Environmental Solutions Limited.

Plate 4.15 - 2012 Photo taken of the Jordan Spring north of the proposed highway alignment in Linstead

More importantly, flooding can be influenced by blocked drains which limit the transmission of floodwaters through the channel and across the existing road embankments. Plate 4.16 identifies the blockage of a segment of the Springvale River located under an abandoned bridge. This prohibits the free flow of the river which consequently overflows its banks and floods the surrounding fields and settlements.

The low-lying areas within which the citrus and cane fields are situated also contribute to the events of floods in the area (Plate 4.17). These regions are prone to flooding as they create a ponding effect, similar to wetlands.

Plate 4.16 - A section of the Springvale river blocked by rubble.

Plate 4.17 - Thomas River flowing through low lying cane fields in Wakefield

ODPEM currently maintains a list of the main flood prone areas in Jamaica which includes the areas of Linstead, Bog walk and Caymanas Gardens. Online research revealed several newspaper articles highlighting flooding in areas close to the alignment. These areas include Wakefield, Linstead and adjoining communities.

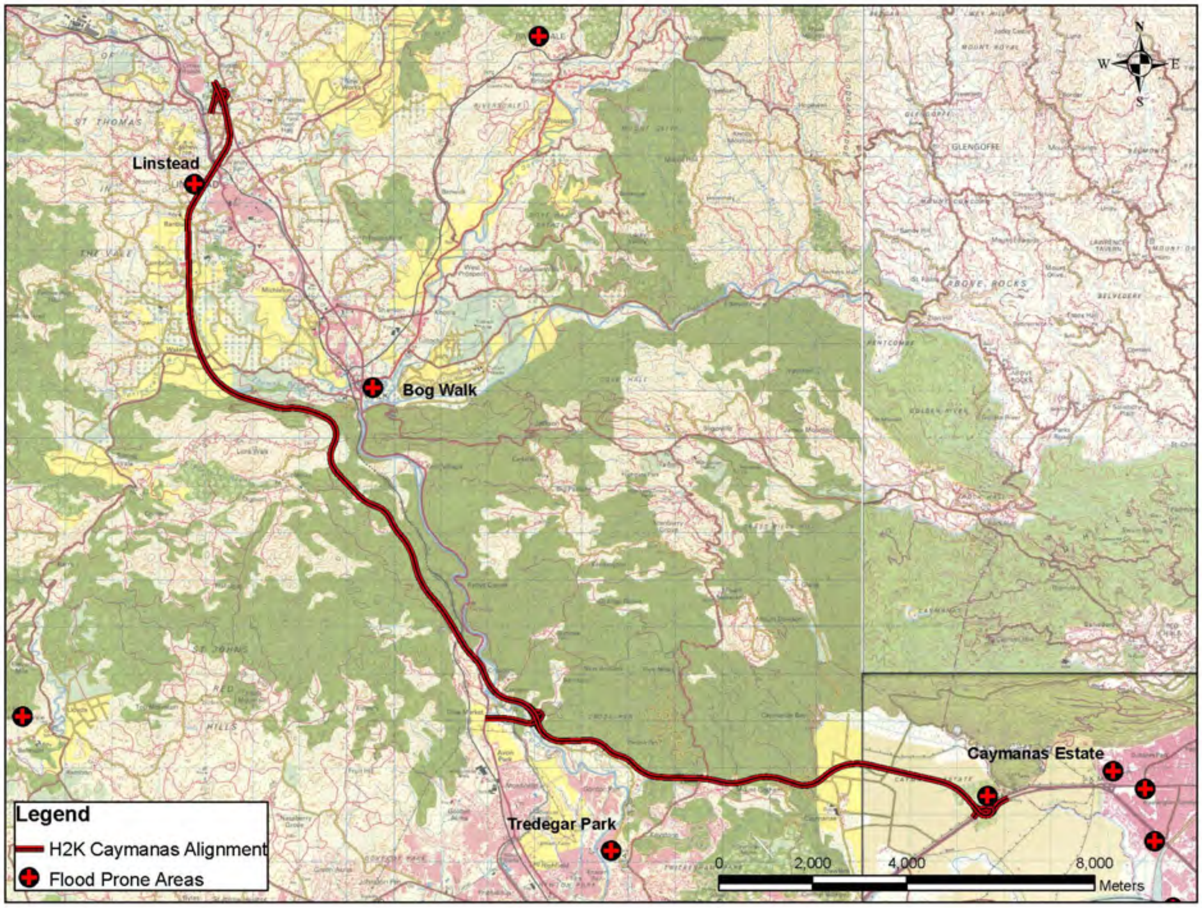

Figure 4-23 - Flood prone areas near to the alignment as identified on ODPEM website

4.1.4.3 Meteorology

Climate Change Effects on Extreme Rainfall

Method

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.

Results

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.

Table 4.8 - 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%

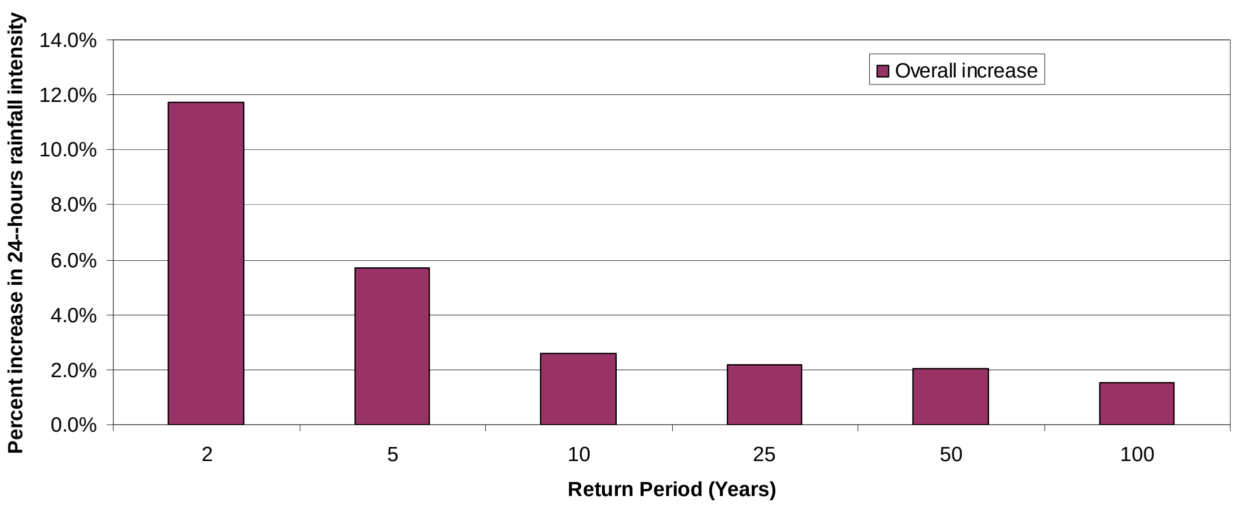

Figure 4-24 - Overall increase in 24-hours rainfall intensity for the period between 1988 and 2009

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 Met office of Jamaica.

Catchment Gauges

The raingauge locations were superimposed on the catchment areas to determine rainfall depths that will be used in the hydrology model (Figure 4-15). A total of 36 gauges were noted inside of and within 4 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 4.9 for the current intensities as well as the recommended design values.

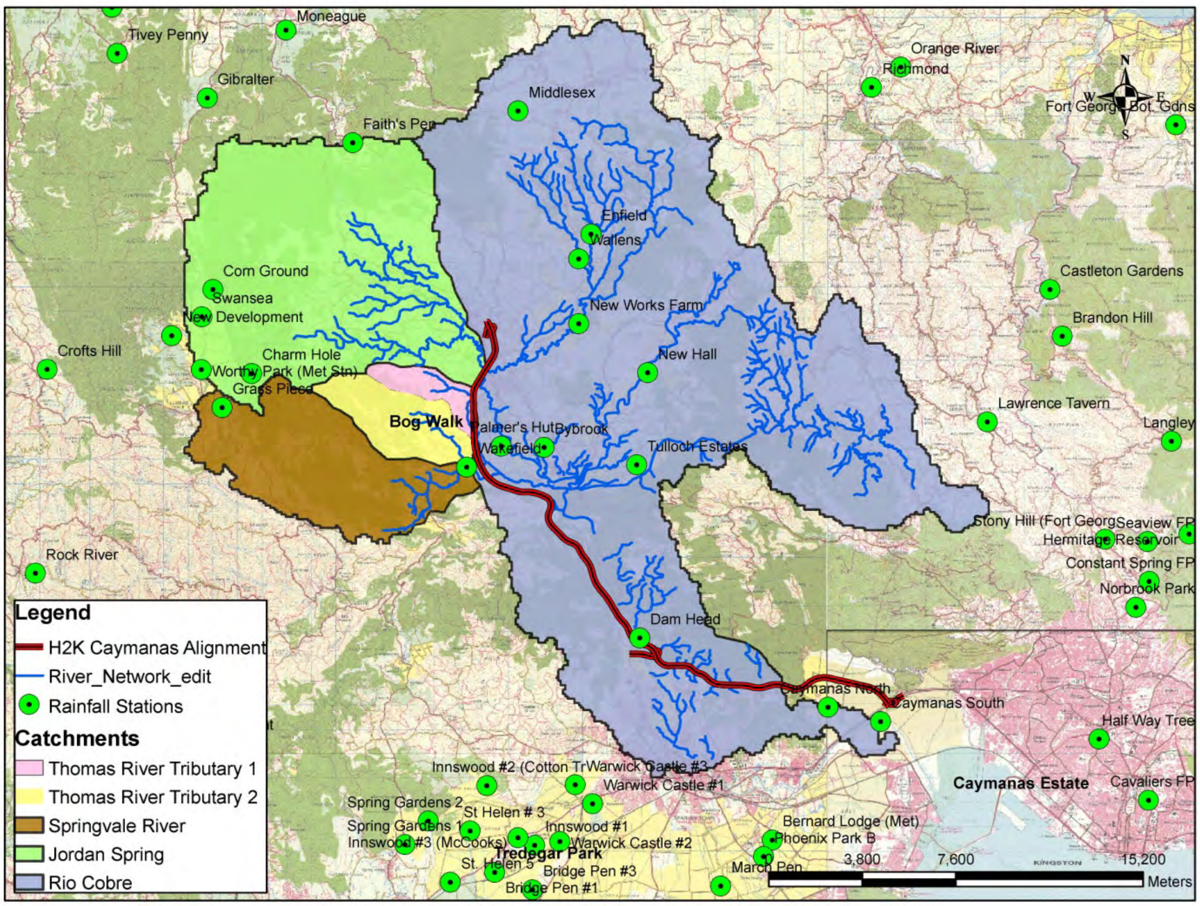

Figure 4-25 - Rainfall gauges within the study area

Table 4.9 - Rainfall intensities recorded by gauges inside of and within 4 km of the overall catchment boundaries

Station Name	CURRENT RAINFALL DEPTHS (mm/24 hr)				RECOMMENDED DESIGN RAINFALL DEPTHS (mm/24 hr)			
	10	25	50	100	10	25	50	100
Brandon Hill	274.7	318.3	349.5	379.5	299.4	342.2	375.7	399.4
Cavaliers FP	346.3	468.7	571.6	682.3	377.5	503.9	614.5	718.1
Constant Spring FP	200.8	240.6	269.5	297.4	218.9	258.7	289.7	313.1
Half Way Tree	182.5	230.0	265.5	300.8	199.0	247.3	285.5	316.6
Langley	359.9	451.2	520.2	589.3	392.3	485.0	559.2	620.2
Lawrence Tavern	269.9	358.3	430.0	505.0	294.2	385.2	462.2	531.6
Norbrook Park	359.9	451.2	520.2	589.3	392.3	485.0	559.2	620.2
Seaview FP	269.9	358.3	430.0	505.0	294.2	385.2	462.2	531.6
Stony Hill (Fort George)	241.8	297.2	339.1	381.2	263.6	319.5	364.6	401.2
Faith's Pen	224.2	257.5	281.0	303.4	244.3	276.9	302.1	319.3
Middlesex	250.1	274.3	290.7	305.9	272.6	294.9	312.5	321.9
Bernard Lodge (Met)	254.4	300.5	332.2	361.9	277.3	323.0	357.1	380.9
Bybrook	193.2	225.4	248.7	271.4	210.6	242.3	267.3	285.6
Caymanas North	225.4	277.3	316.6	355.9	245.7	298.1	340.4	374.6
Caymanas South	198.8	232.9	257.8	282.0	216.7	250.4	277.1	296.8
Charm Hole	292.9	344.1	382.3	420.2	319.3	369.9	411.0	442.2
Corn Ground	310.9	386.4	443.5	500.6	338.9	415.4	476.8	526.9
Dam Head	228.1	263.6	290.4	317.2	248.6	283.4	312.2	333.9
Enfield	212.8	266.4	306.8	347.2	232.0	286.4	329.8	365.4
Grass Piece	266.9	327.1	372.6	418.1	291.0	351.6	400.6	440.1
Innswood #2 (Cotton Tree)	194.3	221.2	240.4	258.7	211.8	237.8	258.4	272.3
New Development	288.3	361.8	418.1	474.9	314.2	388.9	449.5	499.9
New Hall	199.6	237.9	265.7	292.6	217.6	255.8	285.6	308.0
New Works Farm	234.0	300.4	351.6	403.4	255.1	322.9	377.9	424.6
Palmer's Hut	269.0	353.2	416.3	479.1	293.2	379.6	447.5	504.3
Phoenix Park B	209.0	231.6	247.2	261.9	227.9	249.0	265.8	275.7
Swansea	229.8	259.1	280.2	300.4	250.5	278.6	301.2	316.2
Tulloch Estates	214.6	247.8	272.0	295.5	233.9	266.4	292.4	311.0
Wakefield	239.2	309.8	364.5	420.1	260.8	333.1	391.9	442.2
Wallens	196.7	231.4	255.9	279.2	214.4	248.8	275.1	293.8
Warwick Castle #1	206.6	256.3	293.9	331.4	225.2	275.5	315.9	348.8
Warwick Castle #3	252.5	331.8	395.1	460.9	275.2	356.7	424.8	485.1
Worthy Park (Met Stn)	254.0	302.3	338.6	382.8	276.9	324.9	364.0	402.9
Castleton Gardens	270.1	326.0	367.8	409.4	294.4	350.4	395.4	430.9
Orange River	250.0	292.7	323.7	353.9	272.5	314.7	348.0	372.5
Richmond	209.4	225.0	235.4	245.0	228.2	241.9	253.1	257.9

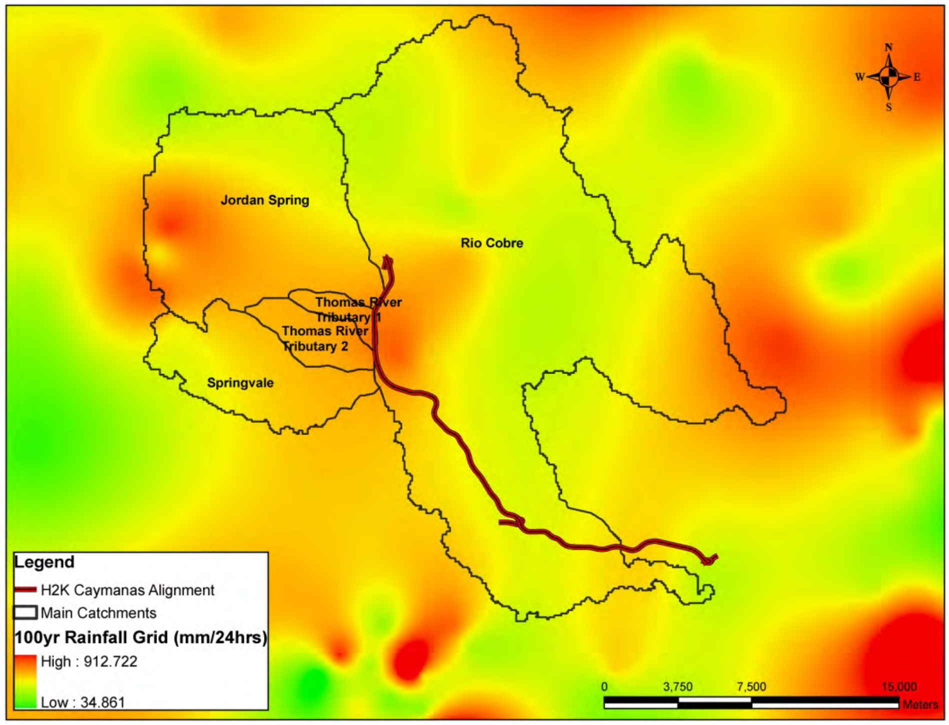

Figure 4-26 - Isohyetal map of the project area

4.1.4.4 Hydrological Modelling

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

The 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)

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 4.10 for the present and future scenarios.

Table 4.10 - Weighted rainfall depth determined for each watershed

Watershed	***Weighted Rainfall Depths (mm/24 hr)***					
	Jordan Spring	**Thomas River Tributary 1**	**Thomas River Tributary 2**	**Springvale River**	**Rio Cobre**	**Fresh River**
Current rainfall	382	426	423	406	336	292
Recommended design rainfall based on Climate Change	402	448	446	428	354	307

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).

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 4-27. It was found that all the catchments had high proportions of Clay loam and Stony loam. The soil types are distributed across the catchments as follows:

1) The outer catchment basin area of the Jordan Spring has high concentration of stony loam while the interior basin has significantly high proportions of clay loam.
2) The first tributary of Thomas River (Thomas River Tributary 1) which forms a part of the Rio Cobre basin has over sixty percent (60%) stony loam with the remaining segments being clay loam.
3) The second tributary of Thomas River (Thomas River Tributary 2) has over eighty percent (80%) stony loam.
4) Majority of the Springvale River catchment comprises of stony loam with the remaining areas having an almost even distribution of clay and clay loam
5) The catchment associated with Rio Cobre has over thirty percent (30%) clay loam material with high proportions of sandy loam.

Land Use

The Land use for each catchment was determined from inspection of the Forestry Department land use map seen in Figure 4-28, as well as satellite imagery of the catchments. The following was noted:

1) The Jordan Spring catchment were observed to have mostly forests, fields and crops with residential settlements on lots more than 1/4 acres in area. The lower reaches of the catchments however had small portions of urban space.
2) Thomas River catchments were comprised primarily of forests and cultivated areas.
3) The Springvale River catchment consists of solely crops, forests and cultivated fields
4) The catchment associated with the Rio Cobre was determined to have significantly high concentrations of forests, fields and crops (over 80%). Concentrations of urban space were identified along the western and southern reaches of this catchment.

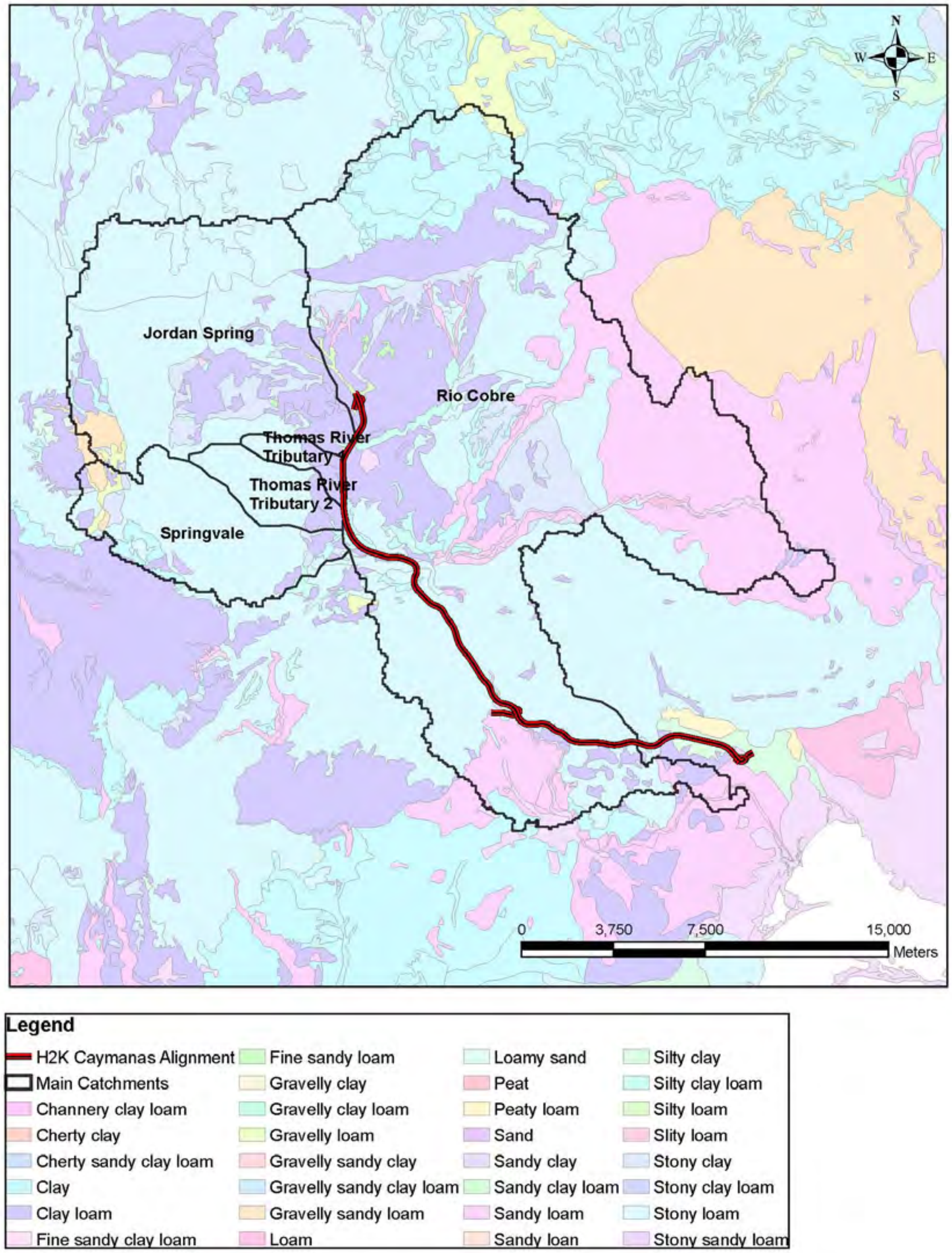

Figure 4-27 - Catchment areas superimposed on soils map of Jamaica

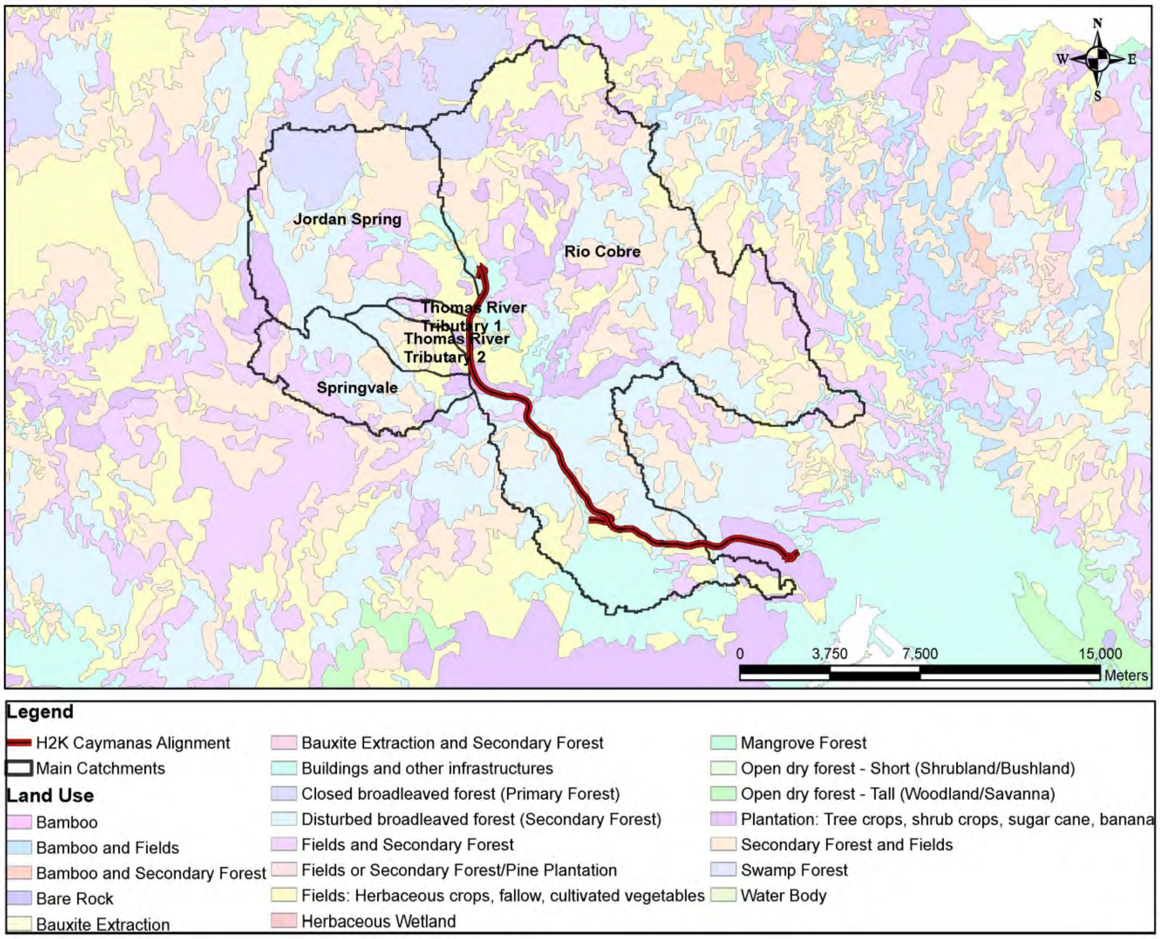

Figure 4-28 - Land Use map of Jamaica with superimposed catchments and highway alignment

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 4.11. The curve numbers for existing conditions were selected for the catchments were as follows:

1) Jordan Spring - 46 (based on the soil composed mainly of clay and the area being predominantly open fields and forests);
2) Thomas River Tributary 1 - 40 (based on the mixed soil composed of stony loam and clay with the area being predominantly cultivated fields and forests);

3) Thomas River Tributary 2 - 40 (based on the soil composed of stony loam and the area being predominantly cultivated fields and forests);
4) Springvale River - 30 (based on the soil composed of stony loam and the area being predominantly cultivated fields and forests);
5) Rio Cobre - 40 (based on the soil texture being a mixture of sandy and clay loams with high proportions of fields and forests).

Table 4.11 - Curve numbers corresponding to soil type and land use

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
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 4.12 below. The development of the highway will impact the curve number and runoff by no more than 0.2% 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 4.12 - Curve Numbers used in SCS model

Curve Number (CN):	***Watershed***				
	Jordan Spring	**Thomas River Tributary 1**	**Thomas River Tributary 2**	**Springvale River**	**Rio Cobre**
Existing Conditions	46	40	40	30	40
Existing Conditions with H2K	46	40	40	30	40
Future Developed Areas	51	44	44	33	44

Runoff

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

- Drainage area size (A) in square miles (square kilometres);
- Time of concentration (Tc) in hours;
- Weighted runoff curve number (RCN);
- Rainfall distribution (see Figure 4-29);
- Total design rainfall (P) in inches (millimetres).

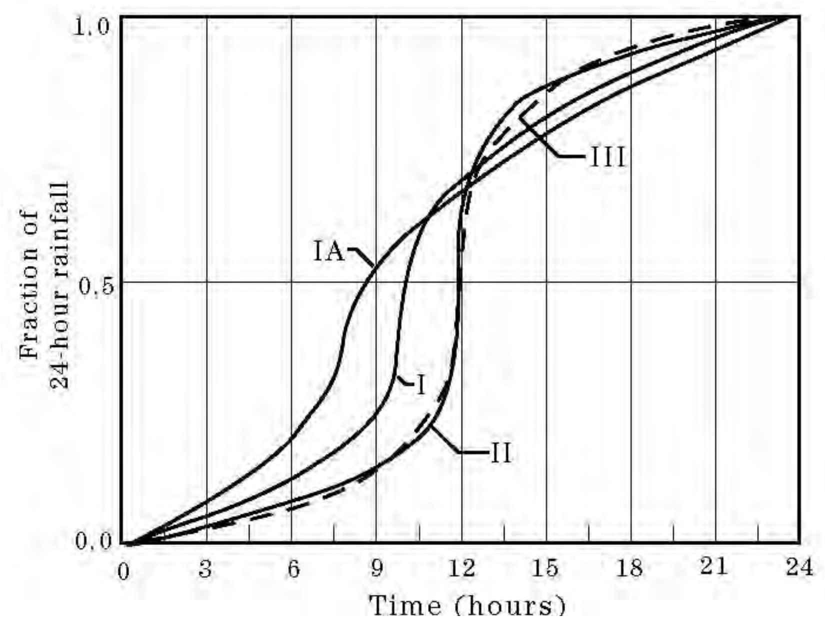

Figure 4-29 - SCS 24-hour Rainfall Distributions

The runoff generated for each catchment where the rivers cross the alignment varies from 110.1 to 3,954.6 cubic metres per second for the existing condition, 111 to 3,999.2 cubic metres per second and 128.1 to 4,829.3 cubic metres per second for the expected future flows. The Thomas River generated the lowest flows while the Rio Cobre produced the largest peak flows. See Table 4.13 for a summary of the runoffs generated for each catchment and respective scenario.

Table 4.13 - Runoff generated for the different catchments impacted by the H2K Caymanas alignment

Hydrology	***Units***	***Location***				
		Jordan Spring	***Thomas River 1***	***Thomas River 2***	***Springvale River***	***Rio Cobre***
Catchment area	HA	8767	406	534	4007	46140
Return period	Years	100	100	100	100	100
Peak runoff						
Existing Condition	m^3/sec	1481.3	110.1	145.7	512.1	3954.6

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.

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 report concluded that common fill materials will be sourced primarily from excavations. However since the cut areas are expected to be in weak limestone, the sub-base, base, concrete and pavement aggregates will have to be sourced from quarries in May Pen or St Thomas.

The closest quarries to the project are located at distances varying from 3 km to 30 km in proximity to the highway alignment.

See Table 4.14 and Figure 4-30 below for the 9 closest quarries in operation to the alignment. Most 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 4.14 - Summary of quarries in proximity to the H2K alignment and their respective characteristics

Location	Parish	Owner	Licence	Distance from H2K (km)	Rock Type
Ferry	St. Andrew	Black Brothers Inc.	--	3.1	Limestone
Bog Walk	St. Catherine	Gloria Matladeen	QL-1365	5.08	Marl
Bog Walk	St. Catherine	Tulloch Estates	QL-485	8.37	Limestone
Braeton	St. Catherine	Gladstone Francis	QL-1566	8.57	Limestone
New Hall	St. Catherine	Kent Industries	QL-1601	10.28	Sand
Harkers Hall	St. Catherine	Leon Martin Dixon	QL-1298	12.94	Sand
Hill Run	St. Catherine	Mogul Construction	QL-1323	16.45	Limestone
Above Rocks	St. Catherine	Agatha Gooden	QL-1516	20.09	Sand
Lawrence Tavern	St. Andrew	Karl Soutar	QL-1395	29.93	Sand

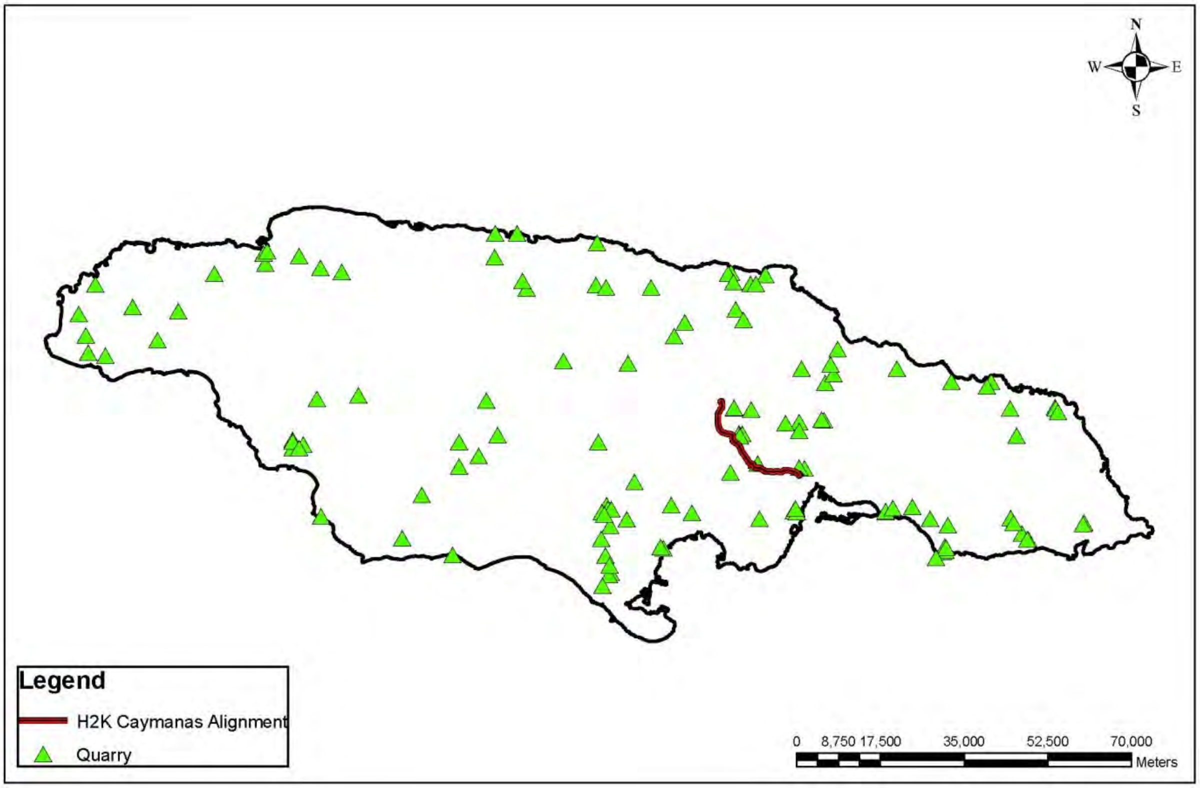

Figure 4-30 - Spatial Distribution of Quarries in Jamaica

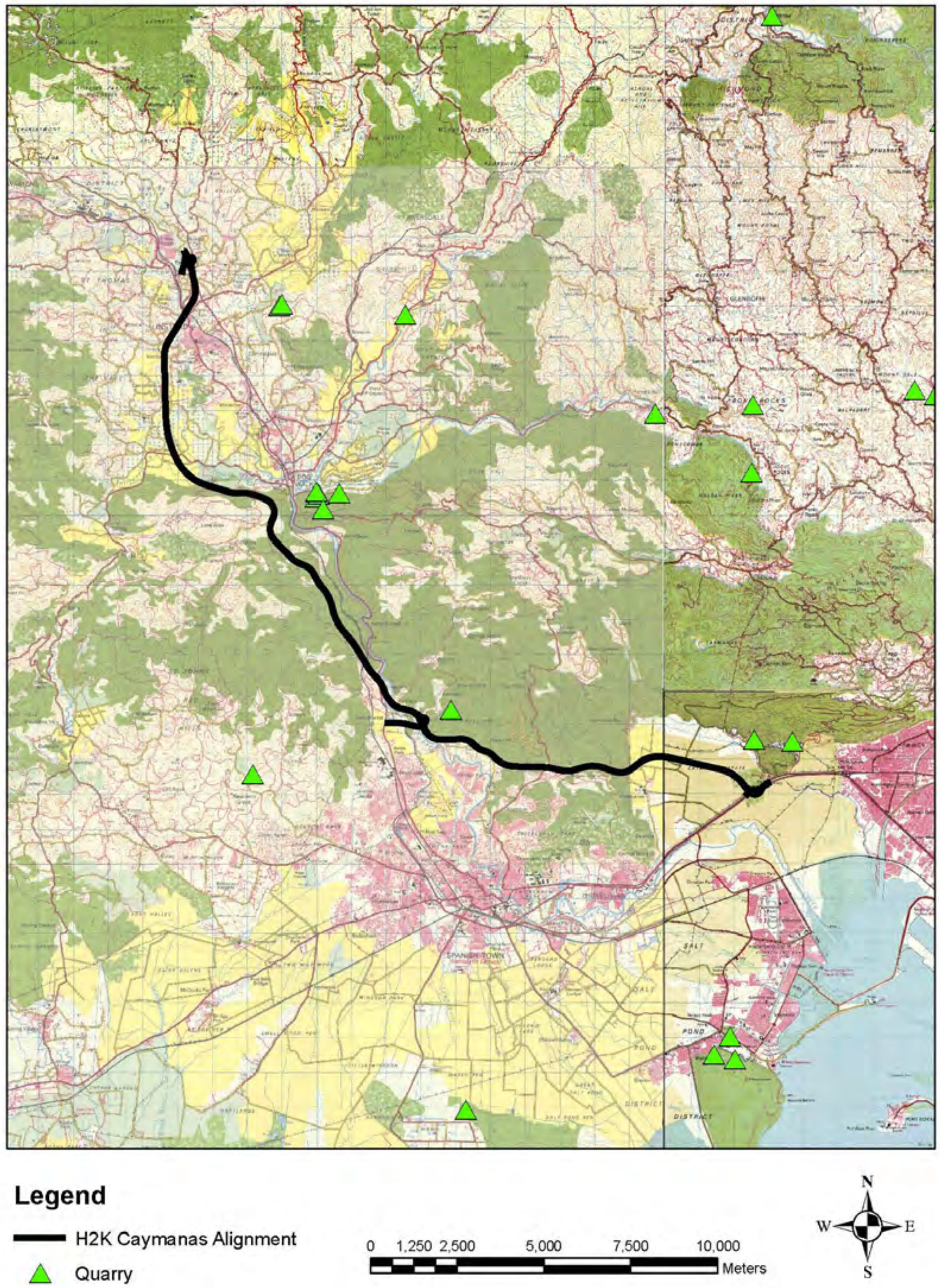

Figure 4-31 - Spatial distributions of quarries in close proximity to the proposed H2K Caymanas alignment

4.1.6 Hazards

4.1.6.1 Landslides

The Bog Walk Fault zone consists of a broad belt of mainly limestones that have been extensively brecciated (Plate 4.2). The brecciation will result in potentially unstable slopes being exposed during and after construction of the highway, so the potential for landslides is high. If the highway route also intersects slivers of volcaniclastic rocks (Cretaceous units), presently just west of the proposed route in the Giblatore area (Figure 4-11) this potential will become even higher. Active landslides have been encountered along, or in the vicinity of, the proposed highway route (Plate 4.18 and Plate 4.19). Of particular note are the fissile brecciated units associated with the fault zone in which they occur as these are found along the proposed highway route (Plate 4.19).

Plate 4.18 - Land slip on the southern edge of the fault zone exposed along the main road at the northern entrance to the Bog Walk Gorge (Walderston formation). This location is within the same Bog Walk Fault zone as will be traversed by the proposed highway.

Plate 4.19 - Soft (can be penetrated with cutlass in photo) brecciated material prone to land slips in fault zone (Undifferentiated Troy/Claremont and Somerset formations)

It was necessary to assess the landslide vulnerability of the environs within the project area given the mountainous areas which the alignment traverses. A simplified approach was taken to assess the vulnerability of the present alignment to landslides, by creating and calibrating GIS model using the landslide inventory from ODPEM, Roads inventory from Survey Department, Faults inventory from Mines and Geology, Soils inventory from Ministry of Agriculture and the topography of Jamaica from Quickbird satellite radar data.

The methodology employed in assessing the landslide vulnerability is as follows:

1. Data collection to include:
    a. Topographic data of Jamaica

   b. Existing landslides inventory for Jamaica
   c. Soils inventory map
   d. Faults map of Jamaica
   e. Roads network
2. Preliminary data analysis
3. Calibration
4. Prepare landslide susceptibility maps

Data Collection and Preliminary Analysis

Landslides

Data was collected regarding observed landslides throughout island of Jamaica. Preliminary examinations revealed number of observed landslides within the inventory was determined to be 2,983. These landslides varied in magnitude but were concentrated in the eastern part of the island. The existing landslides are displayed in Figure 4-32.

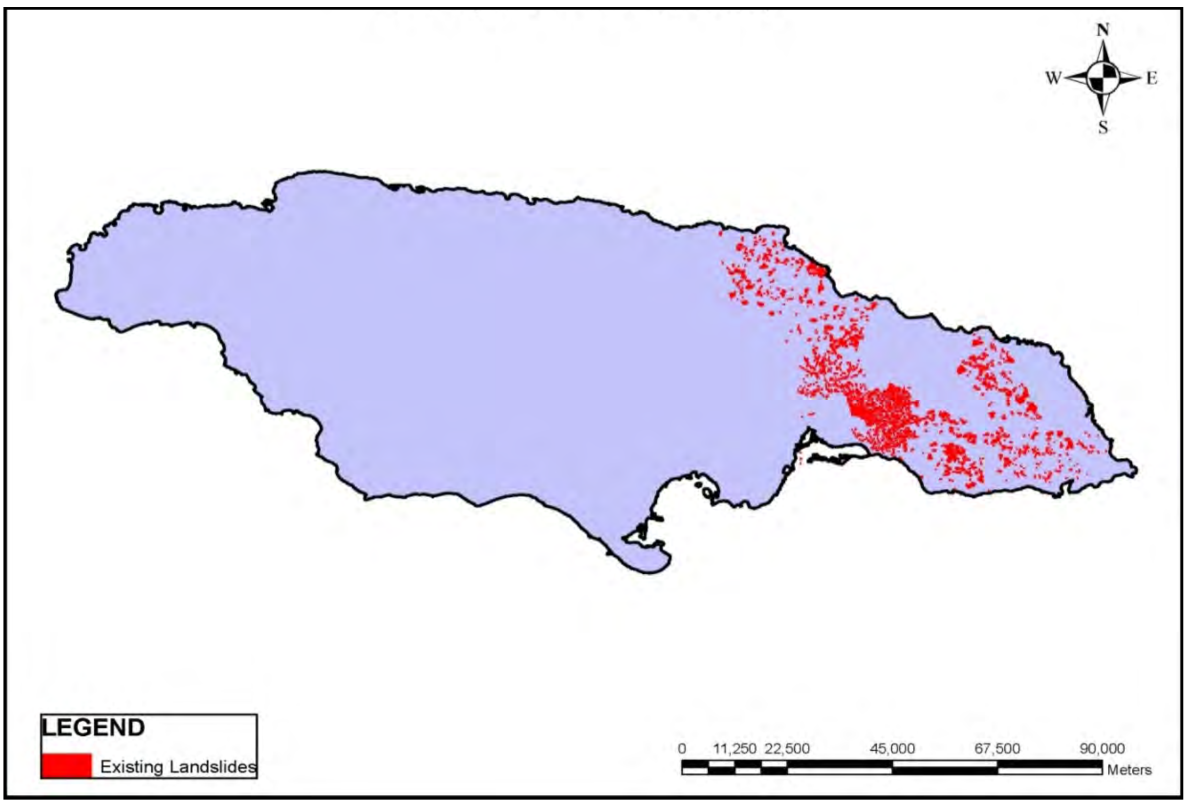

Figure 4-32 - Inventory displaying landslide locations island-wide Topography - Slopes and Landslides

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 (Figure 4-33). 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.

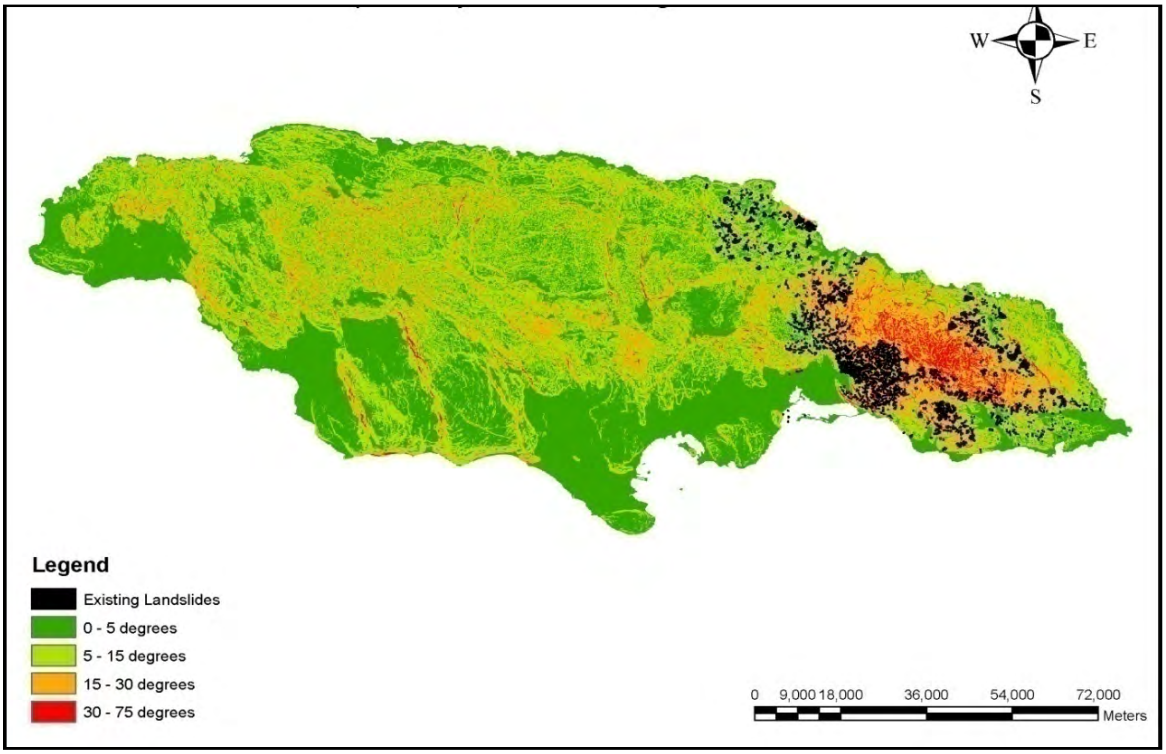

Figure 4-33 - Landslide frequencies influenced by slope angles

It was found that landslide occurrences increase with increasing slope angle. The results revealed that majority of landslides occurred within the ranges of 5° and 30°, with lower landslide occurrences, 9% and 7%, within the 0° - 5° range and 30° and 75°. However, a decrease in landslide occurrences was observed after the slope range 15° - 30°. The results are summarized in Table 4.15. The various types of landslides which occur within the respective slope ranges are shown below on a histogram (Figure 4-34).

Table 4.15 - Landslide frequencies influenced by slope angles

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

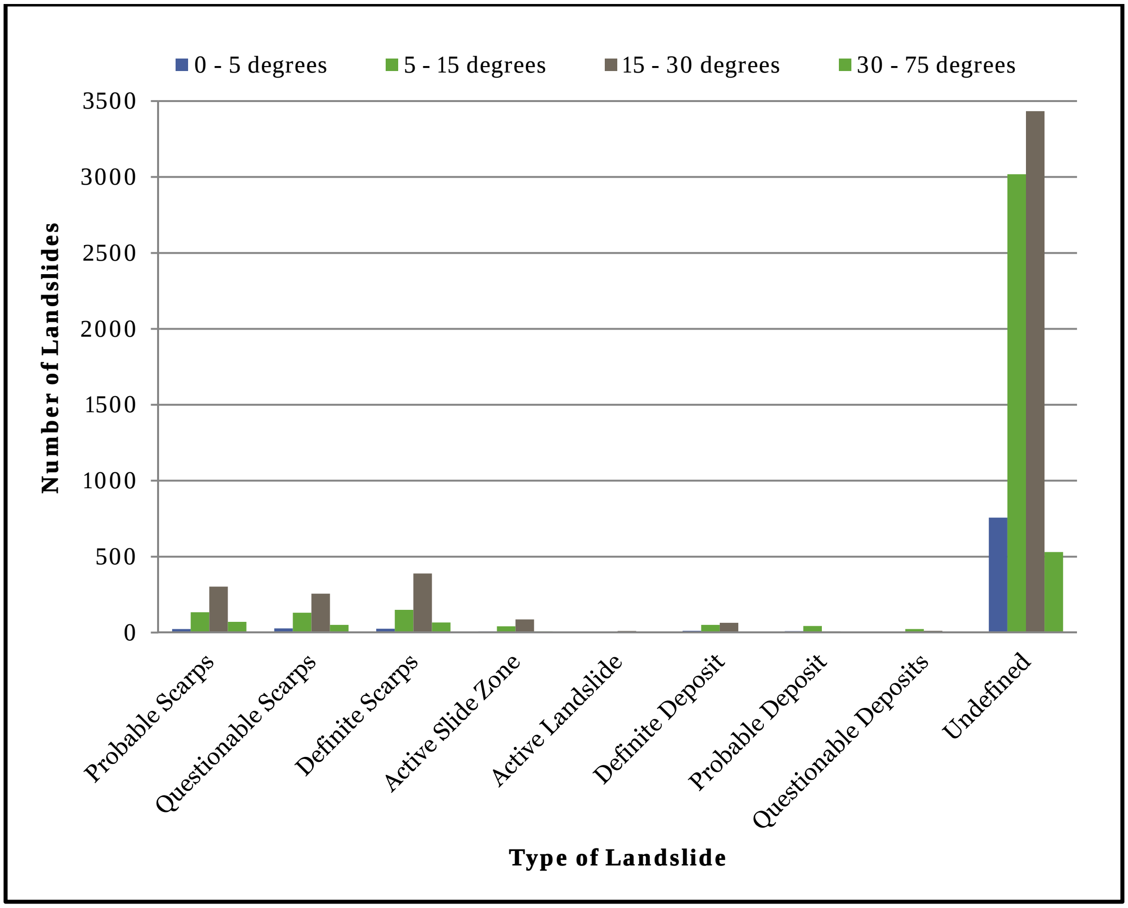

Figure 4-34 - Histogram of landslide frequencies influenced by slope angles

The dominant slopes along the proposed alignment are between 0 to 5 degrees. The segment of the alignment which traverses north of Lime Walk and west of Bog Walk comprises of the steepest slopes, varying from 0 to 30 degrees (See Figure 4-35).

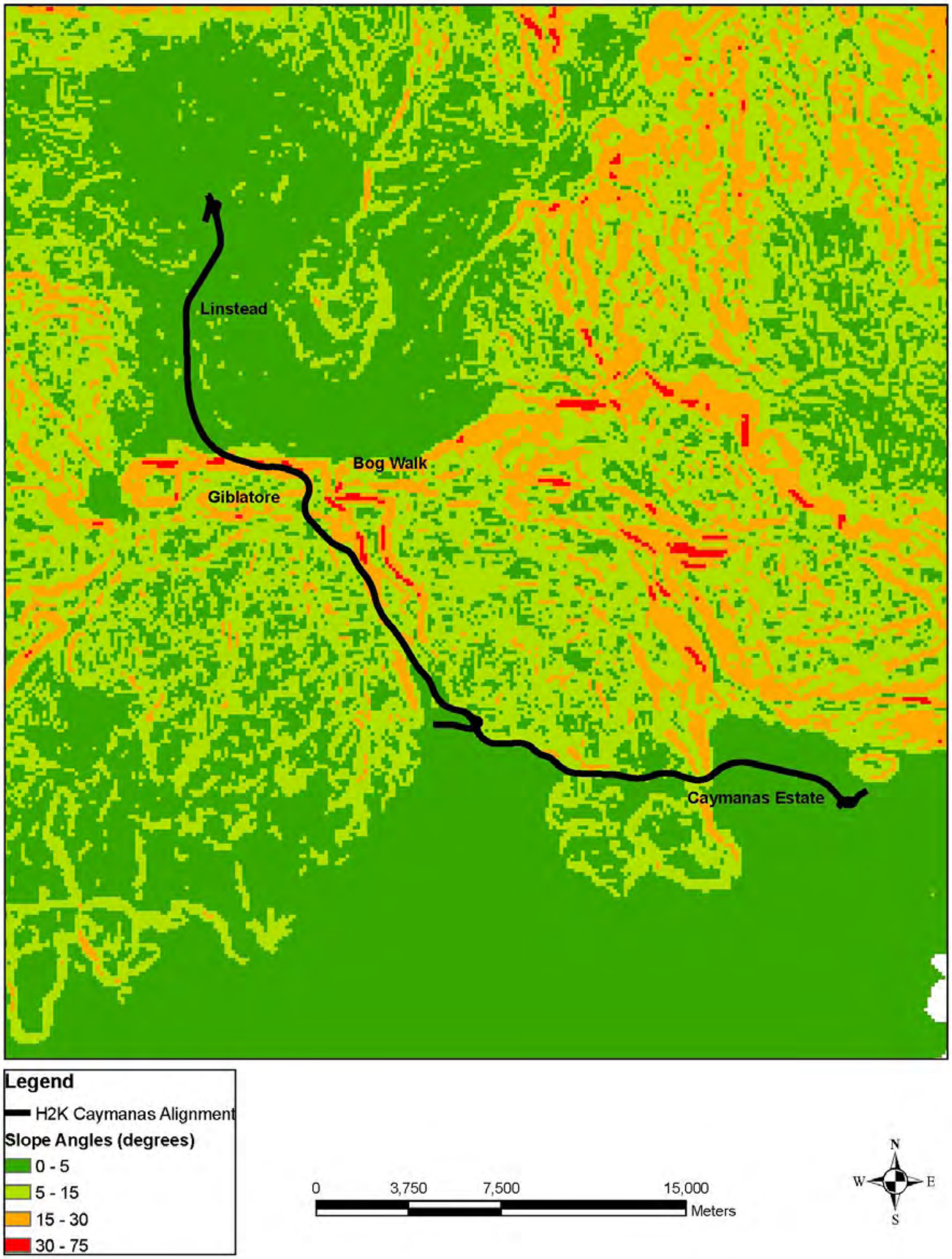

Figure 4-35 - Slope analysis of the terrain through which proposed H2K Caymanas alignment traverses

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 4.16 below illustrates the classification of soil probabilities.

Table 4.16 - 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 4-36 and mapped in Figure 4-37 below.

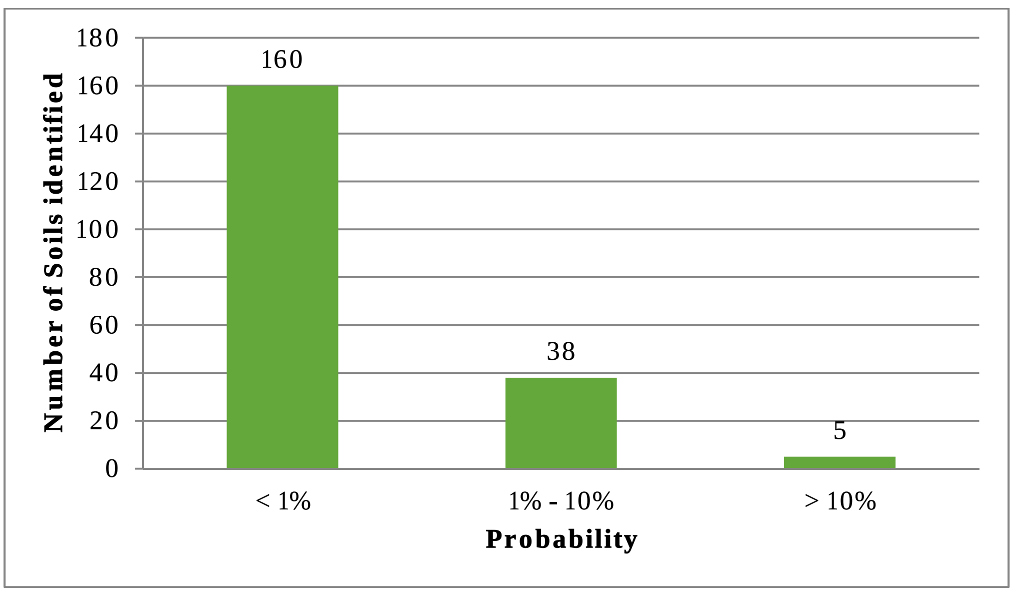

Figure 4-36 - Histogram showing soils classified based on their propensity to cause landslides

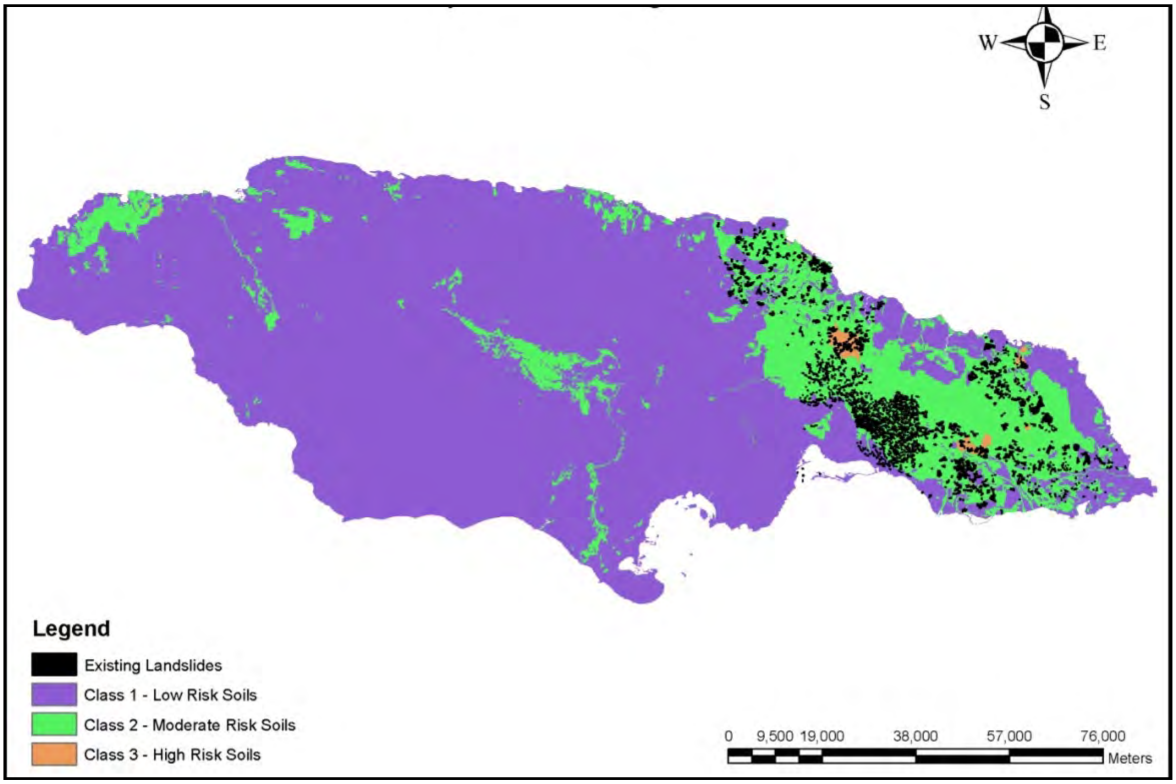

Figure 4-37 - Landslide frequencies influenced by soil properties

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 Figure 4-39.

Table 4.17illustrates the number of landslides which occur within a specific range of distances from fault lines (i.e.) landslide densities. These tabulated values were plotted on a graph (Figure 4-38) for further analysis and mapped in Figure 4-39.

Table 4.17 - 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%

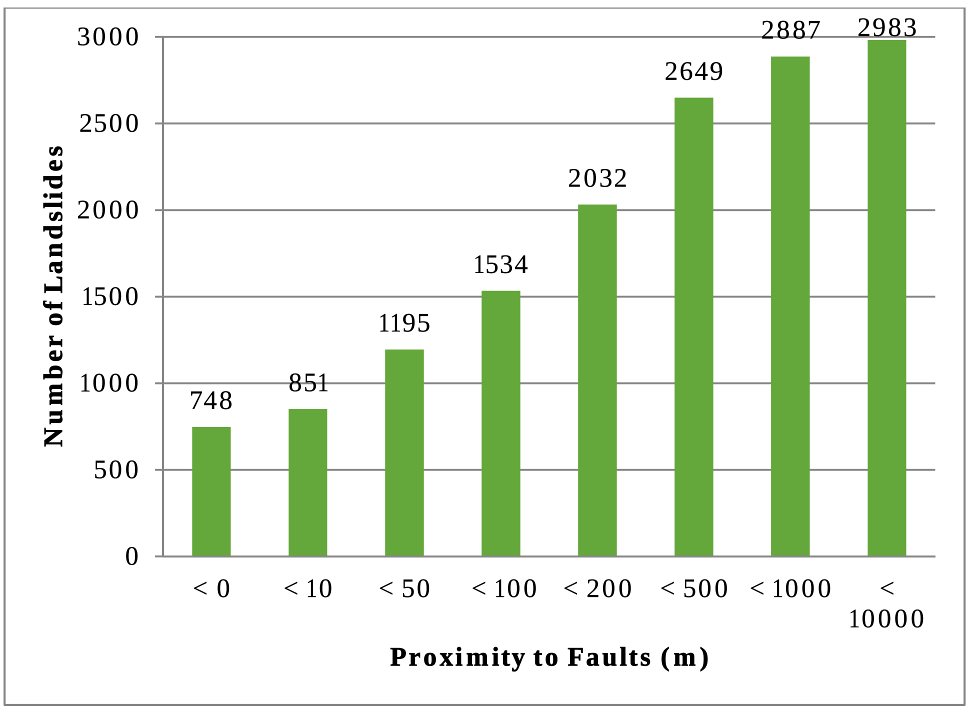

Figure 4-38 - Histogram showing landslide frequencies influenced by fault lines

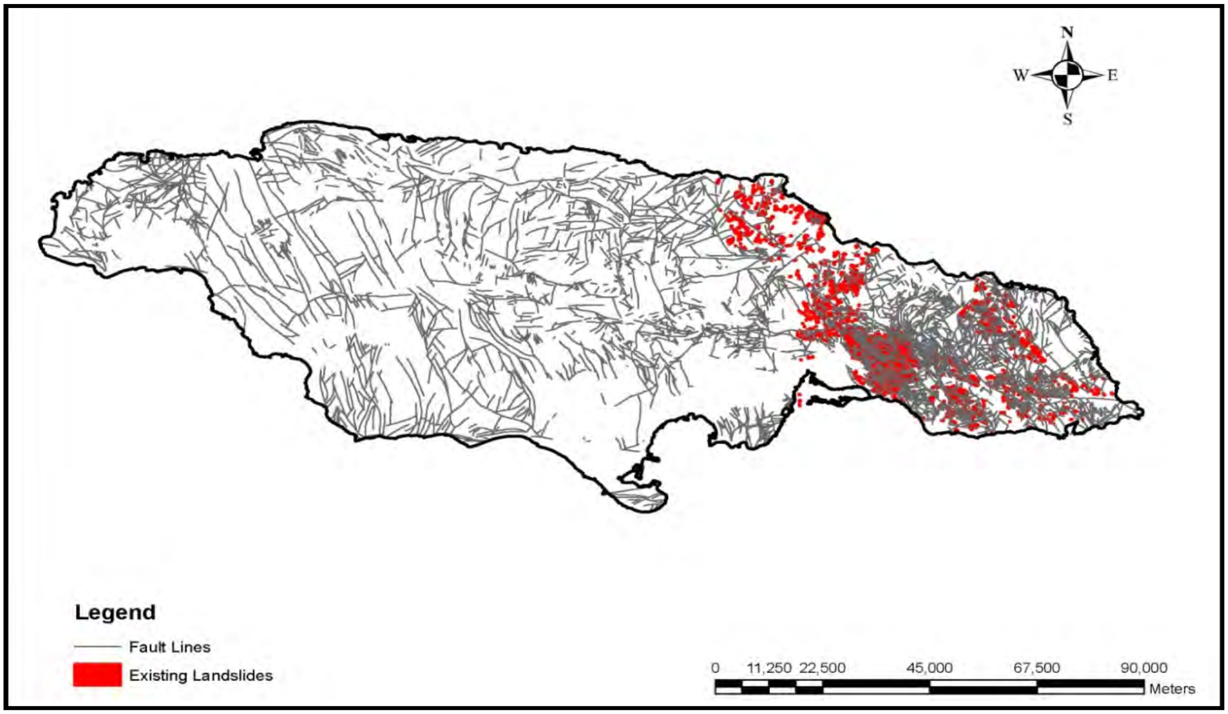

Figure 4-39 - Landslides superimposed faults map of Jamaica

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 4.18 illustrates the relationship between the frequency of landslides and the proximity to the road network throughout Jamaica.

Table 4.18 - Landslide frequency in relation to proximity of roadways

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

The correlation between the number of landslides occurring and their respective proximities to local roads are shown in the histogram below (Figure 4-40) and on the map in Table 4.44.

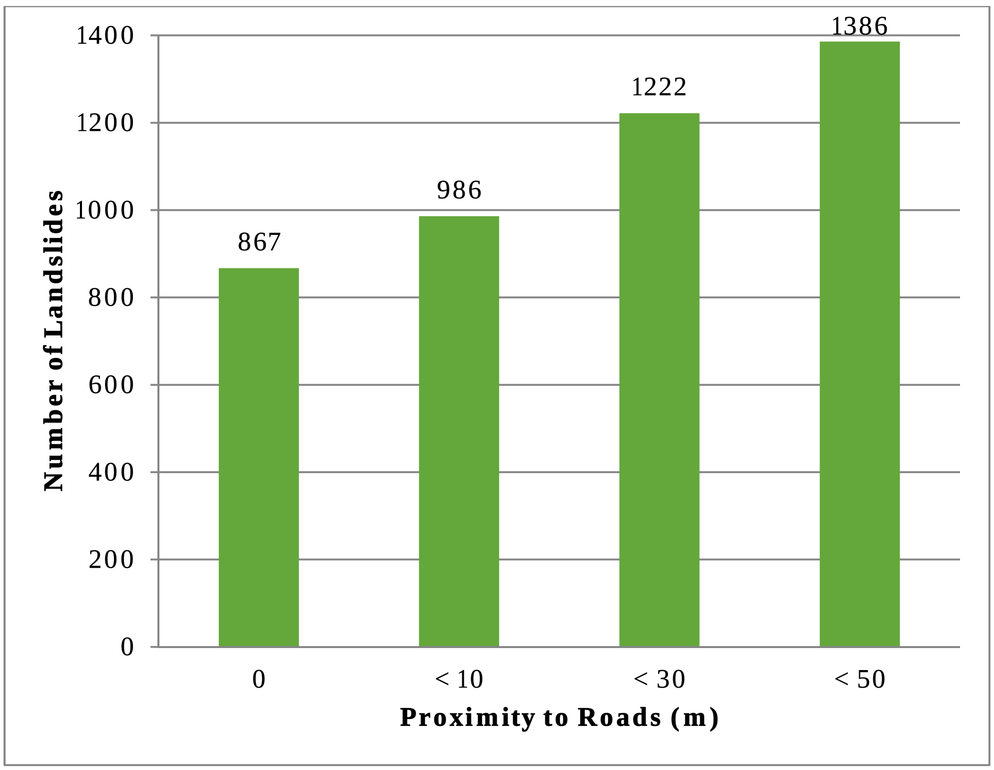

Figure 4-40 - Histogram showing landslide frequencies influenced by the road network

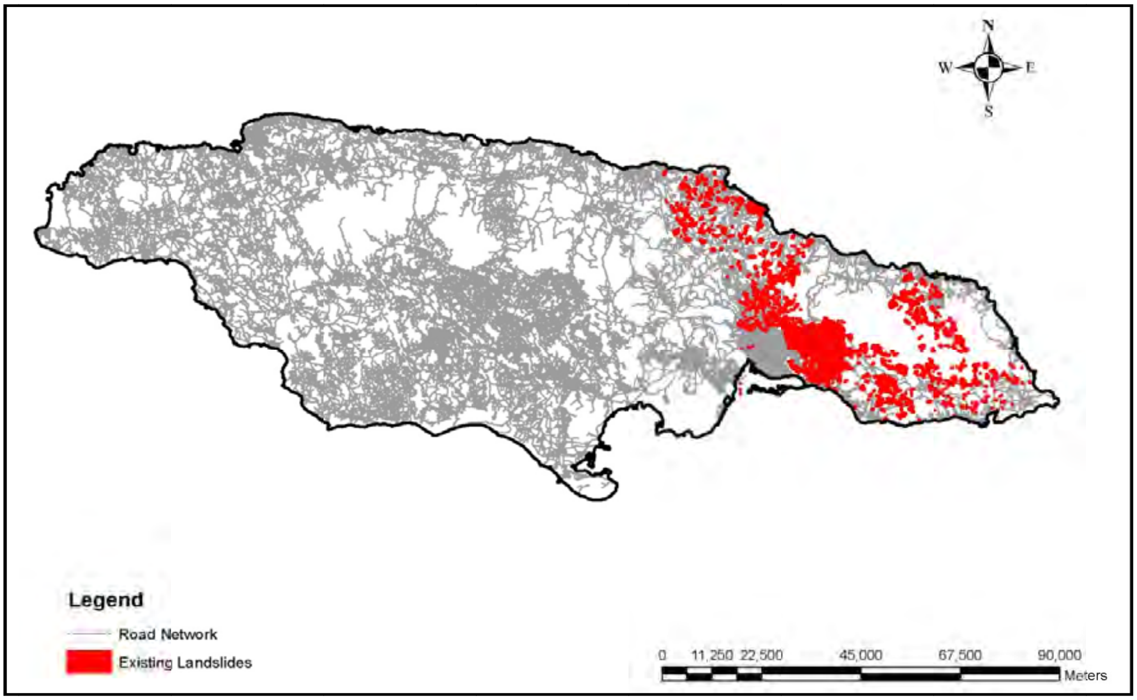

Figure 4-41 - Landslide frequencies influenced by the road network

Analysis

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.

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

Model Results

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 4-42. 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 Caymanas 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 Lime Walk and south of Bog Walk as Figure 4-43 illustrates. The hilly environs in close proximity to Lime Walk runs parallel to the proposed alignment and extends from 1.3km southeast of Wakefield to 1.2km southwest of Bog Walk and 1.02km north of Lime Walk. Other susceptible regions identified include those near to Crescent and Content where the highway will intersect the Rio Cobre. In addition, the steep terrain of the Caymanas Bay creates moderate susceptibility to landslides in the surrounding areas.

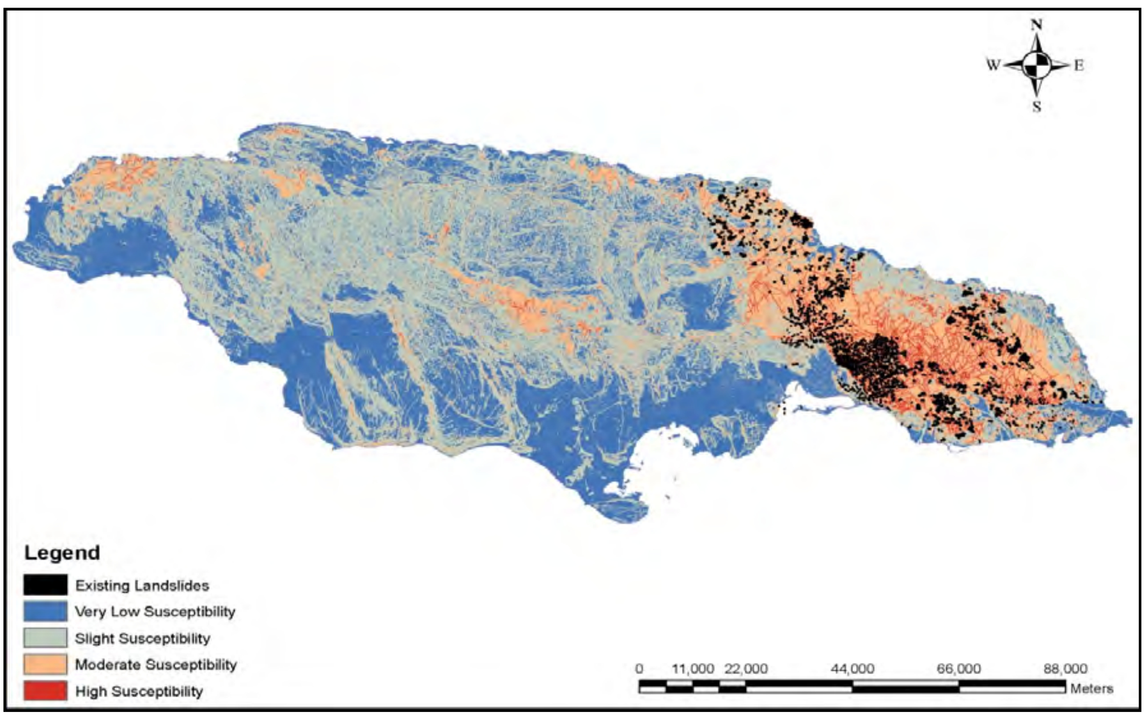

Figure 4-42 - Landslide susceptibility map generated from parameters

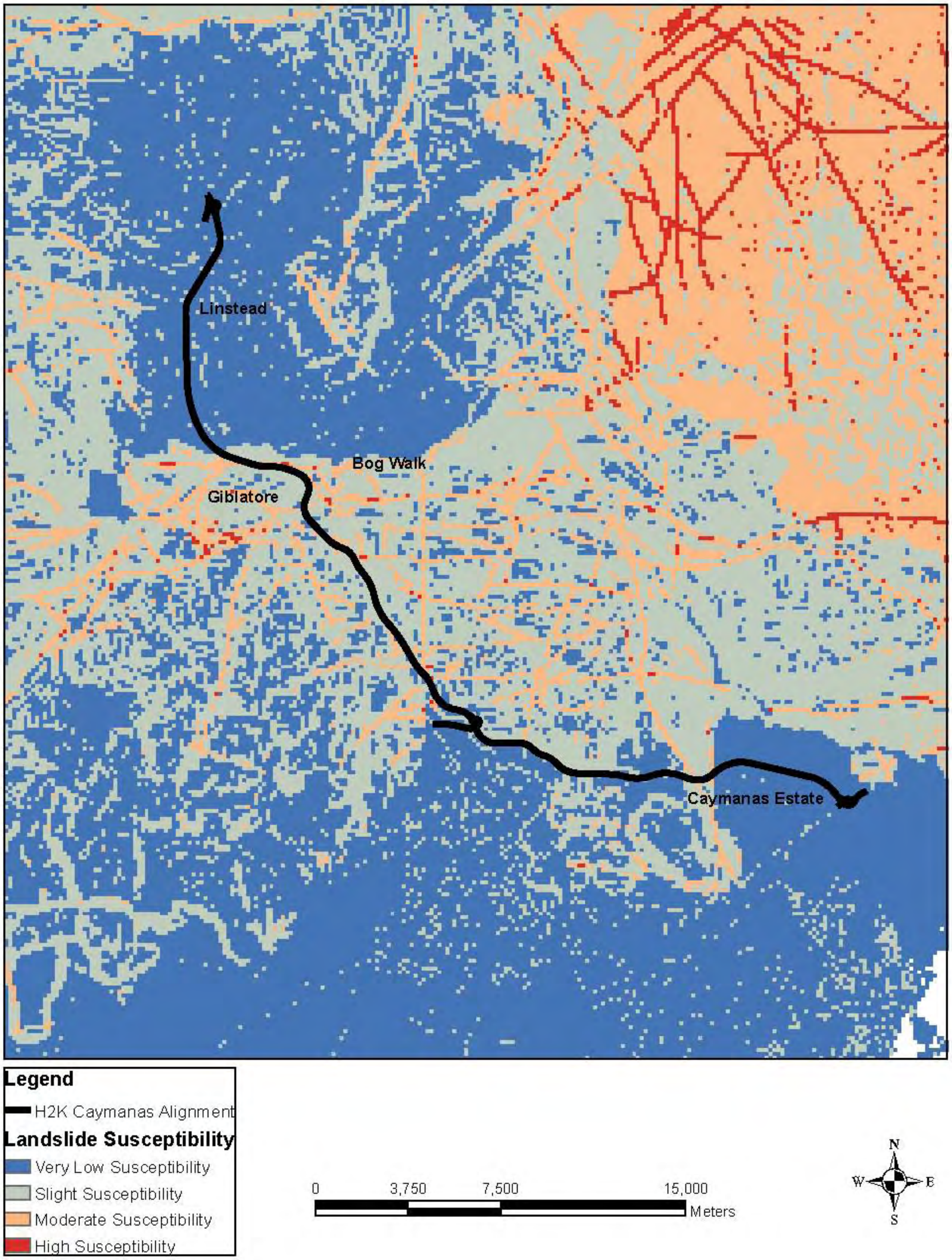

Figure 4-43 - Final landslide susceptibility map along H2K road alignment

Verification

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 4.19 and Figure 4-44. These landslide areas can be classified as having moderate to high susceptibility.

Table 4.19 - Verification illustrates most landslides have occurred in moderate to high susceptible areas.

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

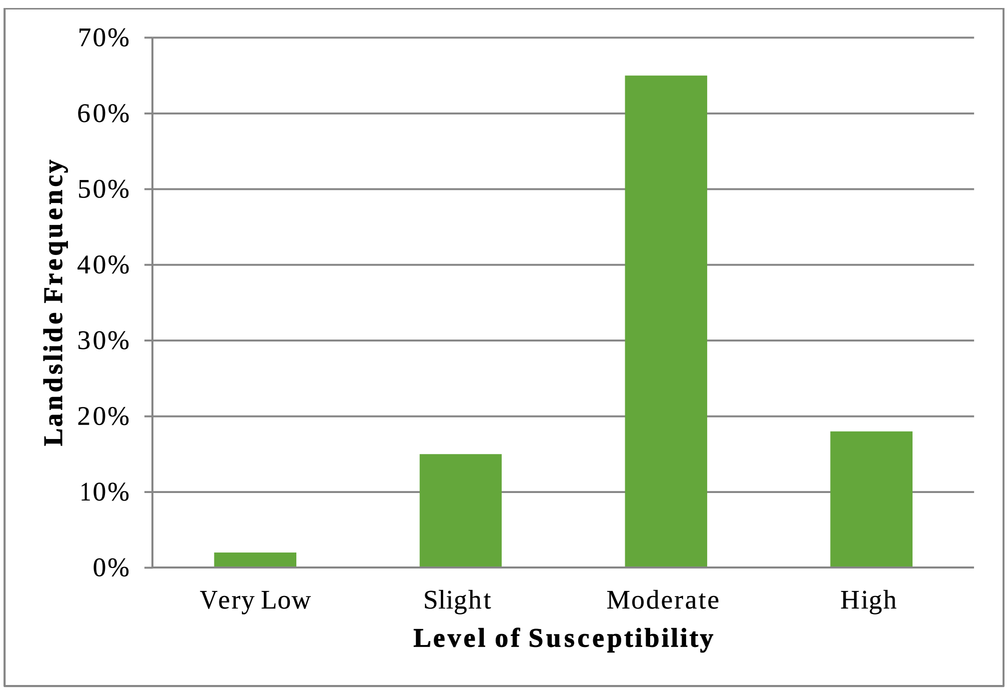

Figure 4-44 - Histogram verifying susceptibility for existing landslides

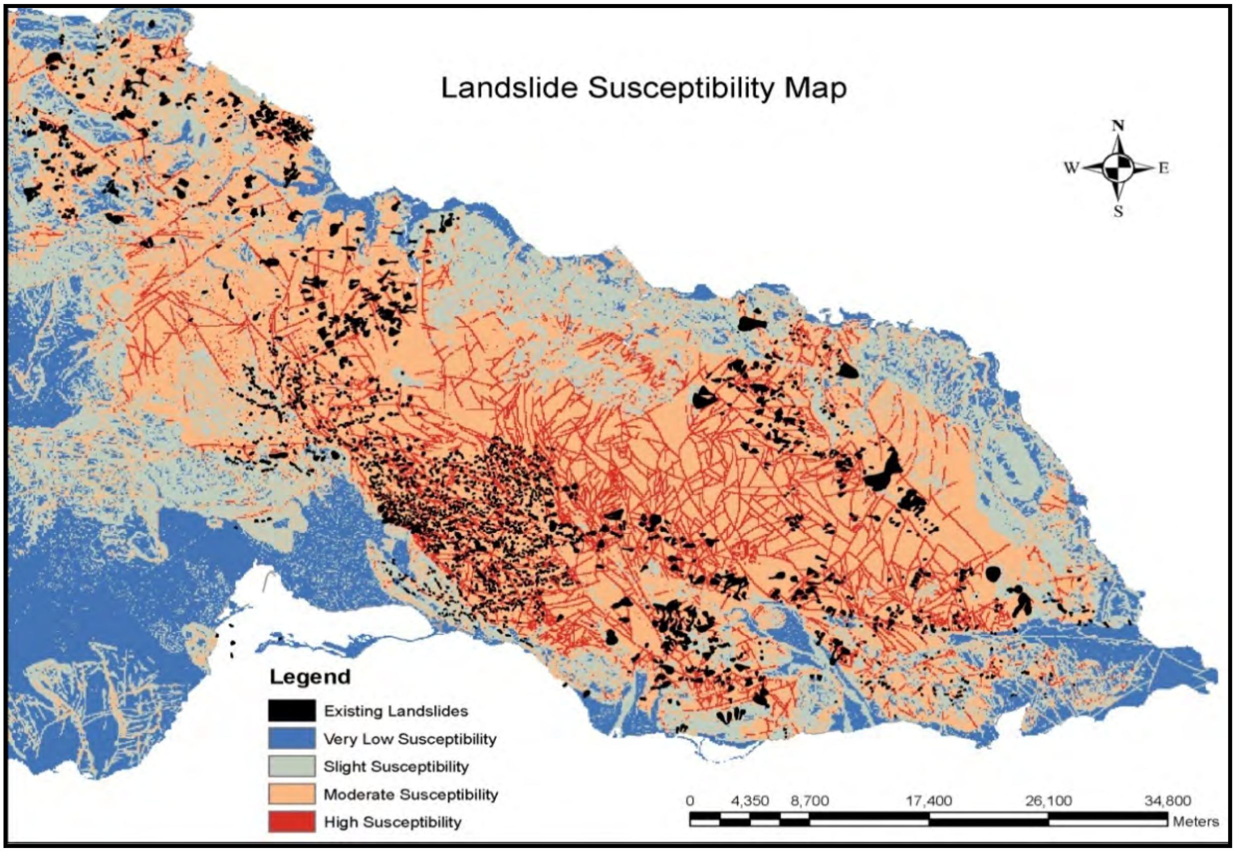

Figure 4-45 - Landslide susceptibility shown for existing landslides

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. The mountainous sections of Lime Walk were investigated for any signs of landslides; however, none could be identified. In addition, anecdotal information was collected but the interviewees had no recollection of landslides occurring within the area.

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 Steep Slopes/Collapse Features/ Subsidence

Over the middle part of the highway's route (from Cow Market north across the plateau to Hermatige/Giblatore) the karst topography includes many depressions in which sinkholes occur; the present alignment of the highway is routed through one of these. There may be issues with caves and sinkhole formation in this region. Cave deposits/dripstone has been identified in the Troy Formation and the possibility of collapse into cave systems at shallow depth is likely to be greater in the older Troy and Claremont limestone units. Of particular concern are the steep, possibly unstable slopes in the limestones overlooking Kent Village (boxed area in Figure 4-46). This area will require more detailed geological appraisal in order to confirm the proposed alignment.

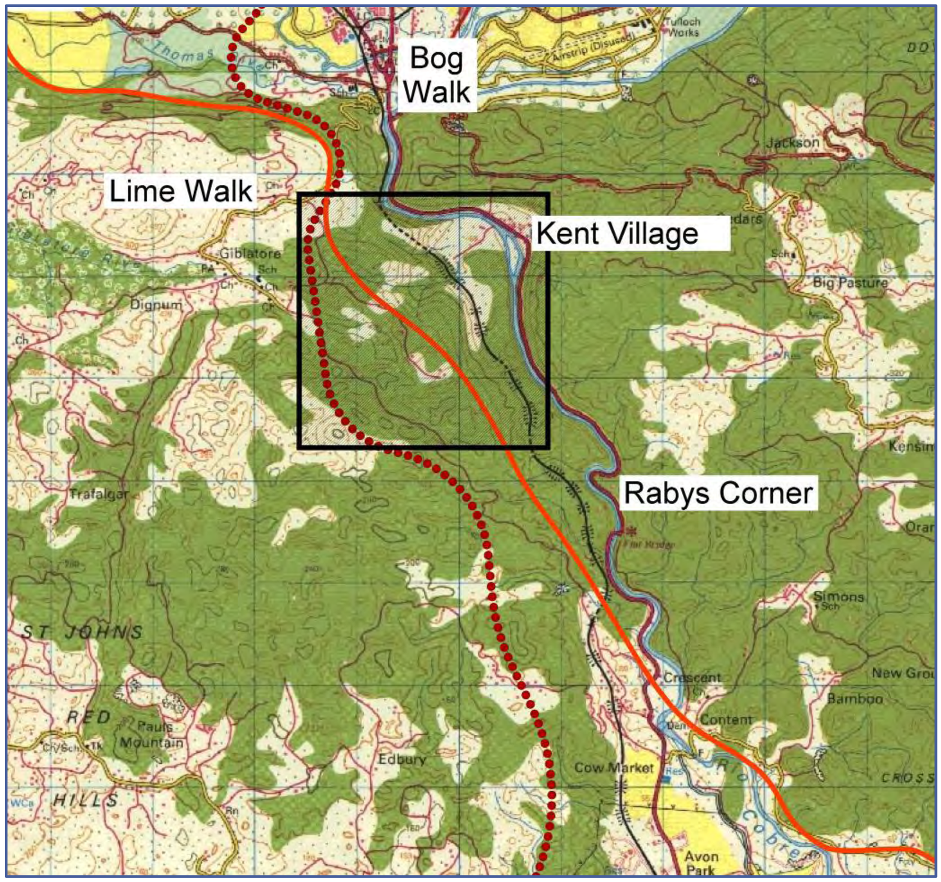

Figure 4-46 - Black box highlights area where revised alignment positions the highway at the top of a very steep slope west of Kent Village (Original route-red dots Revised route – orange line)

4.1.6.3 Flooding

As previously mentioned, flooding in the limestone areas of the proposed highway route will not be a problem under normal conditions of light to moderately heavy rainfall as drainage is mainly subsurface. Under conditions of prolonged, exceptionally heavy rainfall there is a possibility of local flooding of karst depressions and activation of runoff through the system of storm gullies. Under these conditions the boundaries of the gully system catchments give an approximate indication of the relative amounts of runoff for each gully system. At least two of the systems north of the proposed route with single outlets across the highway, cover areas exceeding three square kilometres (circle on Figure 4-9). As is the case for the Gorge bypass section (Figure 4-8) the zones (pink) of internal drainage may provide flood waters that could augment the surface flows through resurgences. Flooding of alluvial zones in the Linstead Basin (floodplains as demarcated in green, Figure 4-7) may be expected in periods of heavy and/or prolonged rainfall. At Caymanas flooding is not likely to be a major problem due to the slope of relatively permeable alluvial fan deposits (Caymanas sandy loam, see description above) towards the northern edge of the estate. This is not a floodplain.

See section 4.1.4 for detailed descriptions of the hydrological features and flood prone areas in the study area.

4.1.6.4 Hurricanes

Hurricanes produce heavy rainfall, high winds, and storm surge, all of which have the potential to cause damage and dislocation at the proposed location. The high velocity winds can cause structural damage. Jamaica lies within the Caribbean hurricane belt and has been directly affected by numerous hurricanes. Hurricanes and tropical storms are frequently accompanied by heavy rainfall. It has also been widely suggested that the Atlantic-Caribbean region is moving, and has already started to move, into a cycle of wetter and more severe tropical disturbances (IPCC, 2001).

During the hurricane season (June to November) these low-pressure systems form in the mid-Atlantic off the African west coast between latitudes 5 to 25 N, and move north-westerly into the Caribbean basin. Detailed storm data are available from the US National Hurricane Center archives for the last 20 years 1987 to 2007. The analysis was conducted on storms passing within 200 km of Jamaica. During that period 8 hurricanes, 3 tropical depression, 6 tropical storms and 1 tropical wave (Table 4.20 and Figure 4-47).

The experience of the last three major hurricanes that affected Jamaica, Gilbert in 1988, Ivan in 2004 and Hurricane Dean in 2006 suggests that the Palisadoes peninsula reduces the build-up of storm surge within the Kingston Harbour. This minimizes the potential threat to the coastline in the north and northeast sections of the harbour where the proposed site is located.

Table 4.20 - Names and categories of storms that passed within 200 km of Jamaica 1987 - 2007

Name	Year	Category	Maximum Wind Speed (Knots)
ARTHUR	1990	Tropical Depression	30
BONNIE	2004	Tropical Wave	25
CHARLEY	2004	Hurricane	65
DEAN	2007	Hurricane	125
DEBBY	2000	Tropical Storm	35
DENNIS	2005	Hurricane	120
EMILY	2005	Hurricane	140
ERNESTO	2006	Tropical Storm	45
GILBERT	1988	Hurricane	115
GORDON	1994	Tropical Storm	40
HELENE	2000	Tropical Depression	30
IRIS	2001	Hurricane	75
ISIDORE	2002	Tropical Storm	45
IVAN	2004	Hurricane	145
LILI	2002	Hurricane	65
MARCO	1996	Tropical Depression	30
OLGA	2007	Tropical Storm	35
WILMA	2005	Tropical Storm	35

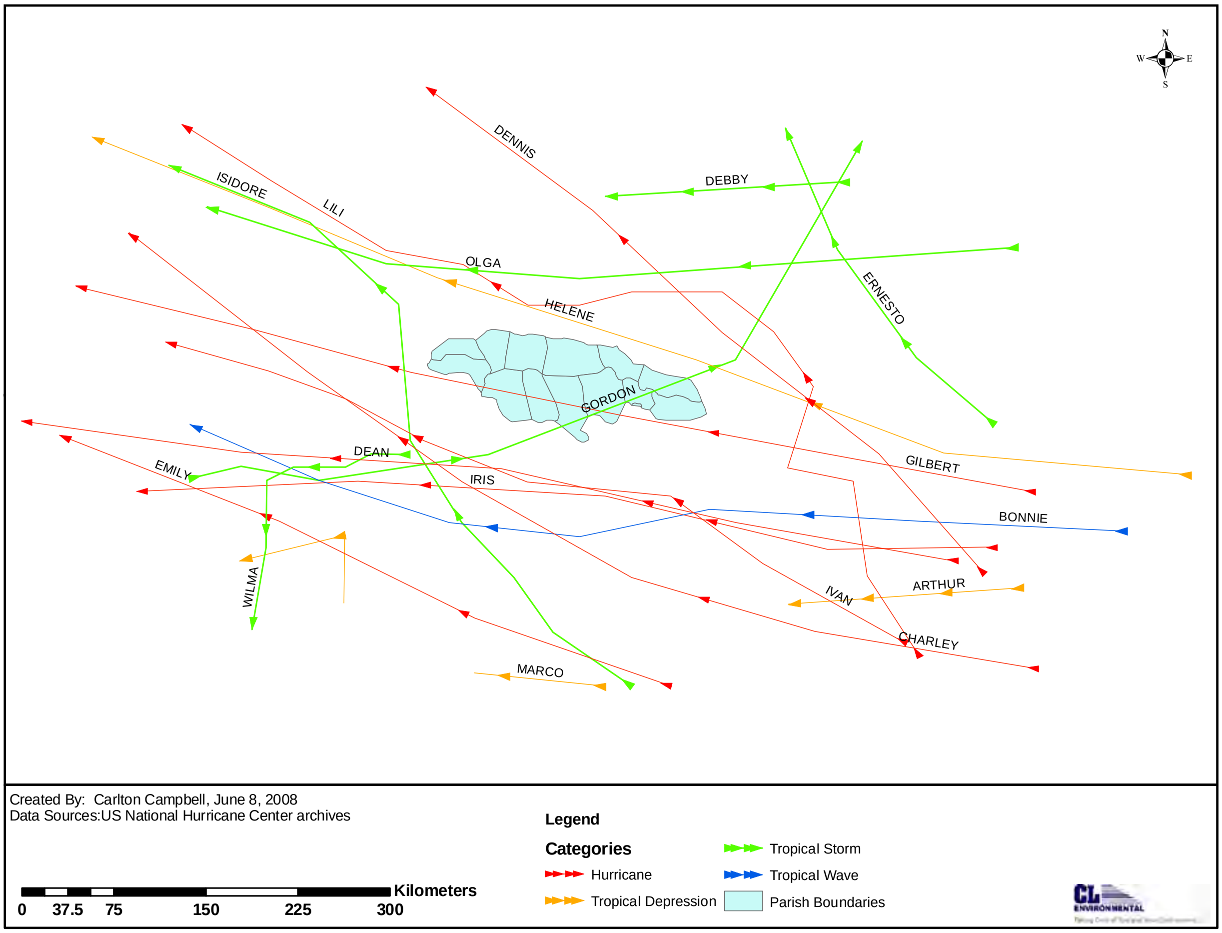

Figure 4-47 - Storms that have passed within 200km of Jamaica within the last 20 years (1987 – 2007)

4.1.6.5 Earthquakes

Figure 4-48 indicates the probability of ground accelerations of a given magnitude being exceeded in a given period. Section 1 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%. Accelerations above 270 gals may be expected for the Caymanas end of the highway. The main concerns will be associated with the geotechnical/engineering issues to be addressed during and after highway excavation, particularly across the Bog Walk Fault zone.

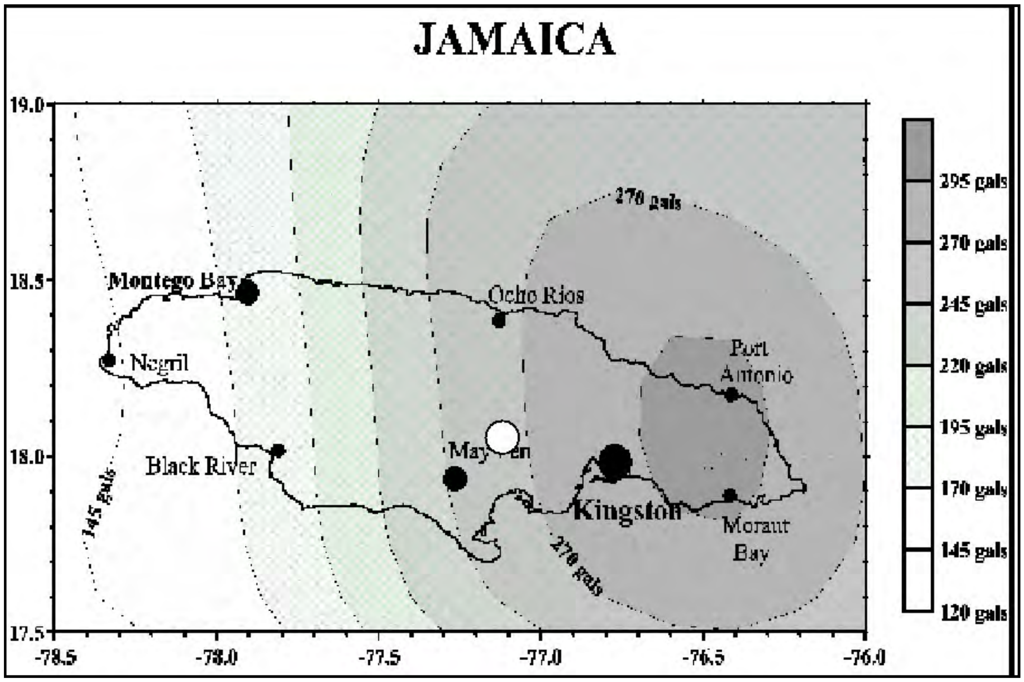

Figure 4-48 - Horizontal ground acceleration with 10% probability of exceedence in fifty years (Shepherd et al. 1999 in CDMP 2001), Contour interval is 25 gals (2.5%g). Modified from CDMP 2001. White spot is location of the Rio Cobre Gorge bypass

4.1.7 Water Quality

4.1.7.1 Methodology

A total of three water quality exercises were conducted.

The first water quality sampling exercise was conducted on March 12th 2012 between the hours of 10:00am and 1:30pm. Weather conditions were fair and sunny at the time of sampling, however, intermittent rainfall began at around 1:00pm.

The second water quality sampling exercise was conducted on March 19th, 2012 between the hours of 10:00am and 1:00pm. Weather conditions were partly cloudy at the time of sampling. During the week prior to this, there had been heavy rainfall island wide.

The third water quality sampling exercise was conducted on March 26th, 2012 between the hours of 9:30am and 12:30pm. Weather conditions were fair and sunny at the time of sampling.

Physicochemical data at each location was recorded using a Hydrolab Minisonde MS-5 water quality multiprobe (See Appendix 3 for calibration certificate). These parameters included temperature, salinity, conductivity, dissolved oxygen, pH, turbidity and total dissolved solids (TDS). 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 NEPA Trade Effluent Standards and the Draft NEPA Ambient Freshwater Quality Standards.

The water sampling locations and coordinates are shown in Table 4.21 and Figure 4-49. No WQ5 sampling station exists as this station was omitted.

Table 4.21 - Water quality sampling locations

STATION	***LOCATION***	***TYPE OF WATER***	***JAD 2001***	
			Northing (m)	**Easting (m)**
WQ1	Tributary at Caymanas Bay	Surface Water	653822.87	759074.52
WQ2	NWC Eastern Headworks 'W' well	Groundwater	653711.13	753836.74
WQ3	Rio Cobre (by Cross Pen)	Surface Water	653742.59	753510.18
WQ4	Rio Cobre (by Dam Head)	Surface Water	654902.97	752030.85
WQ6	Tributary through Cambria Farms canefield	Surface Water	663004.82	745849.40
WQ7	Rio Cobre (by Victoria bridge)	Surface Water	666045.07	746057.75

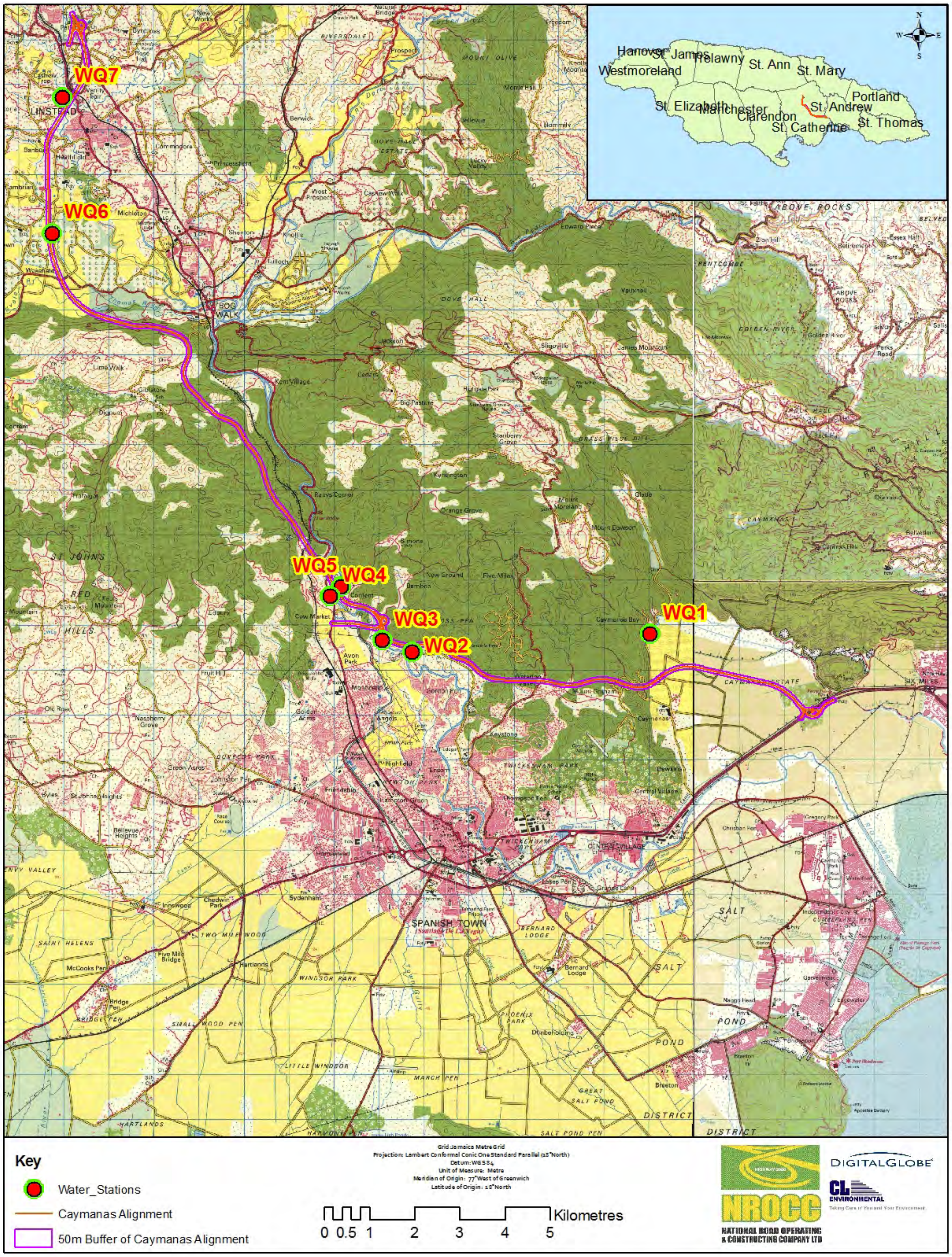

Figure 4-49 – Map showing water quality sampling stations

Plate 4.20 - Photo showing WQ7 – Rio Cobre by Victoria bridge

Plate 4.21 - Photo showing WQ6 – Tributary through Cambria Farms canefield

Plate 4.22 - Photo showing WQ4 – Rio Cobre by Dam Head

Plate 4.23 - Photo showing WQ3 – Rio Cobre by Cross Pen

Plate 4.24 - Photo showing WQ2 – NWC Eastern Headworks 'W' well

Plate 4.25 - Photo showing WQ1 – Tributary at Caymanas Bay

4.1.7.2 Results

Surface Water

1st Sampling Exercise

The results from the first water sampling exercise are displayed in Table 4.22 and Table 4.23 below. All stations excepting for WQ7 had pH values just outside the NEPA upper standard. All stations had dissolved oxygen values compliant with NEPA standards. TDS values for WQ1, WQ4, and WQ7 were non-compliant with the NEPA freshwater standard. Temperature was deemed normal for all stations. Conductivity values at WQ1 and WQ7 were non-compliant with the standard. Faecal coliform at all stations excepting for WQ3 were non-compliant with NEPA standards, and stations WQ1, WQ3 and WQ7 had non-compliant FOG values. All stations had nitrate and phosphate values complaint with the NEPA freshwater standard.

Table 4.22 -Water quality results for first sampling exercise

STATION	TEMP (oC)	COND (mS/cm)	SAL (ppt)	pH	D.O. (mg/l)	TURB (NTU)	TDS (g/l)
WQ1	25.03	1.288	0.68	8.75	4.84	1.2	0.825
WQ3	25.19	0.47	0.24	8.91	8.82	5.4	0.3
WQ4	24.8	0.499	0.25	8.83	8	9.9	0.319
WQ6	25.01	0.422	0.21	8.84	8.12	117.3	0.27
WQ7	25.16	0.706	0.36	8.38	6.42	5.9	0.449
NEPA Ambient Freshwater Std.	-	**0.15 - 0.6**	-	**7 – 8.4**	-	-	**0.12 - 0.3**
NEPA Trade Effluent Stds.	-	-	-	**6.5 – 8.5**	**4**	-	**1**

Values highlighted in red are non-compliant with NEPA Standards

Table 4.23 -Water quality results for first sampling exercise

STATION	TSS (mg/l)	Nitrates (mg/l)	Phosphates (mg/l)	FOG (mg/l)	F. coli (mpn/100ml)
WQ1	26	0.1	0.07	14.29	170
WQ3	12	1	0.11	33.14	20
WQ4	17	0.5	0.1	9.14	140
WQ6	94	<0.1	<0.01	7.14	≥16000
WQ7	8	2.1	0.05	32	16000
NEPA Ambient Freshwater Std.	-	**0.1 – 7.5**	**0.01 – 0.8**	-	-
NEPA Trade Effluent Stds.	**150**	**10**	**5**	**10**	**100**

Values highlighted in red are non-compliant with NEPA Standards

2nd Sampling Exercise

The results from the second water sampling exercise are displayed in Table 4.24 and Table 4.25 below. All stations excepting for WQ7 had pH values just outside the NEPA upper standard. All stations except for WQ1 had dissolved oxygen values compliant with NEPA standards. TDS values for all stations except WQ6 were non-compliant with the NEPA ambient freshwater standard. Temperature was deemed normal for all stations. Conductivity values at WQ1 and WQ7 were non-compliant with the standard. Faecal coliform at stations WQ6 and WQ7 were non-compliant with NEPA standards, and stations WQ1, WQ3 and WQ7 had non-compliant FOG values. All stations had nitrate and phosphate values complaint with the NEPA freshwater standard.

Table 4.24 - Water quality results for second sampling exercise

STATION	TEMP (oC)	COND (mS/cm)	SAL (ppt)	pH	D.O. (mg/l)	TURB (NTU)	TDS (g/l)
WQ1	25.99	1.353	0.71	8.76	3.55	2.2	0.865
WQ3	26.03	0.478	0.24	9.13	9.06	6.8	0.306
WQ4	25.14	0.502	0.25	9.12	8.23	13.5	0.322
WQ6	23.72	0.452	0.23	8.84	8.72	0	0.288
WQ7	24.7	0.706	0.36	8.22	5.92	0	0.451
NEPA Ambient Freshwater Std.	-	***0.15 - 0.6***	-	***7 – 8.4***	-	-	***0.12 - 0.3***
NEPA Trade Effluent Stds.	-	-	-	***6.5 – 8.5***	***4***	-	***1***

Values highlighted in red are non-compliant with NEPA Standards

Table 4.25 - Water quality results for second sampling exercise

STATION	TSS (mg/l)	Nitrates (mg/l)	Phosphates (mg/l)	FOG (mg/l)	F. coli (mpn/100ml)
WQ1	44	<0.1	0.05	15.43	60
WQ3	14	0.2	0.08	15.14	<20
WQ4	21	0.1	0.11	9.71	40
WQ6	5	0.6	0.07	6.57	130
WQ7	3	2	0.03	18.86	3500
NEPA Ambient Freshwater Std.	-	***0.1 – 7.5***	***0.01 – 0.8***	-	-
NEPA Trade Effluent Stds.	***150***	***10***	***5***	***10***	***100***

Values highlighted in red are non-compliant with NEPA Standards

3rd Sampling Exercise

The results from the third water sampling exercise are displayed in Table 4.26 and Table 4.27 below. All stations had pH values just outside the NEPA upper standard. All stations except for WQ1 had dissolved oxygen values compliant with NEPA standards. TDS values for all stations excepting WQ6 were non-compliant with the NEPA ambient freshwater standard. Temperature is deemed normal for all stations. Conductivity values at WQ1 and WQ7 were non-compliant with the standard. Faecal coliform at all stations excepting for WQ1 were non-compliant with NEPA standard, and station WQ6 had a non-compliant FOG value. All stations had nitrate and phosphate values complaint with the NEPA freshwater standard.

Table 4.26 - Water quality results for third sampling exercise

STATION	TEMP (oC)	COND (mS/cm)	SAL (ppt)	pH	D.O. (mg/l)	TURB (NTU)	TDS (g/l)
WQ1	27.46	1.317	0.7	8.85	3.83	8	0.845
WQ3	27.1	0.488	0.25	9.09	9	12	0.312
WQ4	25.98	0.51	0.26	9.03	8.15	15.6	0.326
WQ6	25.05	0.34	0.17	9.14	5.26	28.5	0.217
WQ7	24.97	0.662	0.34	9.36	6.4	0	0.423
NEPA Ambient Freshwater Std.	-	***0.15 - 0.6***	-	***7 – 8.4***	-	-	***0.12 - 0.3***
NEPA Trade Effluent Stds.	-	-	-	***6.5 – 8.5***	***4***	-	***1***

Values highlighted in red are non-compliant with NEPA Standards

Table 4.27 - Water quality results for third sampling exercise

STATION	TSS (mg/l)	Nitrates (mg/l)	Phosphates (mg/l)	FOG (mg/l)	F. coli (mpn/100ml)
WQ1	17	0.4	0.15	7.71	83
WQ3	17	0.5	0.2	7.43	130
WQ4	21	0.5	0.18	9.71	390
WQ6	19	<0.1	0.26	10.86	2200
WQ7	1	1.8	0.02	4.57	4300
NEPA Ambient Freshwater Std.	-	***0.1 – 7.5***	***0.01 – 0.8***	-	-
NEPA Trade Effluent Stds.	***150***	***10***	***5***	***10***	***100***

Values highlighted in red are non-compliant with NEPA Standards

Groundwater

Station WQ2 (NWC Eastern Headworks 'W' well) was the only groundwater sampling point. This is a major well which supplies the Kingston Metropolitan Area with water.

The results from all the water sampling exercises are displayed in Table 4.28 and Table 4.29 below. TDS and pH values on all 3 sampling exercises were non-compliant with the NEPA Ambient Freshwater standards. Conductivity, nitrate and phosphate values were compliant with the NEPA Standard and WHO Guideline (for nitrates) for all three sampling exercises. Values for other physicochemical parameters such as temperature, salinity, turbidity and dissolved oxygen are deemed satisfactory. TSS values stayed extremely low for all three sampling exercises; however, FOG values were slightly elevated. Faecal coliform values also stayed low throughout the three sampling exercises.

Table 4.28- - Groundwater sampling results

STATION	Sample Date	TEMP (oC)	COND (mS/cm)	SAL (ppt)	pH	D.O. (mg/l)	TURB (NTU)	TDS (g/l)
WQ2	March 12th	25.5	0.496	0.25	8.73	7.56	0	0.318
WQ2	March 19th	26.05	0.5	0.25	9.02	7.49	0	0.319
WQ2	March 26th	26.96	0.498	0.25	8.94	7.2	0	0.317
NEPA Ambient Freshwater Std	-		***0.15 - 0.6***	-	***7 – 8.4***	-	-	***0.12 - 0.3***
WHO Guideline	-	-	-	-	-	-	-	

Values highlighted in red are non-compliant with NEPA Ambient Water Standards and/or WHO Guidelines

Table 4.29 - Groundwater sampling results

STATION	Sample Date	TSS (mg/l)	Nitrates (mg/l)	Phosphates (mg/l)	FOG (mg/l)	F. coli (mpn/100ml)
WQ2	March 12th	0	1.1	0.06	16.86	40
WQ2	March 19th	1	0.8	0.09	16	<20
WQ2	March 26th	0	1.1	0.08	10.57	<20
NEPA Ambient Freshwater Std	-	-	***0.1 – 7.5***	***0.01 – 0.8***	-	-
WHO Guideline	-	-	***50***	-	-	-

Values highlighted in red are non-compliant with NEPA Ambient Water Standards and/or WHO Guidelines

Historical Data

Table 4.30 shows historical water quality data for both Eastern Headworks Wells 'W' and 'H'. Turbidity values at both wells stayed low over the years, similar to the current turbidity data. Historical Turbidity values ranged from 0.11 to 0.45 NTU at WQ2, while the current values were 0 NTU. Historical conductivity values at WQ2 (0.452 – 0.459 mS/cm) were also similar to the current conductivity values (0.496 – 0.5 mS/cm).

Historical pH values at WQ2 (7.24 – 7.83) were however much lower than the current pH values (8.73 – 9.02). Historical TDS values at WQ2 (0.256 – 0.274g/l) were on average slightly lower than the current TDS values (0.317 – 0.319g/l). Historical TSS values at WQ2 (256 – 274mg/l) were significantly higher than the current values (0 – 1mg/l), and historical nitrate values at WQ2 (3.2 – 5.1mg/l) were also slightly higher than current values (0.8 – 1.1mg/l).

Table 4.30 - Historical data for Eastern Headworks wells W and H

Parameter	***STATION***			
	WQ2 (Eastern Headworks W)		***Eastern Headworks H***	
	April 1994	***February 1995***	***November 1995***	***April 2003***
True Colour (Hazen)	-	nil	nil	-
Turbidity (NTU)	0.45	0.11	0.26	0.08
Conductivity (mS/cm)	0.452	0.459	0.438	0.464
pH	7.83	7.24	7.24	7.43
TDS (g/l)	0.274	0.256	0.302	0.283
TSS (mg/l)	274	256	302	-
Tot. Alkalinity (mg/l)	262	237	246	249
Tot.Hardness (mg/l)	238	217	255	242
Nitrites (mg/l)	nil	0.001	nil	-
Nitrates (mg/l)	3.2	5.1	-	3.9
COD	0.7	0.8	5.9	1.3
Fluoride (mg/l)	0.09	0.18	nil	0.21
Silica (mg/l)	7.1	8.6	7.4	12
Manganese (mg/l)	-	nil	nil	nil
Iron (mg/l)	nil	0.02	0.09	nil
Aluminium (mg/l)	-	0.01	0.04	nil
Calcium (mg/l)	75	74	64.9	78.9
Magnesium (mg/l)	12.3	8	22.6	10.9
Sodium (mg/l)	11	8.5	12	13
Potassium (mg/l)	0.8	0.8	1	0.94
Sulphate (mg/l)	0.2	5.8	4.2	5.8
Chloride (mg/l)	12	12	26	13

4.1.8 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 micometres 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

4.1.8.1 Methodology

PM2.5 and PM10 particulate sampling was conducted for 24 hours using Airmetrics Minivol Tactical Air Samplers. 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 March 13th, 2012 until 12:00am March 14th, 2012. The second PM10 sampling exercise was conducted from 12:00am on March 27th, 2012 until 12:00am March 28th, 2012. The third PM10 sampling exercise was conducted from 12:00am on April 3rd, 2012 until 12:00am April 4th, 2012.

The first PM2.5 sampling exercise was conducted from 12:00am on March 20th, 2012 until 12:00am March 21st, 2012. The second PM2.5 sampling exercise was conducted from 12:00am on March 29th, 2012 until 12:00am March 30th, 2012. The third PM2.5 sampling exercise was conducted from 12:00am on April 5th, 2012 until 12:00am April 6th, 2012.

PM10 and PM2.5 ambient particulate measurements were conducted at seven (7) locations along the proposed highway route (Table 4.31 and Figure 4-50).

Table 4.31 - Particulate sampling locations in JAD 2001

STATION	LOCATION	JAD 2001	
		Northing (m)	Easting (m)
P1	Caymanas Bay	653912.99	759070.26
P2	Waterloo Valley	653140.87	756676.77
P3	Obama Heights – Cross Pen	653781.64	754234.70
P4	Content	654881.88	752467.18
P5	Dam Head – Old Road	655425.04	751896.26
P6	Cambria Farms	662384.24	745719.85
P7	Vanity Fair - Linstead	666128.41	746416.79

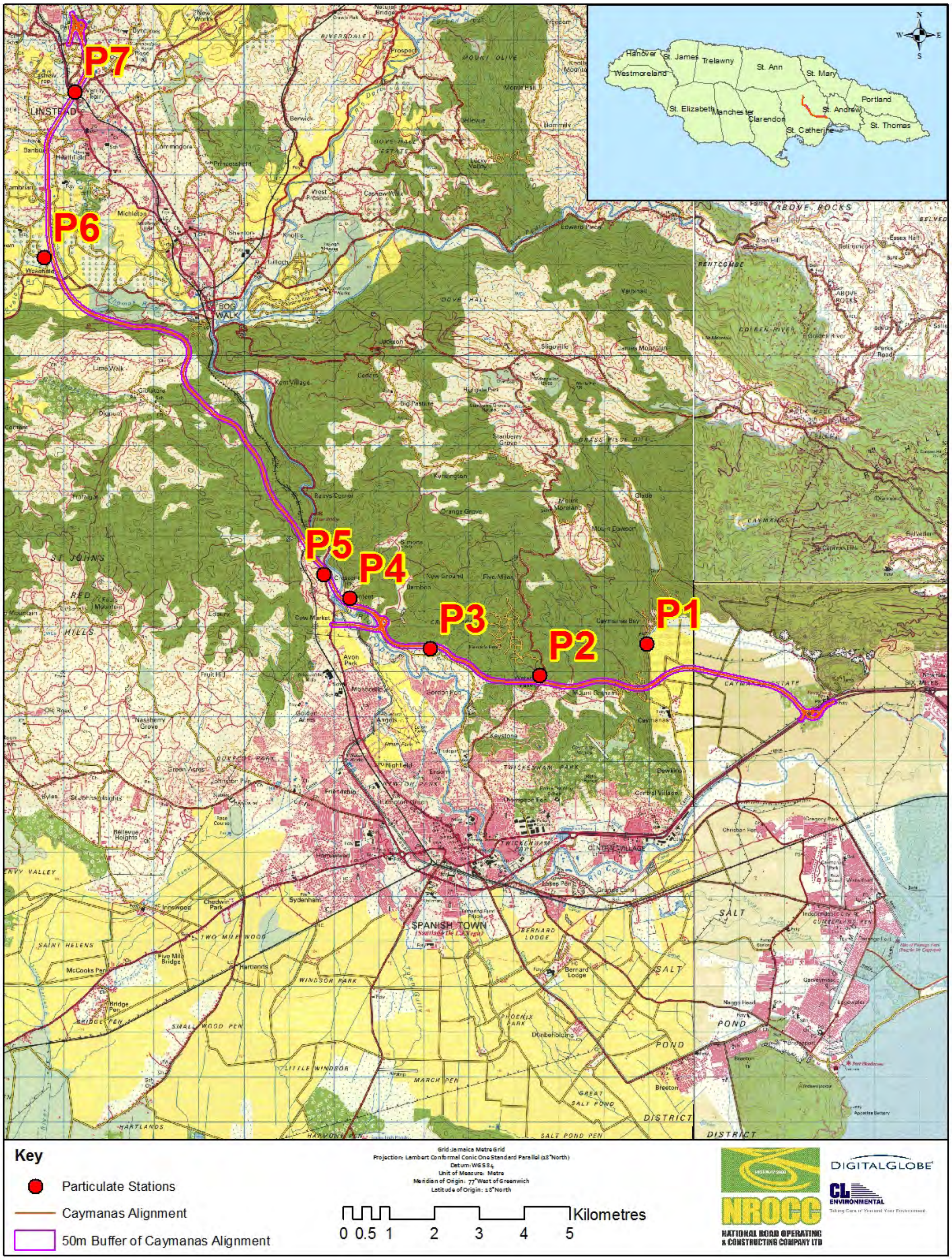

Figure 4-50 – Map showing particulate stations (PM10 and PM 2.5)

Plate 4.26 - Photo showing P3 – Obama Heights, Cross Pen

Plate 4.27 - Photo showing P4 - Content

Plate 4.28 - Photo showing P2 – Waterloo Valley

Plate 4.29 - Photo showing P7 – Bread of Life Church, Vanity Fair, Linstead

4.1.8.2 PM 10 Results

For the first PM 10 sampling event all locations had particulate values compliant with the 24-hour US EPA standard of 150µg/m^3. Station P7 had the highest value of 43.75µg/m^3 as this station is situated close to a busy commercial district and thoroughfare in the Linstead area, and as such will be affected by particulates from vehicular traffic and commercial activities along the roadway. Stations P1 and P2, had the lowest PM 10 values of 23.61µg/m³ and 22.08 µg/m³ respectively. Station P1 is located at a house within the quiet residence of Caymanas Bay and station P2 at a residence in Waterloo valley. Both stations would be prone to minor dust nuisance.

The same trend occurs for the second and third PM 10 sampling events whereby station P7 again had the highest particulate values of 28.19 µg/m³ and 44.03 µg/m³ respectively. However, on these occasions, station P4 (located in the rural hills of Content) had the lowest particulate values of 12.64 µg/m³ (March 27-28) and 26.94 µg/m³ (April 3-4). All locations had particulate values compliant with the 24-hour US EPA standard of 150 µg/m³.

It is evident that PM10 values during the March 13-14 and March 27-28 sampling periods were, on average, lower than values obtained during the April 3-4 sampling period. This was due to rainfall that occurred on March 13th, as well as during days prior to March 27th, which therefore would have kept ambient particulates to a minimum.

The results of all PM10 sampling runs are shown in Table 4.32 below. No result was available for station P5 on April 3-4 due to a pump battery failure.

Table 4.32 - PM 10 Results

STATION	March 13-14, 2012 Result (µg/m³)	March 27-28, 2012 Result (µg/m³)	April 3-4, 2012 Result (µg/m³)	*US EPA Std. (µg/m³)*
P1	23.61	15.42	35.42	**150**
P2	22.08	18.75	35.42	**150**
P3	27.36	16.67	37.22	**150**
P4	35.83	12.64	26.94	**150**
P5	30.42	19.17	N/A	**150**
P6	34.86	23.06	41.94	**150**
P7	43.75	28.19	44.03	**150**

4.1.8.3 PM 2.5 Results

For the first PM 2.5 sampling event all locations had particulate values compliant with the US EPA 24-hour standard of 35µg/m³. Stations P5 and P7 had the highest values of 18.61 µg/m³ and 17.78 µg/m³ respectively. P7 is situated close to a busy commercial district and thoroughfare in the Linstead area, and as such will be affected by particulates from vehicular traffic and commercial activities along the roadway. P5 is located on a minor road branching off of the main road which leads into the Bog Walk gorge. Stations P1 and P2, had the lowest PM 2.5 values of 7.85 μg/m³ and 8.89 μg/m³ respectively. Station P1 is located at a house within the quiet residence of Caymanas Bay and station P2 at a residence in Waterloo valley. Both stations would be prone to minor dust nuisance.

A similar trend occurs for the second and third PM 2.5 sampling events whereby station P7 had the highest PM2.5 particulate values of 18.47 μg/m³ and 20.97 μg/m³ respectively. Station P1 (located in the quiet residential area of Caymanas Bay) had the lowest particulate values of 6.67 μg/m³ (March 29-30) and 9.17 μg/m³ (April 5-6). All locations had particulate values compliant with the 24-hour US EPA standard of 35 μg/m³.

The results of all PM2.5 sampling runs are shown in Table 4.33 below.

Table 4.33 - PM 2.5 Results

STATION	March 20-21, 2012 Result (μg/m³)	March 29-30, 2012 Result (μg/m³)	April 5-6, 2012 Result (μg/m³)	*US EPA 24-hr Std. (μg/m³)*
P1	7.85	6.67	9.17	**35**
P2	8.89	10.28	10.83	**35**
P3	10.42	16.25	11.94	**35**
P4	11.25	9.3	9.58	**35**
P5	18.61	8.19	20.28	**35**
P6	16.67	12.08	12.92	**35**
P7	17.78	18.47	20.97	**35**

4.1.9 Ambient NO_x and SO_2

The measurement of ambient Nitrogen Oxides and Sulphur Dioxide was measured at six locations which are similar to the proposed Caymanas to Linstead alignment. Passive diffusion tubes were setup from September 19, 2011 to October 7, 2011 after which they were capped, packaged and sent to Enviro Technology Services Plc for analyses. Table 4.34 below outlines the results which are expected to be similar or lower along the proposed alignment.

Table 4.34 - Ambient NO_x and SO_2 concentrations

Stations	Exposure Data		Time (hr.)	NO_2 (µg/m³)	NO_X (µg/m³)	NO (µg/m³)	SO_2 (µg/m³)
	Date On	Date Off					
McCooks Pen Primary	19/10/2011	7/11/2011	454.8	11.98	13.55	1.57	2.25
Fraizers Content	19/10/2011	7/11/2011	453.3	7.89	6.68	ND	1.18
Ridge Mountain	19/10/2011	7/11/2011	451.9	2.47	9.44	6.97	0.54
Giblatore (IGL)	19/10/2011	7/11/2011	448.9	5.24	6.53	1.29	1.87
Willowdene - Bog Walk	19/10/2011	7/11/2011	448.8	12.54	11.96	ND	1.55
Vanity Fair	19/10/2011	7/11/2011	448.7	18.89	18.34	ND	1.44

ND: Below the limit of detection (0.103 µg NO_x, 0.014 µg NO_2 and 0.019 µg SO_2)

4.1.10 Ambient Noise Climate

4.1.10.1 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 9th, to 7:00 hrs Monday 12th, March 2012. The readings were taken at nine (9) locations (Stations N1 – N9) listed below in Table 4.35 and depicted in Figure 4-51.

Table 4.35 - Station numbers and locations in JAD2001

STATION	LOCATION	JAD 2001	
		Northing (m)	Easting (m)
N1	Caymanas Bay	653912.99	759070.26
N2	Waterloo Valley	653140.87	756676.77
N3	Obama Heights – Cross Pen	653781.64	754234.70
N4	Content	654881.88	752467.18
N5	Dam Head – Old Road	655425.04	751896.26
N6	Wakefield Orange fields	661134.19	746403.38
N7	Cambria Farms	662384.24	745719.85
N8	Banbury, Linstead	665219.09	745813.14
N9	Vanity Fair, Linstead	666128.41	746416.79

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. 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:

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

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 4.30, Plate 4.31 and Plate 4.32 shows noise monitoring outdoor kits at three locations.

Plate 4.30 - Photo showing noise meter at Station N9 - Vanity Fair, Linstead

Plate 4.31 - Photo showing noise meter at Station N7 - Cambria Farms

Plate 4.32 - Photo showing noise meter at Station N4 - Content

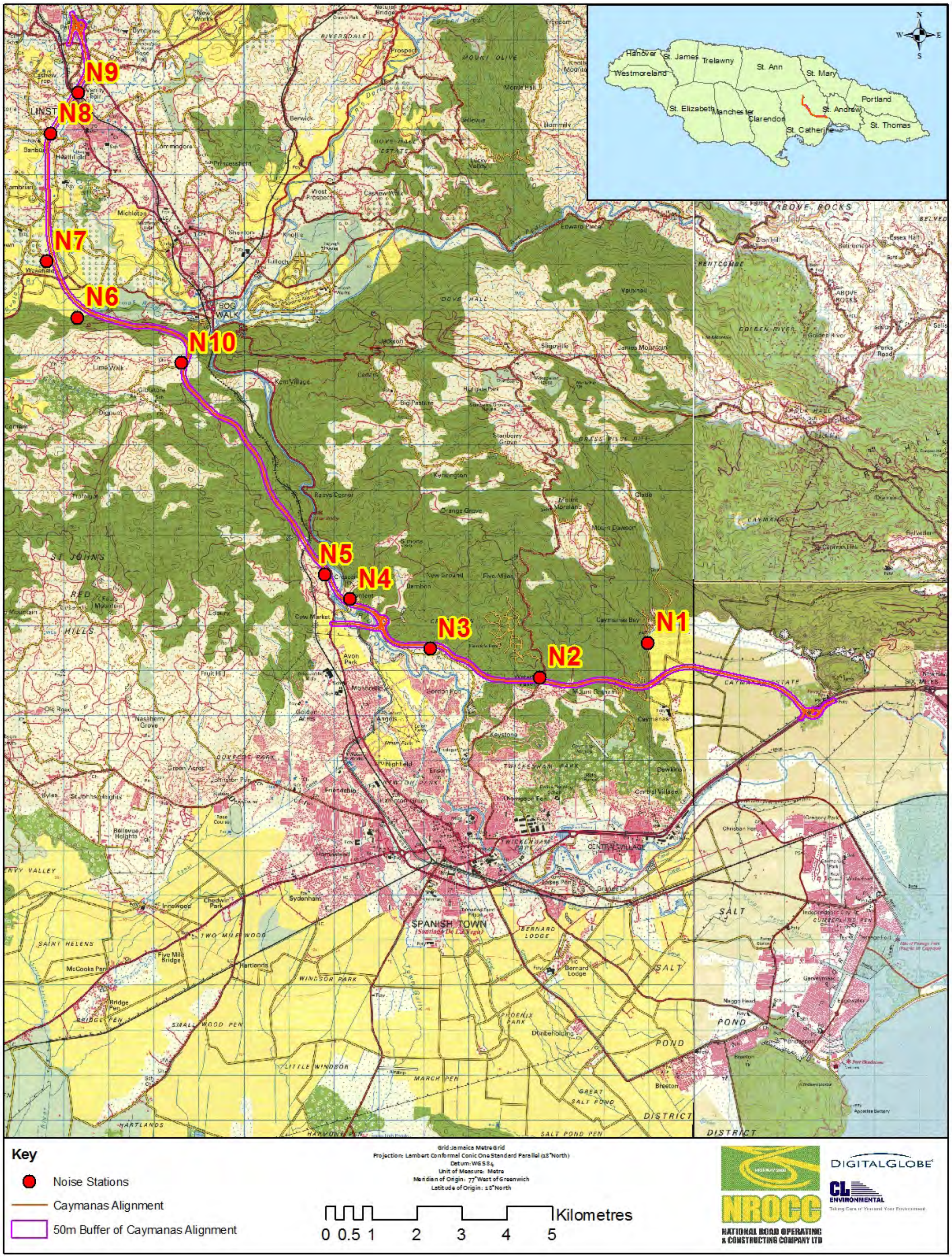

Figure 4-51 – Map showing locations of noise survey stations

4.1.10.2 Results

This section outlines the results of the seventy two (72) hour noise monitoring exercise at the nine (9) monitoring stations.

Stations 1- Caymanas Bay

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 27.5 dBA which occurred at 3:35:30 am on March 10, 2012 to a high (Lmax) of 86.3 dBA which occurred at 3:13:30 pm on March 10, 2012. Average noise level for this period was 51.4 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-52.

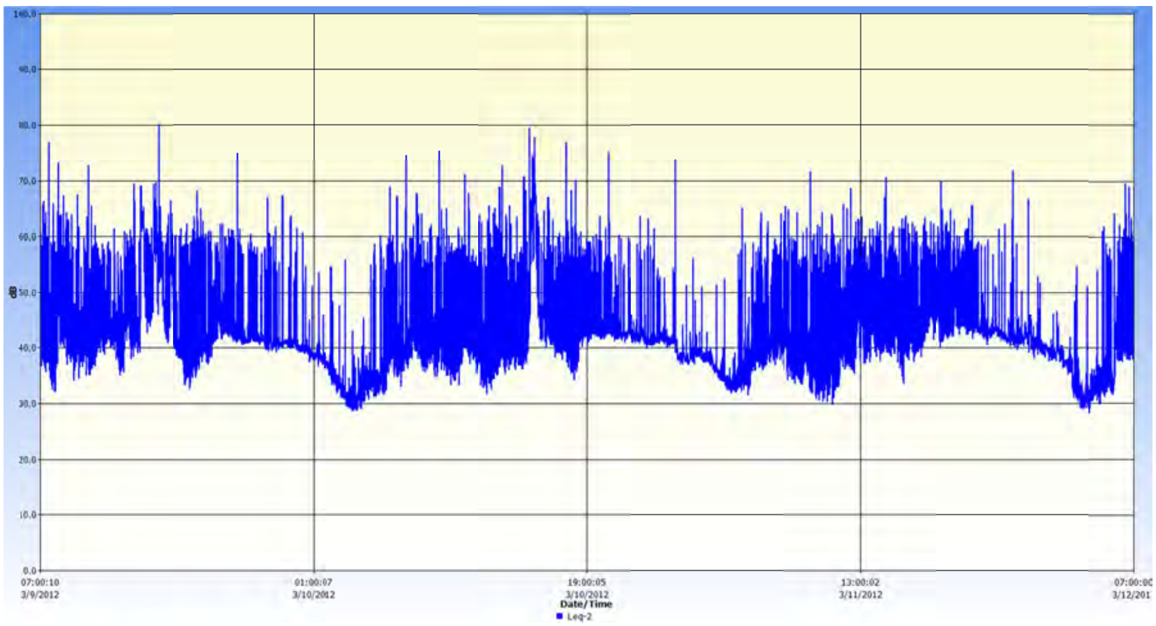

Figure 4-52 - Noise fluctuation (Leq) over 72 hours at Station 1

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 31.5 Hz. (octave frequency range is 28 - 35 Hz) (Figure 4-53).

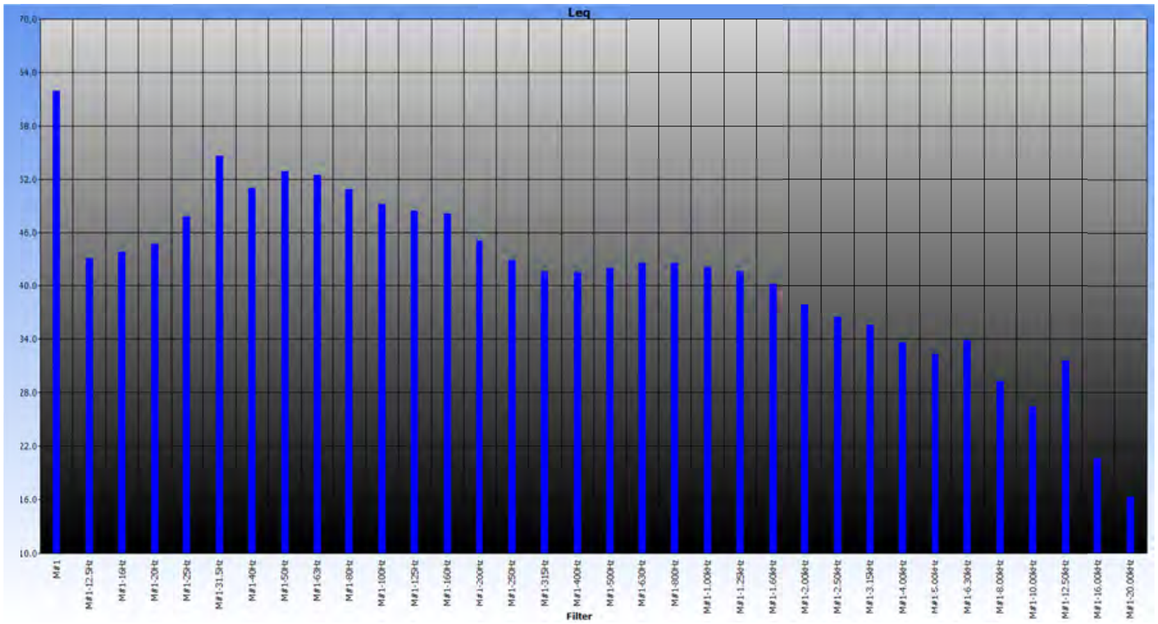

Figure 4-53 - Octave band spectrum of noise at Station 1

L10 and L90 – Caymanas Bay

The two most common **Ln** values used are **L10** and **L90** and these are sometimes called the 'annoyance level' and 'background level' respectively. **L10** is almost the only statistical value used for the descriptor of the higher levels, but **L90**, 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 4-54 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) ≈41.7% of the time, large fluctuations (L10 – L90) ≈30.5% of the time and ≈27.8% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 51.4 dBA and 34.5 dBA respectively.

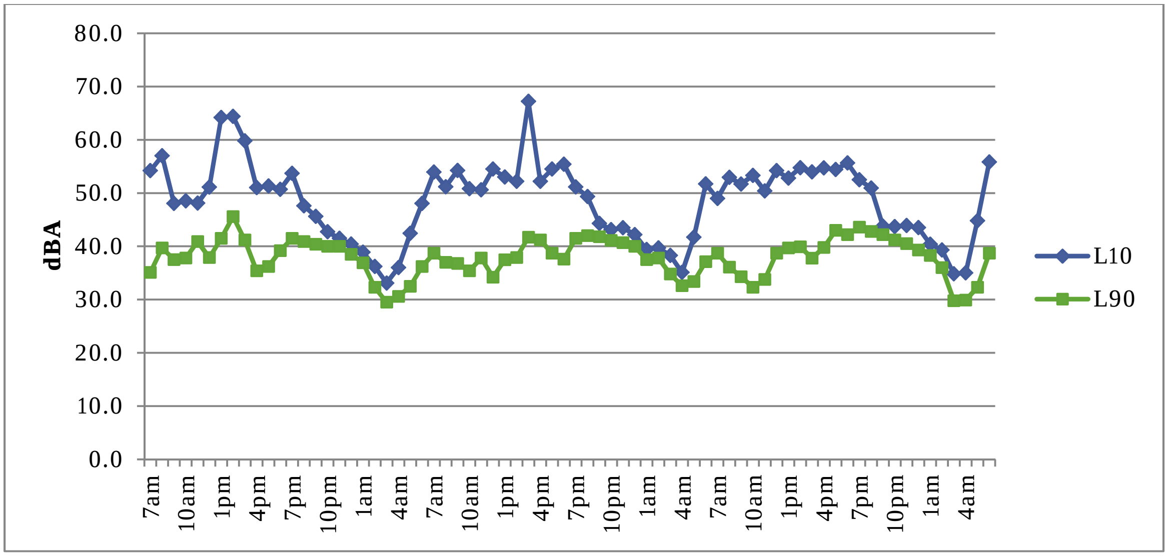

Figure 4-54 - L10 and L90 for Station 1

Station 2 – Waterloo Valley

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 25.4 dBA which occurred at 4:43:20 am on March 10, 2012 to a high (Lmax) of 76.8 dBA which occurred at 7:55:00 am on March 9, 2012. Average noise level for this period was 49.0 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-55.

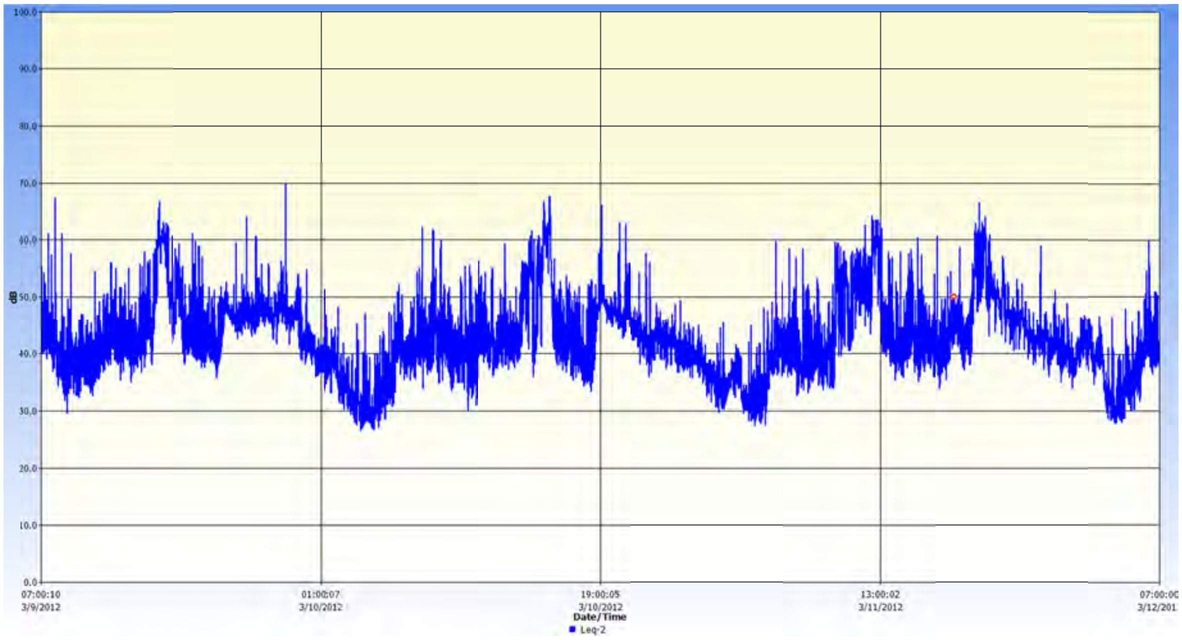

Figure 4-55 -Noise fluctuation (Leq) over 72 hours at Station 2

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 50 Hz. (octave frequency range is 45 - 56Hz) (Figure 4-56).

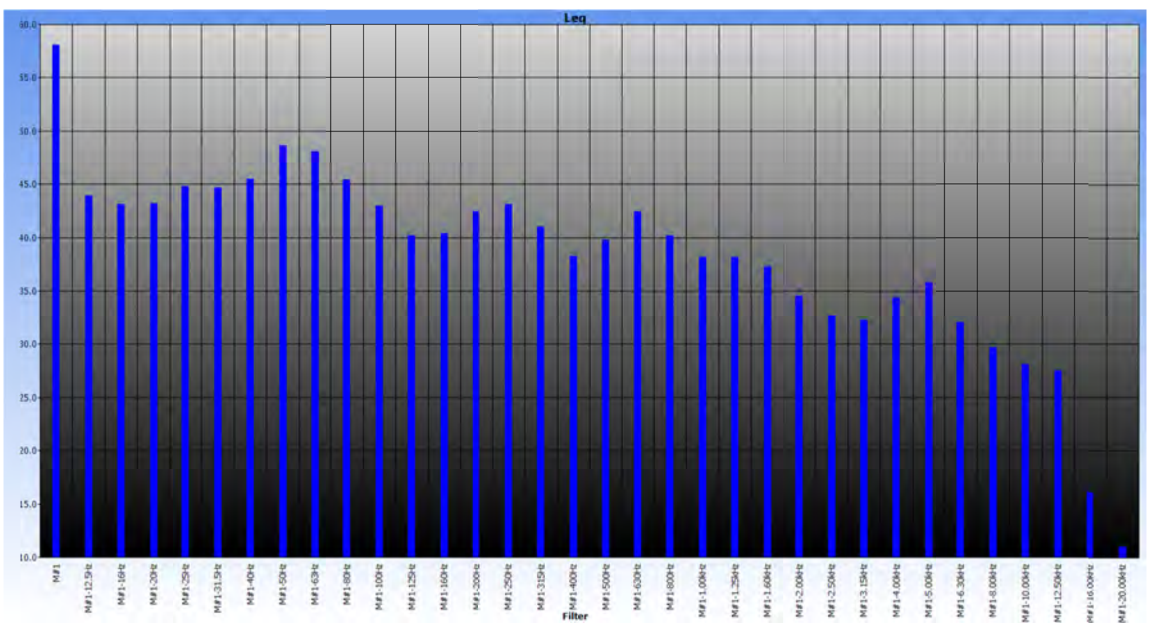

Figure 4-56 -Octave band spectrum of noise at Station 2

L10 and L90 – Waterloo Valley

Figure 4-57 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) ≈79.2% of the time, no significant fluctuations (L10 – L90) ≈15.3% and large fluctuations (L10 – L90) ≈5.5% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 51.3 dBA and 34.8 dBA respectively.

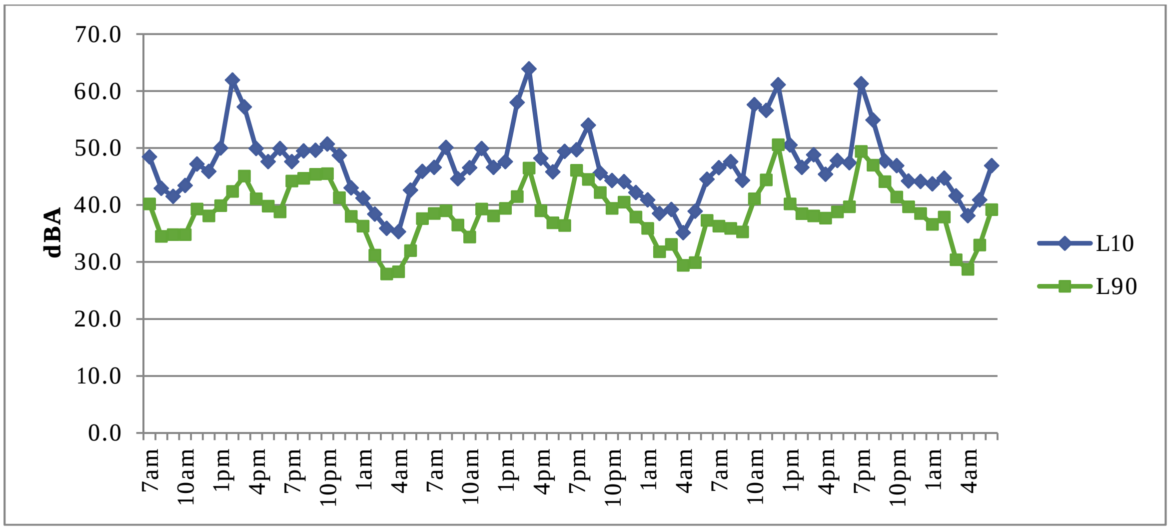

Figure 4-57 - L10 and L90 for Station 2

Station 3 – OBAMA HEIGHTS – Cross Pen

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 26.4 dBA which occurred at 4:45:00 am on March 12, 2012 to a high (Lmax) of 85.1 dBA which occurred at 7:52:20 pm on March 9, 2012. Average noise level for this period was 52.0 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-58.

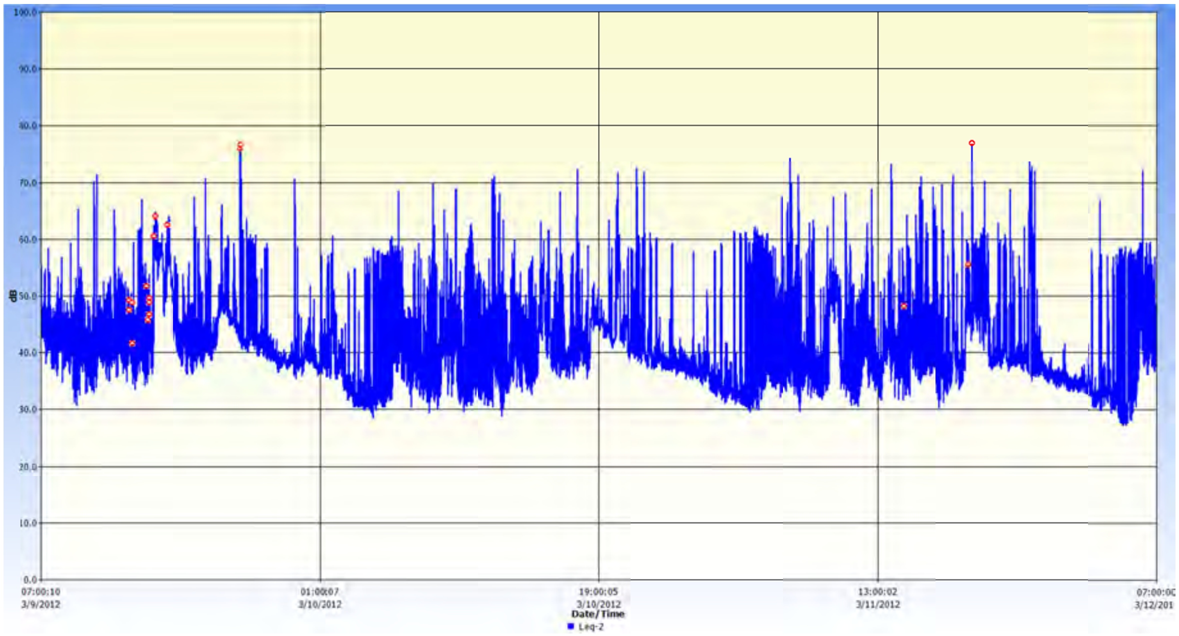

Figure 4-58 - Noise fluctuation (Leq) over 72 hours at Station 3

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 12.5 Hz. (octave frequency range is 11 - 14 Hz) (Figure 4-59).

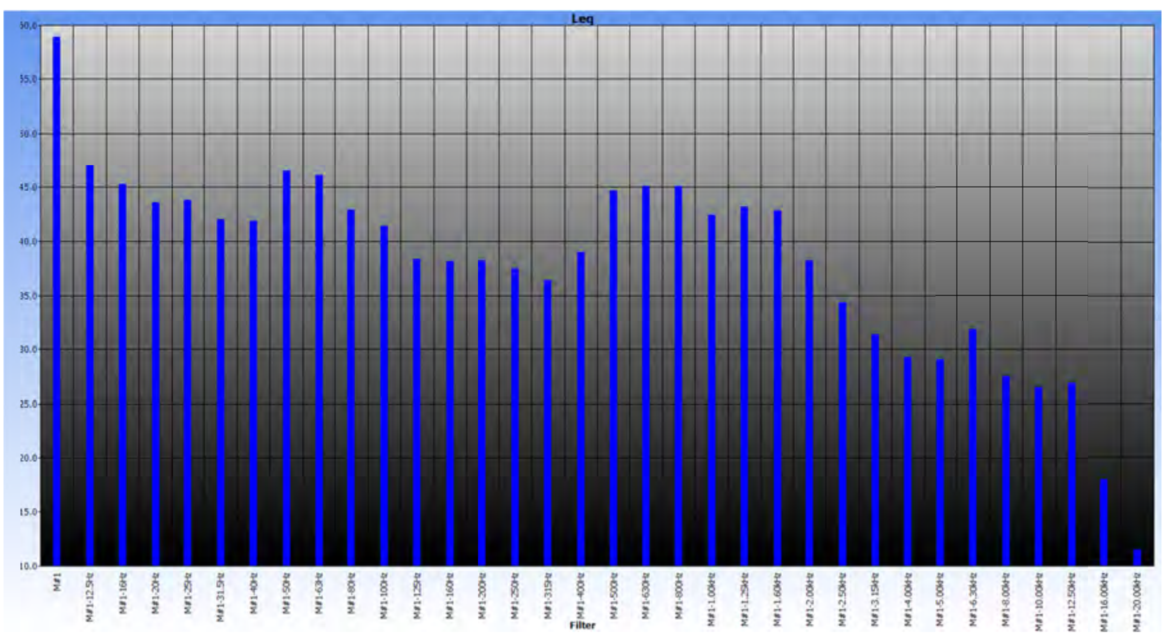

Figure 4-59 - Octave band spectrum of noise at Station 3

L10 and L90 – Obama Heights, Cross Pen

Figure 4-60 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) ≈52.8% of the time, moderate fluctuations in the noise climate (L10 – L90) ≈34.7% of the time and no significant fluctuations (L10 – L90) ≈12.5% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 53.7 dBA and 33.6 dBA respectively.

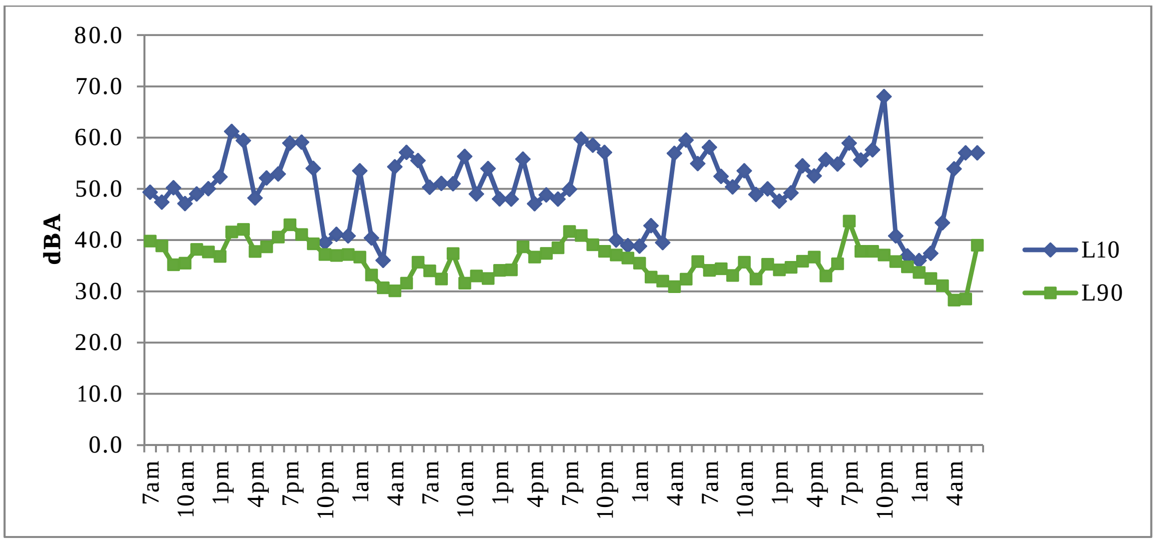

Figure 4-60 - L10 and L90 for Station 3

Station 4 – Content

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 30.5 dBA which occurred at 4:19:10 am on March 12, 2012 to a high (Lmax) of 81.1 dBA which occurred at 3:30:00 pm on March 11, 2012. Average noise level for this period was 53.3 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-61.

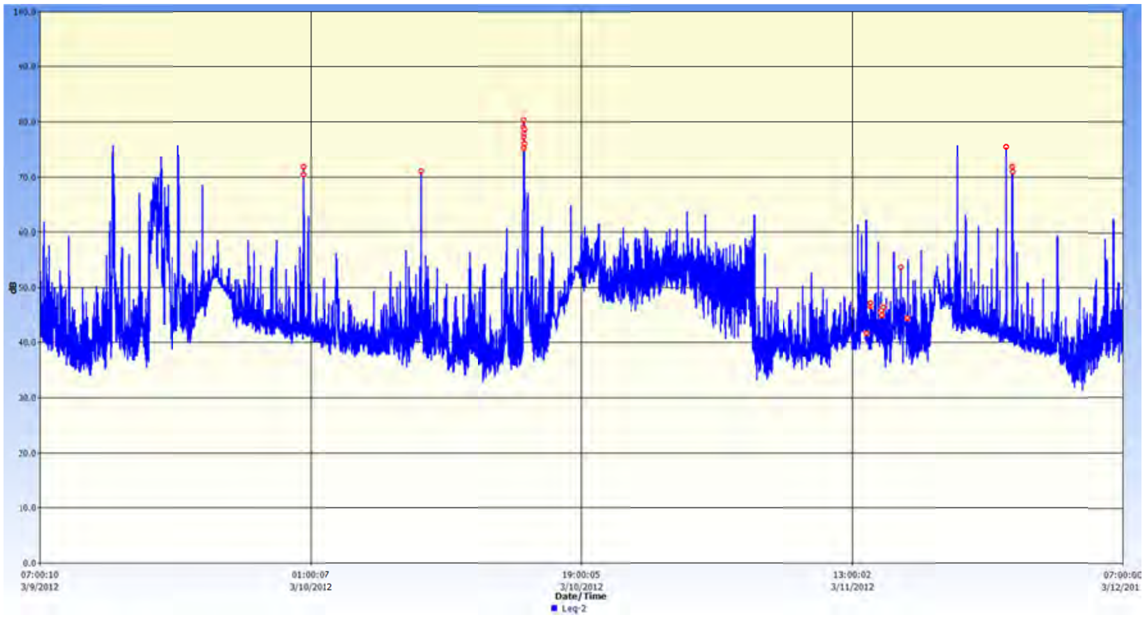

Figure 4-61 - Noise fluctuation (Leq) over 72 hours at Station 4

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 63 Hz. (octave frequency range is 56 - 71 Hz) (Figure 4-62).

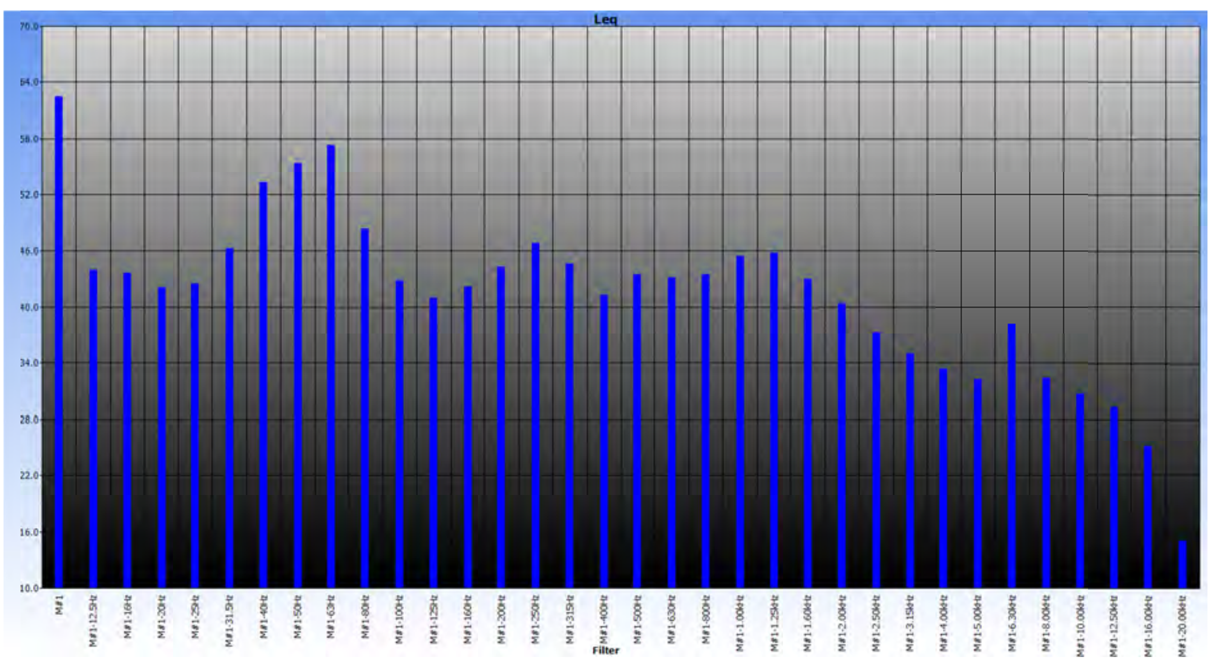

Figure 4-62 - Octave band spectrum of noise at Station 4

L10 and L90 – Content

Figure 4-63 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) ≈59.7% of the time, no significant fluctuations (L10 – L90) ≈31.9% of the time and large fluctuations in the noise climate (L10 – L90) ≈8.4% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 53.0 dBA and 38.0 dBA respectively.

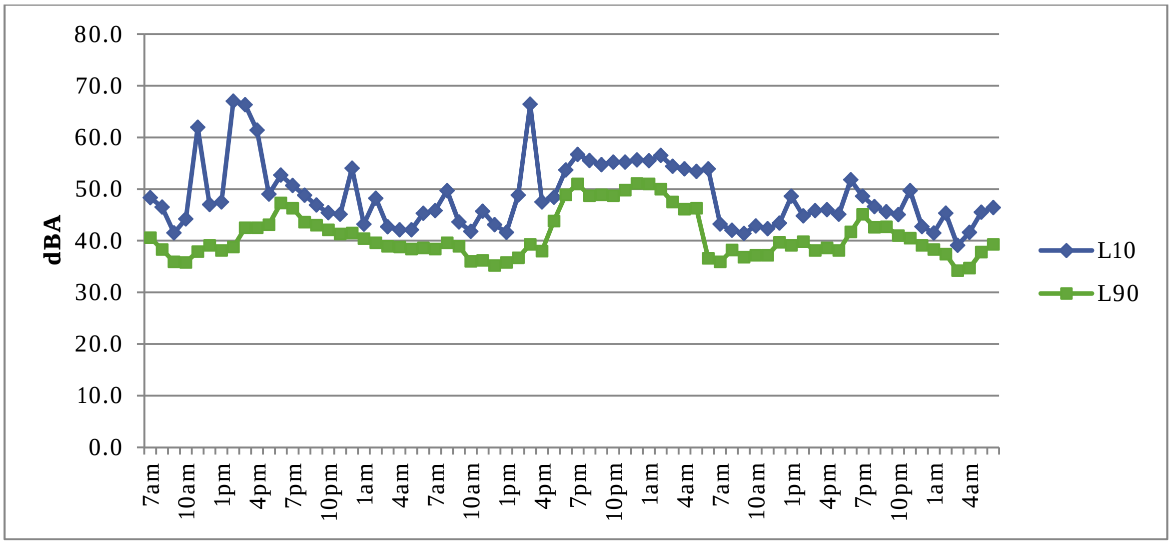

Figure 4-63 - L10 and L90 for Station 4

Station 5 – Old Road, Dam Head

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 30.4 dBA which occurred at 4:19:10 am on March 12, 2012 to a high (Lmax) of 82.8 dBA which occurred at 7:12:00 pm on March 11, 2012. Average noise level for this period was 59.2 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-64.

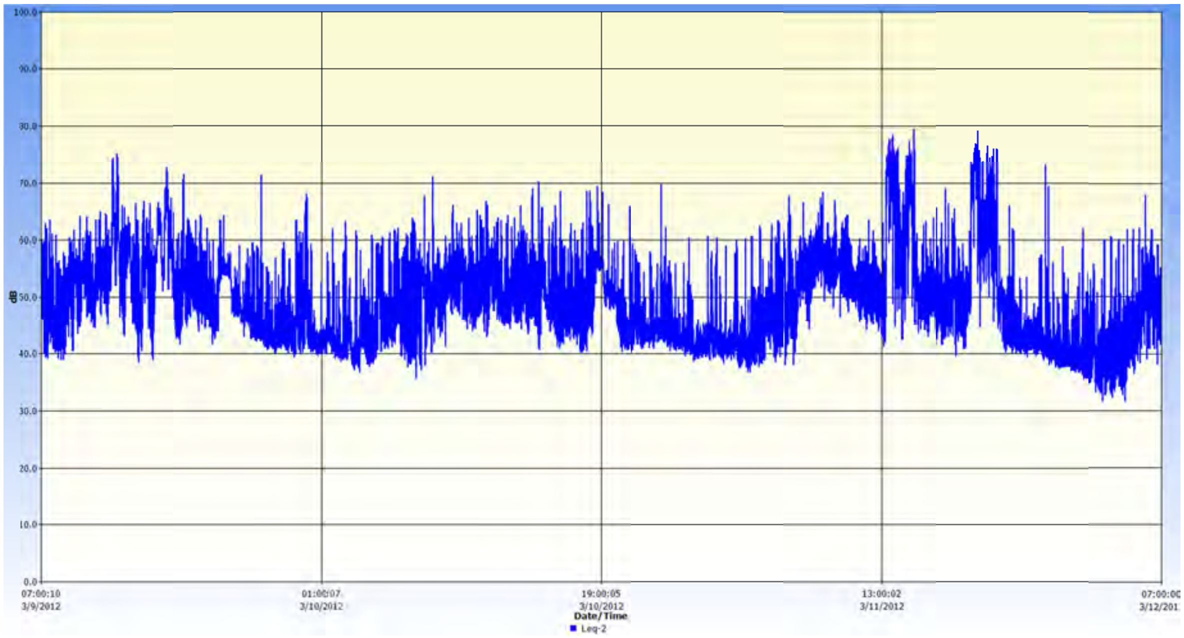

Figure 4-64 - Noise fluctuation (Leq) over 72 hours at Station 5

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 630 Hz. (octave frequency range is 561 - 707 Hz) (Figure 4-65).

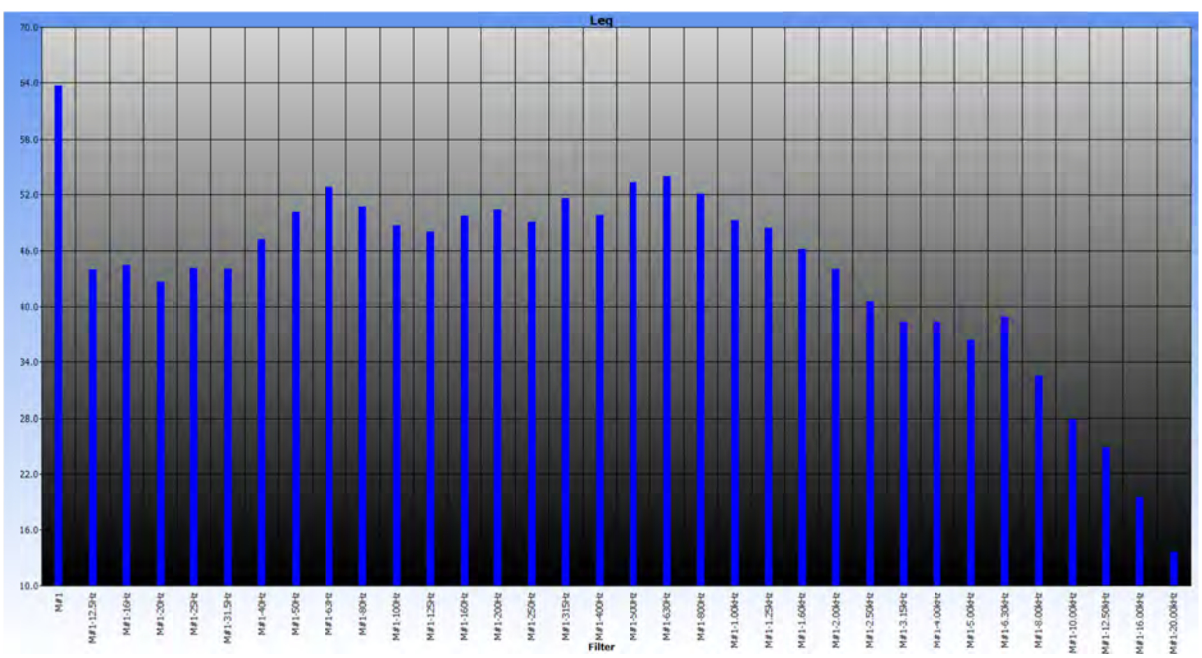

Figure 4-65 - Octave band spectrum of noise at Station 5

L10 and L90 – Old Road, Dam Head

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) ≈76.4% of the time, large fluctuations in the noise climate (L10 – L90) ≈19.4% of the time and no significant fluctuations (L10 – L90) ≈4.2% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 58.5 dBA and 40.6 dBA respectively.

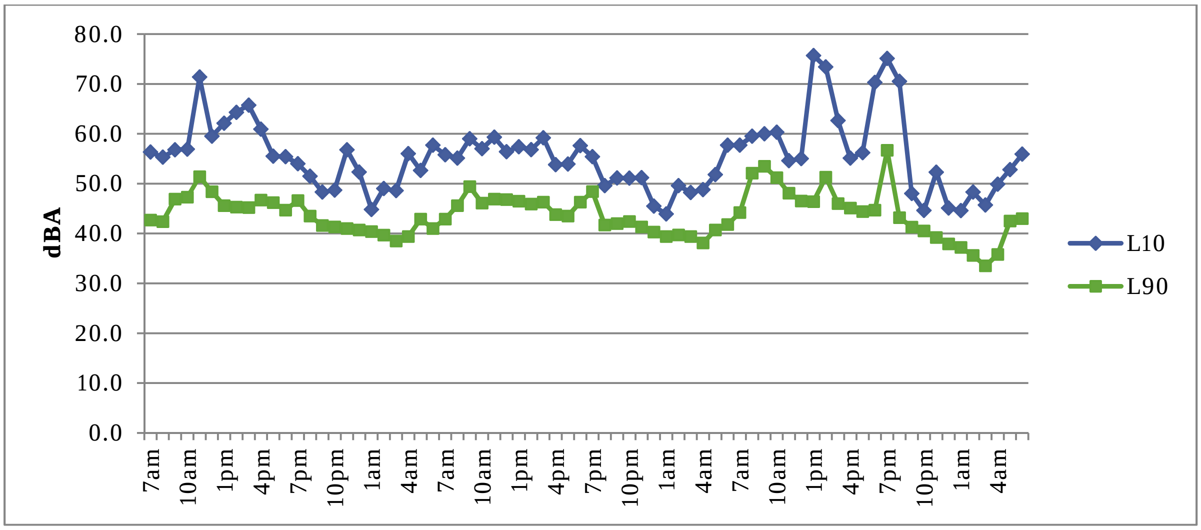

Figure 4-66 - L10 and L90 for Station 5

Station 6 – Wakefield Orange Field off Barry Road

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 26.4 dBA which occurred at 11:11:00 am on March 9, 2012 to a high (Lmax) of 73.5 dBA which occurred at 2:41:00 pm on March 9, 2012. Average noise level for this period was 49.1 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-67.

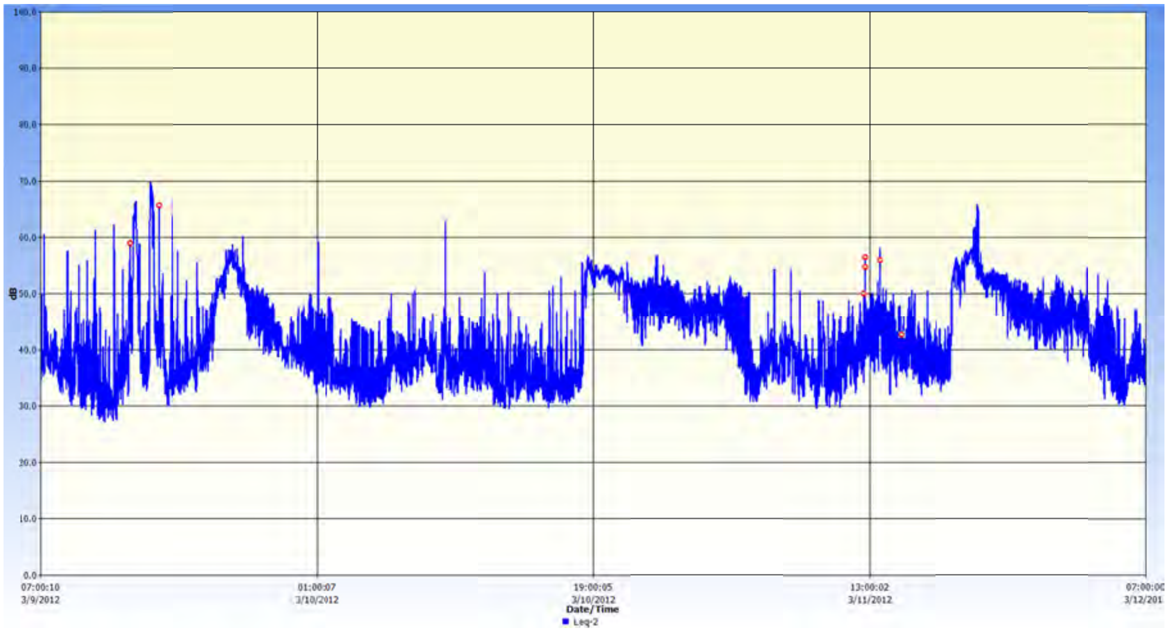

Figure 4-67 - Noise fluctuation (Leq) over 72 hours at Station 6

Octave Band Analysis at Station 6

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz. (octave frequency range is 56 - 71 Hz) (Figure 4-68).

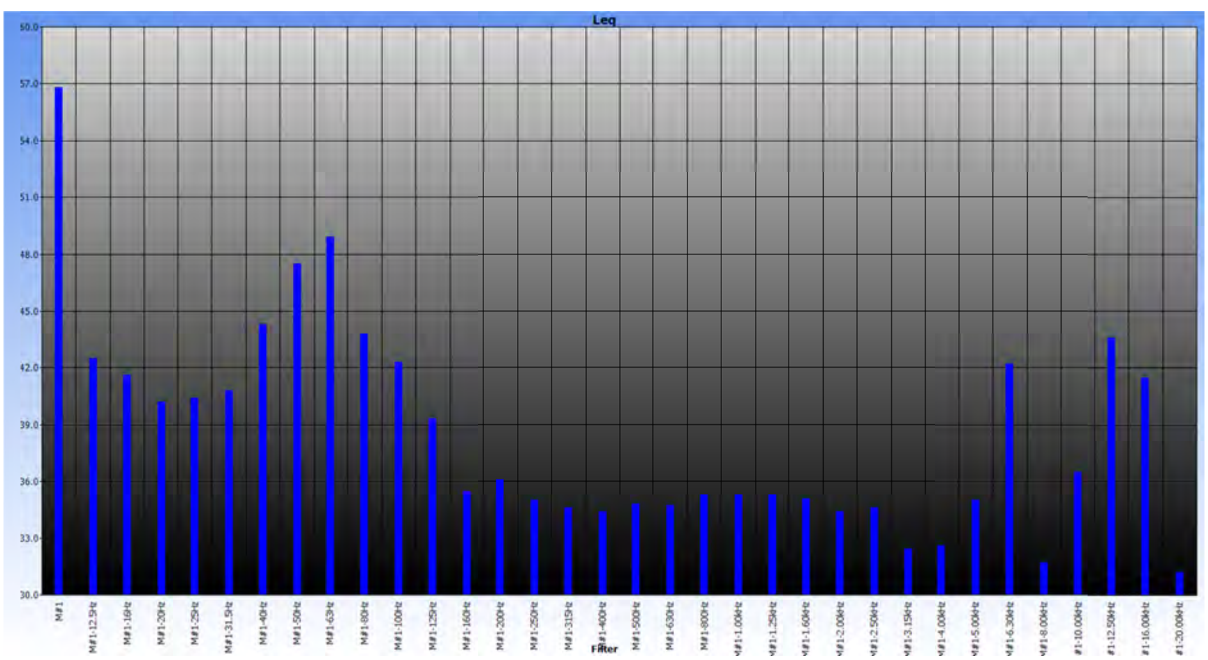

Figure 4-68 - Octave band spectrum of noise at Station 6

L10 and L90 – Wakefield Orange Field off Barry Road

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) ≈80.6% of the time, no significant fluctuations (L10 – L90) ≈12.5% of the time and large fluctuations in the noise climate (L10 – L90) ≈6.9% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 52.3 dBA and 33.3 dBA respectively.

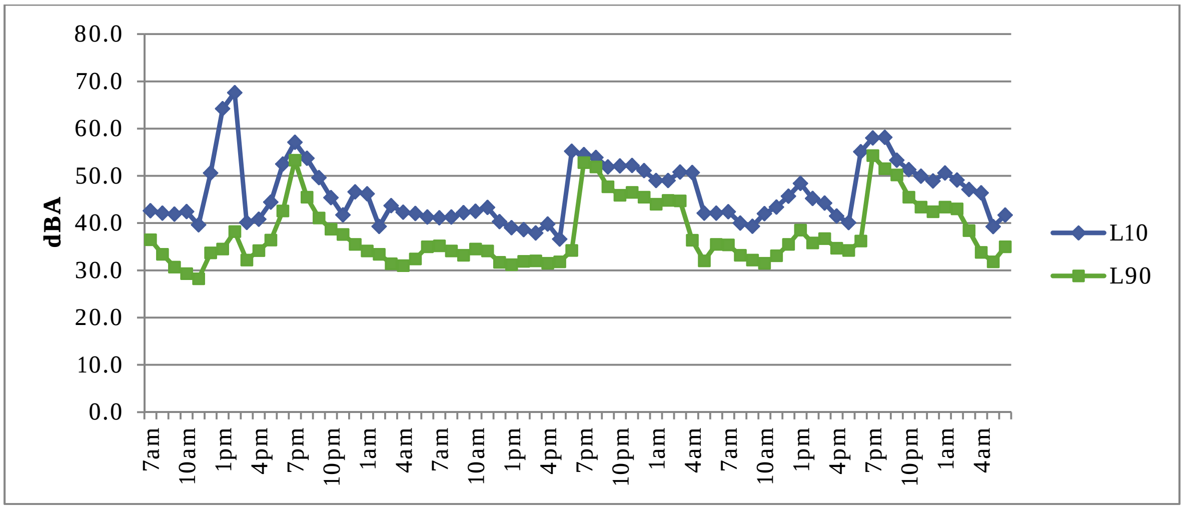

Figure 4-69 - L10 and L90 for Station 6

Station 7 – Cambria Farms

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 27.3 dBA which occurred at 4:13:30 am on March 10, 2012 to a high (Lmax) of 87.1 dBA which occurred at 6:28:50 pm on March 10, 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 4-70.

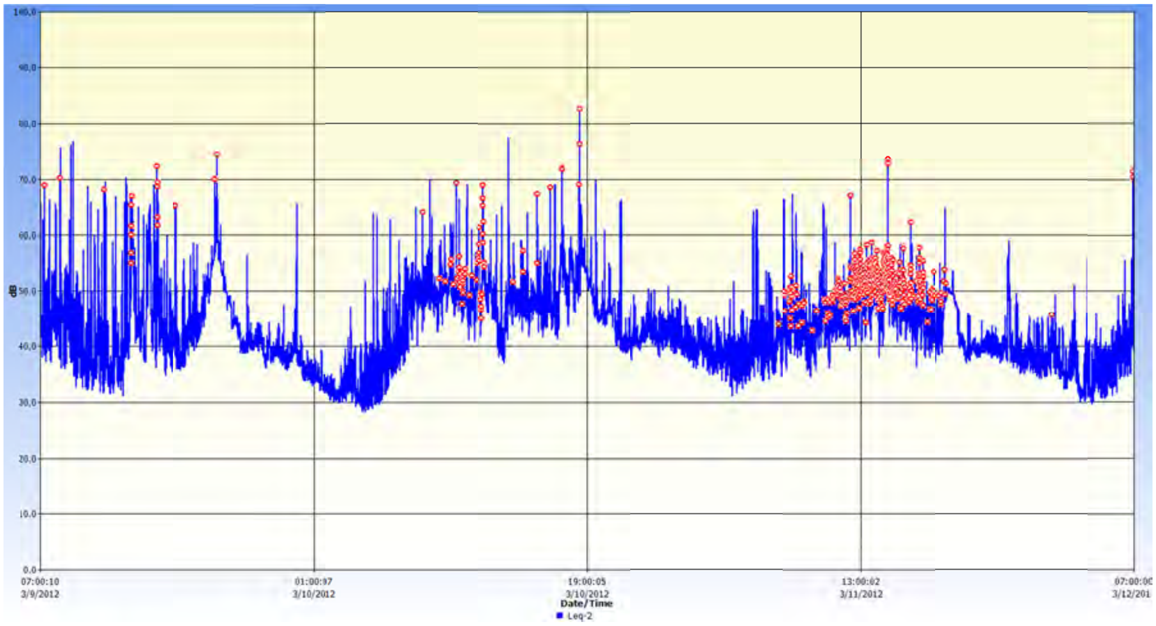

Figure 4-70 - Noise fluctuation (Leq) over 72 hours at Station 7

Octave Band Analysis at Station 7

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz. (octave frequency range is 11 - 14 Hz) (Figure 4-71).

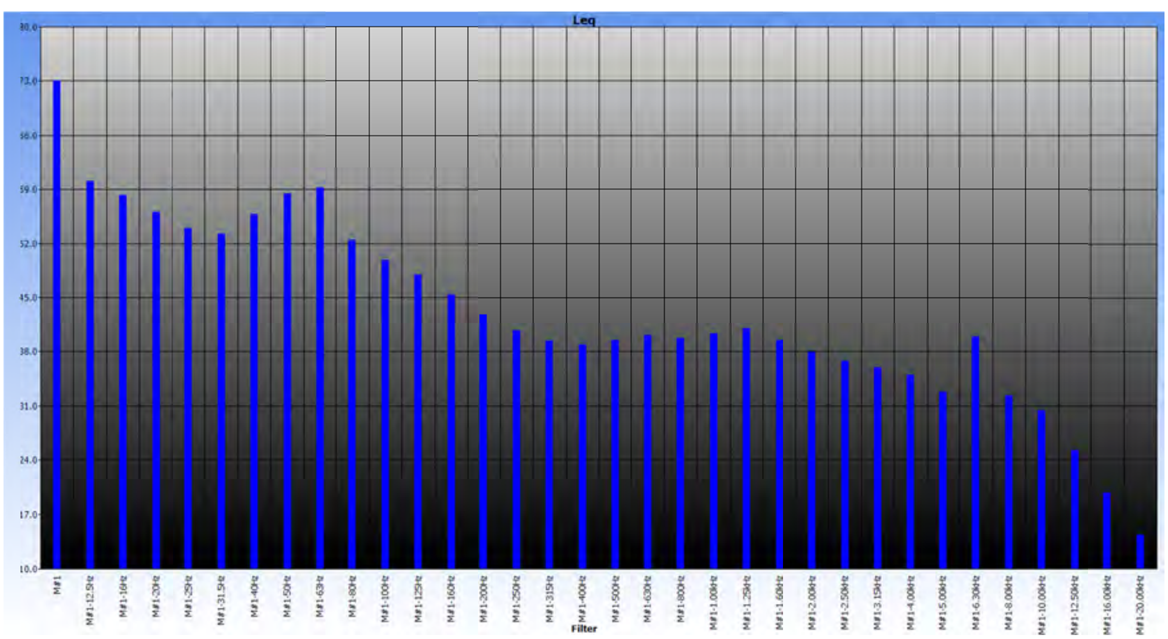

Figure 4-71 - Octave band spectrum of noise at Station 7

L10 and L90 – Cambria Farms

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) ≈72.3% of the time, no significant fluctuations (L10 – L90) ≈20.8% of the time and large fluctuations in the noise climate (L10 – L90) ≈6.9% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 51.6 dBA and 34.8 dBA respectively.

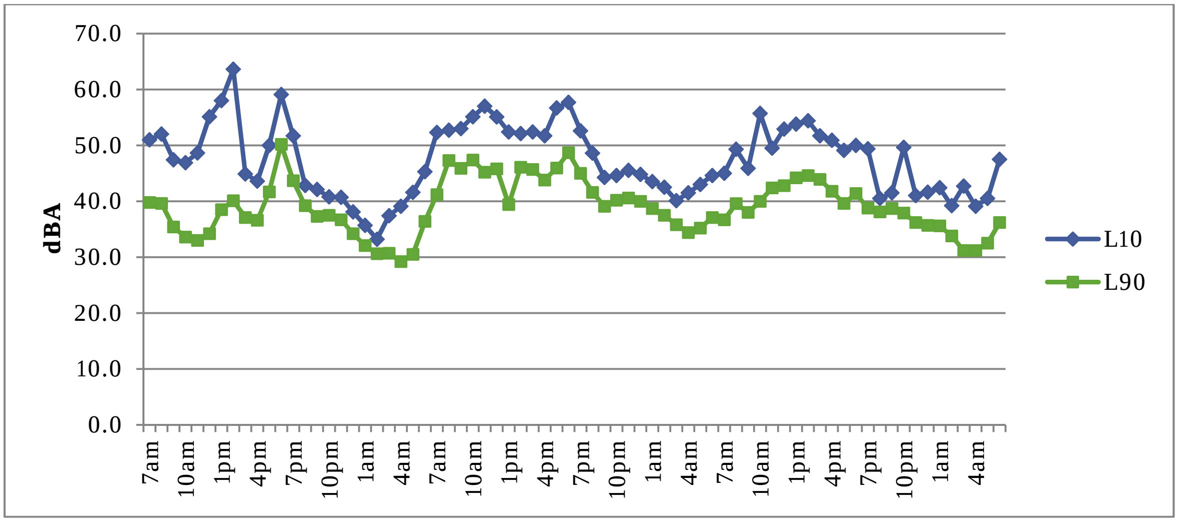

Figure 4-72 - L10 and L90 for Station 7

Station 8 – Banbury, Linstead

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 30.3 dBA which occurred at 9:10:30 am on March 9, 2012 to a high (Lmax) of 91.3 dBA which occurred at 7:12:10 pm on March 11, 2012. Average noise level for this period was 53.6 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-73.

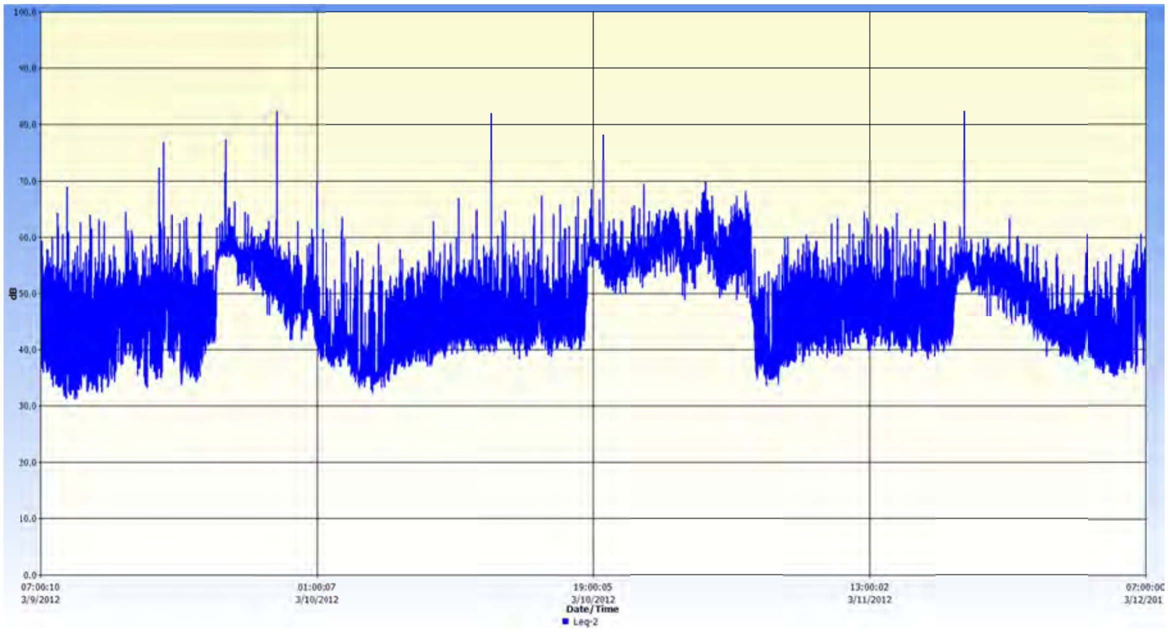

Figure 4-73 - Noise fluctuation (Leq) over 72 hours at Station 8

3.8.1 *Octave Band Analysis at Station 8*

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz. (octave frequency range is 56 - 71 Hz) (Figure 4-74).

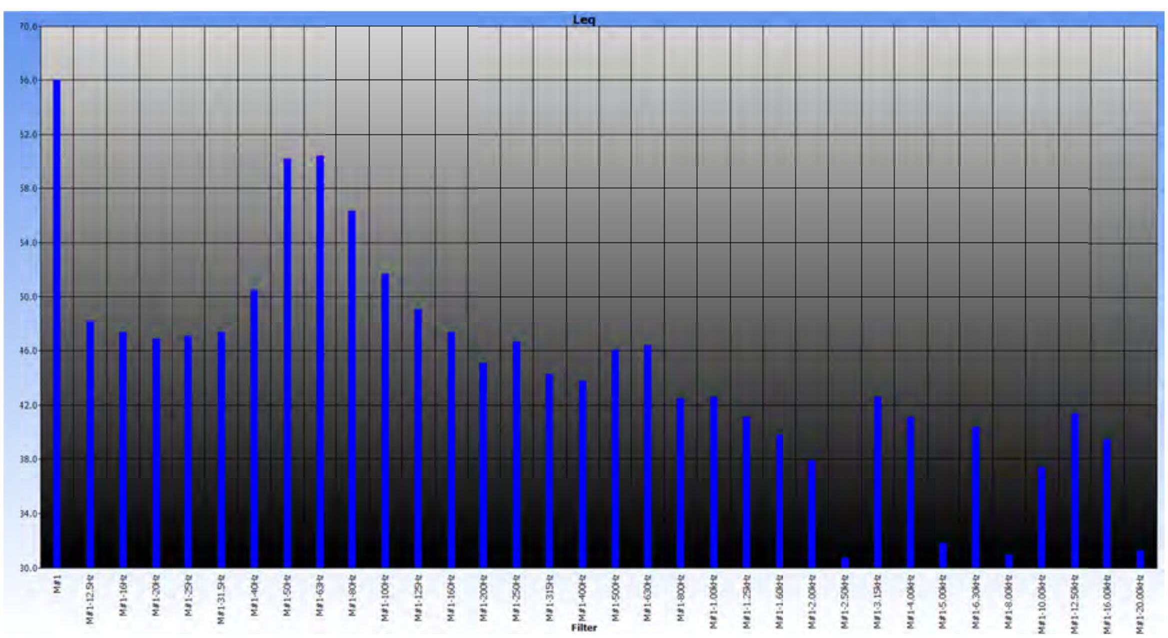

Figure 4-74 - Octave band spectrum of noise at Station 8

L10 and L90 – Banbury, Linstead

Figure 4-75 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) ≈75% of the time, large fluctuations in the noise climate (L10 – L90) ≈16.7% of the time and no significant fluctuations (L10 – L90) ≈8.3% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 55.0 dBA and 40.8 dBA respectively.

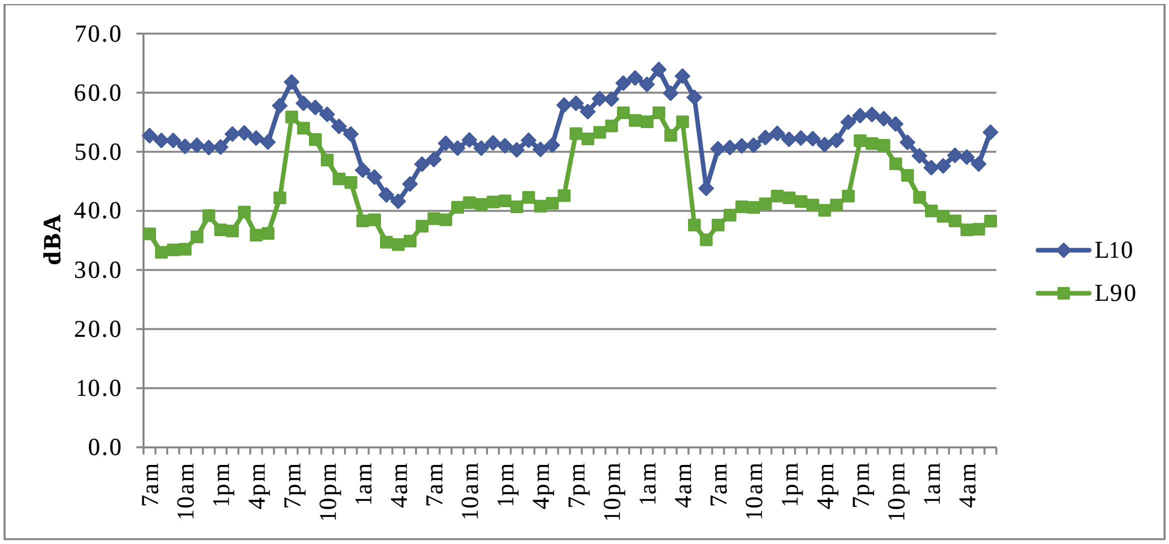

Figure 4-75 - L10 and L90 for Station 8

Station 9 – Vanity Fair, Linstead

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 30.7 dBA which occurred at 4:30:00 am on March 10, 2012 to a high (Lmax) of 97.8 dBA which occurred at 3:46:00 pm on March 9, 2012. Average noise level for this period was 60.6 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-76.

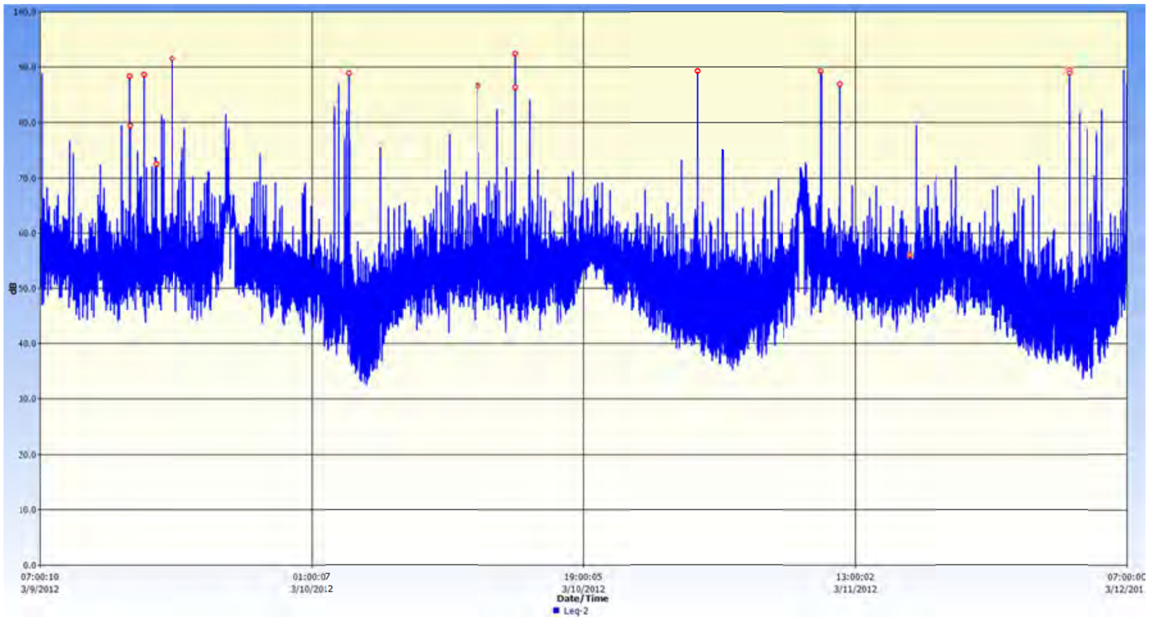

Figure 4-76 - Noise fluctuation (Leq) over 72 hours at Station 9

Octave Band Analysis at Station 9

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 4-77).

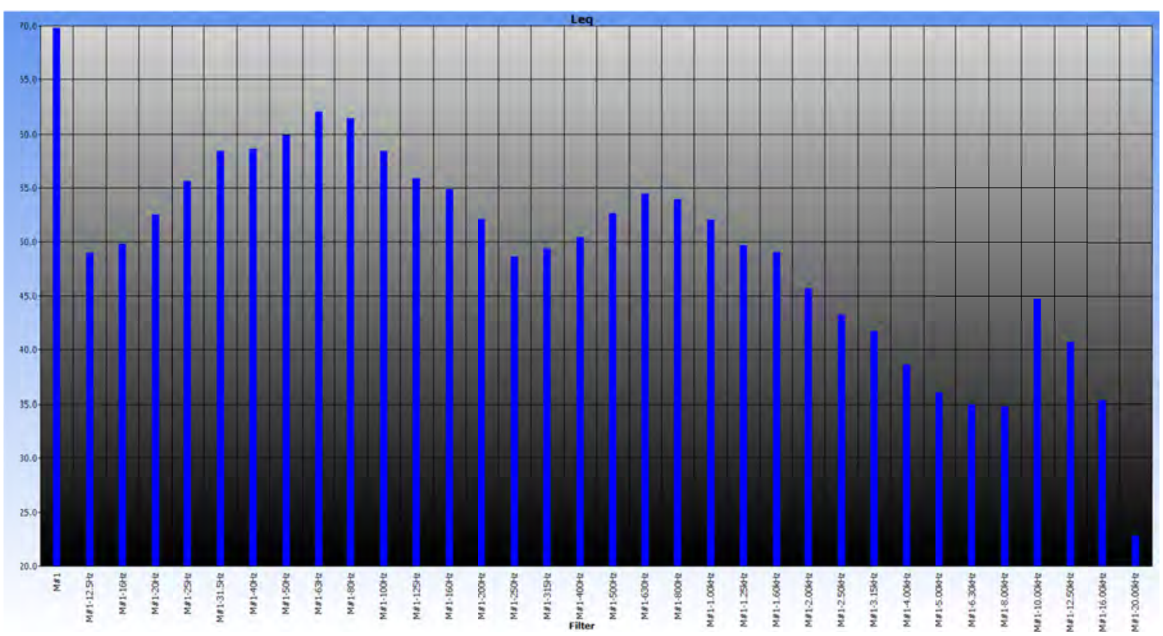

Figure 4-77 - Octave band spectrum of noise at Station 9

L10 and L90 – Vanity Fair, Linstead

Figure 4-78 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) ≈90.3% of the time and large fluctuations in the noise climate (L10 – L90) ≈9.7% of the time in the noise climate at this station. It is important to note that at no point was there were no fluctuations in the noise climate (L10 – L90).

The overall L10 and L 90 at this station for the time assessed were 58.2 dBA and 43.6 dBA respectively.

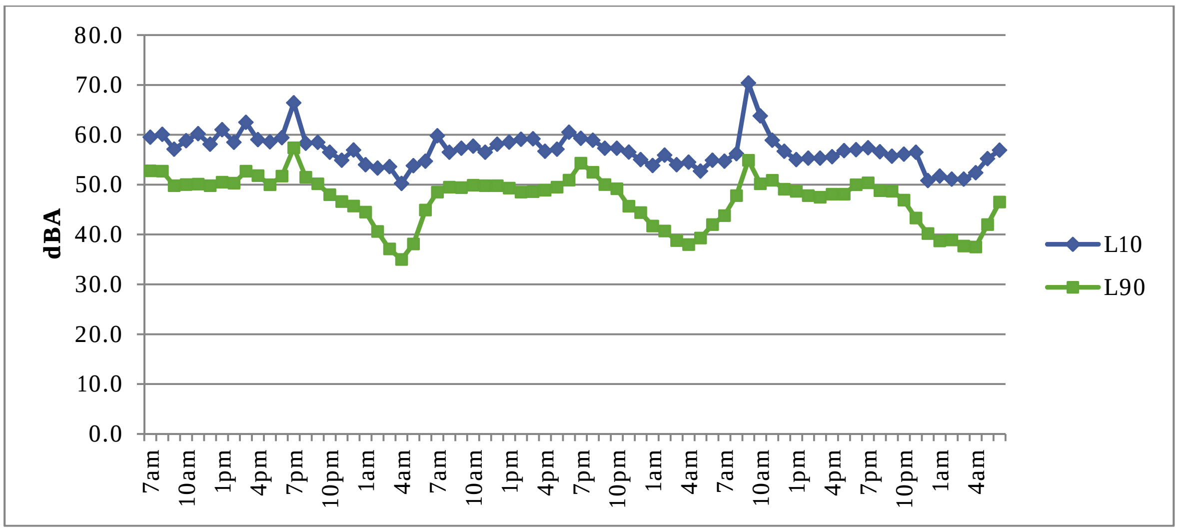

Figure 4-78 - L10 and L90 for Station 9

4.1.10.3 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 4.36. Two stations (5 and 9) 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, 8 and 9.

Table 4.36 - 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	53.1	55	45.4	50
2	Residential	50.7	55	42.1	50
3	Residential	52.6	55	51.0	50
4	Residential	54.6	55	49.8	50
5	Residential	61.1	55	49.3	50
6	Agricultural	50.4	65	45.6	60
7	Agricultural	52.4	65	42.3	60
8	Residential	52.8	55	54.8	50
9	Residential	60.9	55	60.3	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 4.37.

Table 4.37 - 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, hospitals and auditoriums.

Based on the land use categories in Table 4.37, 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 stations with the exception of stations 5 and 9 were in compliance with the FHWA standard for the 72 hours measured. Station 5 and 9 were compliant with the FHWA standard approximately 93.1% and 98.6% of the 72 hours respectively (Figure 4-79 to Figure 4-87).

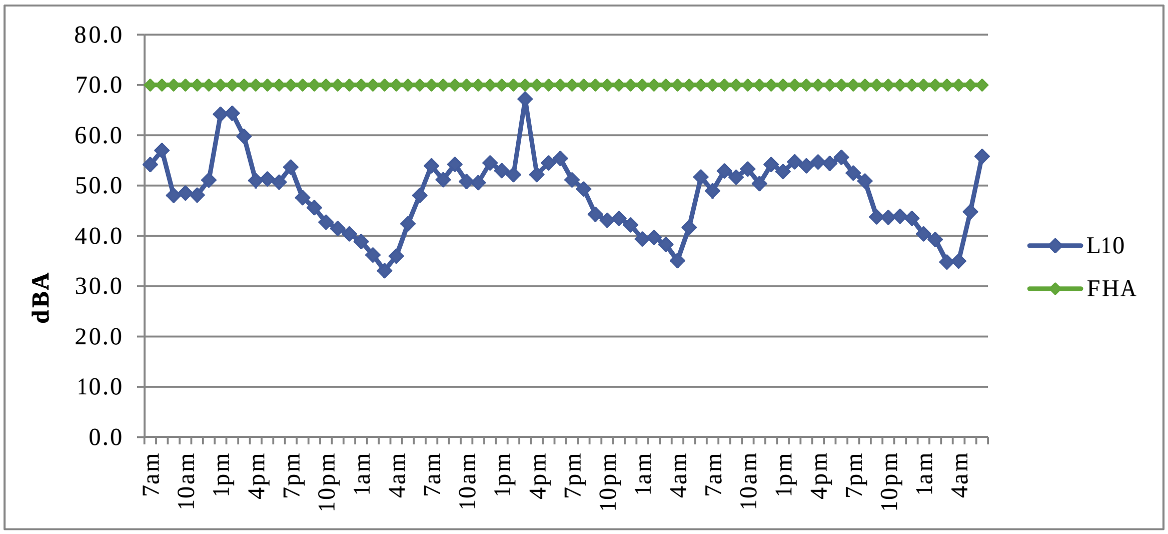

Figure 4-79 - Comparison of L10 at Station 1 with FHA standard

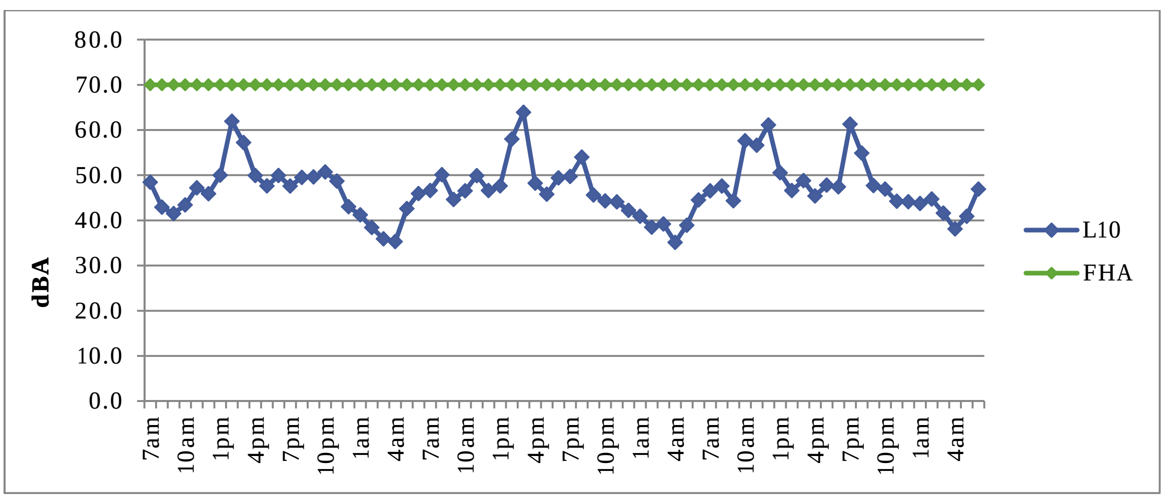

Figure 4-80 - Comparison of L10 at Station 2 with FHA standard

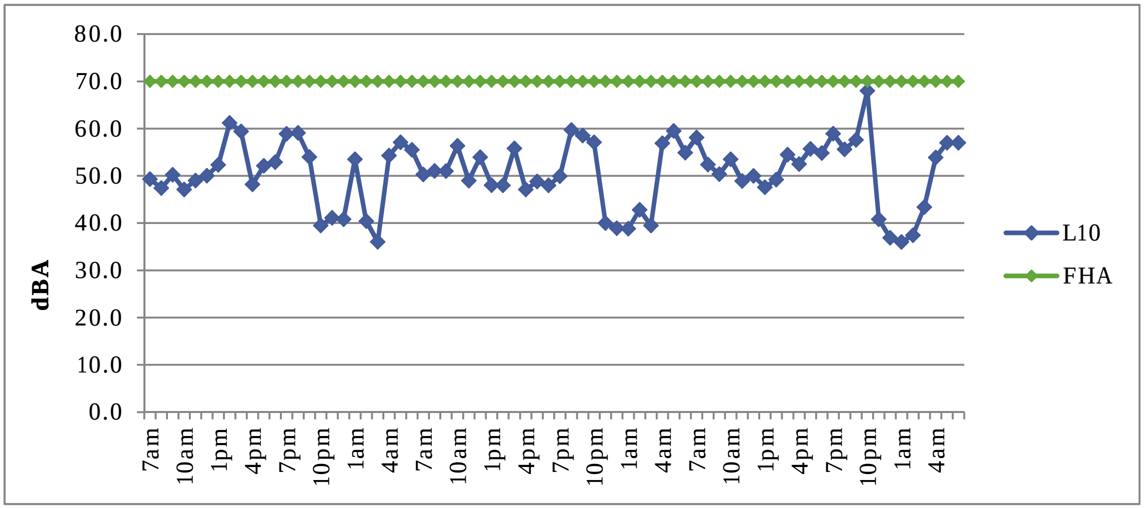

Figure 4-81 - Comparison of L10 at Station 3 with FHA standard

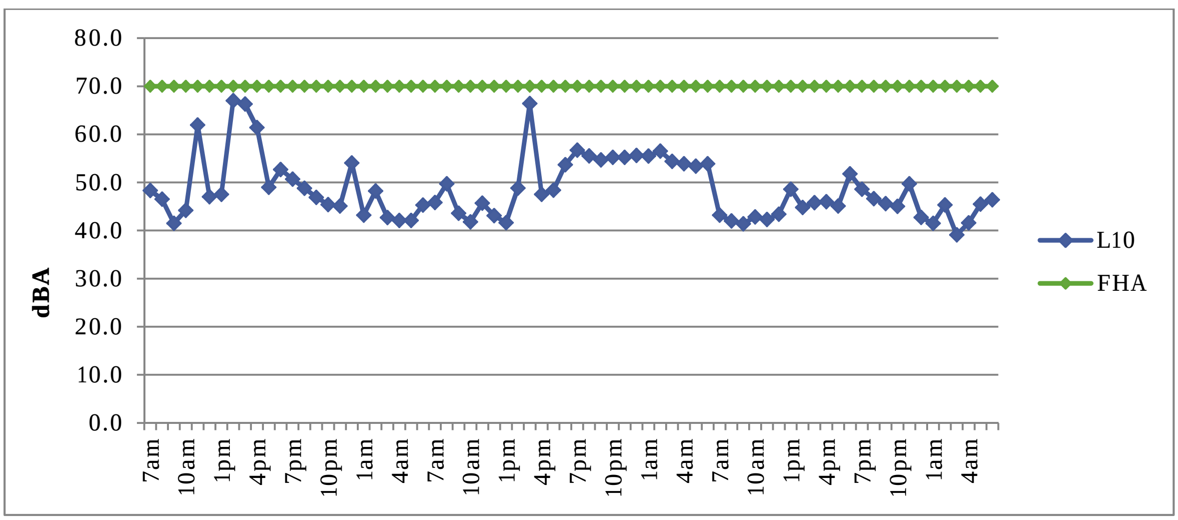

Figure 4-82 - Comparison of L10 at Station 4 with FHA standard

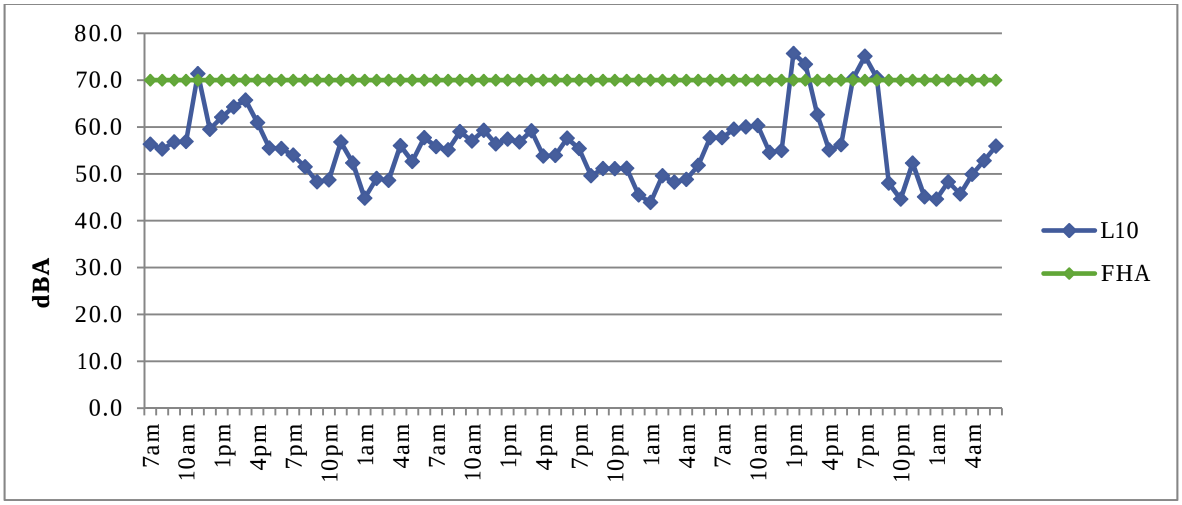

Figure 4-83 - Comparison of L10 at Station 5 with FHA standard

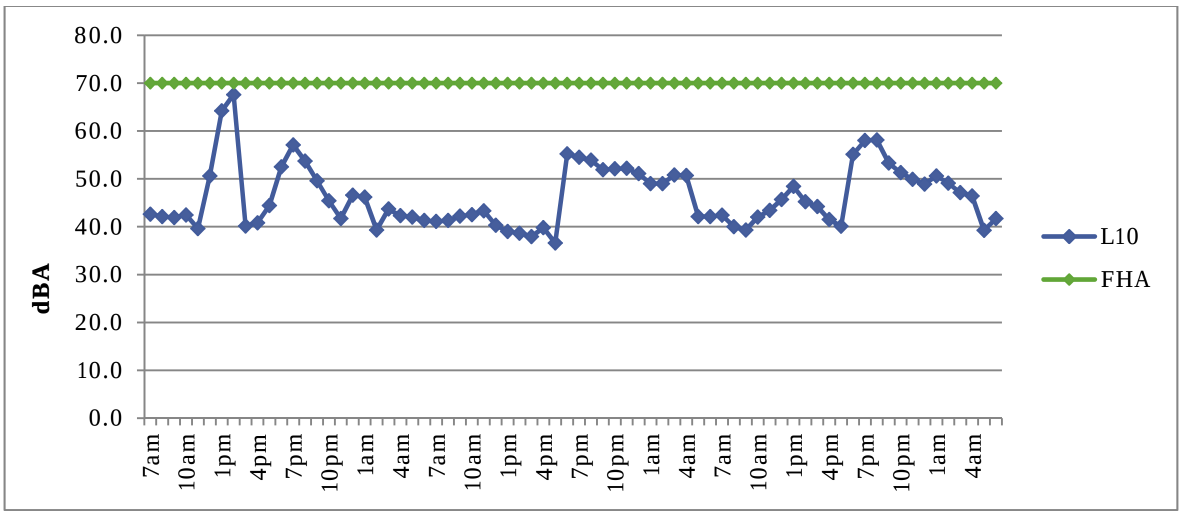

Figure 4-84 - Comparison of L10 at Station 6 with FHA standard

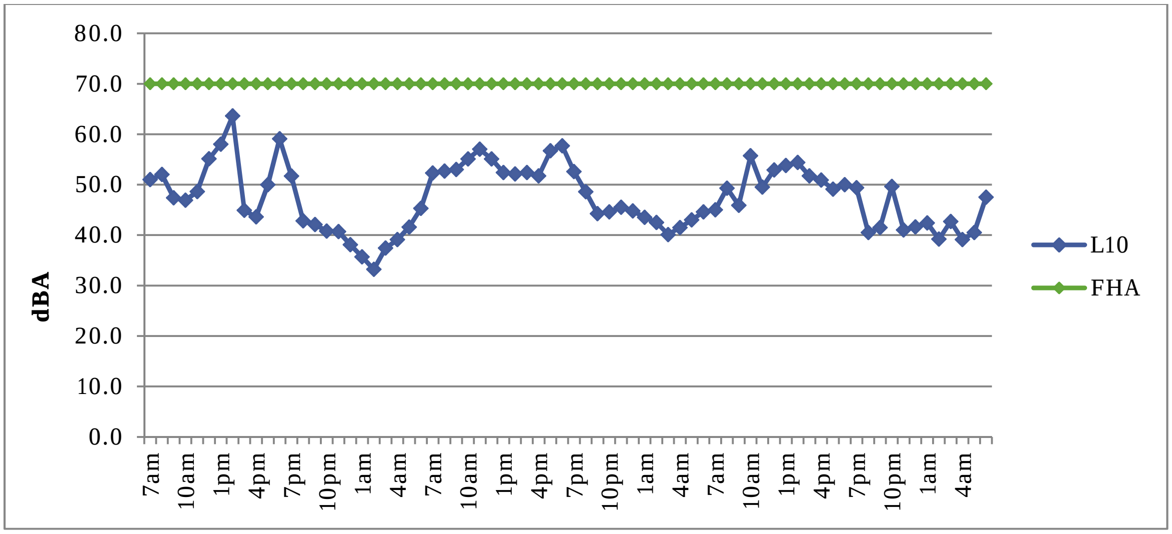

Figure 4-85 - Comparison of L10 at Station 7 with FHA standard

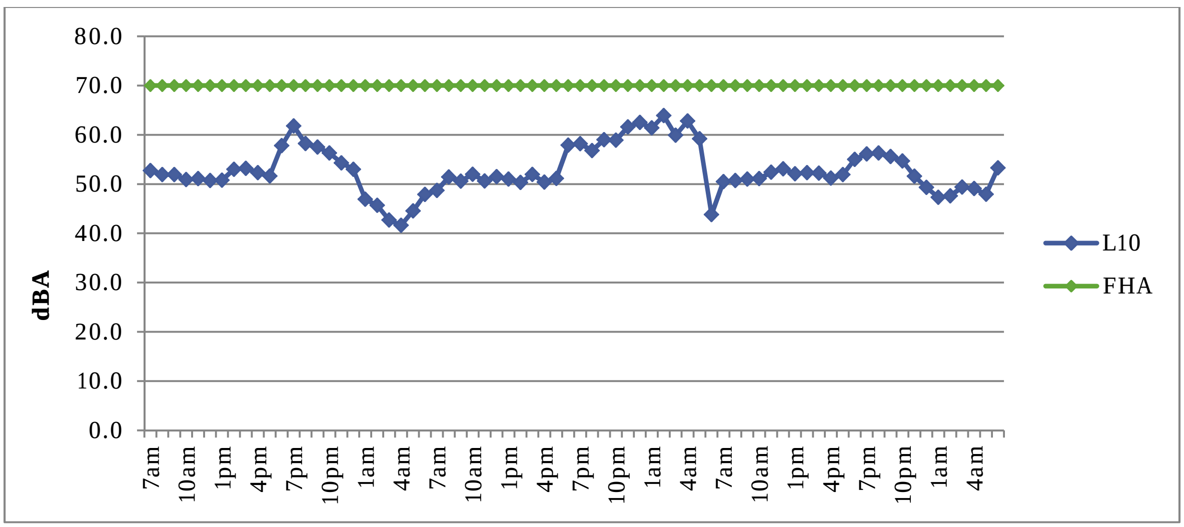

Figure 4-86 - Comparison of L10 at Station 8 with FHA standard

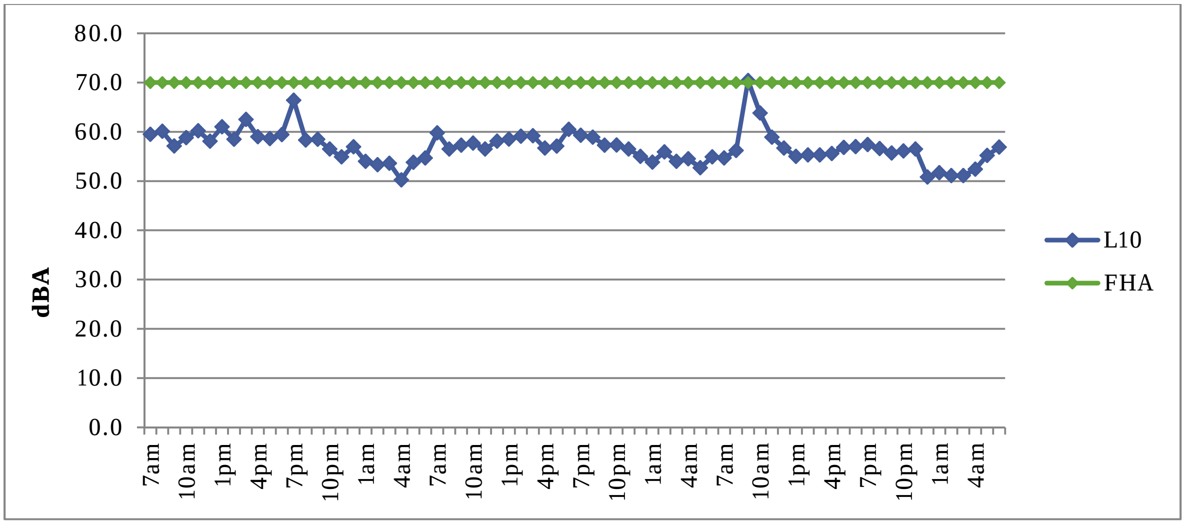

Figure 4-87 - Comparison of L10 at Station 9 with FHA standard

4.2 BIOLOGICAL ENVIRONMENT

4.2.1 Flora

A series of inland vegetation surveys were conducted on August 24, 2011, February 4, 2012 and March 24, 2012. The purpose of this scope of work was to identify and characterise the terrestrial flora-composition prevalent in the area in which highway construction activities would be conducted.

4.2.1.1 Climate, Flora and Ecology of Jamaica

This section aims to introduce the general climate of Jamaica and the natural vegetation types common to inland limestone and alluvial communities, similar to what should have been seen in the study area. The common impacts to the ecology resulting from highway developments will also be briefly outlined.

General Climate and Flora of Jamaica

Jamaica is the third largest island of the Greater Antilles in the West Indies. Situated just south of Cuba, Jamaica forms part of the string of Caribbean islands stretching in an arc from Florida to Venezuela. The island has a maximum length, from east to west, of about 235 km (146 mi); and the maximum width is approximately 80 km (50 mi). The total area of the country is 10,991 km^2 (4,244 mi^2) (Encarta, 1996).

As a result of the island's geographic location (i.e. situated within and surrounded by the Caribbean Sea) the tropical climate of Jamaica is relatively stable and as such, is able to support a rich, tropical flora. The mean annual temperature in coastal regions is approximately 26.7°C (80°F), but north-eastern trade winds frequently moderate the extremes of heat and humidity. Mean annual temperatures in the plateau and mountain areas average 22.2°C (approximately 72°F) at elevations of 900 m (2,950 ft), and are considerably less at higher elevations where tropical climate and ecological characteristics begin to transition into temperate features (Asprey & Robins, 1953; Encarta, 1996). Maximum precipitation tends to occur during the months of May, June, October, and November. The island is also subject to hurricanes in late summer and early autumn (Encarta, 1996).

Jamaica's major ecological boundaries are typical of several Caribbean islands and are demarcated by a wet northern coast, a central montane region, and a dry southern plain (Asprey & Robins, 1953). An important determining factor for these zones is rainfall, which is itself dependent upon the prevailing winds and the presence/absence of mountainous obstructions in its path. As a result, annual precipitation is characterised by wide regional variations, where more than 5,080 mm (200 in) of rainfall occurs annually in the mountains of the north-east, compared to only 813 mm (32 in) in the vicinity of Kingston (the capital) just to the southern lee of the Blue Mountain range (Asprey & Robins, 1953).

Owing to these ecological boundaries, the island's vegetation may be categorised into three broad headings: coastal, lowland and montane (Asprey & Robins, 1953). However, in this treatise, focus was placed on the lowland and montane components, which represent the zones encountered by the planned development.

The lowland terrestrial vegetation communities of Jamaica may occur over limestone, alluvium and shale as well as occupy swamps and marshes. Of particular interest, for this project, were those communities occurring over alluvium and limestone. Approximately 67% of Jamaica consists of a limestone plateau composed of hard, limestone rock and derived soils that tend to be characteristically bauxite-red (also known as "terra-rosa"). Many of these areas are under cultivation.

Rainfall and drainage tend to be important factors that distinguish limestone vegetation types that occur in these lowland areas. Two such types commonly exist; namely, the dry limestone scrub forest and wet limestone forest (Asprey & Robins, 1953). The former may be characterised as having sparse vegetation cover: consisting mainly of thorny tree/shrub species growing on bare, broken stone or jagged honeycomb rock. The soil and leaf litter are virtually absent except for those areas where they may be deposited in cervices within the limestone substrate or where it collects on level areas. The plants that grow in these areas have well developed, sprawling root systems capable of utilising every crevice present for anchorage. Dynamics such as aspect, slope, drainage and soil deposition levels may significantly affect species composition.

The wet limestone forest community typically develops inland on areas of limestone rock, where the annual rainfall averages 1,905 mm (75 in) and occurs at elevations from 305 – 762 m (1000 – 2500 ft). The wet limestone forest is usually more mesophytic and luxuriant than the dry type, resulting in more forest trees as well as epiphytes and lianas (e.g. aroids, bromeliads and orchids). The undergrowth is usually sparse due to the rocky substratum or the dense shade present (Asprey & Robins, 1953). Degraded variants of these plant communities exist in proximity to the study area.

The dry, southern coast of the island consists of large, low-lying plains that had been formed as large alluvial deltas of meandering rivers. The rich alluvium deposits of sand, gravel and loam is well distributed over faulted limestone. In the 1800's these areas were exploited for sugar-cane agriculture, some of which exist today or have been allowed to revert to secondary communities (Asprey & Robins, 1953). In other cases, these lands have been converted to pasture as or housing developments.

Montane vegetation may be categorised into three main types; namely, lower montane, montane sclerophyll and montane mist forests. Such vegetation communities occur along slopes of shale or limestone at altitudes of approximately 457 – 762 m (1,500 – 2,500 ft). The main canopy ranges up to 24 m (80 ft) with little stratification. Some tree species present are buttressed; occurring occasionally with epiphytes and lianas. Disturbed variants of the lower montane rain forest occur over the hilly terrains in the path of this planned development.

Common Highway Impacts on the Local Ecology

The direct environmental impact from a highway development is linear and extends along its length. This 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. These factors will be discussed further in the recommendations section of this study.

The emphases of this work were to characterise and describe the flora current within the study area as well as to identify, discuss and offer mitigations for any perceived impact (direct or indirect) on the local environment. The methodologies used to obtain and analyse the data necessary to accomplish these goals were also discussed and rationalised.

4.2.1.2 Site Description

The planned highway development is expected to impact a linear, southeast to northwest area located centrally within the parish of St.

Catherine. The proposed footprint for this major highway project begins in the southeast of the parish, in the Caymanas Estate area, approximately 1.55 km NW from Central Village. At this point, the highway interlinks with the existing Mandela Highway at Ferry. From there it will cut a 100 m swath, first north, then WNW towards the hills of Caymanas Bay through relatively flat cane-fields and pastureland. The highway then continues over the hills in this region, through Waterloo Valley and along the southern periphery of Cross Pen. In these areas, the roadway passes through or fringes semi-contiguous, submontane, limestone-rubbled, and woodland stands showing various (often significant) levels of anthropogenic influence. The highway will eventually cross the Rio Cobre River near Content. From here, the highway will continue over a section of the St. Johns Red Hills, in a direction somewhat parallel to the Bog Walk Gorge and existing train line. The highway maintains a path east and north of Giblatore and Lime Walk (respectively), thereafter descending towards the plains of Linstead at Wakefield. The final segment of this roadway will then travel northwards, through the outskirts of the town of Linstead, terminating near the end of the Linstead Bypass.

The planned road construction is, therefore, slated to impact several land use types namely, agricultural, residential and semi-industrial areas as well as pre-disturbed natural habitats. The terrain to be encountered is also variable in substrate, slope and aspect. Because of these factors, a decision was made that the vegetation within study area should be assessed under two broad categories, “lowland” and “highland” areas.

The Lowland Areas

There were two main lowland areas: one located southerly, to the east of Central Village (Figure 4-88) and the other, adjacent to the large town of Linstead in the north (Figure 4-89). The vegetation in these areas showed severe anthropogenic influence, evidenced by large-scale orange and sugar cane cultivation, as well as several hectares of pastureland. Some isolated dwellings and settlements were also encountered, especially within the northern lowland areas thus influencing the characteristics of the nearby flora with the persistence of garden ornamentals and fruit trees.

Additionally, there were established and informal road networks that varied in class and maintenance. These ranged from relatively well maintained arterial roads to avenues and lanes in developed human communities (Figure 4-90).

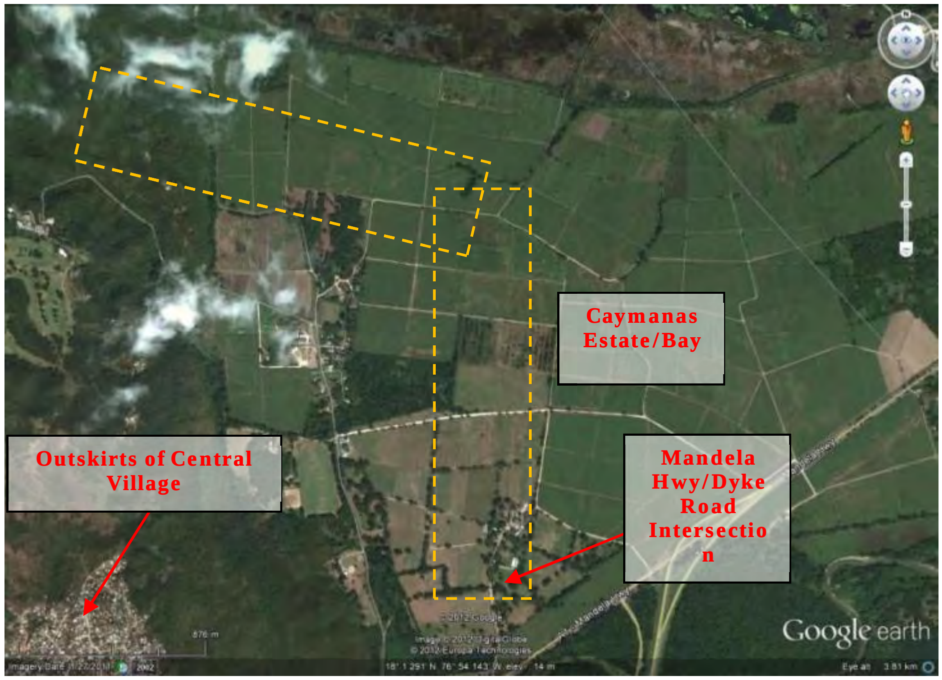

Figure 4-88 - Satellite image of the SE lowland regions of the planned highway development. Highlighted area shows the general & adjacent lands and communities that may be affected by the rights-of-way

A section of the original corridor was amended during the assessment. This route is still within the Caymanas Sugar Estate; however, the route is now closer to Ferry River, in the vicinity of the Ferry Police Station. The dominant plant was *Saccharum officinarum* (Sugarcane), which was bordered by trees and shrubs that lined the access routes; for example, *Cordia alba* (Duppy Cherry), *Guazuma ulmifolia* (Bastard Cedar), and *Ficus maxima*. Common shrubs included White Sage (*Lantana camara*), Dandelion (*Cassia occidentalis*), and several *Sida* spp.

At the proposed location of the interchange, several trees with diameters greater than 20cm were observed. These were Poinciana (*Delonix regia*), Guango (*Samanea saman*) and Silk Cotton Tree (*Ceiba pentandra*). Of significance, there were over 15 Guango (*Samanea saman*) visible from the major thoroughfare, that is, the Mandela Highway. In addition, the Guango trees served as a habitat for the endemic climber, God Okra (*Hylocereus triangularis*).

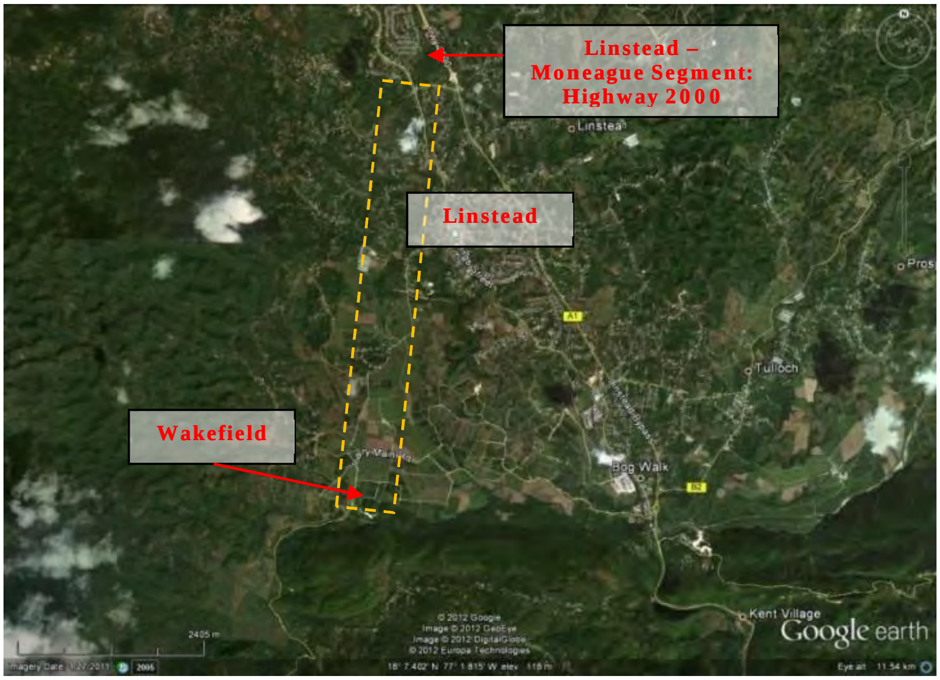

Figure 4-89 - Satellite image of the NW lowland regions of the planned highway development. Highlighted area shows the general & adjacent that may be affected by the rights-of-way

Highland Areas

In general, the highland areas appeared significantly less disturbed than the lowland areas. Nonetheless, man's influence on the environment could be seen with the occurrence of a few village-settlements and isolated dwellings. These were usually associated with subsistence agriculture of several fruit trees (such as Ackee, Breadfruit, Star-apple and Allspice), including some pastureland. There were two main "highland" areas to be impacted by the highway development, namely those areas between Caymanas Bay and Content (easterly) and between Dam Head and near Lime Hill (westerly) (Figure 4-90).

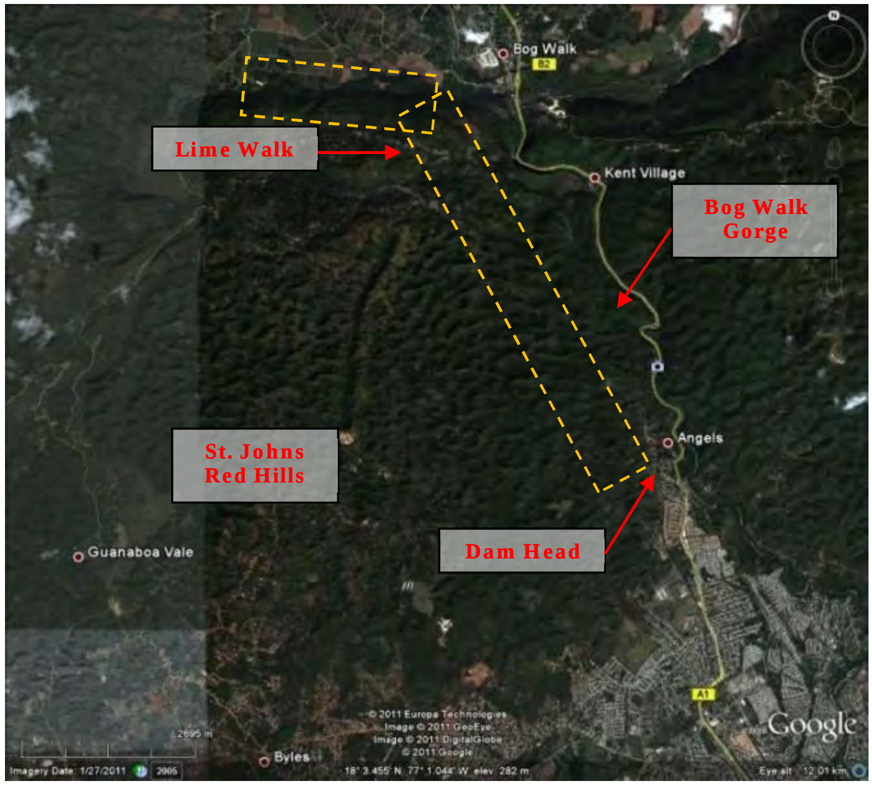

Figure 4-90 - Satellite image of the western highland regions of the planned highway development (a section of St. Johns Red Hills). Highlighted area shows the general & adjacent lands that may be affected by the rights-of-way

The westerly regions constituted lands occupied mainly by disturbed lowland/submontane seasonal evergreen rainforest (Caribbean Vegetation Mapping Initiative, 2000). Here, the forest floor was quite rocky in most areas associated with approximately 45 – 60 degree slopes. These factors appeared to result in little to no accumulation of soil or detritus at these locales. Access to the vegetation existed mainly in the form of overgrown tracks and pathways (some too narrow or broken for vehicular traffic). Asphalted surfaces were virtually non-existent in higher elevations and existed primarily upon the lower to mid slopes of the hilly terrain.

Plate 4.33 - Section of roadway along southern slopes of the St. Johns Red Hills towards Giblatore

The elevations of the easterly rights-of-way (Figure 4-91) differed somewhat in topography and vegetation type. The terrain appeared less steep than the western highland areas, consisting mainly of approximately 20 – 30 degree gradients. The vegetation also appeared indicative of increased levels of disturbance and reduced rainfall. According to the Caribbean Vegetation Mapping Initiative (2000), the area is occupied by a mixture of lowland semi-deciduous and disturbed lowland/submontane semi-deciduous forests. Road penetration and class were also improved and coupled with gentler slopes, seemed to have allowed for easier access to anthropogenic influence.

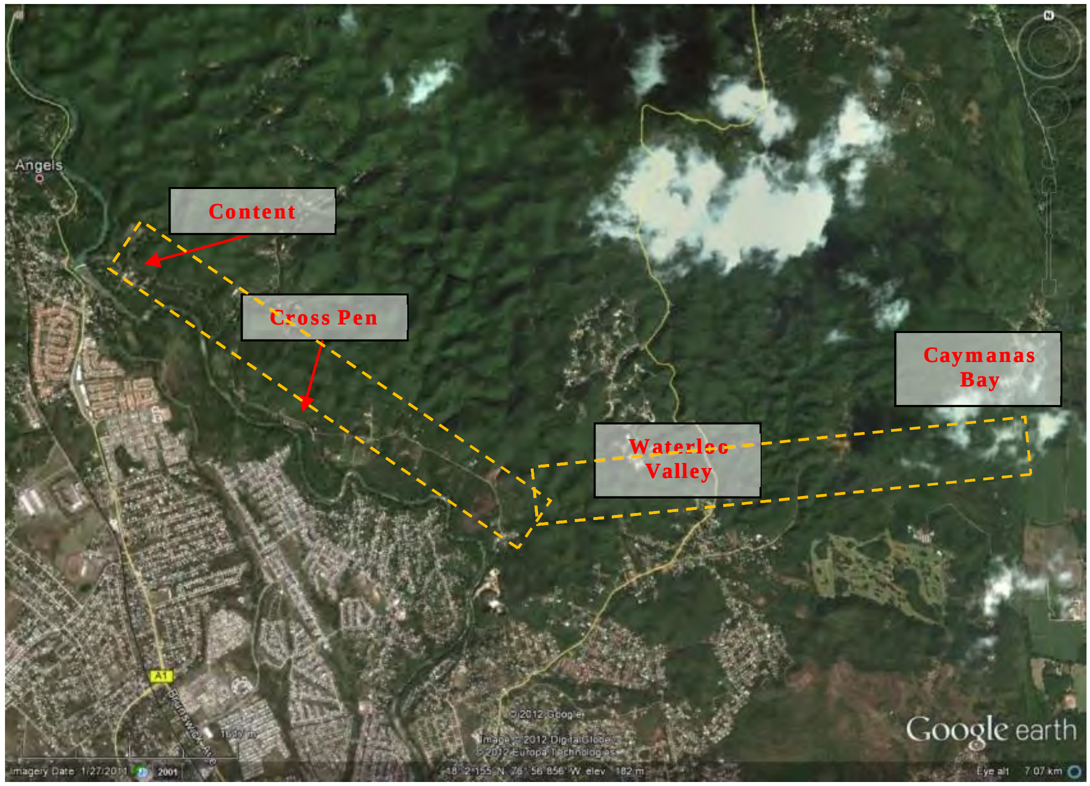

Figure 4-91 - Satellite image of the eastern highland regions of the planned highway development. Highlighted area shows the general & adjacent lands that may be affected by the rights-of-way

Plate 4.34 - Quarry activity located within the eastern highlands near Cross Pen

4.2.1.3 Methodology

An important part of any vegetation survey is determining the most efficient way to effectively sample the plant community. From carefully chosen samples one can feel confident in extrapolating the sample information to describe the entire community. Key factors that affect any environmental impact assessment/study include the dynamics of the study area itself as well as the man-made constraints of the individual project (e.g. scope and timeline for completion). As such, the implementation of methodologies that balance accuracy and efficiency is important to the rapid floristic survey.

The dynamics of the study area were as such that the planned footprint of the highway project encounters a range of botanical communities and land-use types. This varied from highly modified lands (used for agricultural, semi-industrial and residential purposes) to degraded homogenous woodlands on shallow slopes, to disturbed, yet dense forest vegetation growing on often-times steep, rocky terrain. Owing to this variation in topography and land use, two approaches were used in assessing the vegetation along the planned corridor.

Window surveys were conducted for the modified lands, typically occurring on the plains toward the NW and SE sections of the study area (Figure 4-88, Figure 4-89 and Figure 4-90) and the degraded woodlands, found on the shallow slopes of the eastern elevations (Figure 4-91). In these locales, the existing road network was utilised to traverse the communities to be affected by the proposed development. Stops (locations A-J) were made at regular intervals to conduct walk-throughs for more thorough investigations. This process was aided by a Trimble GeoExplorer™ 6000 Series GeoXT™ handheld GPS unit programmed with the coordinates of the highway path. Notes were made regarding the phanerophytic and herbaceous plant species encountered and the land-use types observed.

The vegetation of the western highlands was deemed to be more ecologically important; therefore, a thorough field assessment was required. Here, a combination of plot-less[3] field-sampling methodologies

3 Plot-less methods involve measuring distances for a random sample of trees, typically along a transect, and recording the characteristics of interest for this sample (Mitchell 2007)

was employed. These procedures included the Point-Centred Quarter (PCQ) Method coupled with a series of walk-through floral inventories. The advantage of using plot-less methods, rather than standard plot-based techniques, is that they tend to be more efficient. Plot-less methods are faster, require less equipment, and may require less labour (Barbour et al., 1987; Mitchell, 2007).

The PCQ method involved the selection of a random point, the area around which was divided into four 90° quarters according to the directions of a compass. The nearest tree in each quarter was then identified and its height, diameter at breast height (DBH), and distance from the central point, measured. A sample site was determined wherever the existing access-roads or trails intersected the proposed highway corridor. Within each sample-location, two sample-points were then selected (approximately 100 m apart on either side of the highway footprint) and the PCQs carried out.

In 2011, an earlier alignment for this highway was proposed: beginning east of Spanish Town, continuing over the St. Johns Red Hills, finally descending and connecting with the existing Linstead Bypass – just north of Bog Walk. In August of that year, an assessment for the St. Johns Red Hills area (the western highland areas) was carried out along the original rights-of-way. The current rights-of-way, however, was deemed to have differed only marginally from the previous and therefore, three data points (locations K-M) from the 2011 assessment were incorporated into this report (). Owing also to the new alignment, two additional sites were chosen for PCQ assessment on the northern descent towards Wakefield and Linstead (locations N & O).

The sample locations and points were determined also with the aid of a Trimble GeoExplorer™ 6000 Series GeoXT™ handheld GPS unit. Between the PCQ points a walkthrough was carried out where the species composition was noted and later ranked according to a DAFOR[4] scale.

The data collected from the PCQ surveys was used to help characterise the flora by estimating the absolute tree density for the highland study area, overall, as well as for each location (A-D) within (Equation 1). Species

[4] DAFOR occurrence rank: usually a subjective scale of specie occurrence within an area of study. The acronym refers to, **D**ominant, **A**bundant, **F**requent, **O**ccasional, **R**are.

indices such as relative density (Equation 2), relative cover (Equation 3) and relative frequency (Equation 4) were also calculated: so as to determine the importance/dominance of a tree-species in each location (Equation 5).

Equation 1:

$$\text{Absolute density } (\lambda) = \frac{10000}{\bar{r}^2} \text{ (\# of trees/ha), where } \bar{r} = \text{mean distance for all points.}$$

Equation 2:

$$\text{Relative Density (species } k) = \frac{\lambda_k}{\lambda} * 100 \text{ (\%), where } \lambda_k = \text{absolute density for species } k.$$

Equation 3:

$$\text{Relative Cover (species } k) = \frac{Total\ BA\ of\ species\ k\ in\ sample\ location}{Total\ BA\ of\ all\ species\ in\ sample\ location} * 100 \text{ (\%),}$$

where BA = Basal Area.

Equation 4:

$$\text{Relative Frequency (species } k) = \frac{Ansolute\ frequency\ of\ species\ k}{Total\ frequency\ of\ all\ species} * 100 \text{ (\%)}$$

Equation 5:

Importance (species k) = *relative density* + *relative cover* + *relative frequency*. This ranges from zero to a maximum of 300 (which would indicate a pure stand of species k in one ha).

Virtually all plant species encountered during the field surveys were identified in-situ or samples collected and taken to the University of the West Indies Herbarium for later identification.

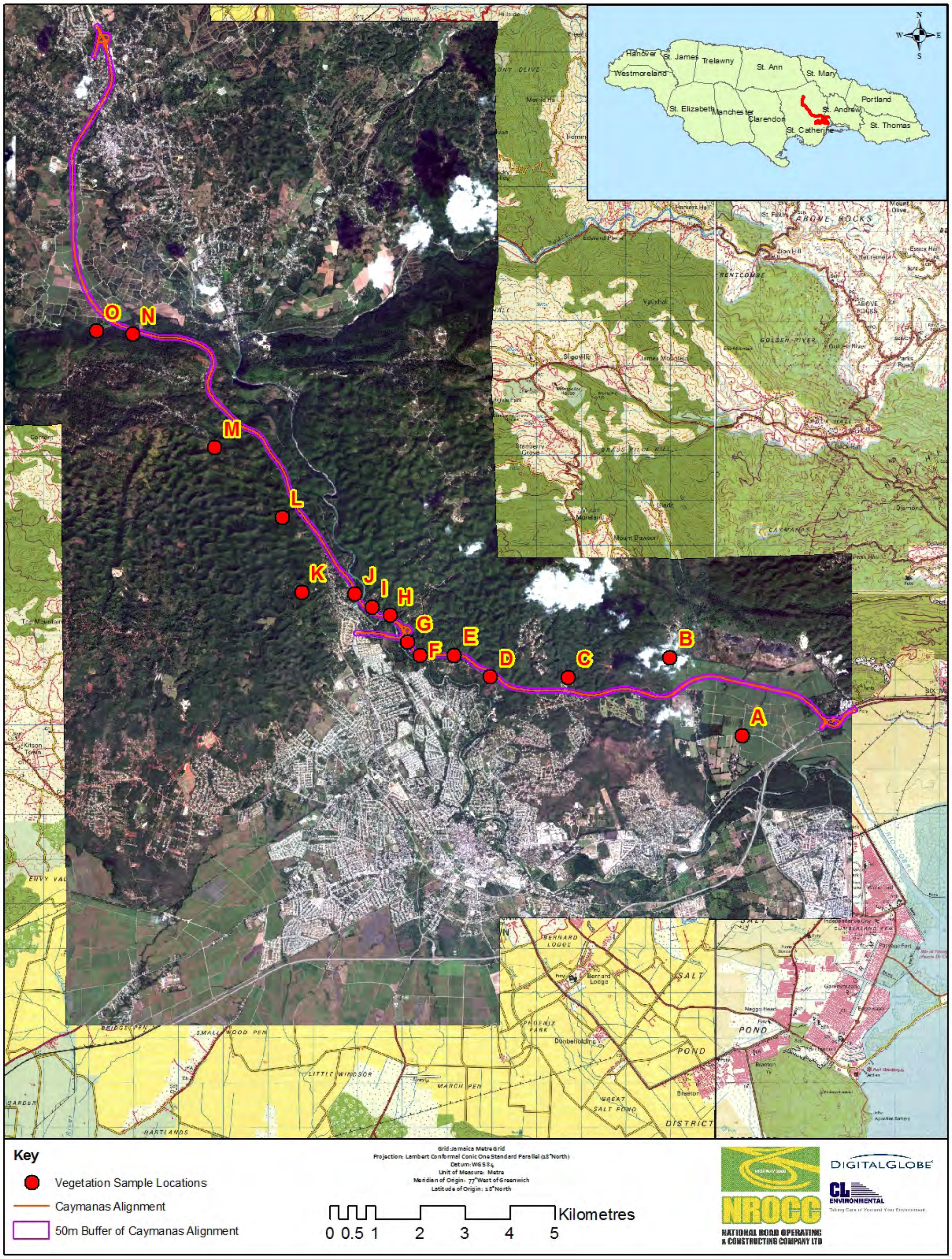

Figure 4-92 - Map of 2011 planned North-South highway development from Caymanas to Linstead, showing original sample locations (red dots)

4.2.1.4 Results and Discussion

A typical highway development is, of course, linear in design and as such may traverse one or more ecological communities and land-use types. This section will attempt to classify the major vegetation communities to be affected within the study area as well as list some of the indicative plant species and environmental factors present that aided in the categorising the flora. The report begins at the highway's proposed origin in the southeast in Caymanas Bay and continues due northwest until its termination near Linstead. The community and land cover classification system used here was outlined by Grossman *et al.* (1991).

South-Eastern Lowland Areas

For a complete list of all the species encountered in this region and their respective DAFOR abundance ratings, see Appendix 8.

Locations A-B

These sites were located within Caymanas, the southern-most region of the highway project (Figure 4-92). Large sections of the estate appeared to be used as pastureland (Plate 4.35); however, roadways and tracks were frequently bordered by tree species such as *Cordia alba* (Duppy Cherry), *Guazuma ulmifolia* (Bastard Cedar), *Leucaena leucocephala* (Lead Tree) and *Samanea saman* (Gunago). *Cocus nucifera* (Coconut) trees were also cultivated here. Herbs and climbers were well represented, with *Rivina humilis* (Bloodberry) and *Stachytarpheta jamaicensis* (Vervine) commonly occurring; along with the frequent roadside climbers, *Antigonon leptopus* (Coralita) and several *Ipomoea* spp. The endemic epiphyte, *Hylocereus triangularis* (God Okra), was a conspicuous constituent. Towards the western fringes of the estate (bordering the eastern highland areas) trees and shrubs, such as *Acacia tortuosa* (Wild Poponax) and *Pisonia aculeata* (Cockspur) became more frequent. The waterlogged sections of the property contained the reed-grass *Typha domingensis* (Plate 4.36).

Plate 4.35 - Pastureland occupying sections of Caymanas Estate. Note the trees lining a pathway (background)

Plate 4.36 - Section of the Caymanas Estate showing canal (foreground) with Typha domingensis (Reed Mace) and utility poles (background)

For a complete list of all the species encountered in this region and their respective DAFOR abundance ratings, see Appendix 8.

Location C

This was the first accessible site of the eastern highlands (). The flora here was characteristic of a Disturbed Dry Limestone Forest; though atypically dominated by the legume, *Leucaena leucocephala* (Lead Tree) (Plate 4.37). Sections of the community also showed superficial degradation to a Scrub-type class: having increased abundance of *Haematoxylum campechianum* (Logwood) trees (Plate 4.38) (Grossman *et al*., 1991). Other key constituents of the tree-canopy were *Adenanthera pavonina* (Red Bead Tree), *Bauhinia divaricata* (Bull Hoof), *Guazuma ulmifolia* (Bastard Cedar) and the endemic, *Thrinax parviflora* (Broom Thatch). *Bursera simaruba* (Red Birch) was a conspicuous emergent through a canopy that had an average height of 4 – 5 m. Herbs, such as the Guinea Grass (*Panicum maximum*); the endemic, pungent *Lantana jamaicensis*; *Sansevieria trifasciata* (Tiger Cat); and *Stachytarpheta jamaicensis* (Vervine), were also quite common – especially along roadsides. *Abrus precatorius* (Crab Eyes) and *Urechites lutea* (Nightshade) were two of the commonly occurring climbers.

Plate 4.37 - Roadway through Location C, bordered on both sides by Leucaena leucocephola (Lead Tree) and Delonix regia (Poinciana) trees

Plate 4.38 - Scrub-type vegetation in Location C

Locations D-G

These sites were located within vegetation that may be classified as semi-contiguous stands of Disturbed Thorn Thicket communities growing mainly over alluvium (Plate 4.39), with broken limestone outcroppings frequently occurring in some locales (Plate 4.40). The flora was populated by various thorny leguminous phanerophytes characteristic of this type of vegetation; namely, Acacia tortuosa (Wild Poponax) and Haematoxylum campechianum (Logwood) (Grossman et al., 1991). Cassia emarginata (Senna Tree) the endemic epiphyte Hylocereus triangularis (God Okra) and the ground bromeliad Bromelia penguin (Ping-Wing) were other commonly occurring diagnostic species. However, the frequent occurrence of Thrinax parviflora (Broom Thatch) juveniles were indicative of the original Dry Limestone Forest from which these communities were derived (Grossman *et al.*, 1991).

The ground component thrived along roadsides and in areas with adequate soil-substrate. The grasses, *Panicum maximum* (Guinea Grass) and *Rhynchelytrum repens* (Natal Grass) were abundant to frequent, respectively, as well as the escaped ornamental, *Sansevieria trifasciata* (Tiger Cat), was conspicuously common. The inclusion of the well-armed *Pisonia aculeata* (Cockspur) made traversing this diminutive vegetation type (of approximately 3.0 m) challenging.

Plate 4.39 - Thorn thicket vegetation of Location D

Plate 4.40 - Thorn thicket growing over exposed limestone. Picture taken at local quarry near Site D

Location H-I

The vegetation here was similar to the last, which transitioned into lands occupied by dwellings and subsistence agriculture. Anthropogenic influence on species composition was exhibited with the increased presence of fruit trees such as, *Annona squamosa* (Sweet Sop), *Blighia sapida* (Ackee), *Chrysophyllum cainito* (Star Apple), *Citrus* spp. and *Cocus nucifera* (Coconut). Ornamentals, namely *Delonix regia* (Poinciana) (planted along roadsides and some fences), *Hibiscus rosa-sinensis* (Shoe-Black), *Jatropha integerrima* and *Jatropha podagrica* (Coral Plant) were also common. Nonetheless, the communities here were still dominated by *Leucaena leucocephala* (Lead Tree) and *Haematoxylum campechianum* (Logwood). The endemic plants *Piper amalago* (Black Jointer) and *Thrinax parviflora* (Broom Thatch) were also observed here.

Intermediate Areas

For a complete list of all the species encountered in this region and their respective DAFOR abundance ratings, see Appendix 8.

Location J

Located on the western side of the Rio Cobre, at Dam Head (), this site will be earmarked for the construction of a bridge to facilitate the crossing of the proposed highway. The flora consisted mainly of the grass, *Panicum maximum* (Guinea Grass) as well as *Sporobolus* and *Paspalum* spp. Shrubs were well represented with ornamentals such as *Allamanda cathartica* (Yellow Allamanda), *Lantana camar*a (Wild Sage) and *Plumbago scandens* frequently occurring. Several fruit trees were also encountered namely, *Blighia sapida* (Ackee), *Mangifera indica* (Mango) and *Ricinus communis* (Castor Oil Plant).

Western Highland Areas:

The floral communities present on the western highland areas exhibited various states of anthropogenic influence. On lower elevations the vegetation types ranged from thorn thickets dominated by leguminous phanerophytes and shrubs, such as *Acacia tortuosa* (Wild Poponax) and *Cassia emarginata* (Yellow Candle Wood), to cultivated tree-stands adjacent to village communities consisting primarily of *Blighia sapida* (Ackee) and *Pimenta dioca* (Allspice). On the higher slopes the vegetation appeared less disturbed but the predominance of *Haematoxylum campechianum* (Logwood) among well represented stands of the endemic palm, *Thrinax parviflora* (Broom Thatch) showed a disturbed community in secondary regeneration.

In analysing the data collected from the PCQ's, it became apparent that the level of disturbance of the flora could be somewhat correlated to the variation observed in tree-densities. For example, on the elevated slopes of location L the estimated tree-count was 2,433 trees ha-1. Here the forest vegetation appeared least disturbed and was conspicuously different from what was observed in locations K, M and N. These displayed evidence of cutting for charcoal burning and animal/crop husbandry and hence, had the lowest tree-counts (starting at a minimum of 374 trees ha-1) (figure 4-93).

The overall (average) tree-density was calculated at 938 trees ha^{-1} (figure 4-93). However, the highest density was seen at location O; located on the northern face of the St. Johns Red Hills (3,834 trees ha^{-1}, estimated). This site somewhat resembled location L in forest constitution. However, site O was located near the interface with a large parcel of agricultural land where the occurrence of several young trees and cultivated *Musa sapientum* (Banana) plants mixed with the original vegetation at the forest-fringe; most likely influencing the determined results.

The occurrences of endemic plants were also frequent throughout the sample sites. Endemic trees and shrubs encountered include *Commocladia velutina* (Velvet-leaved Maiden Plum), *Cordia bullata*, *Eupatorium heteraclinium*, *Lisianthus longifolius* (Jamaican Fuchsia), *Piper amalago* (Black Jointer), *Roystonea altissima* (Mountain Cabbage) and *Thrinax parviflora* (Broom Thatch). Also endemic and ecologically important herbs such as *Bidens dissecta*, *Agave* spp. and *Bromelia pinguin* (Ping-Wing) were common, especially on high rocky slopes.

For a complete listing of these species please see Appendix 8.

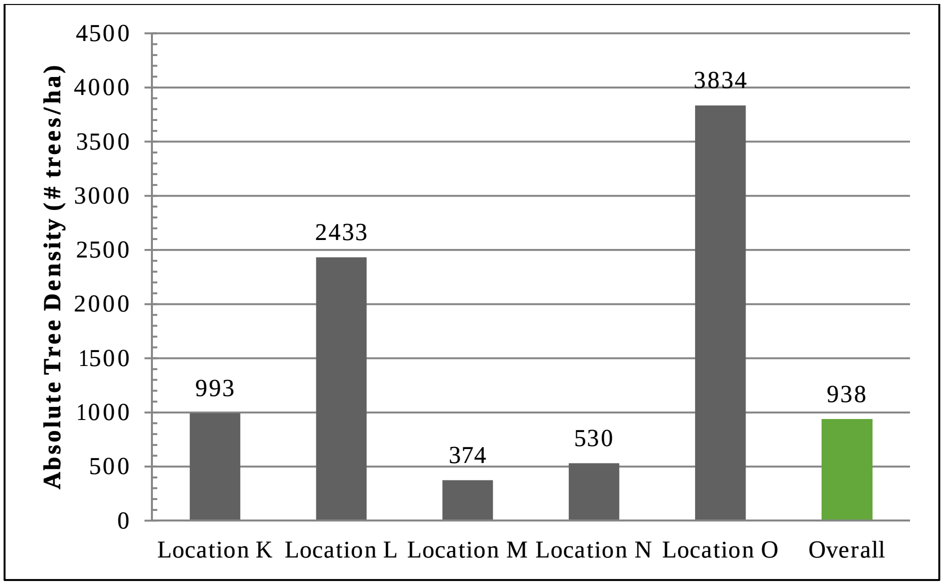

Figure 4-93 - Absolute tree densities for each PCQ sample location within the highland areas; compared with the average/overall tree density for all sample locales combined

Location K

Location K was situated due NW of location J () upon a flattened area upon the slopes of the St. Johns Red Hills at 193 m altitude). The sample site was located within a sparsely populated settlement/village community where the dominance of the fruit tree, *Blighia sapida* (Ackee) was conspicuous (figure 4-94). This possibly infers that the area was once modified for the subsistence cultivation of Ackee.

Plate 4.41 - Fruiting plant (centre) of Bromelia pinguin (Ping-Wing)

Other cultivated fruit species encountered include Annona squamosa (Sweet Sop), Melicoccus bijugatos (Guinep), Bixa orellana (Anatto), Citrus aurantifolia (Lime), Pimenta dioca (Allspice), Manilkara zapota (Naesberry) and Ricinus communis (Castor Oil Plant). Ornamental trees such as Delonix regia (Poinciana) were frequent as well as the occasional occurrence of Caesalpinia pulcherrima (Barbados Pride). Owing to the high occurrence of cultivated flora, the vegetation may be described as being an area of Mixed Subsistence Agriculture with Dwellings (Grossman et al., 1991). The average canopy height was approximately 6.7 m.

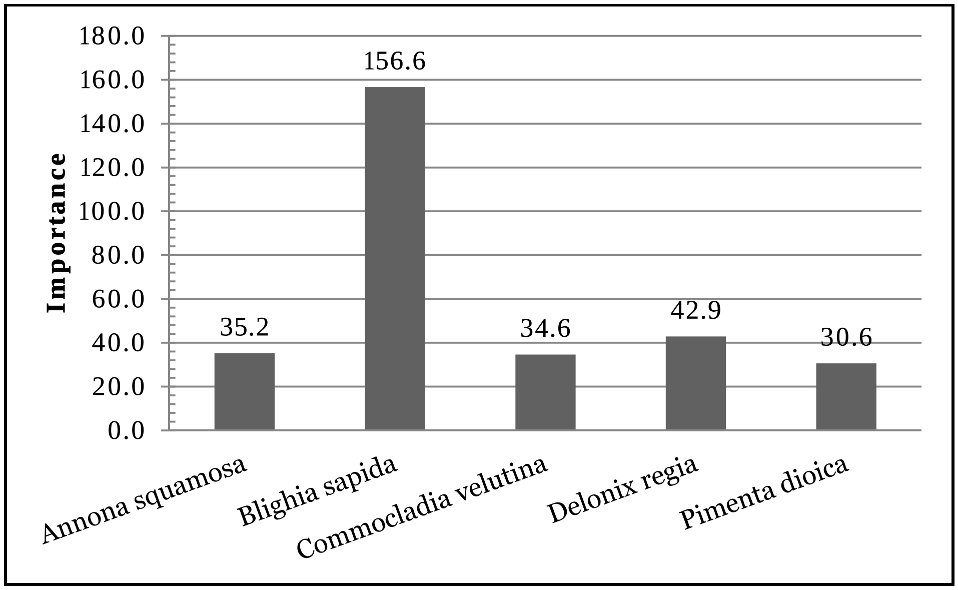

Figure 4-94 - Importance indices for tree species situated within Location K

Location L

Location L was the second highest locale at 269 m altitude and showed the least disturbance, although dominated by the thorny *Haematoxylum campechianum* (Logwood) tree. The other tree species that were encountered in the PCQ surveys seemed to share somewhat equal importance (figure 4-95). Ferns such as *Adiantum sp*., *Nephrolepis sp*. and *Thelypteris dentata* were frequent among the ground layer component. Several endemic plant species were also encountered, namely, *Bidens dissecta*, *Commocladia velutina*, *Cordia bullata*, *Eupatorium heteraclinium*, *Lisianthus longifolius* (Jamaican Fuchsia), *Piper amalago* (Black Jointer) and *Thrinax parviflora* (Broom Thatch). All these species occurred on steep, rocky substrate and constituted a canopy with a diminutive average height of 3.6 m. These features along with a high tree density are characteristic of a Disturbed Mesic Limestone Forest (Grossman *et al*., 1991).

Location M

This location was situated high upon the northern face of the St. Johns Red Hills area at 318 m altitude and included several equally occurring tree species such as *Ateramnus lucidus*, *Bastardia bivalvis*, *Bumelia* sp. and *Randia aculeata* (Indigo Berry). Myrtaceous trees such as *Pimenta dioca* (Allspice) and *Syzigium jambos* (Rose Apple) were conspicuous dominants as these grew unobstructed in once cleared pastureland. The flora here seemed to be a further degraded variant of the Disturbed Mesic

Limestone Forest (Grossman *et al*., 1991), previously seen in Location L, due to the presence of several fern and endemic angiosperm species. The average vegetation canopy height at this location was 6.4 m. Cultivated vegetation within established residential communities was encountered further north from this location (such as Lime Walk and others as one descended the northern slope). For importance analysis see figure 4-96.

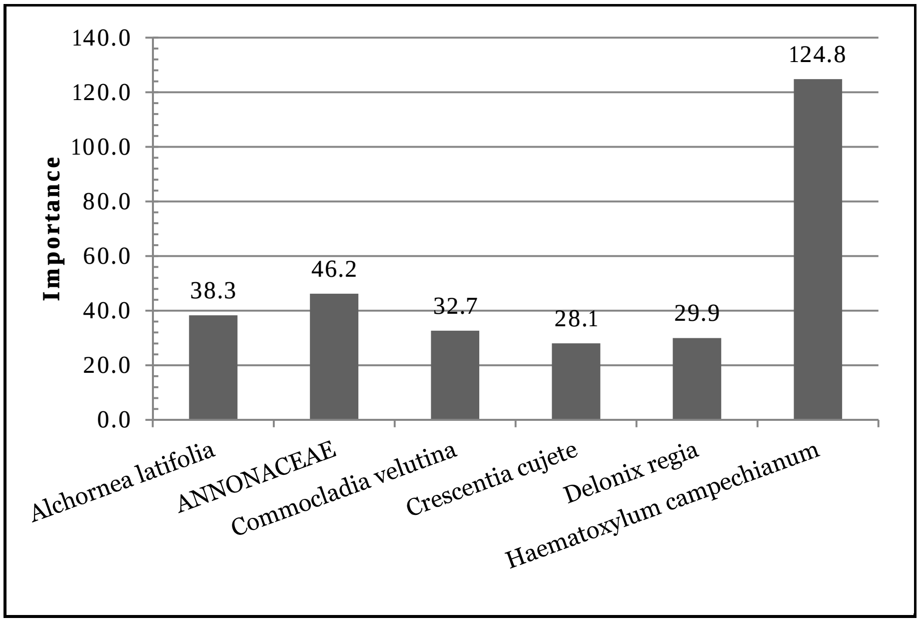

Figure 4-95 - Importance indices for tree species situated within Location L

Plate 4.42 - Section of Location L showing thick vegetative canopy layer

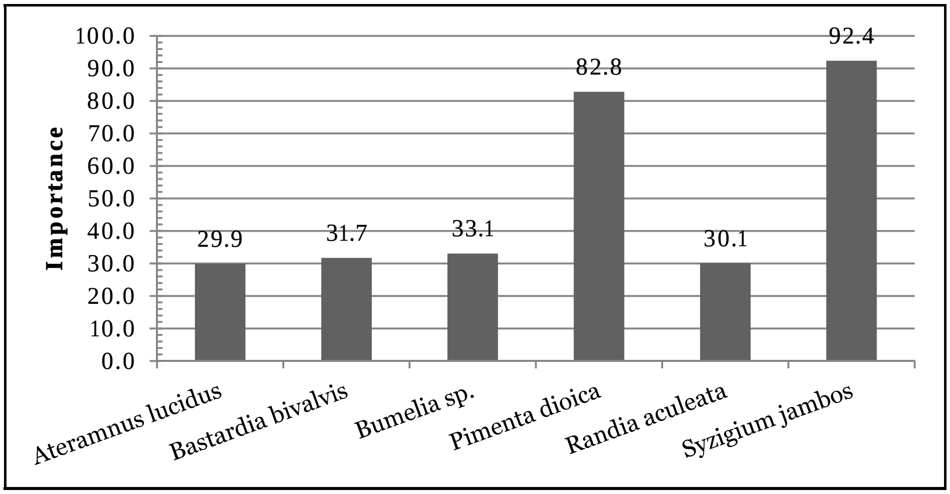

Figure 4-96 - Importance indices for tree species situated within Location M

Location N

This was located along the northern slope of the St. Johns Red Hills (), consisting of vegetation showing contrasting levels of recovery from anthropogenic disturbance. The site for the first PCQ appeared to have been cleared and fenced, leading to the dominance of the ground cover in sections by grasses such as *Panicum maximum* (Guinea Grass) in open areas (Plate 4.43) and *Paspalum* sp. in partially shaded areas. Additionally, phanerophytes such as *Spathodea campanulata* (African Tulip Tree) and *Cecropia peltata* (Trumpet Tree) were determined to be important based on their relative density, cover and frequency (figure 4-97). These, along with the *Bursera simarouba* (Red Birch) tended to be common remnants of cleared vegetation or disturbed locales.

Several climbing and epiphytic species were encountered in both locales. However, the most common were *Abrus precatorius* (Crab Eyes), *Thunbergia alata* (Black-Eyed Susan) and *Thunbergia fragrans* (White Nightshade).

The flora of the second PCQ site appeared less disturbed and higher in species richness. The ground layer was populated by the grass *Paspalum* sp.; several fern species such as *Nephrolepis* sp. and *Thelypteris dentata*; as well as the ground orchid *Oeceoclades maculata*. *Adenanthera pavonina* (Red Bead Tree) was quite important with an estimated density of 132 trees ha^{-1}. However, several, large representatives of *Cordia gerascanthus* (Spanish Elm) were encountered but due to the random component of the field method, their contribution may have been under-represented at 66 trees ha^{-1}. Endemics, namely *Piper amalago* (Black

Jointer), *Roystonea altissima* (Mountain Cabbage) and *Thrinax parviflora* (Broom Thatch), were also frequent here.

Plate 4.43 - Storage tank and cleared area planted with Guinea Grass (Panicum maximum) found in Location N

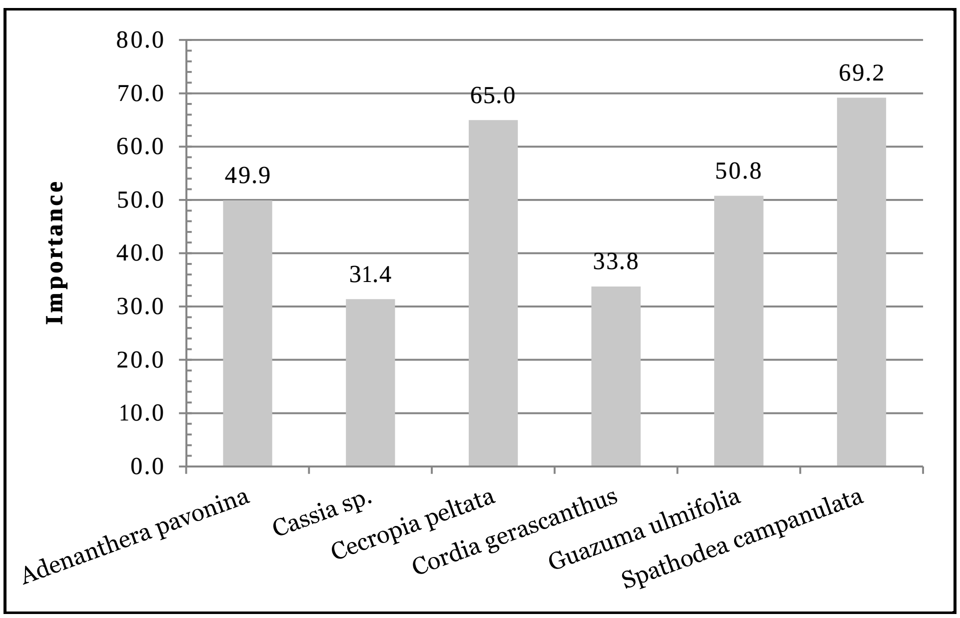

Figure 4-97 - Importance indices for tree species situated within Location N

Plate 4.44 - Section of Location N populated by several Red Bead Trees (Adenanthera pavonina)

Location O

This site was located adjacent to large-scale agricultural lands; in particular *Citrus* orchards (Plate 4.45 and Figure 4-98). As a result the vegetation, which was dominated by the tree *Schefflera* sp., was quite disturbed with several *Musa sapientum* (Banana) and *Delonix regia* (Poinciana) species occurring frequently (Figure 4-98). The ground component was sparse with a few ferns such as *Nephrolepis* and *Adiantum* spp. as well as the *Panicum maximum* (Guinea Grass). Climbers and epiphytes were few, however, *Mikania micrantha* (Guaco) and *Mucuna pruriens* (Cowitch) were commonly observed. No endemic plants were encountered.

Plate 4.45 - Agricultural lands adjacent to Location O, occupied by Citrus spp.

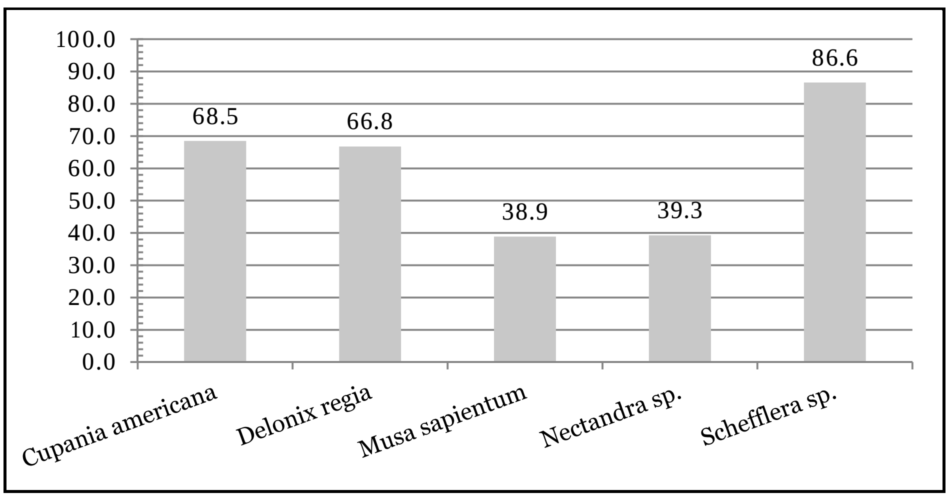

Figure 4-98 - Importance indices for tree species situated within Location O

The Northern Flatlands

These were mainly lands used for the large scale cultivation of *Citrus* spp. and *Saccharum officinarum* (Sugar Cane) (Figure 4-89 & Plate 4.46). Ornamentals such as *Codieum variegatum* (Garden Croton), *Nerium oleander* (Oleander), *Hibiscus rosa-sinensis* (Shoe Black) and *Lantana camara* (Wild Sage) were common. Various palms (Arecaceae) including *Cocos nucifera* (Coconut) were incorporated into the landscape of several developments. Other fruit trees, such as *Mangifera indica* (Mango) *Blighia sapida* (Ackee), *Artocarpus altilis* (Breadfruit) and several *Annona* spp., were typical of the man-made communities. For a complete list of all species encountered in this region and their respective DAFOR abundance rating, see Appendix 8.

Plate 4.46 - Agricultural lands with Citrus spp. (foreground: dark green area) and Saccharum officinarum (Sugar Cane, background: light green area)

4.2.1.5 Conclusions & Recommendations

The vegetation communities present within the study area exhibited various levels of anthropogenic influence and as such would be affected by a development such as this in various ways. The overall assessment of the study site is that the vegetation in each locale sampled was disturbed but the upper regions of the St. Johns Red Hills show the least disturbance as well as the highest endemism and as such care should be taken in carrying out the development in these areas. Figure 4-99**Error! Reference source not found.** summarises this study's characterisation of the flora for the areas investigated.

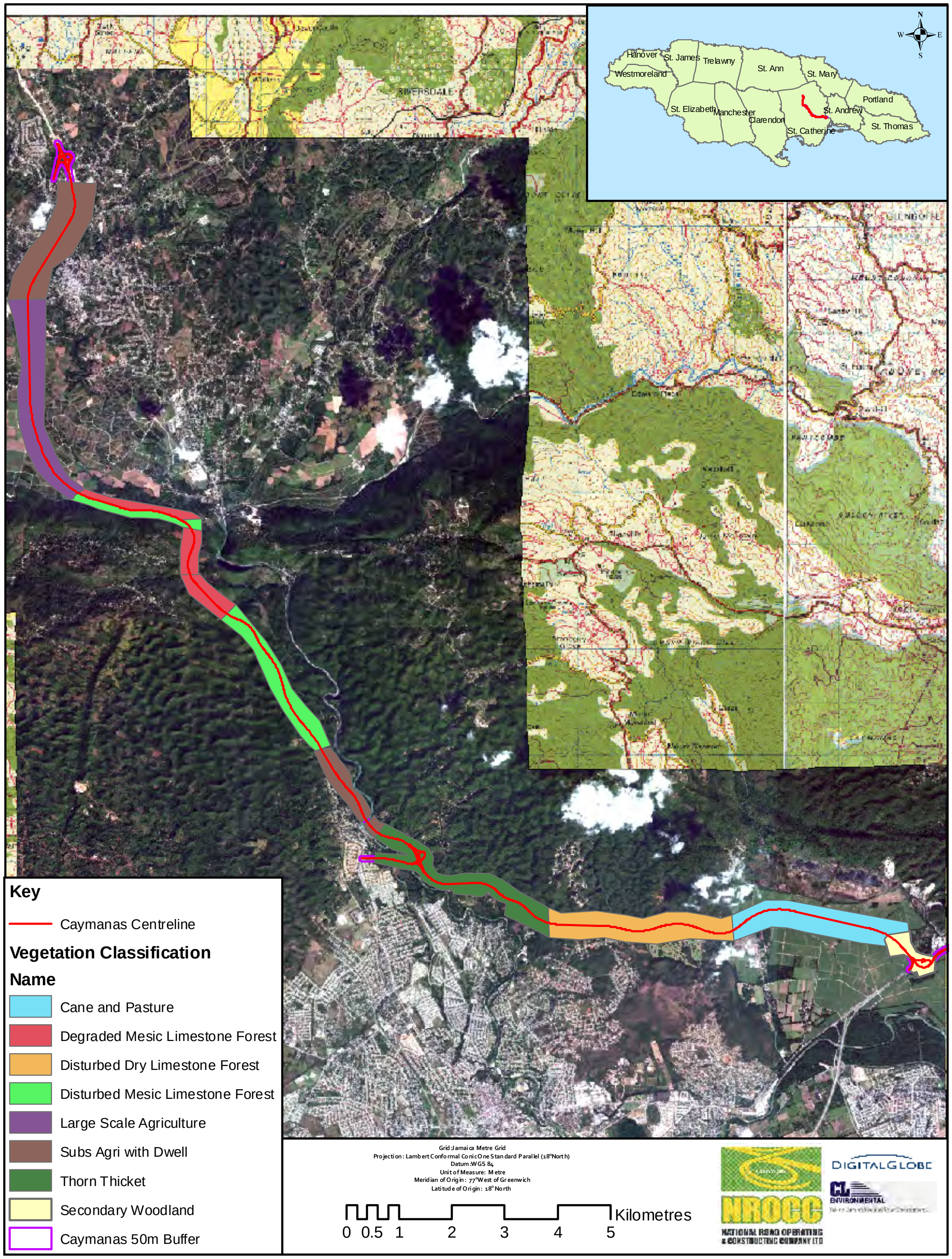

Figure 4-99 – Map depicting floral classification along the Caymanas to Linstead alignment

4.2.2 Fauna

4.2.2.1 Summary

The Avifauna and Invertebrate was studies at five sites, covering all major habitat types. The Herpetofauna was also studied at 5 sites but an additional site was examined. Thirty five species of birds were identified the Gully forest while 41 was observed in the Caymanas Hills; the other sites had much lower diversity. A number of endemic species were forest dependent, however they do not require primary forests and do thrive even is secondary forests.

The only amphibian observed was *Rhinella marina* ten species of Reptiles, belonging to 5 genera were recorded. These populations here appear to be an extension of the population recorded for the adjoining Red Hill area. The Arthropod fauna is also improvised, with a maximum of 13 land snails and 10 arthropod species recorded for any area.

Since none of the species recorded are known to be endangered or needing any special conservation measures, standard good environmental practice should be adequate to conserve these species.

4.2.2.2 Study Sites

The area is dominated by dry limestone forest. Additionally there were sections which may be described as Gully Forests; as the name suggests these occurred in narrow, sometimes deep valleys, where the moisture level was distinctly higher than the open areas. The forest in the area has been the subject of significant amount of human activity and there were significant cane plantations. The study sites that were established (Figure 4-100) ensured representation of the major habitat types.

The habitat types were placed in three categories:

1) Gully forest
    a. Transect 1
2) Dry limestone forest
    a. Transect 2 – secondary forest
    b. Transect 3 (below St Jago Heights) – disturbed forest
    c. Transect 4 (Caymanas Hills) – disturbed forest
3) Canefields
    a. Transect 5 - Caymanas

Figure 4-100 - Location of transects used in the avian study

4.2.2.3 Methods

Avifauna

The line transect method was selected for the avifauna assessment since there were a number of accessible foot paths, trails and roads in the vegetation. The line transect 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).

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.

Herpetofauna

The macro habitats were first identified and pictures taken. The micro-habitats were then identified and pictures taken when necessary. Active specimen collection and identification were then conducted and pictures were taken where necessary; specimens were then generally released.

Invertebrate Fauna

At each sampling site transects were established. All butterflies and spiders etc. observed within a belt of ± 5 m along the transect line were recorded. Litter and rotting logs were searched. To increase the number of species collected from the vegetation a sweep net was used along the transect. A 15 cm sweep net with cotton bag will be swept from side through the shrub and herb layer while the researcher walk along the transect. The species will later be identified and counted. Sampling for land snails was done by a combination of hand search of soil surface and trees. All snail specimens were identified using the features of their shells.

4.2.2.4 Identification

Some of the species detected were identified in the field, in other cases specimens were collected for verification or identification in the laboratory. Some material were readily identified; in other cases identification was done using available literature, and by comparison with specimens at the Entomology museum at the Department of Life Sciences, University of the West Indies, or the Museum of the Natural History Division of the Institute of Jamaica. It will not always possible to identify some material to the level of species. In such cases classification was done to the nearest taxon.

4.2.2.5 Results

Avifauna

The data from the three major habitat types, Gully forest, Dry limestone forest/Woodland, and cane fields are presented separately.

Birds of the Gully forest

Thirty five species of birds were identified during the assessment. The species diversity in the gullies was higher than the adjacent dry limestone forest. The gully forest is located in old river bed or gully which is usually between the limestone hills. The vegetation in gully consists of plants typical of the dry limestone forest along with several introduced species. The gullies have higher moisture content than the open forest as a consequence; the trees here are taller and have a larger DBH than those in the open forest. In addition, several fruit trees which are not seen in the dry limestone forest are usually present in the gully. This provides habitat for dry limestone bird species and other species which would be seen in moist forest. For example birds such as the Greater Antillean Pewee, Greater Antillean Elaenia, Yellow-shouldered Grass quit, which are usually found at higher altitudes and cooler areas were seen in the gully forest.

Thirteen of the 35 bird species identified are endemic to Jamaica. Only six of the endemic species are forest dependent. Only one migrant warbler was observed during the assessment, although the survey was carried in the month of February, where some of the migrant warblers were expected to be present. The Chestnut Mannikin, an introduced species was observed during the assessment.

Birds of the Dry limestone forest/ woodland

The avian fauna distribution from the three transects varied in the dry limestone forest. However, bird species that are typical of a dry limestone forest (Downer 1990) were represented in the three transects. These birds include Caribbean Dove, Parakeets, Hummingbirds, Jamaican Woodpeckers, Orioles and Warblers.

Forty one species of birds were observed in the Caymanas Hills. Twelve of the islands 29 endemic birds were identified in the area. However, only 8 of the 12 endemics were forest dependent. The dry limestone forest in Caymanas Hills was the least disturbed forest of the three areas surveyed.

The other two transects in disturbed limestone forest yielded fewer species compared to Caymanas Hills. There were also fewer endemic bird species (n=3 and n=4). It should also be noted that none of the endemic birds were forest specialist.

The high number of endemic forest specialist in the Caymanas Hills suggests that the forest is in good health. Interestingly, although the survey was carried in the month of February, when some of the migrant warblers were expected to be present, only a few were observed.

Birds of the Canfields

Seventeen bird species were observed in the canefields; this was lower than the dry limestone forest in Caymanas Hills. This is as a result of the monoculture nature of the cane fields, where there are few or no other trees present. Several ground feeding birds such as the Common Ground Dove and Zenaida Dove were seen foraging on the cane roads. The yellow face grass quits were seen in the canefields and the grasses along the road. No water birds that are usually associated with irrigation canals were observed because the fields were mature and were no longer waterlogged. One endemic bird, the Jamaican Euphonia was seen in the canefields, however it is utilizes a wide variety of habitats. 981No migrant warbler was observed in the field. Of note is that one recently introduced species, the Orange Bishop, was observed in the canefields.

Herpetofauna

The only amphibian observed was *Rhinella marina*. Specimens of genus *Eleutherodactylus* were expected as the species are not rare and have a wider range. The relatively dry habitats and absence of microhabitats such as bromeliads may have contributed to their absence.

Table 4.38 - Amphibians and Reptiles recorded in study area

Genus	Species	Area 1		Area 2		Area 3		Area 4		Area 5		Area 6	
		Seen	DAFOR Scale	Seen	DAFOR Scale	Seen	DAFOR Scale	Seen	DAFOR Scale	Seen	DAFOR Scale	Seen	DAFOR Scale
AMPHIBIANS													
Rhinella	marina	Y	O	Y	O	Y	O	-	-	-	-	Y	O
REPTILES													
Celestus	crusculus cundalli	Y	O	Y	O	-	-	-	-	Y	O	Y	O
Aristelliger	praesignis	Y	O	Y	O	Y	F	Y	F	Y	F	Y	F
Hemidactylus	mabouia	Y	O	Y	O	Y	O	Y	O	-	-	Y	O
Sphaerodactylus	argus henriquesi	Y	O	Y	O	-	-	-	-	-	-	-	-
Sphaerodactylus	parkeri	-	-	-	-	-	-	-	-	-	-	Y	O
Anolis	grahami grahami	Y	F	Y	F	Y	F	Y	F	Y	F	Y	F
Anolis	lineatopus lineatopus	Y	F	Y	F	Y	F	Y	F	Y	F	Y	F
Anolis	opalinus	Y	F	Y	F	Y	F	Y	F	Y	F	Y	F
Anolis	sagrei	-	-	-	-	Y	F	-	-	-	-	-	-
Anolis	valencienni	-	-	-	-	-	-	Y	O	-	-	-	-

Ten species of Reptiles, belonging to 5 genera were recorded. All the *Anolis* that were expected in this type of habitat were recorded. Of interest was *Anolis lineatopus lineatopus* as there were several different colourations. The *Lineatopus* species group is one of a few reptiles that has several subspecies and it is not clear what was the significance of the different colourations recorded here.

The study area is sandwiched between two known reptilian population centres, Hellshire Hills area the Red Hills Area. The species from the Hellshire Hills are only known from that region and Portland Ridge Areas are mostly rare, endangered species and are currently protected. The species from the Red Hills area are widespread, not listed as endangered, and have been recorded before and after the introduction of human settlements to that area. However, these two populations have been kept apart by the geographical layout of the area with the Rio Cobre River cutting between them.

No endangered species were recorded during this study; the population is akin to the Red Hills population, although a number of expected species were not recorded. Since the of amphibians and reptiles are not listed as endangered and have been recorded before and after the introduction of human settlements to that area, and since the populations mirror those of Red Hills, there is no need for special conservation measures targeting the groups.

Invertebrate Fauna

The invertebrate fauna was relatively low in diversity (Table 4.39and Table 4.40). The Mollusc was most diverse in with 13 of Jamaica's 500 species being present. While the area has a lot of limestone, it is quite dry and this is likely to be the major factor affecting the land snail populations. Not surprisingly land snails was absent from the highly disturbed habitat of the cane fields.

The Arthropod fauna was also very improvised. The cane fields (Site 5) with a large amount of rapidly growing herbs (weeds) and limited irrigation water was the most diverse.

The invertebrate fauna is characteristic of areas with high level of human disturbance. Species which are generally widespread in distribution and which can tolerate a wide variety of habitats (generalists) dominate the fauna. Such species do not need any special conservation measures

Table 4.39 - Summary of Land Snail fauna of the area (details in Appendix 9)

Habitat	No. Families	No. Species	No. and % Endemics	No. and % Introduced
Site 1	4	5	3	1
Site 2	9	13	9	
Site 3	6	9	3	
Site 4	7	8	5	
Site 5	0	0		

Table 4.40 - Summary of Arthropod fauna of the area (details in Appendix 9)

	Site 1	Site 2	Site 3	Site 4	Site 5
No. Families	8	5	4	7	10
No. Species	10	5	4	8	12

4.2.2.6 Conclusions

This area has been the subject of significant human activity, very intense in many cases; consequently all the species observed are generalist capable in surviving in a wide variety of habitats. The species diversity is comparatively low. There were no species requiring specific conservation efforts and proper environmental management should suffice to conserve these species.

4.3 LAND USE

4.3.1 Previous

Previous land use along the proposed North – South Highway and its environs are summarized from the Jamaica National Heritage Trust (JNHT) Archaeological Impact Assessment of Highway 2000 North - South Link Development Project (April 2012).

For the assessment, the JNHT divided the study area into 4 zones based on topography and vegetation cover- Zones 1, 2, 3 and 4.

- Zone 1 runs through the Caymanas (East St. Catherine Plains).
- Zone 2 runs from Mount Gotham the Rio Cobre Dam.
- Zone 3 runs from Crescent to Lime Walk (Karst limestone hills and plateau).
- Zone 4 runs from Wakefield to Byndloss (Linstead, Bog Walk Basin).

In the early days European settlements created barriers to the development of the country until lands were cleared for agricultural pursuits. However, the transformation of the landscape would have taken place beginning with the Taíno clearing for the planting of fields and the opening of trails.

The Spanish settled near to the Taíno and seemed to have continued using the Taíno trails. In some places the English constructed new roads but they also used the Taíno-Spanish trails. The construction of roads disturbed natural vegetation but opened areas for agricultural pursuits.

The road that traverses the karst limestone zone along which the proposed alignment will travel in parts may be one of Taíno trails, which may have been used by the Spanish and subsequently the British became the main route to the north coast up to 1770 when the road through the Bog Walk Gorge was constructed.

4.3.1.1 Agro-Industries

The early 17th century settlers produced and exported crops that required a small labour force. Chief crops were tobacco indigo, cocoa, cotton and pimento.

4.3.1.2 Sugar Estates

The Spanish introduced the sugar cane into the island. They grew sugar on a small scale and erected small mills. It was not until the 1660's that an attempt was made to put the sugar industry on a regular footing by Sir Thomas Modyford, the English governor (Senior 1983:157-8).

The large-scale production of sugar was undertaken in the Linstead Basin. Sugar dominated the region from the end of the 17th century to the end of the 19th century with each estate having its own mill. Throughout this period some estates also changed hands.

A down turn in the fortunes of sugar resulted in a change to other produce; first bananas, then cattle and finally citrus. This change is noted for the estates such as Rose Hall, Byndloss, Mickleton and Bybrook.

4.3.1.3 Pens and the Dairy Industry

During the 18th and 19th centuries cattle was raised and food provisions grown on estates called pens. Pens were established on lands unsuitable for the growth of sugar cane. Some estates that suffered from the fallout in sugar also took up pen keeping.

Pens produced livestock, grass, and ground provisions for the local market. These pens supplemented their income by growing pimento, cotton and logwood for export. Worn out cattle from estates were purchased and fattened for the local market. Timber for building small craft and wharf-pilings were produced. The word 'Pen' in the place names in the study area recalls the former industry of pen keeping.

4.3.1.4 Coffee

Coffee was grown in the hilly areas by small settlers. In more recent times a branch of the Wallenford Coffee works has been established at Jew Pen (Bog Walk).

4.3.1.5 Citrus

With the demise of the sugar and banana estates in the Linstead- Rio Cobre Basin a section of the land was put into citrus cultivation.

4.3.1.6 Peasant Farming

In the post emancipation period many settlements emerged in the area as large acres of lands were cleared for peasant farming in the hilly regions. Staples such as cassava, yam, and other foodstuff were grown replacing natural vegetation. Some areas have now been abandoned (demographic shift of population) but the domesticated plants still thrives in these places.

4.3.2 Existing

The proposed alignment of the North South Highway is surrounded by various land use. These include agricultural, commercial, industrial, residential, educational and recreational. Other uses include motor rally route, airstrip, caves, burial grounds (behind homes or private property), power lines, wells/pump houses, water pipelines, telecommunication modules and cellular towers.

Agriculturally, the study area has sugar cane, citrus and apple farming (Caymanas and Tru Juice). Commercially, the study area has offices, restaurants, bars, two markets (Bog Walk and Linstead), stalls, garages, block making facilities and factories such as the Tru Juice and Nestle Factory. There are eight quarries within the study area, five of which are limestone, two marl and the other sand.

There are also health facilities which include the Linstead Hospital and health centres such as Giblatore, Bog Walk and Linstead.

There are 60 settlements (residential areas) within the (Social Impact Area (SIA)) with the major towns being Spanish Town, Bog Walk and Linstead (Table 4.41).

Table 4.41 – Settlements within the SIA

Angels	Dignum	New Haven
Avon Park	Duhaney Park	Passage Fort
Bamboo	Ensom Pen	Pinnacle Pen
Banbury	Five Miles	Rabys Corner
Bernard Lodge	Garveymeade	Rifle Range
Bog Walk	Giblatore	Rose Hall
Buxton Town	Gordon Pen	Russell Pen
Byndloss	Grange Lane	Simons
Cambrian	Gregory Park	Six Miles
Cashew Tree	Heathfield	Spanish Town
Caymanas	Independence City	Tamarind Farm
Caymanas Bay	Kent Village	Thompson Pen
Caymanas Park	Keystone	Time And Patience

Central Village	Lakes Pen	Tredegar Park
Christian Pen	Lime Walk	Vanity Fair
Content	Linstead	Victoria
Cow Market	Michleton	Wakefield
Crescent	Monticello	Washington Gardens
Cross Roads	Mount Gotham	Waterford
Dawkins	New Ground	Waterloo Valley

Educationally there are 36 schools within the SIA, these listed in Table 4.42.

Table 4.42 – Schools within the SIA

Balcombe Drive All Age	Marlie Hill Primary
Balmagie Primary	McGrath Comprehensive
Belmont Park Primary	Port Henderson Primary
Bog Walk Comprehensive	Portmore Community College
Crescent Primary & Jnr. High	Rock Hall All Age
Cumberland High	Rosemount Primary & Jnr. High
Dinthill Technical High	Seaward Primary & Jnr. High
Duhaney Park Primary	Simon All Age
Edith Dalton High	Spanish Town High
Eltham High	Spanish Town Basic
G C Foster College	St Jago High
George Headley Primary	St. Catherine Primary
Giblatore Primary	St. Jago Basic
Gregory Park Primary	Tredegar Park All Age
Homestead Primary	Wakefield Primary
Jericho Primary	Waterford Primary
Johnathan Grant High	Waterford High
Linstead Primary & Jnr. High	White Marl Primary & Jnr. High

4.3.3 Future Developments

The Urban Development Corporation (UDC) has zone the Caymanas Estate lands for residential, industrial (major industrial estate) and commercial.

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 June 4 - 6, 2012.

Approximately 220 structures will be impacted by the proposed highway alignment (Figure 4-101). Of these structures, approximately 52% are found between Crescent and Content.

These vary from stalls, houses, church, wells/pump house, shops, cell tower, farms, pens, used car lot and unfinished structures. The size and conditions vary.

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

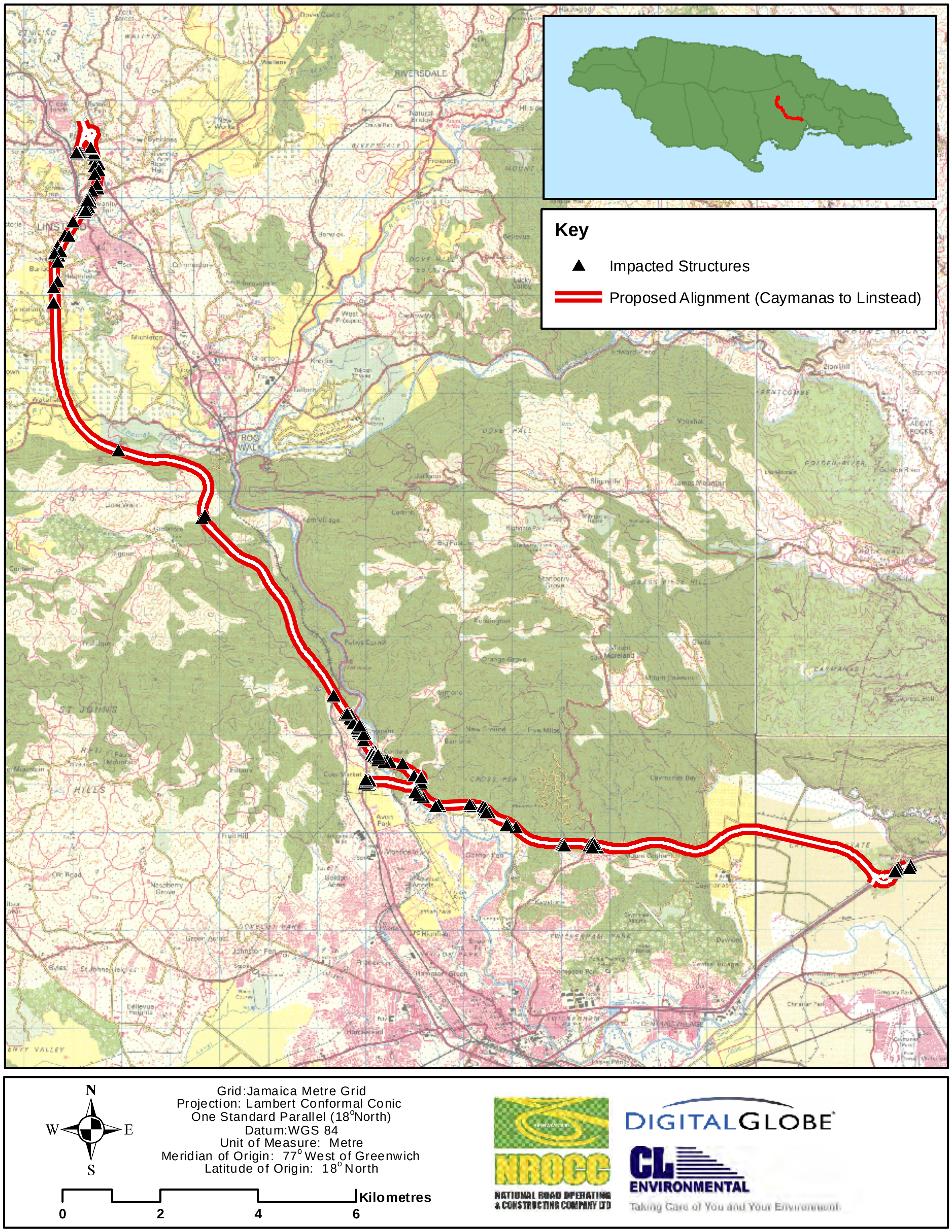

Figure 4-101 – Map showing locations of impacted structures

4.5 SOCIOECONOMICS

4.5.1 Introduction

The Social Impact Area (SIA) for this study was demarcated at approximately three (3) kilometers around the proposed Linstead to Caymanas Highway location. This is shown in Figure 4-102 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.

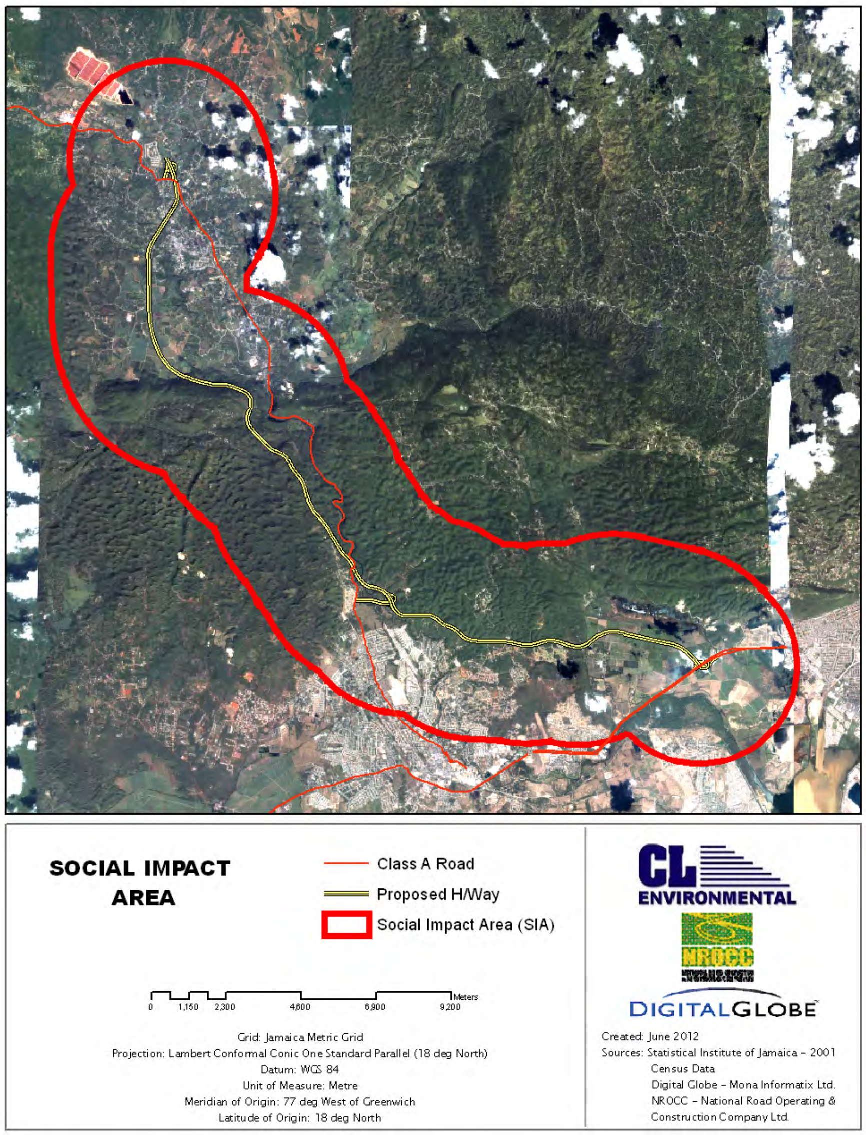

Figure 4-102 - Social Impact Area of the proposed Linstead to Caymanas highway

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. Catherine over the last inter-censal period (1991-2000) was 2.63% per annum.

Based on the growth rates, at the time of this study the population was approximately 293,450 persons and is expected to reach 561,556 persons over the next twenty five years, if the current population growth rate remains the same.

Based on Figure 4-103 the age of the SIA population could be described as fairly youthful and mostly female, with the majority of the population concentrated between ages 0-49. Since the SIA also has a substantial mature population, this contributes to an established labour force to support the population. However the fact that it is largely female could indicate either a high female birth rate or a high rate of male emigration from the SIA.

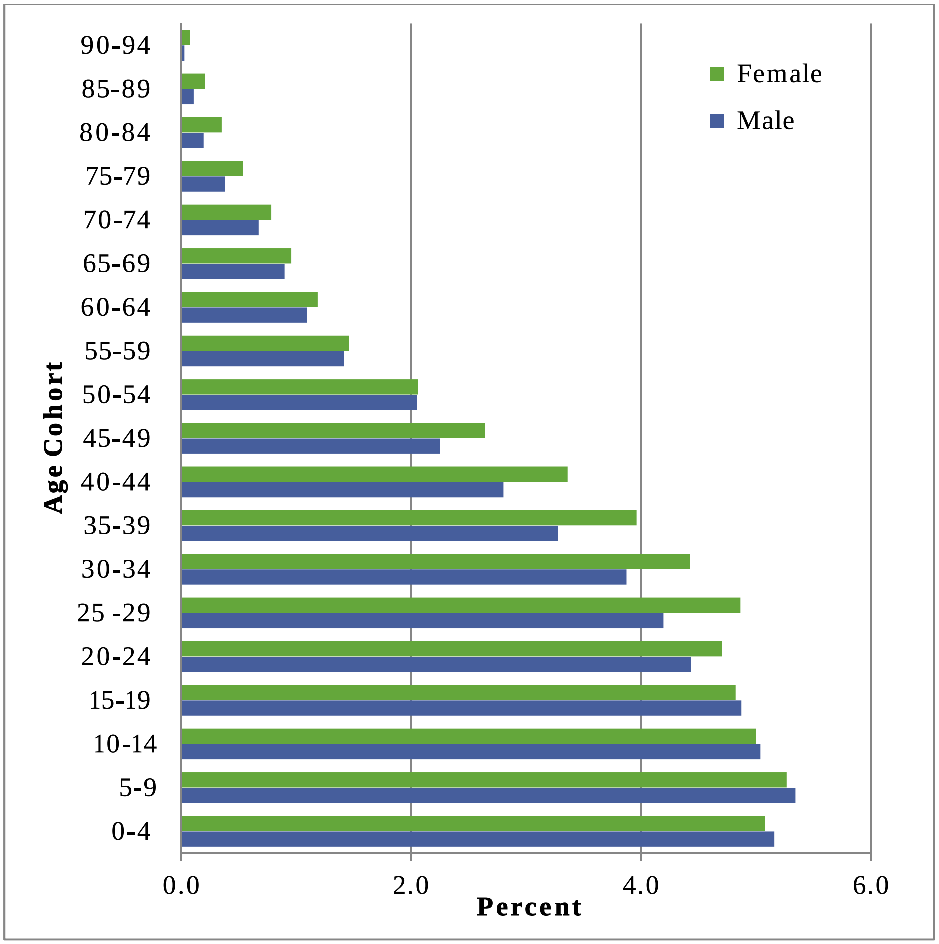

Figure 4-103 - Age cohort as a percentage of the SIA population by sex

The sex ratio (males per one hundred females) in the SIA in 2001 was 84.7, which indicates that a higher percentage of the population in the SIA were females. Only the 0-19 years category had marginally more males than females (Table 4.43). This sex ratio was lower than the national (Jamaica) (96.9) thus indicating that the national populations has a higher level of males. Notably, the SIA sex ratio is much lower than the regional (St. Catherine) ratio of 120.4. This indicates a much higher male population at the regional level.

Table 4.43 - Male to female ratio with in the SIA

AGE COHORT	Male Population	Female Population	Males/Hundred Females
0-4	11381	11198	101.6
5-9	11786	11615	101.5
10-14	11113	11032	100.7
15-19	10749	10637	101.1
20-24	9781	10374	94.3
25 -29	9252	10729	86.2
30-34	8546	9762	87.5
35-39	7233	8738	82.8
40-44	6185	7415	83.4
45-49	4966	5828	85.2
50-54	4526	4549	99.5
55-59	3128	3223	97.0
60-64	2418	2623	92.2
65-69	1988	2117	93.9
70-74	1490	1731	86.1
75-79	841	1194	70.5
80-84	435	782	55.6
85-89	245	461	53.1
90-94	65	173	37.9

4.5.3.2 Dependency Ratio

The total population within the SIA in 2001 was approximately 220,555 persons (STATIN 2001 Population Census). The 15-64 years age category accounted for approximately 64% of this population, with the age 0-14 years 31% and the age 65 and over category accounting for approximately 5%.

Table 4.44 shows the percentage composition of each age category to the population. This is compared on a national, regional and local level (at varying distances from the proposed highway). The data shows that the percentage contribution to the population for the 0-14 years category was lower in the SIA (local) when compared to the regional (St. Catherine) and the national figures. However, the 15-64 categories were above the regional and national rates, whilst the local 65 & over category were again lower than the regional and national figures.

Table 4.44 - Age categories as a percentage of the population (Source: STATIN Population Census 2001)

Age Categories	Jamaica (%)	St. Catherine (%)	SIA - 4km (%)	SIA - 2km (%)	SIA - 1km (%)
0 - 14	32	32	31	31	32
15 - 64	60	62	64	63	63
65 & Over	8	6	5	5	5

The child dependency ratio for the SIA in 2001 was 484 per 1000 persons of labour force age; old age dependency ratio stood at 82 per 1000 persons of labour force age; and societal dependency a ratio of 566 per 1000 persons of labour force. This indicates that the youth (child dependency) is more dependent on the labour force for support when compared with the elderly. Comparisons of the dependency ratios indicate that the child, aged and societal dependency ratios for the study area (SIA) are somewhat less than the regional and national figures (Table 4.45).

Table 4.45 - Comparison of dependency ratios within the SIA (population per 1000)

Category	*Jamaica*	*St. Catherine*	*SIA*
Child Dependency	539	521	484
Old Age Dependency	128	93	82
Societal Dependency	667	614	566

Overall, the societal dependency within the SIA is a little more than half of the population (57%). Although, the SIA's dependent population is far lower than the regional and national figures in general it conforms to national and regional norm, where the dependent population is larger than the working population (Figure 4-104).

The SIA's societal dependency is not excessively high. The numbers indicate that although the bulk of dependents are youths that there is also a fairly robust number representing the working population. This can be viewed as a development opportunity as it would seem that there exists a good sized working population to support increased investment in employment generating initiatives.

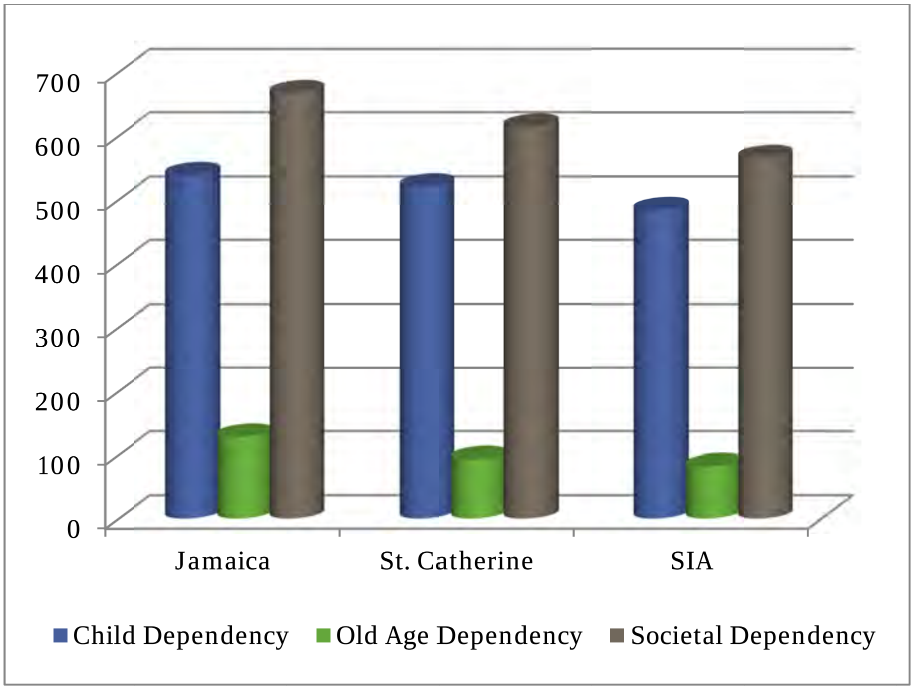

Figure 4-104 - Comparison of dependency ratios

4.5.3.3 Population Density

The SIA has a land area of approximately 30km² and a population of about 220,555 persons. The population density of the area is roughly 7,350 persons per square kilometre. This is a far greater density than that of the parish of St. Catherine and also considerably higher than the national population density figure of 238 persons per square kilometre (Table 4.46). This is to be expected, as the SIA takes in a large portion of the residential settlements in Linstead, Bog Walk, Spanish Town and Portmore. Although the inclusion of these high density residential settlements have pushed up the overall population density figure, the SIA still has large tracts of agricultural and passive lands within its central and south eastern regions.

Table 4.46 - Comparison of population densities

Category	***Jamaica***	***St. Catherine***	***SIA***
Land Area (km²)		111	30
Population		482,010	220,555
Population Density	238	4,342	7,352

Figure 4-105 shown below demonstrates where the largest concentration of the SIA population is located. These areas have approximately 1,025 to 2,060 persons residing within the Enumeration Districts. For the most part the proposed highway runs through the less populous areas within the SIA, except when small segments of the alignment briefly skirt Spanish Town and Portmore.

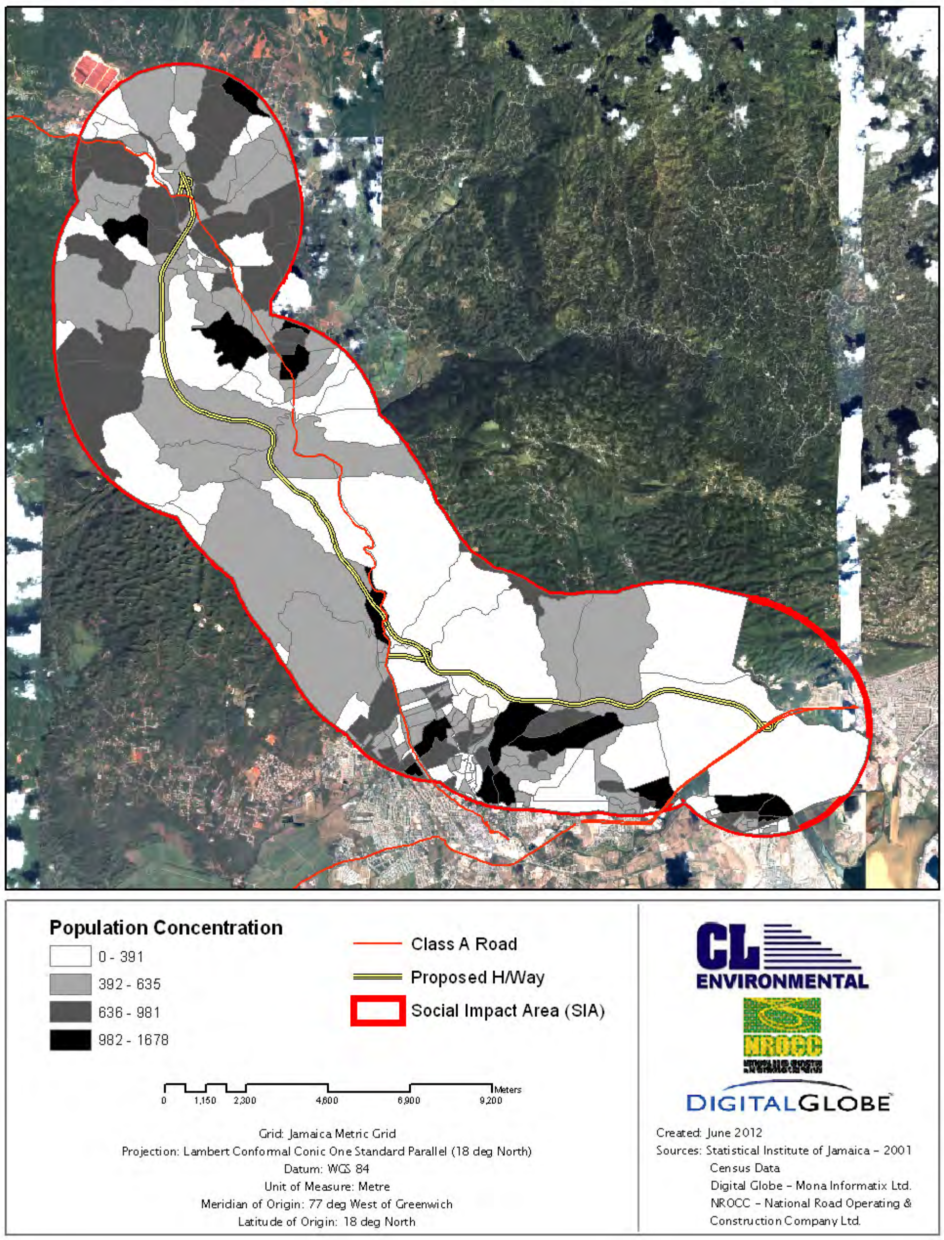

Figure 4-105 - Population concentration within the SIA

Infrastructural development normally acts as an impetus for other kinds of development, commercial , industrial and residential being key among these. The SIA is a prime location for the expansion of all three categories. Therefore, the construction of this proposed highway could result in increased population densities within the SIA. High population densities put an added strain on physical and social amenities/infrastructure and can result in their rapid deterioration and the associated social ills. Considering that the SIA already has the propensity for high population concentration within specific areas, future growth will have to be properly guided by the planning authorities.

4.5.4 Education

When educational attainment within the SIA is calculated as a percentage of the total population it becomes evident that there is a propensity towards the attainment of a primary and secondary school education. As shown in Table 4.47 this pattern is consistent with the national and parish percentages.

Table 4.47 - Education attainment as a percentage of the population of persons 4 years and older

Category	***Jamaica***	***St. Catherine***	***SIA***
Pre-Primary	4.7	5	4
Primary	31.2	28	27
Secondary	49.7	49	50
University	3.1	4	4
Other Tertiary	5.9	8	9
Other	2.8	3	3
Not Stated	1.7	2	2
None	0.9	1	1

Figure 4-106 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 wider SIA area is educated to the primary and secondary level with a fair scattering of schools located close to existing transportation routes and growth centres. Table 4.48 lists the schools within the SIA.

Although the main purpose of the proposed highway might not be to cater for school age public transportation, an opportunity exists to improve access to some schools within the Wakefield, GIblatore and Victoria areas.

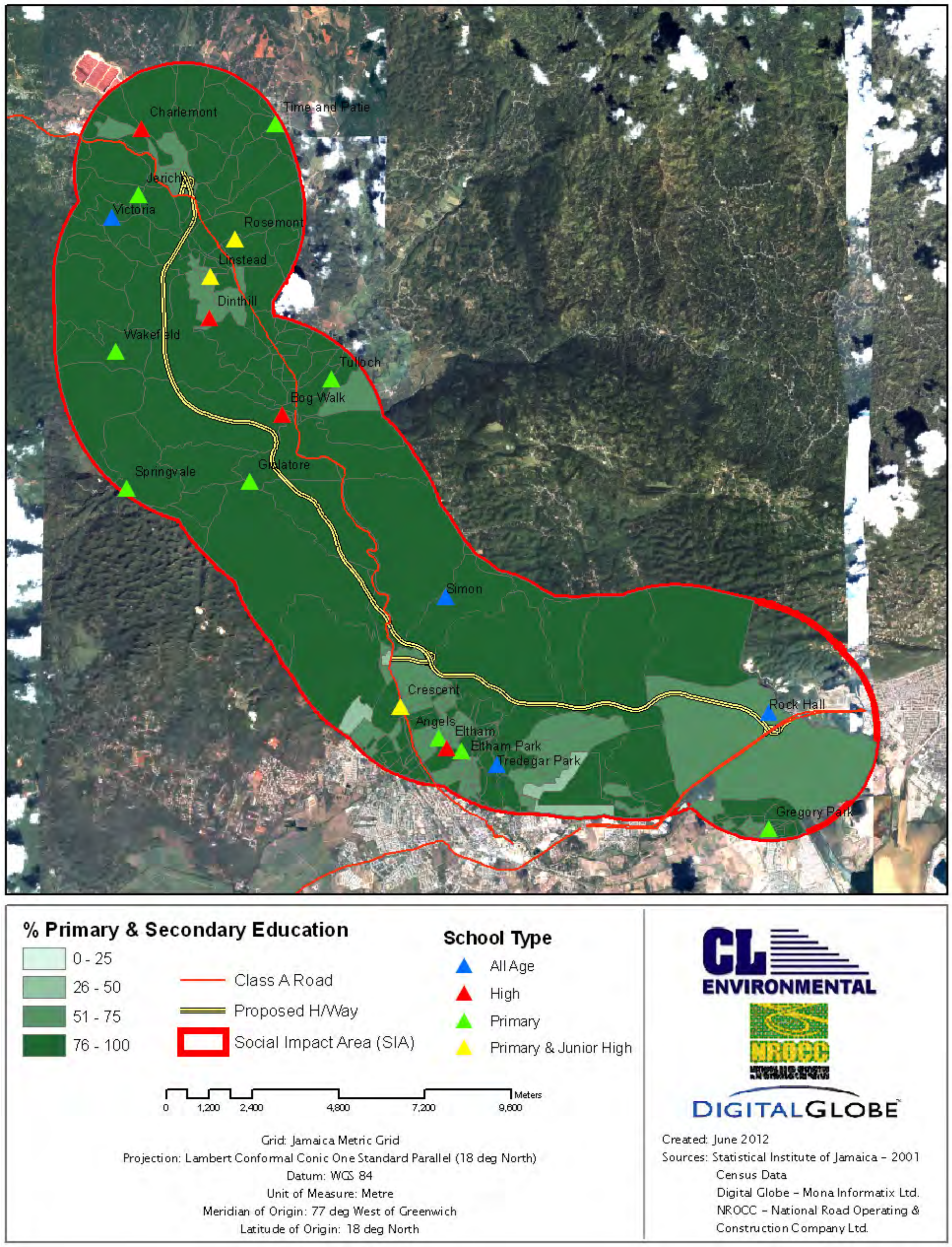

Figure 4-106 - Percent primary and secondary education and location of schools within the SIA

Table 4.48 - Schools located within the SIA

Name	Type
Rock Hall	All Age
Gregory Park	Primary
Jericho	Primary
Spanish Town	Primary
Springvale	Primary
Tulloch	Primary
Wakefield	Primary
Bridgeport	Primary
Naggo Head	Primary
Waterford	Primary
Giblatore	Primary
Independence C	Primary
Portsmouth	Primary
Eltham Park	Primary
Southborough	Primary
Angels	Primary
Crescent	Primary & Junior High
Linstead	Primary & Junior High
White Marl	Primary & Junior High
Rosemont	Primary & Junior High
St Jago	High
Dinthill	High
Johnathan Gran	High
Waterford	High
Charlemont	High
Spanish Town	High
Bog Walk	High
Jose Marti	High
Cumberland	High
Eltham	High
Simon	All Age
Victoria	All Age
Tredegar Park	All Age

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 41,740 housing units, 57,351 dwellings and 60,032 households within the SIA in 2001. The average number of dwelling in each housing unit was 1.37 and the average household to each dwelling was 1.05. The average household size in the SIA was 3.67 persons per household (Table 4.49).

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

Table 4.49- Comparison of national, regional and local housing ratios (Source: STATIN Population Census 2001)

	Jamaica	***St. Catherine***	***SIA***
Dwelling/Housing Unit	1.2	2.56	1.37
Households/Dwelling	1.03	0.39	1.05
Average Household Size	3.48	5.33	3.67

Approximately 71.11% of the housing units in the SIA were of the separate detached type, 27.58% were attached, 0.40% part of a commercial building, 0.09% categorized as other, 0.04% improvised housing, and 0.8% did not state.

The majority of the households in the SIA in 2001 used 1-3 rooms for sleeping (89%). Approximately 7.1% of the households occupied four rooms, 3.4% used five rooms and 0.6% did not report the number of rooms used for sleeping. Most of the households (37.1%) used two rooms for sleeping (Figure 4-107).

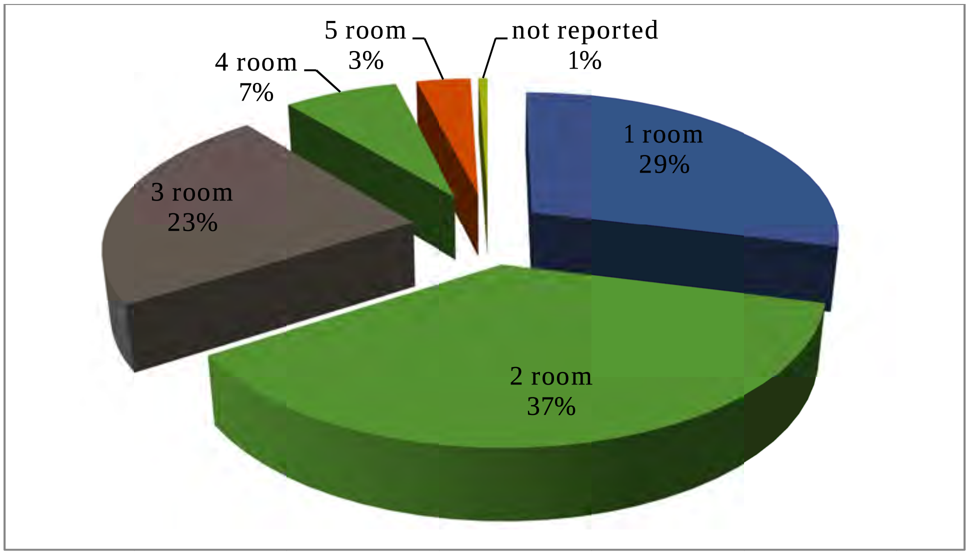

Figure 4-107 – Rooms used for sleeping in the SIA

4.5.6 Land Tenure

In 2001, 23% of the households in the SIA owned the land on which they lived. Approximately 9% leased the land on which they were, 9% rented, 9% lived rent free, 3% "squatted" and 1% had other arrangements. The largest percentage (48%) did not report the type of ownership arrangements they had. This could be evidence of additional informal or illegal arrangements that respondents were unwilling to reveal (Table 4.50).

Table 4.50 - Comparison of percentage household tenure; nationally, by parish and SIA

Category	Jamaica	St. Catherine	SIA
Owned	37.5	30	23
Leased	5	7	9
Rented	14.8	10	9
Rent Free	17	12	9
Squatted	2.9	2	3
Other	0.9	1	1
Not Reported	21.9	39	48

There were a smaller percentage of households in the SIA owning the land they lived on (Figure 4-108), those renting and living rent free compared to the national and regional setting. Otherwise, there were higher or comparable percentages seen for all other land tenure categories when compared to the national and regional figures.

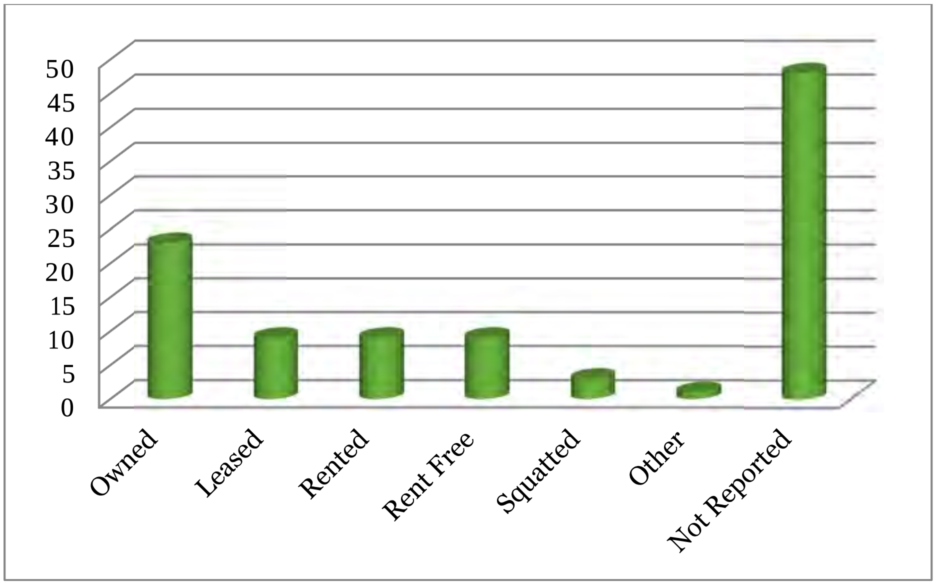

Figure 4-108 - Percent Household by Land Tenure within the SIA

As shown in Figure 4-109, the proposed highway falls mostly within areas of the SIA that are recording between 0-75% of land ownership. Should privately owned lands need to be acquired to facilitate the construction of the highway, lands in the northern and central areas of the SIA seem the most likely to be targeted from this category.

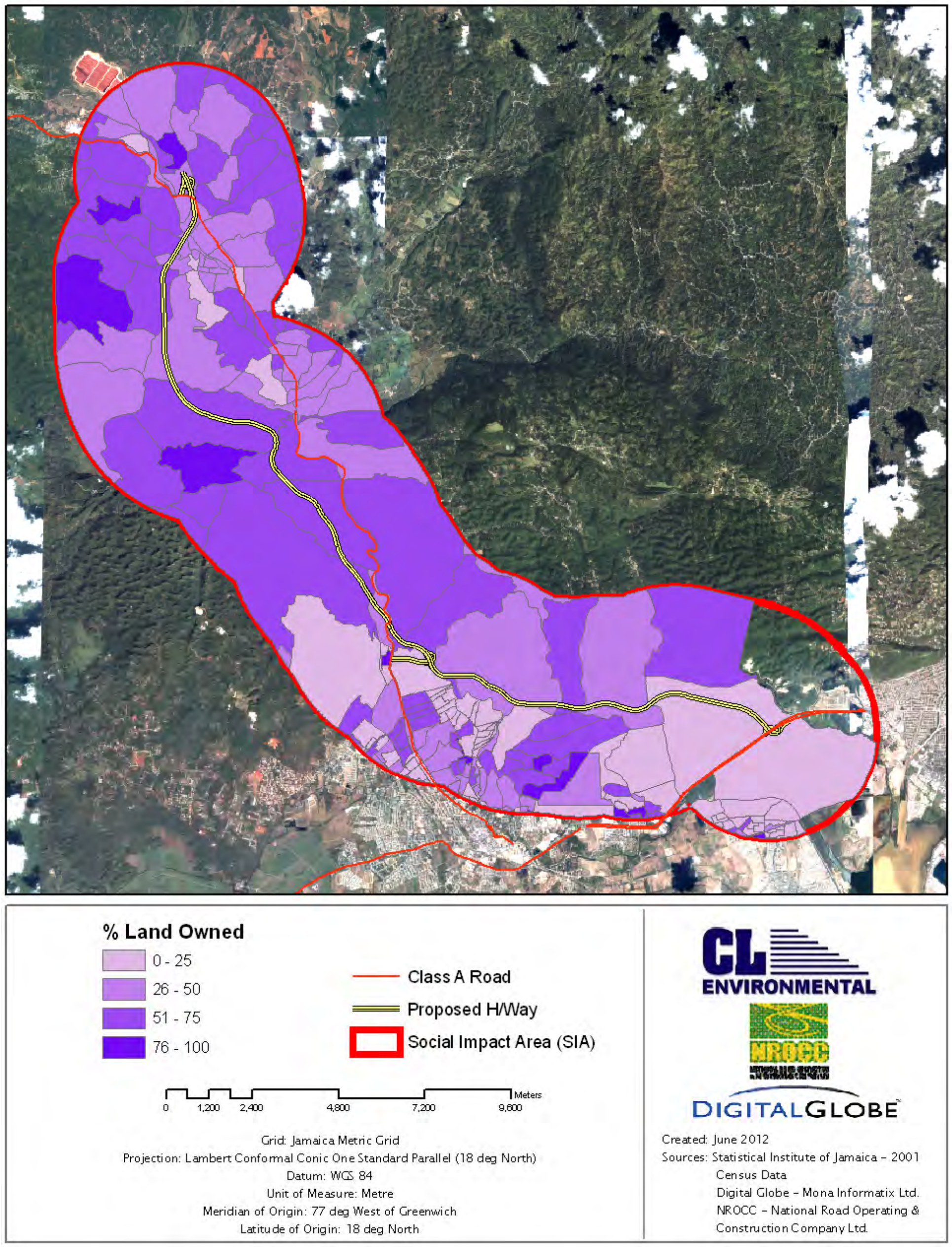

Figure 4-109 - Percent land ownership within the SIA

4.5.7 Infrastructure

4.5.7.1 Lighting

There are a lower percentage of households in Jamaica using electricity when compared with the regional and SIA households. However, there was an increase in the households using kerosene in Jamaica as their main means of lighting, when compared with the regional and SIA. Table 4.51 details the percentage of households using a particular category of lighting.

Table 4.51 - Percentage households by source of lighting

Category	***Jamaica***	***St. Catherine***	***SIA***
Electricity	87	89	93
Kerosene	10.6	8	5
Other	0.4	1	0.4
Not Reported	2	2	2

As shown in Figure 4-110, most SIA households (which accounts for 75% to 100%) utilize electricity as their main source of lighting. For the most part the proposed highway falls within the areas of high household electricity use.

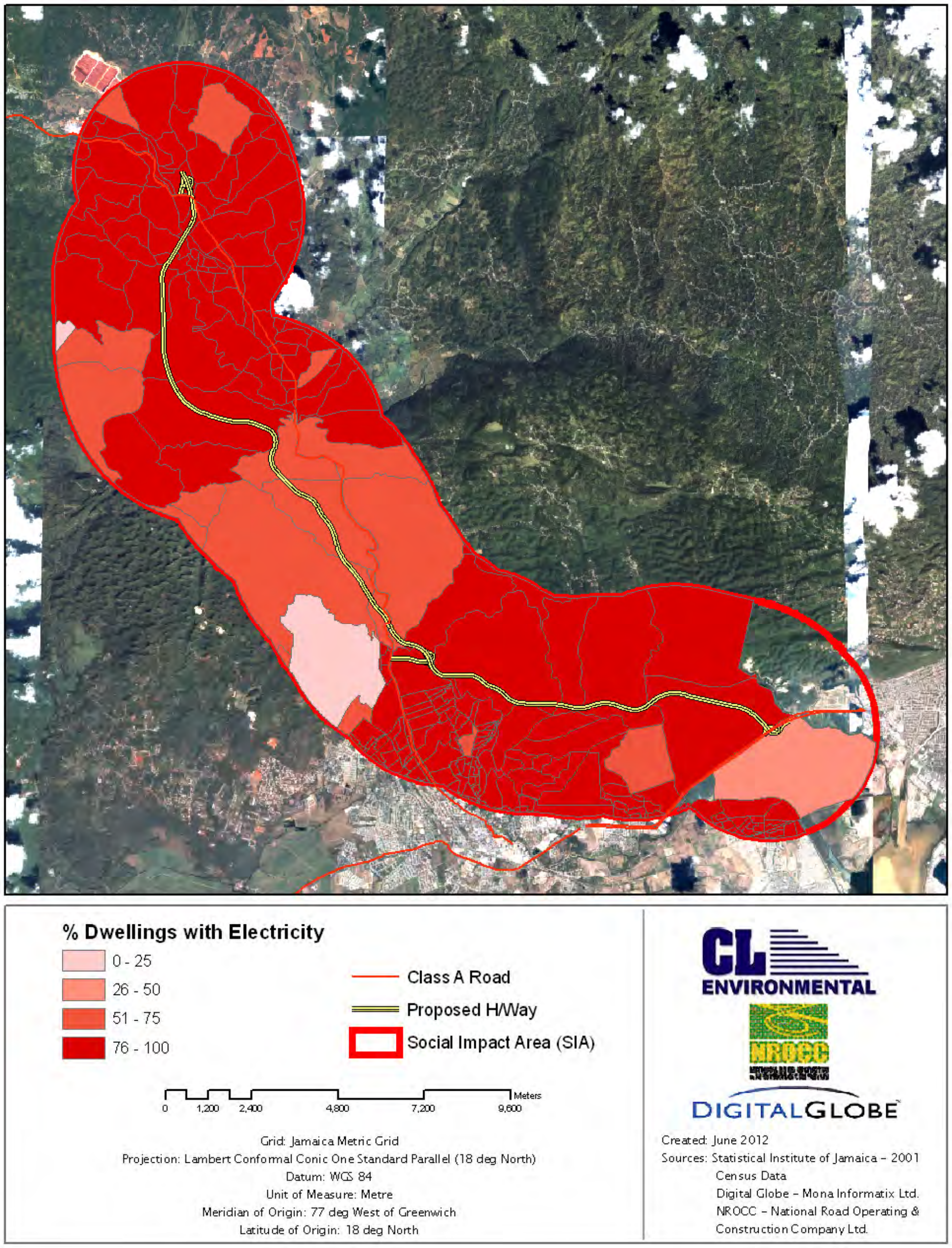

Figure 4-110 - Percent dwelling with electricity within the SIA

4.5.7.2 Telephone/Telecommunications

St. Catherine and the study area are 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) and Flow. The cable distribution lines and poles shown below belong to the LIME network. For the most part the distribution lines and poles follow major transportation routes and even intersect parts of the northern leg of the proposed highway (Figure 4-111).

At least two companies have expressed interest in conduits along the highway to carry their cables.

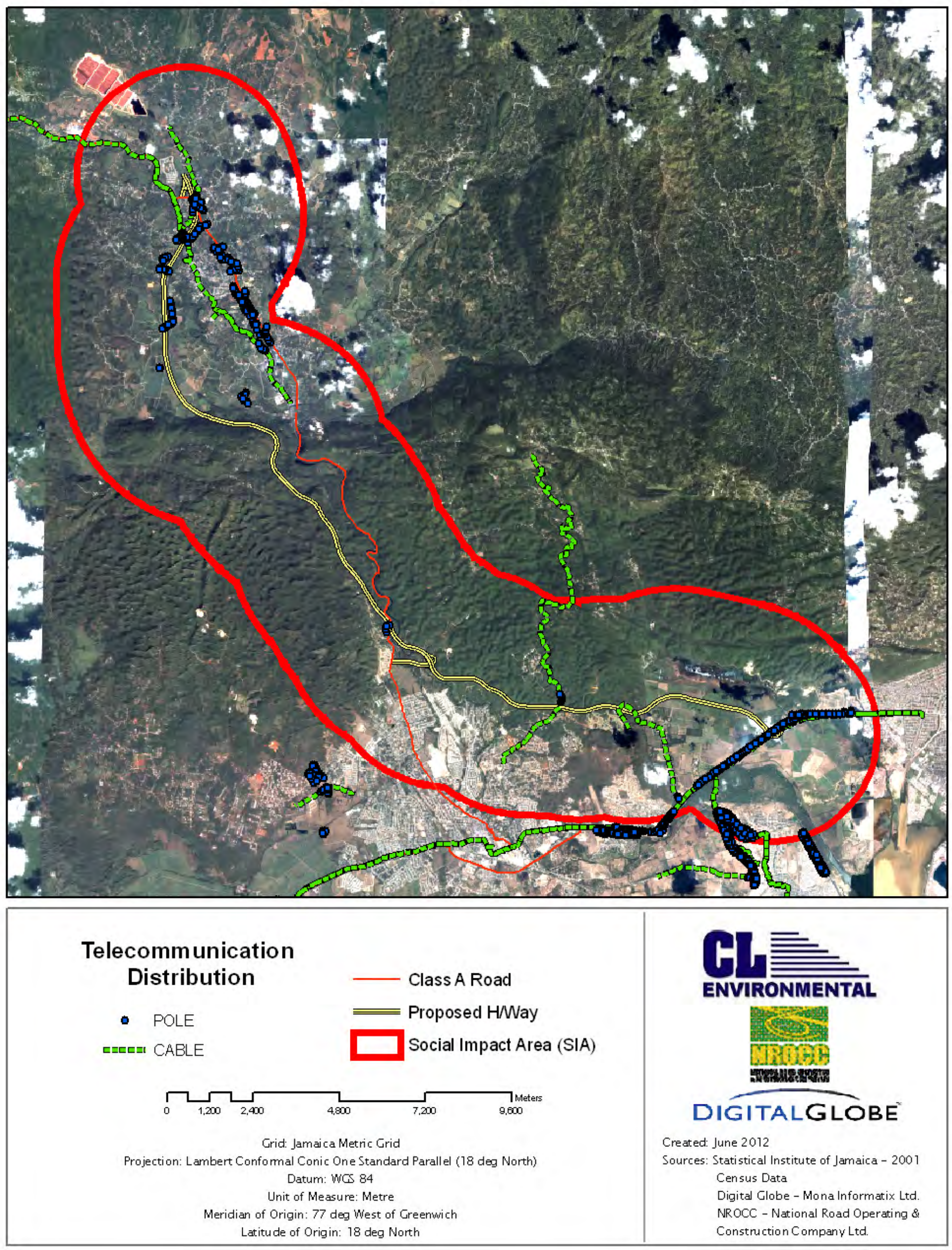

Figure 4-111 - Telecommunication Distribution/Points (LIME) within the SIA

4.5.7.3 Domestic Water Supply

As seen in Table 4.52, the greater portion of SIA households (86%) receives its domestic water supply from the National Water Commission (NWC). This was more than both the regional and national figures of 79% & 73% respectively. Conversely, households utilizing a private source of water supply (14%) were lower than the regional and national average (Figure 4-112). Water demand in the SIA is 66,648,364 litres per day.

Table 4.52 - Percentage of Households by water supply

	Category	Jamaica	St. Catherine	SIA
Public Source	Piped in Dwelling	43.8	56	65
	Piped in Yard	16.3	18	18
	Stand Pipe	10.5	3	2
	Catchment	1.9	2	1
Private Source	Into Dwelling	6.3	4	4
	Catchment	9.9	5	3
	Spring/River	4.6	5	0
	Other	4.5	5	4
	Not Reported	2.2	3	3

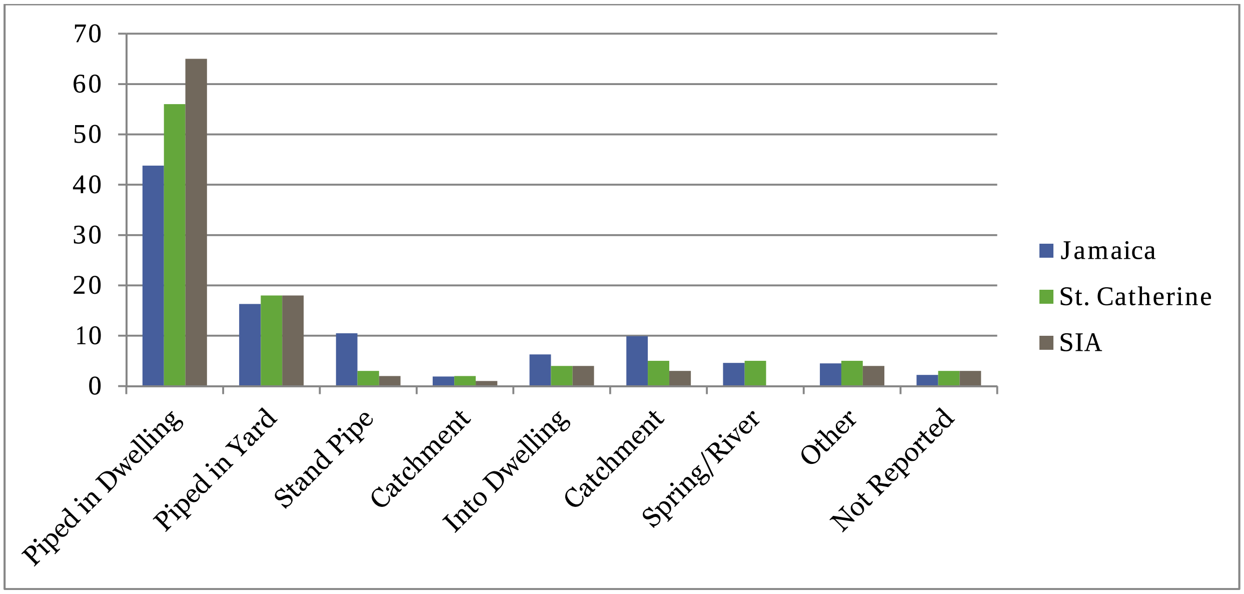

Figure 4-112 - Percent water piped to dwelling

Although the proposed alignment of the highway runs primarily through areas with a lower percentage of water piped to dwellings, the SIA has a generous network of rivers and wells to support increased development (Figure 4-113). The contamination of these water sources as a result of development activities must however be prevented.

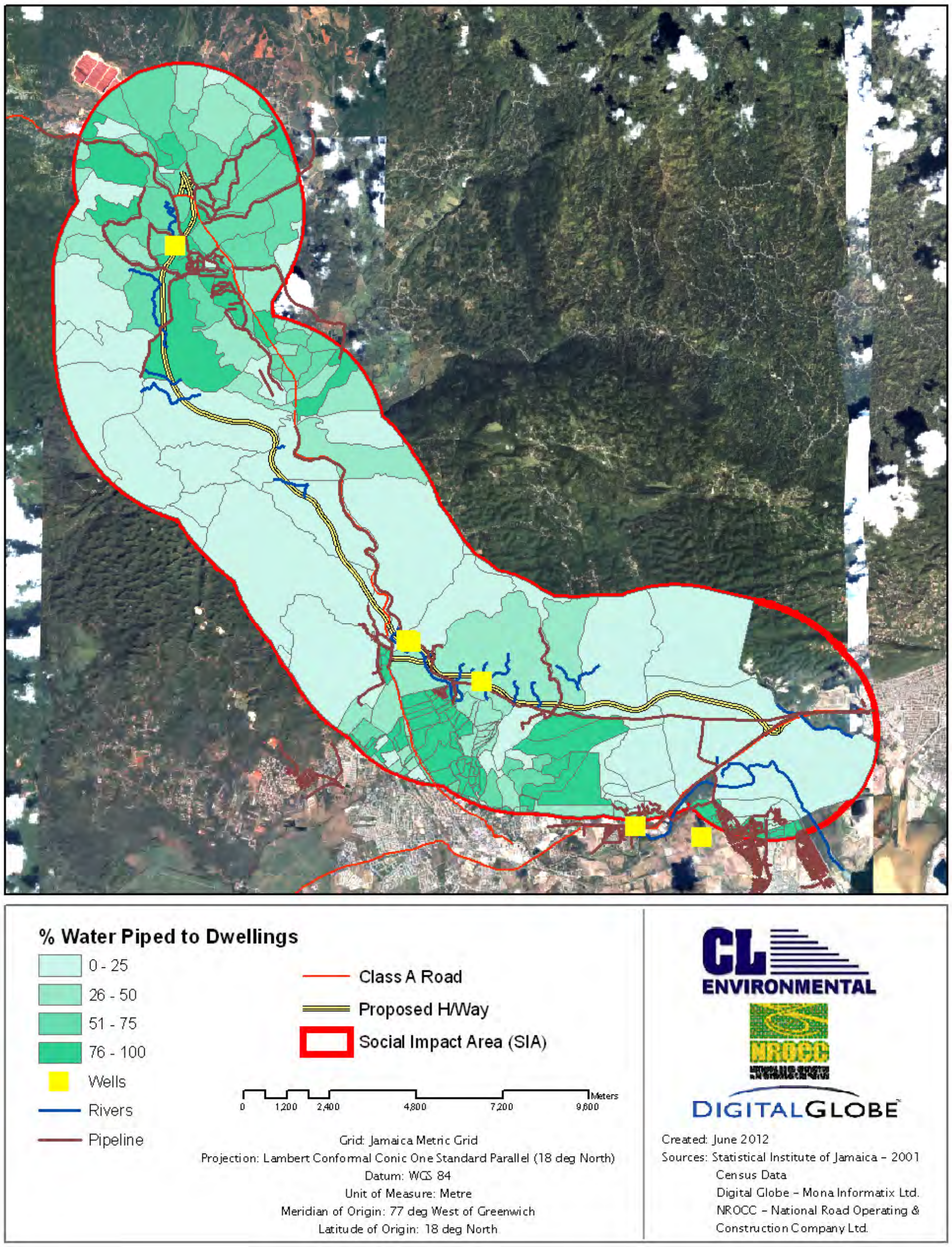

Figure 4-113 – Percentage of households with piped water in dwellings within the SIA

4.5.7.4 Wastewater Generation & Disposal

It is estimated that approximately 53,318,691 litres/day of wastewater is generated within the study area and is expected to increase to 102,032,479 litres/day over the next twenty five years.

A higher percentage of households used water closets within the SIA when compared to the regional and national data (Table 4.53). 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' (Figure 4-114).

Table 4.53 - Percentage households by method of sewage disposal (Source: STATIN Population Census 2001)

Disposal Method	Jamaica	St. Catherine	SIA
Pit Latrine	37.9	31.9	22
Water Closet	58.2	62.4	73
Not Reported	1.4	4	4
No Facility	2.5	1.8	2

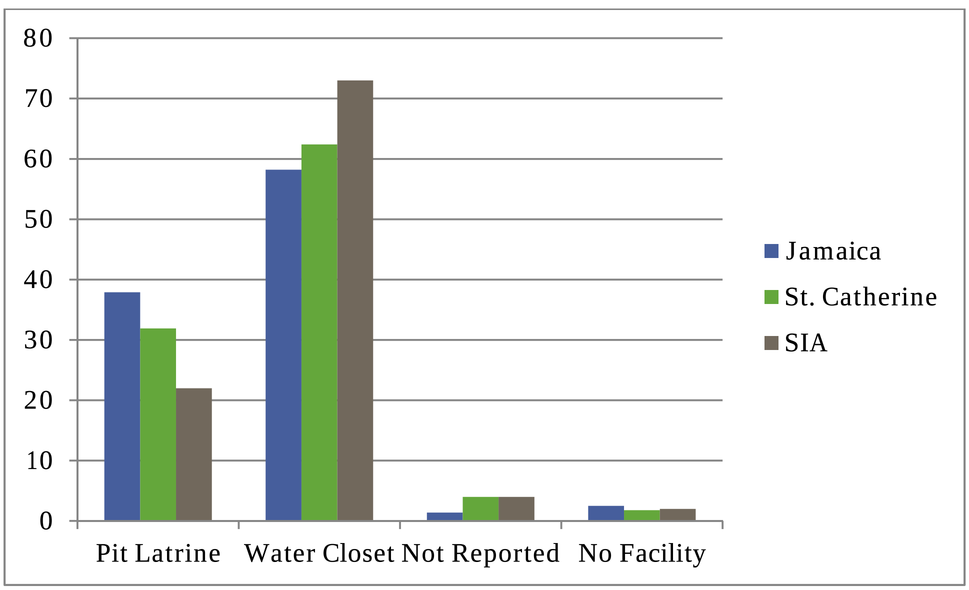

Figure 4-114 - Percent comparison of sewage disposal methods

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. The waste is transported to the Riverton landfill located in Kingston.

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 246.7 tonnes (≈246,731.5 kg) of solid waste per day in 2001. Based on the population growth, it has been estimated that at the time of this study, approximately 440.2 tonnes (≈ 440,175 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 842.3 tonnes (≈ 842,334 kg).

The 2001 census data indicated that approximately 58.5% of the households in the parish of St. Catherine had their garbage collected by public means (National Solid Waste Management Authority), with a higher percentage (68.2%) in the SIA. It also observed that the next preferred method of disposal in the SIA (26.2%) was by burning (Table 4.54).

Table 4.54 - Percentage households by method of garbage disposal (Source: STATIN Population Census 2001)

Disposal Method	Jamaica	St. Catherine	SIA
Public Collection	47.7	58.5	68.2
Private Collection	0.5	0.3	0.4
Burn	43	33.7	26.2
Bury	1.2	0.8	0.4
Dump	6	5.1	3
Other Method	0.3	0.3	0.5
Not Reported	1.3	1.2	1.2

Figure 4-115 demonstrates that the areas with the highest rates of public garbage collection were within the residential areas of Linstead, Bog Walk, Spanish Town and Portmore. These towns and cities would fall under the NSWMA's jurisdiction. However the more rural areas, which account for a larger section of the SIA, would utilize other methods of garbage disposal, chief among these being burning, as shown in Figure

4-116. Significant construction activities occurring within these areas should ensure that private methods of garbage disposal are consistently employed so as not to add to the existing strain that burning might have on the natural environment.

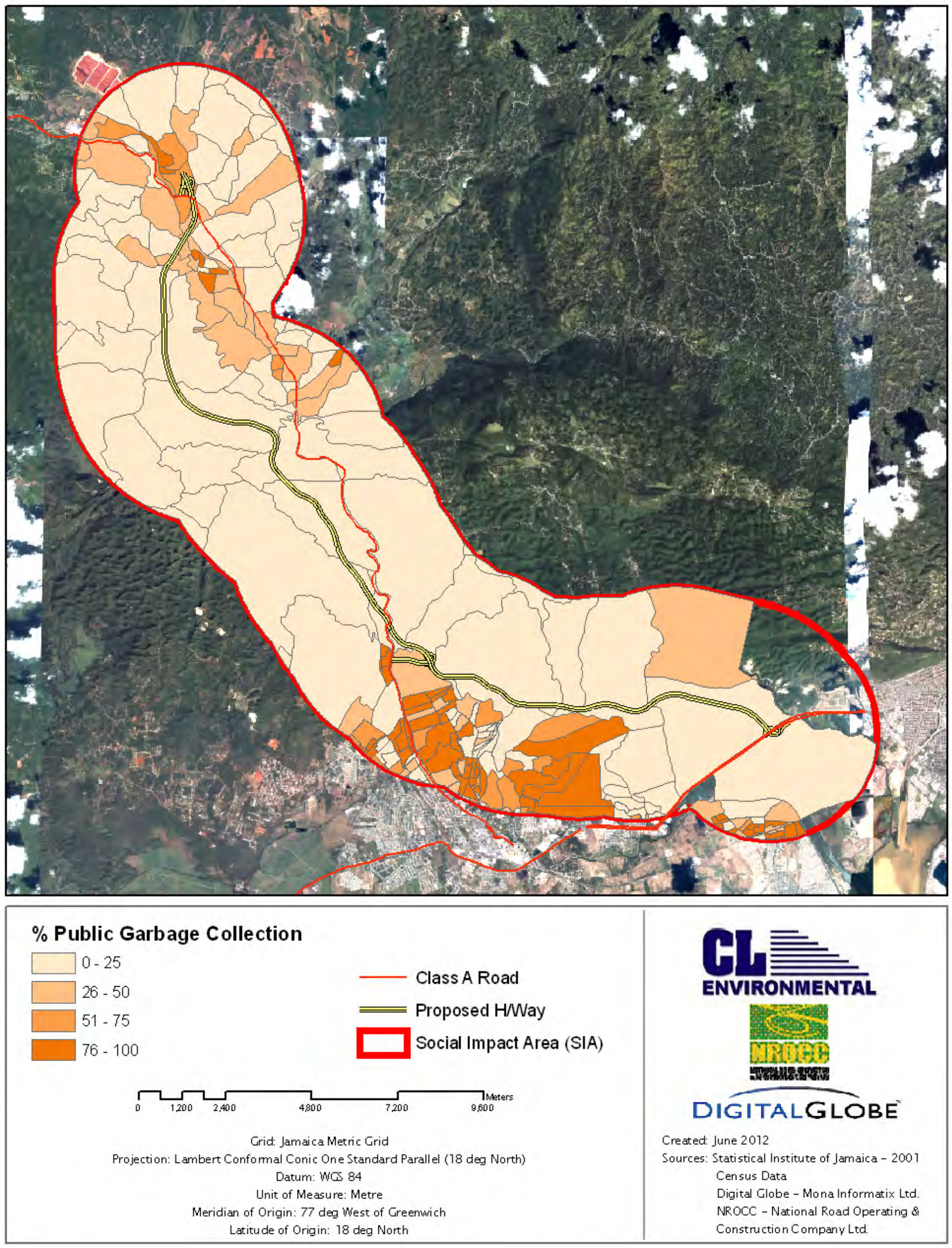

Figure 4-115 - Percent public garbage collection within the SIA

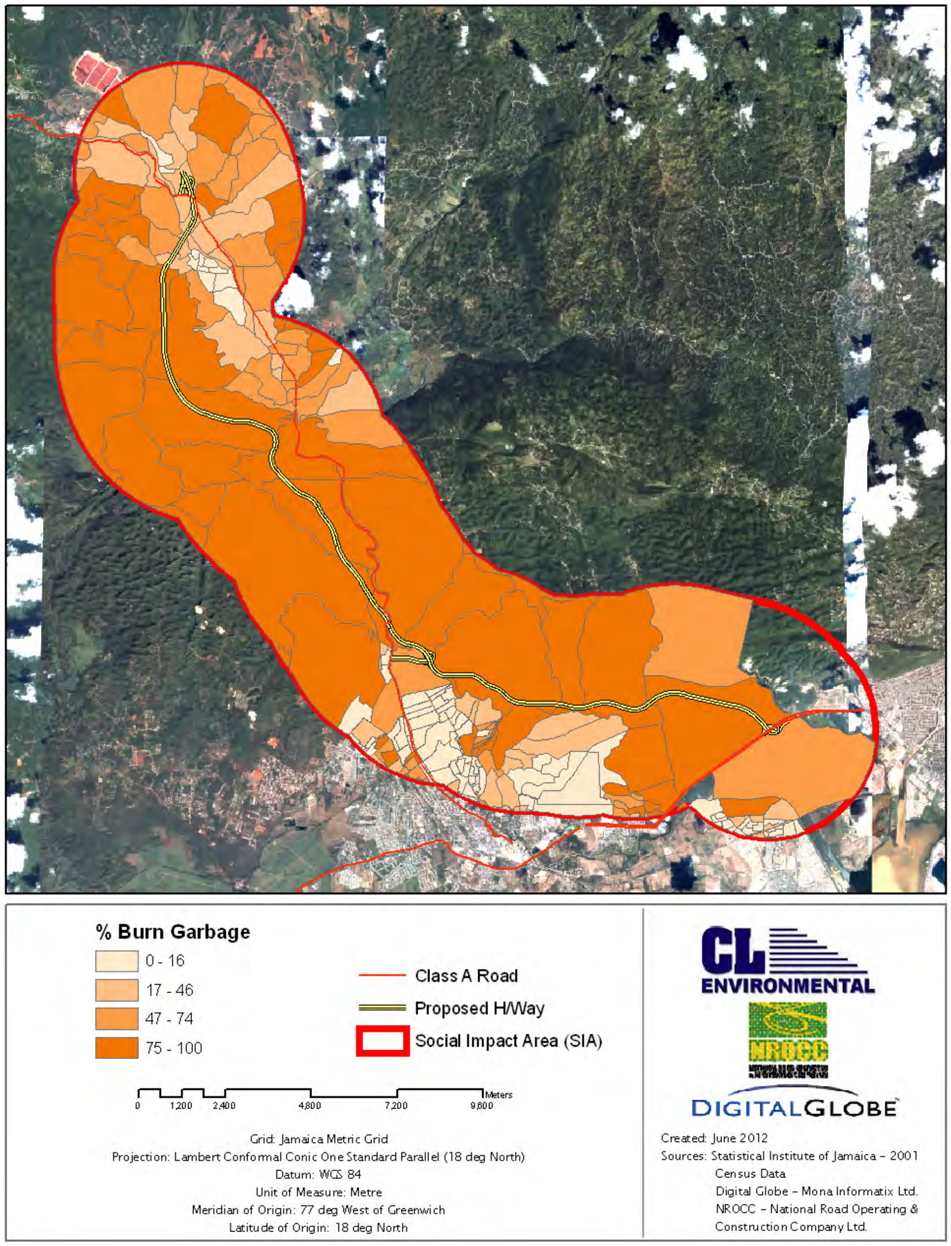

Figure 4-116 - Percent burning garbage within the SIA

4.5.8 Traffic

The increased residential developments taking place in the south central parts of St. Catherine are increasing congestion in Spanish Town. Spanish Town is the main transit route for trips from Kingston to the north coast and vice versa. The construction of this phase (Caymanas to Linstead) will result several benefits to commuters, these will include:

- Less congestion on the existing roads which traverse through Spanish Town;
- Safer driving conditions for motorists and pedestrians;
- The reduction of travelling time.

A 2008 traffic study report by Steer Davis Gleave Limited stated that this leg of Highway 2000 is expected to attract motorists which subsequently will generate significant volumes of traffic. Traffic models in 2007 predicted if this leg was completed by 2010, AADT to be 11,076, in 2011 and increase to 16,756 in 2021. The expected traffic impacts are as follows:

1. This phase of the highway will provide additional access points which will enable commuters from Kingston, Spanish Town and further areas to access the highway without going all the way to the Vineyards or Spanish Town toll booth. They will therefore avoid the congestion on the Spanish Town bypass when travelling to Kingston or to western Parishes. It was predicted that the reduction of traffic will vary from 30 to 35 percent entering Spanish Town from this route.
2. Similarly, for commuters from Portmore and beyond, the Mandela Highway (Caymanas) connection will provide an alternative to going through the Spanish Town congestion when travelling to North of St Catherine; the Old Harbour road A1 will also be reduced significantly.

Along the H2K Caymanas 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.

4.5.9 Services

4.5.9.1 Health Services

There is one hospital located within the SIA - Linstead Hospital. It is situated towards the end of the alignment in Linstead and is a public hospital belonging to the Southeast Health Region. This Type C hospital currently has 50 beds (29 in the maternity ward, 21 for medical care and four in accident and emergency for observations) and a staff compliment of 82. Its annual patient load is 30,143 persons. Accident and emergency care, medical care, minor surgery, mental health, out-patient clinic, pharmacy, ambulance and obstetrics are the major services provided and it is open on a 24 hour basis for all services except pharmacy and X-ray. [5] However, in a February 2011 Gleaner article, it was stated that Linstead Hospital had "a dilapidated maternity ward and the Alcan Ward which is in dire need of rehabilitation."[6] The hospital has become stressed with increased patient numbers, limited resources and inadequate staffing.

Linstead Hospital serves five parishes, St. Catherine, St. Andrew, St. Ann, St. Mary and Clarendon receives referrals from health centres in Linstead and other facilities in neighbouring parishes. Emergency cases are referred to Spanish Town Hospital, Kingston Public Hospital, National Chest Hospital and Bustamante Hospital for Children.

Spanish Town, a Southeast Health Region Type B hospital is not located within the 3 km of the proposed alignment, but is situated on the southern outskirts of the SIA. Inpatient and outpatient services in at least the five basic specialties (general surgery, general medicine, obstetrics and gynaecology, paediatrics and anaesthetics) are offered here. X-ray and laboratory services are usually available to serve hospital patients as well as those from Primary Health Care and the local private sector.

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[5] http://www.serha.gov.jm/Linstead.aspx

[6] http://jamaica-gleaner.com/gleaner/20110212/news/news5.html

Four public health centres are located within the SIA:

- Bog Walk - Type II Health Centre
- Christian Pen - Type III Health Centre
- Giblatore
- Linstead - Type III Health Centre

Two of the health centres located in the SIA are Type III (Christian Pen and Linstead). Population served at these centres is about 20,000 persons and 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 (Bog Walk) provides similar services, however this centres is serviced by a visiting Doctor and Nurse Practitioner and a population of about 12,000 persons is served[7].

[7] http://www.serha.gov.jm/HealthCClassification.aspx

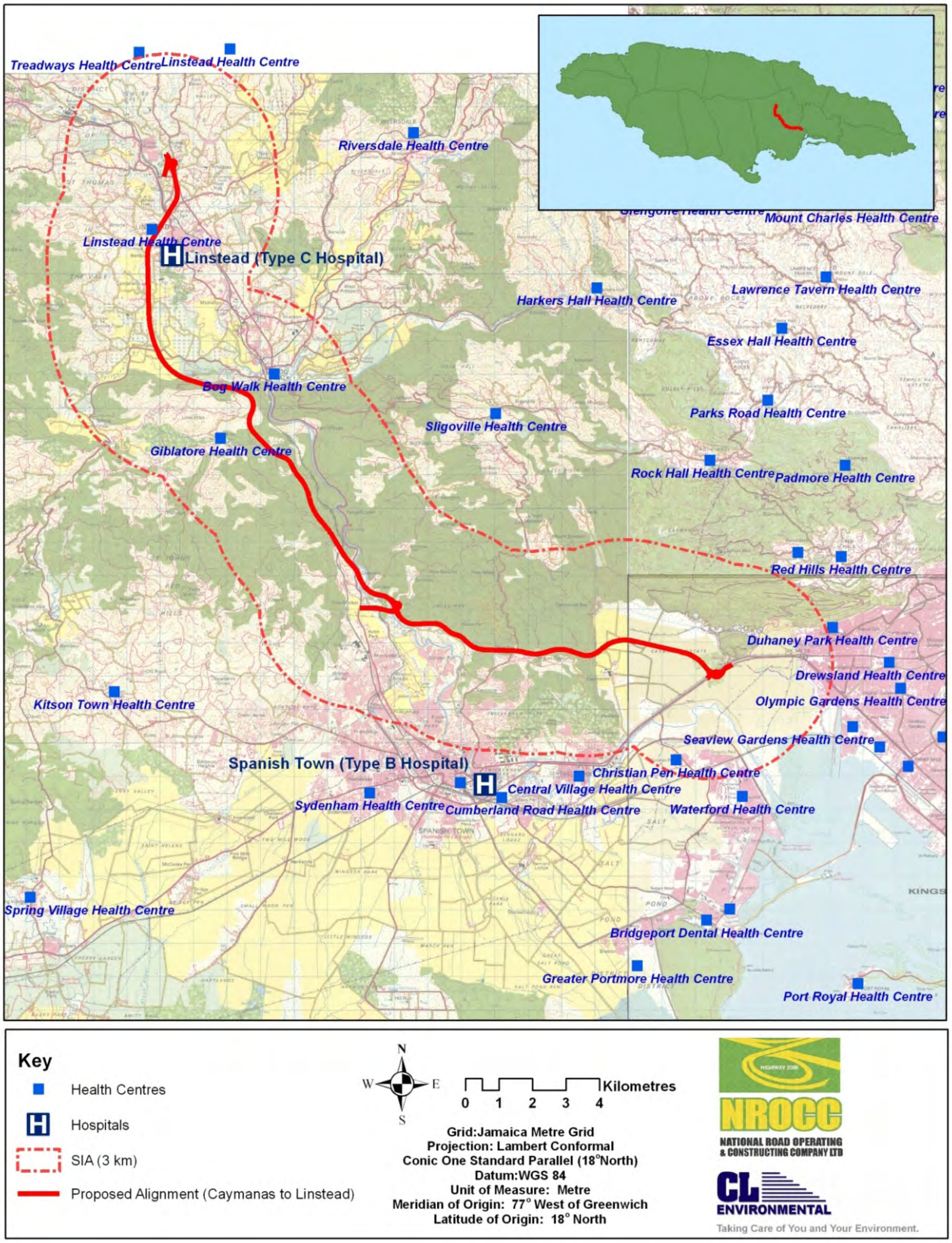


Figure 4-117 - Health services located within and around the SIA for the proposed highway alignment

4.5.9.2 Other Services

Fire Stations

As seen in Figure 4-118, there is one fire station located within the SIA – Vanity Fair, Linstead. This station is located at the northern end of the proposed highway.

Currently, this station has one fire engine with a water capacity of ≈ 6,365 litres (1,400 imperial gallons). There is also a fire station worth mentioning located in the south western end of the general study area in Spanish Town, about 3 km south of the proposed alignment.

Police Stations

The following 4 police stations are found within the SIA (Figure 4-118):

- Bog Walk
- Caymanas Park
- Ferry
- Linstead

Post Offices

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

- Bog Walk
- Linstead
- Portmore, Gregory Park

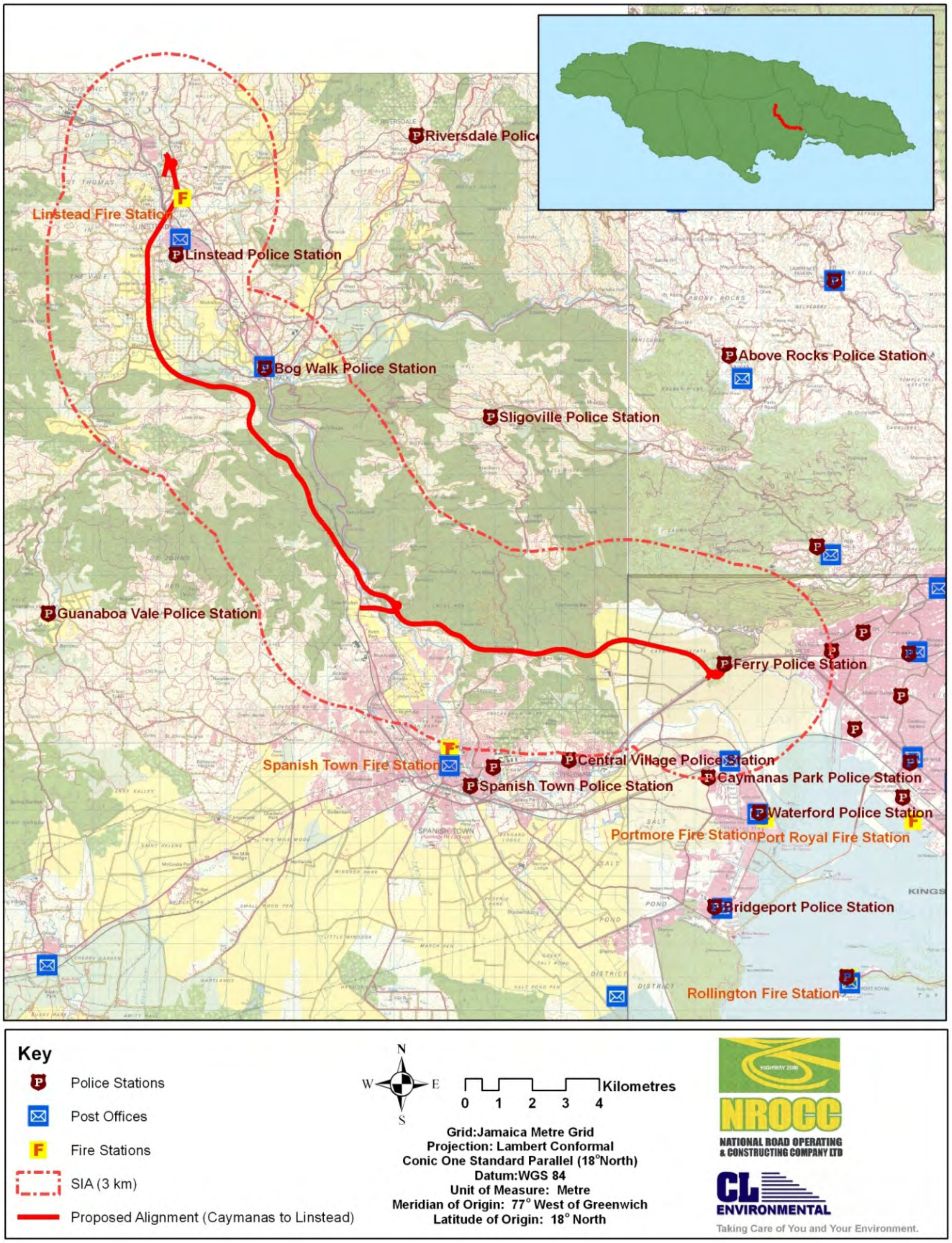


Figure 4-118 – Police stations, fire stations and post offices in vicinity of the SIA for the proposed highway alignment

4.5.10 Community Perception

4.5.10.1 Introduction

On March 23, 24, 26 and 28, 2012, one hundred and fifty five (155) community questionnaires were administered within a two kilometre radius of the area proposed for the construction of a Toll Road from the existing A1 Toll Road in the vicinity of the Mandela Highway on/off ramp to Linstead. Approximately forty five percent (45.16%) respondents were female and 54.84% were male.

Of the one hundred and fifty five (155) respondents age cohort distribution was as follows; 11.61% were age 18-25 years , 16.13% were age 26-33 years, 15.48 % were age 34-41 years, 19.35% were age 42 – 50 years, 16.77% were age 51-60 years and 20.66% were older than sixty years of age.

Twenty one communities were visited. These communities were Waterloo, Cooreville Gardens, New Haven, Gordon Pen, Central Village, Keystone, Eltham Meadows, Washington Gardens, Duhaney Park, Banbury, Rosemount, Vanity Fair, Wakefield, Heathfield, Victoria, Michelton, Rosehall, Giblatore, Montecello, Avon Park and Commodore.

4.5.10.2 Results and Findings

Approximately forty three percent (43.2%) of all respondents had heard of the National Road Operating and Constructing Company (NROCC). It was observed that more males knew of NROCC than females; 71.6 % of males were aware compared to 28.4% of females. Of the 43.2% of respondents who had heard of NROCC, 46.3% had heard only of the company's name but were unaware of the company's services. The remaining 53.7% of respondents knowing of NROCC, indicated that NROCC was involved in highway and general road construction as well as toll road construction. Based on comments made by interviewers during daily reviews, 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, 37.4% of respondents were aware of the proposal and 62.6% 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. Individuals interviewed also indicated their expectation of having existing off roads in the vicinity of the proposed areas upgraded.

Concerns highlighted, related to the possibility of high toll fees, as well as making currently accessible areas inaccessible. 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.

Gordon Pen

1.6% of respondents were interviewed in the Gordon Pen Community. Twenty five percent of the respondents indicated that they had heard of NROCC, while 75% indicated they did not. Approximately thirty seven percent (37.5 %) of respondents stated they were aware of the proposed toll road construction. Regarding project concerns, 12.5 % of respondents were concerned about the timeline for the project to become reality. All of the interviewees thought the project will have a positive personal impact as commuting will be easier, traffic congestion would be minimal and travel time would be less.

Waterloo

6.45% of respondents were interviewed in the Waterloo Area. Thirty percent of respondents had heard of NROCC while 70% indicated they did not. None of the respondents who knew of NROCC were aware of the proposed toll road project while 14.3% of respondents who did not know of NROCC knew of the toll road project. Of the total number of interviewees only 10% was aware of the project. Regarding project concerns, 30% of all respondents expressed concern. Approximately thirty percent (33.3%) expressed concern about the possible introduction of criminals into the community when the road is constructed. Approximately thirty percent (33.3%) expressed concern relating to the location of the road within/close to the community and 33.4% of respondents were concerned about negative impacts to residents as a result of the presence of the road. Respondents were uncertain about whether the project would affect their lives in a positive or negative manner; but anticipated an easier commute as it was expected that travel time would be reduced, and traffic would be minimal.

New Haven

0.65% of respondents were interviewed in the New Haven Area. All of the respondents had heard of NROCC but were not aware of the proposed the toll road construction project. Regarding project concerns, all respondents were concerned about the possibility of increase toll costs and the possible employment opportunities. Respondents were uncertain about whether the project would affect their lives in a positive or negative manner; but anticipated an easier commute as it was expected that travel time would be reduced

Cooreville Gardens

1.29% of respondents interviewed were from Cooreville Gardens. All of the respondents had never heard of NROCC and were not aware of the proposed toll road construction project. Regarding project concerns, no respondent expressed concern but thought the project would have a positive personal impact as the road infrastructure should be improved and commuting time is anticipated to be faster and easier and there should be less traffic.

Washington Gardens

3.87% of respondents were interviewed in Washington Gardens. Approximately thirty percent (33.3%) of respondents had not heard of NROCC. Approximately eighty three percent (83.3%) of respondents were not aware of the toll road construction project. Regarding project concerns, 16.7% of respondents expressed concern specifically indicating that persons living along the footprint of the toll road should be relocated. Approximately eighty three percent (83.3%) of respondents had no project concerns. Approximately eighty three percent 83.3% of respondents also indicated that they thought the project could have a positive impact in commuting. As it related to the ease or difficulty in commuting, all of respondents anticipated that commuting would be with the toll road.

Duhaney Park

3.23% of respondents were interviewed in Duhaney Park. Forty percent (40%) of respondents had heard of NROCC and 60% indicated they had never heard of a company called NROCC. All of respondents were not aware of the proposed toll road construction project and did not express any concerns. On the issue of ease or difficulty in commuting, all respondents indicated that commuting should be easier due to better road infrastructure, better traffic flow and less travelling time.

Central Village

1.94 % of respondents were interviewed in Central Village. Approximately thirty three percent (33.3%) of respondents had heard of NROCC and 66.7% indicated they had never heard of a company called NROCC. All of respondents were not aware of the proposed toll road construction project and did not express any concerns. Approximately thirty three percent 33.3% of respondents indicated that they expected the project to affect their lives positively. The remaining 66.7% were non-committal. On the issue of ease or difficulty in commuting, 33.3% respondents indicated that commuting should be easier due to better road infrastructure.

Keystone

5.16% of respondents were interviewed in Keystone. Half of the respondents (50%) had heard of NROCC and 50% indicated they had never heard of a company called NROCC. Approximately sixty two percent (62.5%) of respondents were not aware of the proposed toll road construction project. Approximately eight seven percent (87.5%) of respondents did not express any project concerns. Approximately twelve percent (12.5%) of respondents indicated project concerns. Concerns raised related to the proximity of the highway to the Keystone community, whether the Sligoville main road would be used as an access point to the toll road, the level of security intended for the highway in light of incidents on the existing toll road, the potential employment opportunities and the potential for the toll road to create an access point for criminals to enter the Keystone community. On the issue of ease or difficulty in commuting, 87.5% of respondents indicated that commuting should be easier due to better traffic flow and less travelling time.

Eltham Meadows

2.58% of respondents were interviewed in the Eltham Meadows area. 25% respondents had heard of NROCC and also about the toll road project. The 75% of interviewees who had never heard of NROCC were also not aware of the proposed toll road construction. 100% of respondents did not have any project concerns. 25% of respondents indicated a possible positive impact as employment opportunities may arise. The remaining 75% of respondents were non-committal. 100% of respondents indicated that commuting will be easier as it is anticipated that there will be less traffic congestion and travel time is expected to be reduced.

Montecello

3.23% of respondents were interviewed in the Montecello area. All of those interviewed knew of the toll road project and the bypass upgrade project. On the issue of project concerns, 100 % of respondents expressed no concerns about the project. Regarding possible project impact all interviewees thought the project would have no impact. Regarding the ease of commuting, 100% of respondents indicated that commuting would be easier as the road infrastructure would.

Avon Park

3.23% of respondents were interviewed in the Avon Park area. 40.0% of respondents had heard of NROCC while 60.0% of respondents did not hear of NROCC. Of the interviewees who did not know of NROCC, 33.3% were aware of the toll road project and the bypass upgrade project. The remaining 66.7% did not know of any of the project components. Of the remaining 40.0% of respondents who had heard of NROCC 80% of respondents were not aware of the bypass project or the toll road project. The 20% of respondents who were aware of the toll road project and bypass project were made aware by enquiries made to land surveyors, who indicated that the road would needed to be widened to facilitate highway construction works. On the issue of project concerns, 100 % of respondents expressed no concerns about the project. Regarding possible project impacts 40.0% of interviewees thought the project would have a positive impact. None of respondents indicated a negative impact while 60.0% of respondents thought the project would have no impact. Regarding the ease of commuting, 80% of respondents expected less traffic thereby making commuting easier while 20% of respondents were noncommittal on the potential ease or difficulty in commuting

Victoria

3.87% of respondents were interviewed in Victoria. Approximately eight three (83.3%) of respondents had not heard of NROCC. All of the respondents were not aware of the toll road construction project. Regarding project concerns, 33.3% of respondents expressed concern. All respondents expressing concern indicated the increased chance of flooding which may be caused by the new road construction or a change in the footprint of the existing main road. There was also the concern that the existing road through the Victoria community may be cut off. 33.3% of respondents also indicated that they thought the project could have a positive impact as it would result in development of the community. As it related to the ease or difficulty in commuting, 83.3% of respondents anticipated that commuting would be easier as the road infrastructure will be improved and motorists will have access to another traffic corridor. The remaining 16.7% of respondents indicated a difficulty in commuting primarily due to the possibility of minor roads or alternate roads in the community being blocked off.

Heathfield

3.23% of respondents were interviewed in Heathfield. Sixty percent (60%) of respondents had not heard of NROCC. 40% of all respondents were aware of the toll road construction project. Regarding project concerns, all of the respondents did not express concern. All respondents indicated that the project would not affect their lives but indicated that they anticipated an easier commute. Forty percent (40%) of the respondents indicated that the toll road would provide an easier alternate route especially at times when the Gorge is blocked.

Banbury

5.16% of respondents were interviewed in the Banbury area. Approximately sixty two (62.5%) of respondents had never heard of NROCC while 37.5% of respondents had heard of NROCC. Approximately twelve percent (12.5%) of respondents expressed project concerns specifically as it related to the potential to create a dust nuisance. Approximately eight seven percent (87.5%) of respondents did not express any project concerns. All of the respondents indicated that the project would not affect their lives in any way. 75% of respondents indicated the expectation that commuting will be easier. Reasons stated for an easier commute were related to less traffic, a better alternate route daily and also during times of inclement weather when the Gorge is blocked. 25% of respondents were non-committal.

Wakefield

3.87% of respondents were interviewed in the Wakefield area. Approximately sixty seven (66.67%) of respondents had never heard of NROCC while 33.33% of respondents had heard of NROCC. All of the respondents did not have any project concerns. Approximately thirty three (33.3%) of respondents indicated that the project would not affect their lives in any way while 66.67% indicated a positive effect. Approximately sixty seven (66.67%) of respondents indicated the expectation that commuting will be easier. Of this 66.67%, 66.67% indicated ease in commuting especially if an access point was located near to the Wakefield community. Approximately thirty three (33.33%) of respondents were non-committal.

Vanity Fair

3.23% of respondents were interviewed in the Vanity Fair area. Sixty percent (60%) of respondents had never heard of NROCC while 40% of respondents had heard of NROCC. All of the respondents did not have any project concerns. Forty (40%) of respondents indicated that commuting will be easier as there will be a better alternate route when the Gorge is impassable. Forty percent (40%) anticipated that there would be less traffic congestion and travel time should be quicker. Twenty percent (20%) of respondents were non-committal.

Michleton – Michleton Meadows

10.32% of respondents were interviewed in Michleton – Michleton Meadows area. Approximately thirty seven percent (37.5%) of respondents had heard of NROCC while 62.5% of respondents did not hear of NROCC. Of the interviewees who did not know of NROCC, 10.0 % were aware of the toll road project.

On the issue of project concerns, 81.2% of respondents expressed no concern about the project. Approximately eighteen percent (18.3%) of respondents expressed concerns. Of this 18.3%, 33.3% of respondents expressed concern about the increased chance of flooding resulting from the road construction; 33.3% were concerned about the residents chances for employment during the project and 33.4% were concerned about the road construction encroaching on minor roads and the lack of maintenance of the local roads. Regarding possible project impact interviewees thought the project would have appositive impact. Approximately six percent (6.3%) of respondents indicated a negative impact due to the possibility of community vendors losing business. 56.2% of respondents thought the project would have no impact and 37.5% of respondents indicated a positive impact. The main reasons stated related to improved road infrastructure and the ease of commuting (66.7%) correlated to better alternate route when the Gorge is impassable and less traffic and possible employment opportunity (33.3%). As it related to the ease of commuting 75% of respondents indicated that the project would make commuting easier, 12.5% indicated a difficulty in commuting and 12.5% did not respond.

Commodore

3.23% of respondents were interviewed in the Commodore area. Forty percent (40%) of the respondents had never heard of NROCC. 80% of all respondents knew of the toll road project while 20% of interviewees did not know of the proposed toll road construction. Respondents did not have any project concerns. All respondents (100%) indicated that commuting will be easier. The reasons varied and included better transportation (20%), an increase in public transportation on the roads (20%) and better road infrastructure (20%). Twenty percent (20%) of respondents saw the potential positive of the project as the project could introduce employment opportunities while 20% did not express any specific reason they thought commuting would be easier.

Rose Hall - Byndloss

10.32% of respondents were interviewed in the Rose Hall – Byndloss area. Approximately forty four percent (43.7 %) of respondents had heard of NROCC while 56.3% of respondents did not hear of NROCC. Of the interviewees who did not know of NROCC, 22.2 % were aware of the toll road project. Of the respondents who indicated that they aware of NROCC 42.9% were also aware of the toll road project. Respondents indicated that awareness was through conversation and a previous survey done in the past. On the issue of project concerns, 12.5% of respondents expressed concern which related to the issue of relocation of residents and businesses. Regarding possible project impact interviewees thought the project would have appositive impact. 0.0% of respondents indicated a negative impact while 31.3% of respondents thought the project would have no impact. In general respondents perceived the toll road as positive. The main reasons stated related to improved road infrastructure and were the ease of commuting (13.3%), a better alternate route when the Gorge is impassable (26.7%), less traffic (40%), better access to public transportation(20%).

Rosemount – Constant Spring District

10.32% of respondents were interviewed in the Rose Hall – Constant Spring District area. Approximately forty three percent (43.7 %) of respondents had heard of NROCC while 56.3% of respondents did not hear of NROCC. Of the 43.7% of respondents who had heard of NROCC, all knew of the toll road project and 60% knew of both components of the project. Respondents indicated that they were made aware of the toll road project through conversation and the media. On the issue of project concerns, 33.3%% of respondents expressed some concern. 20% respectively expressed concerns about the need to also improve the road infrastructure from Bog Walk to Spanish Town, the long time being taken for the project to begin, the possibility of increase traffic flow through Constant Spring District with the introduction of the toll road, the potential pollution to the rives and the projected lifespan of the project and to anticipated toll fee. Regarding possible project impact interviewees thought the project would have appositive impact. Approximately seven percent (7.1%) of respondents indicated a negative impact attributed to the need to pay the toll fee. Approximately sixty four percent (64.3%) of respondents thought the project would have no impact and 28.6% indicated the project would have a positive impact. The main reasons stated for a potential positive impact were the ease of commuting (25%), faster movement of traffic (25%), shorter travel time (25%) and the easier commute between Kingston and Spanish Town especially for emergency purposes (25%).

Giblatore

9.68% of respondents were interviewed in the Giblatore area. Approximately seventy three percent (73.3%) of respondents had heard of NROCC while 26.7% of respondents did not hear of NROCC. Of the interviewees who did not know of NROCC, 50 % were aware of the toll road project. Of the remaining 73.3% of respondents who had heard of NROCC all knew of the toll road project. Respondents indicated that they were made aware of the toll road project through conversation, a community meeting, enquiries made of land surveyors conducting a survey in 2006. On the issue of project concerns, respondents expressing concerns were concerned about dust pollution, the potential benefits for the community, the ability to access the toll road from Giblatore, the need to widen the Giblatore road in the Bog Walk vicinity. Regarding possible project impact 53.3% of interviewees thought the project would have appositive impact. 0.0% of respondents indicated a negative impact while 46.7% of respondents thought the project would have no impact. In general respondents perceived the toll road as positive. The main reasons stated were the ease of commuting, improved road infrastructure (33.2%) especially to transport farm produce, a better alternate route when the Gorge is impassable 6.7%), less traffic (26.7%), better access to public transportation (6.7%), potential employment opportunity (6.7%) and the possibility of property value appreciation (6.7%). Approximately thirteen percent (13.3%) of respondents were noncommittal on the potential ease or difficulty in commuting.

4.5.10.3 Jamaica Environmental Trust (JET)

Consultation with the Chief Executive Officer of JET, Mrs. Diana Macauly, indicated that they had concerns with the proposed project. These issues related to:

i. The impact the proposed alignment will have on the flora and forested areas directly (removal) or indirectly (opening up areas that were previously inaccessible resulting in potential deforestation), and

ii. The potential demand on the existing quarries to provide material for fill, especially the already high demand for the existing highway expansion and the Palisadoes Shoreline Improvement Project.

4.5.10.4 New Era Homes

Consultation was also held with the management of New Era Homes to ascertain if they have any concerns with the proposed highway. They had no objections in principle; however; their main concern was with the potential for a noise nuisance from the highway and what steps were being taken to prevent that from affecting the occupants of the Caymans Country Club.

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, artefacts sample collection and analysis, cultural heritage contexts interpretation and analysis and recording significant cultural assets to be affected.

(4) Recording and Analysis of Artefacts - All archaeological features, including artefacts, were recorded by means of sketches, digital

photographs, GPS, survey, and field notes. Where artefact assemblages are identified, samples will be collected and recorded for analysis.

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

Individuals familiar with the site was interviewed and this information noted to add to the data base on sites.

In all 19 sites have been noted for the area with 10 of these sites showing a Taíno presence. A total of 235 pieces of artefacts were collected from the surface of seven sites namely Caymanas, Cross Pen, Content, Crescent, Dignum Mountain, Harker and Wakefield. The team recorded a number of historic structures and features such as the Rio Cobre Dam and pipeline, the railway lines at Crescent and Vanity Fair, the great house ruin at Cross Pen.

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

5.0 AESTHETICS

5.1 VIEWSHED

5.1.1 Methodology

In order examine the potential impact of the proposed highway alignment between Caymanas and Linstead on the aesthetics of the surrounding study area, a viewshed analysis was undertaken using ESRI ArcGIS Spatial Analysis *Viewshed* tool. A continuous raster surface containing height values such as a digital elevation model (DEM) is utilised as the main input data. Cells in this input surface that can be seen from observation points or lines are identified and assigned a value different from those cells that cannot see the observer point. This tool is useful when the visibility of an object is being questioned and in this instance, we are interested in ascertaining how visible the proposed alignment will be from surrounding areas.

In the viewshed analysis carried out previously for the proposed Spanish Town to Linstead alignment, a total of seven towns in proximity to the alignment were selected as the observer points:

(1) Angels
(2) Bog Walk
(3) Cross Roads
(4) Giblatore
(5) Green Acres
(6) Linstead
(7) Spanish Town (central)

In order to allow for comparisons between the viewshed results of both the Spanish Town to Linstead and the Caymanas to Linstead proposed alignments, the seven above-listed towns, as well as 6 additional observation areas were utilised in the viewshed analysis described herein for the Caymanas and Linstead alignment. Collectively, the following represent the observer towns used:

(1) Angels
(2) Big Pasture
(3) Bog Walk
(4) Caymanas
(5) Cross Roads
(6) Cypress Hall
(7) Giblatore
(8) Green Acres
(9) Gregory Park
(10) Linstead
(11) Mount Dawson
(12) Spanish Town (central)
(13) Spring Vale

All towns were represented as point locations, with the exception of Giblatore and Spring Vale, which were represented by means of lines following the major road that runs through each town. As seen in Figure 5-1, Giblatore and Spring Vale exist west of the mountainous region through which both proposed highway alignments pass through. Both towns are situated in relatively complex terrain and as such a single point would not have represented these towns adequately.

All observations points were assigned an offset height of 1.5 metres (~ 5 feet) in order to account for the average height of an observer at each point. Additionally, the horizon of sight for each position was considered and concluded to be greater than the distance between each observation point and the road. As such, a "sight radius" was not created for each viewshed analysis.

Unfortunately, engineered road heights were not available for the proposed alignment and as such the elevation along the road area was assumed to be equivalent to the height values modelled in the DEM. This is an important assumption that should be borne in mind when interpreting the viewshed results, since it is likely that the landscape will be altered in order to accommodate the construction of the road.

Once the viewshed for each observation point and line was generated, the area of road that can be seen from each was obtained. For the purposes of this exercise, the expanse of road was measured to be a 50-metre buffer along the proposal alignment centreline. This buffered area was utilised to calculate the area of visible road and subsequently the percentage of visible/ not visible road.

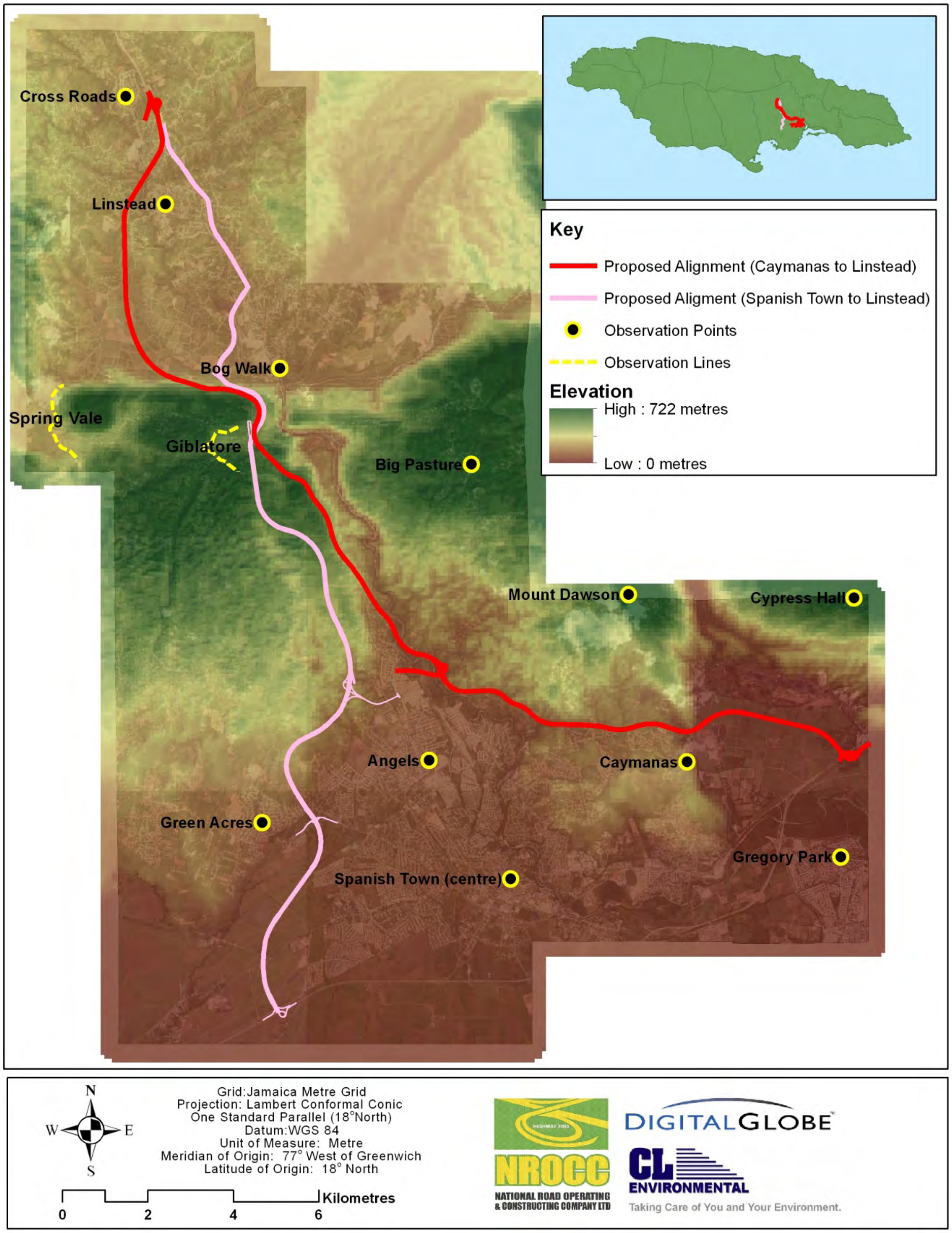


Figure 5-1 – Observation points and lines used in the viewshed analysis for the proposed Caymanas to Linstead highway alignment

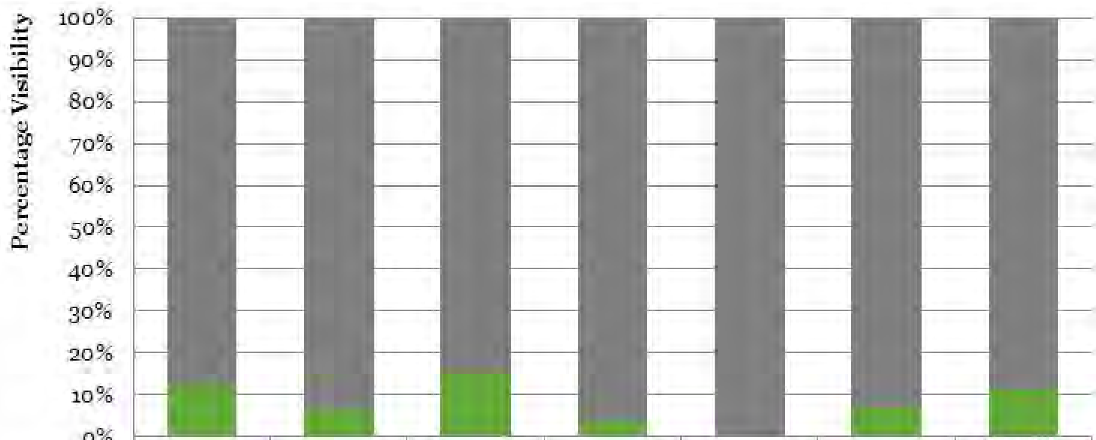
5.1.2 Results

Figure 5-2 shows the percentage of road that is visible from each observer town. As mentioned previously, it must be noted that percentages seen here are representative of the proposed road with similar heights as the DEM and not engineered heights.

All towns, with the exception of Green Acres and Big Pasture (as observed from the points illustrated in Figure 5-1) will be able to see the proposed highway alignment. Less than 10% of the proposed road alignment will be seen by persons situated in Bog Walk, Giblatore, Gregory Park, Linstead and Spring Vale. As seen in Figure 5-6, the visible areas from Bog Walk (6%) and Giblatore (3%) are located two kilometres or less west and east of the towns respectively, with no other section of the proposed road north or south of these observation towns being visible. On the other hand, in the case of Gregory Park (Figure 5-12), the visible areas are over 2 km away from the observation point and are located directly north of the Giblatore point at the start of the alignment and northwest in proximity of Caymanas. The 7% of road visible from the relatively large town of Linstead is located between 4 and 5 km south of this town, and coincides with areas visible from persons situated in Bog Walk. Sections of the proposed alignment towards its end in Linstead are visible from Spring Vale and these areas total 5% (Figure 5-16).

Visible sections of the proposed road from Spanish Town and Angels (collectively constituting a large percentage of population in the study area) are similar with 11% and 12% of road visible respectively. On the other hand, the town of Caymanas, situated east of Angels, will be able to see as much as 16% of the proposed alignment, with these visible areas restricted to the first the start of the proposal alignment, east and north of Caymanas (Figure 5-7). A similar 16% of road is seen from Cross Roads observation point, however these are situated towards the end of the alignment and are as far as 10 km south from this point (Figure 5-8).

The towns of Mount Dawson and Cypress Hall are situated on the hills north of the start of the alignment. From these towns respectively, as much as 17% and 19% of the road alignment are visible, though with varying expanses of visible as seen in Figure 5-14 and Figure 5-9.



	Angels	Bog Walk	Cross Roads	Giblatore	Green Acres	Linstead	Spanish Town (central)
Not Visible	88%	94%	84%	96%	100%	93%	89%
Visible	12%	6%	16%	4%	0%	7%	11%

Figure 5-2 – Percentage of road along the Caymanas to Linstead alignment visible from each observation point.

It is interesting to note the differences in percentage of visible road from those towns that coincided for the viewshed analysis undertaken for this alignment and that done previously for the Caymanas to Spanish Town alignment. Collectively, the percentage of visible road from the seven towns for each of these alignments area comparable (totalling 56% of visible road); however as illustrated below in Figure 5-3, differences for viewshed between the individual towns are apparent. Of mention is the difference in visible road from Cross Roads between the Spanish Town to Linstead and Caymanas to Linstead alignments. In the former, approximately 6% of road is visible from this observer point, yet in the case of the Caymanas to Linstead alignment, as much as 16% of the road is visible. Similar increases in percentage visibility are seen for the towns of Angels, Giblatore and Linstead. On the contrary, for the town of Green Acres, whilst 12% of the proposed Spanish Town to Linstead alignment was visible, no section of the Caymanas to Linstead alignment could be seen from. Spanish Town and Bog Walk similarly exact smaller percentages of visible road for the Caymanas to Linstead alignment.

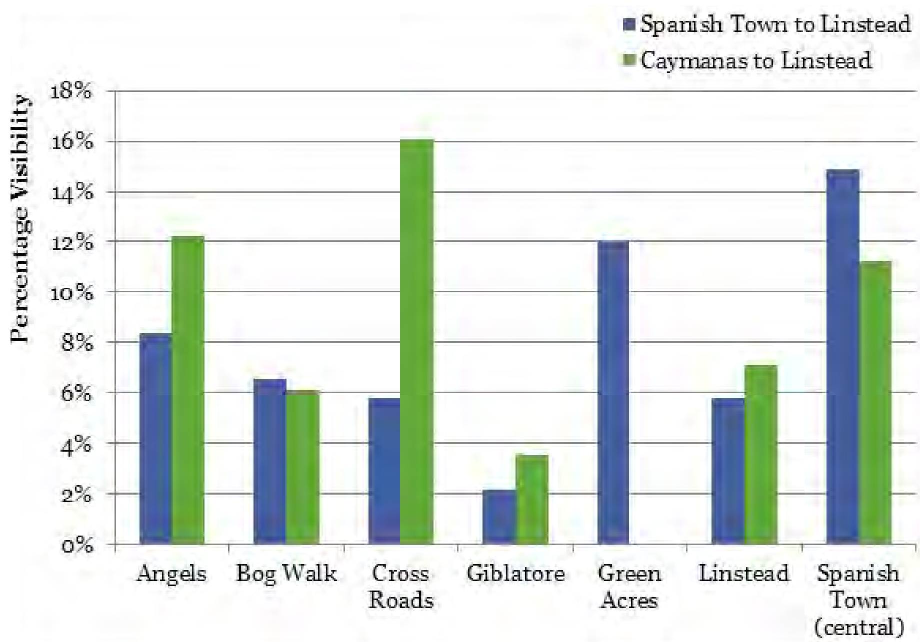


Figure 5-3 – Comparison of visible area between Caymanas to Linstead and Spanish Town to Linstead proposed alignments

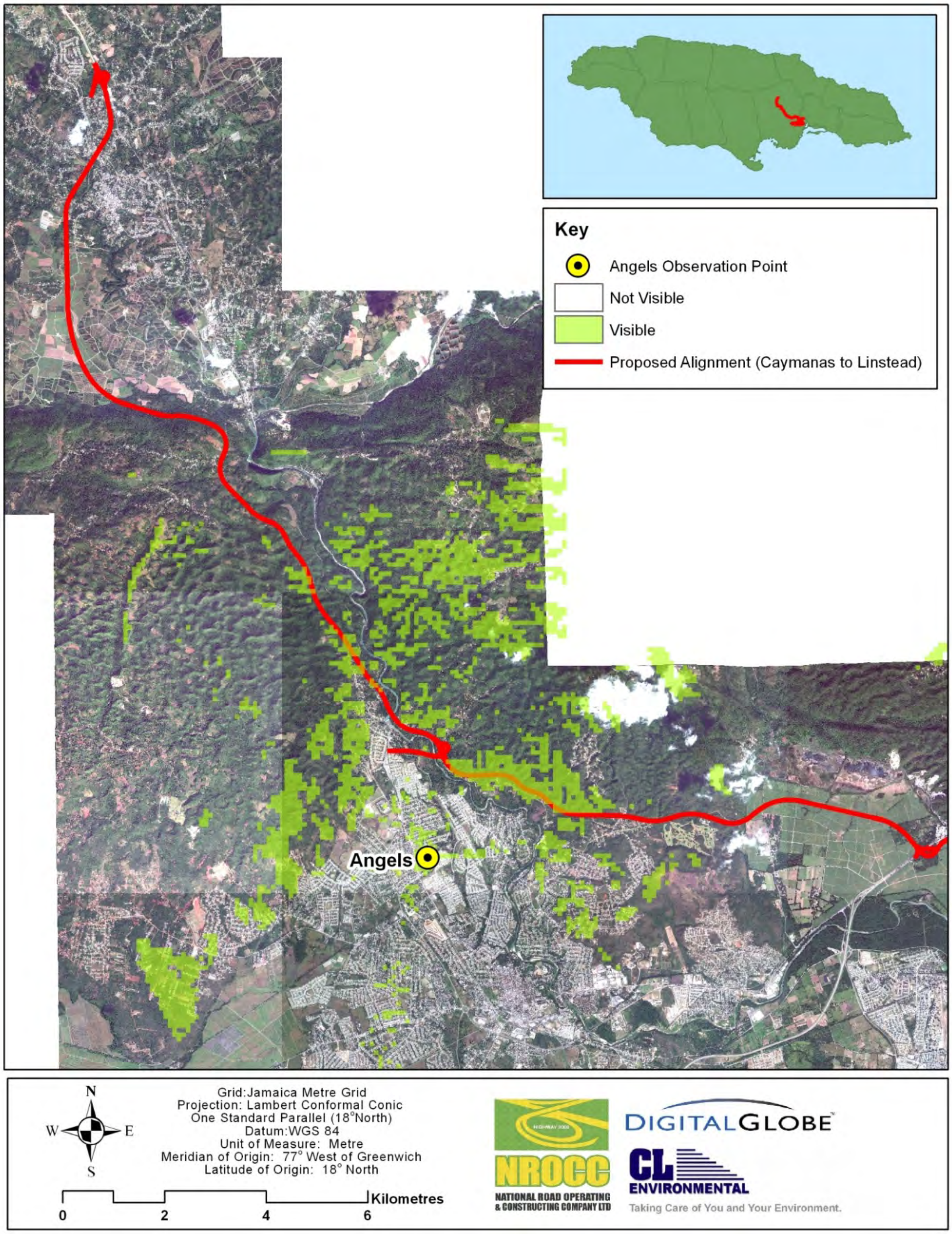


Figure 5-4 – Viewshed from Angels observation point, Caymanas to Linstead alignment

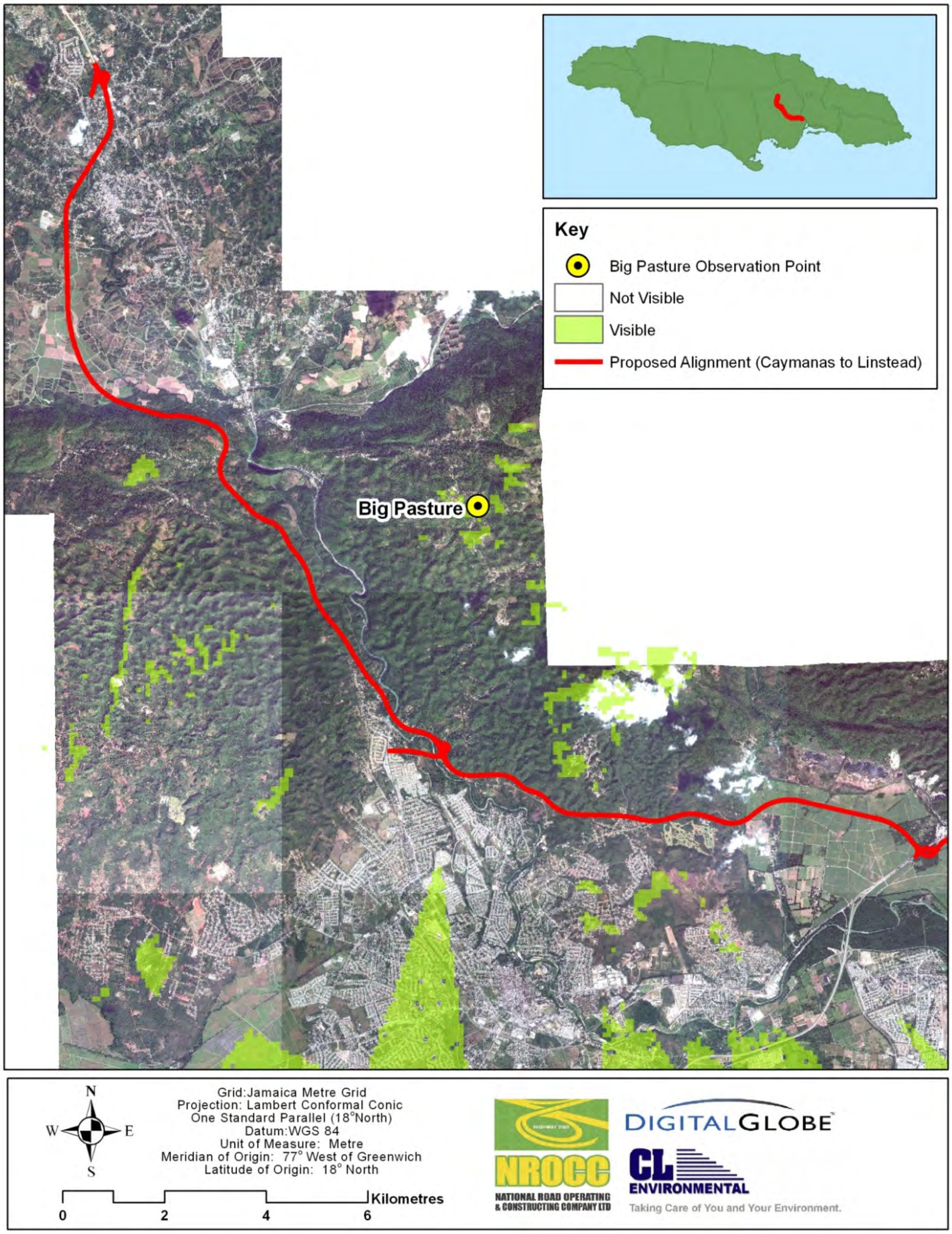


Figure 5-5 - Viewshed from Big Pasture observation point, Caymanas to Linstead alignment

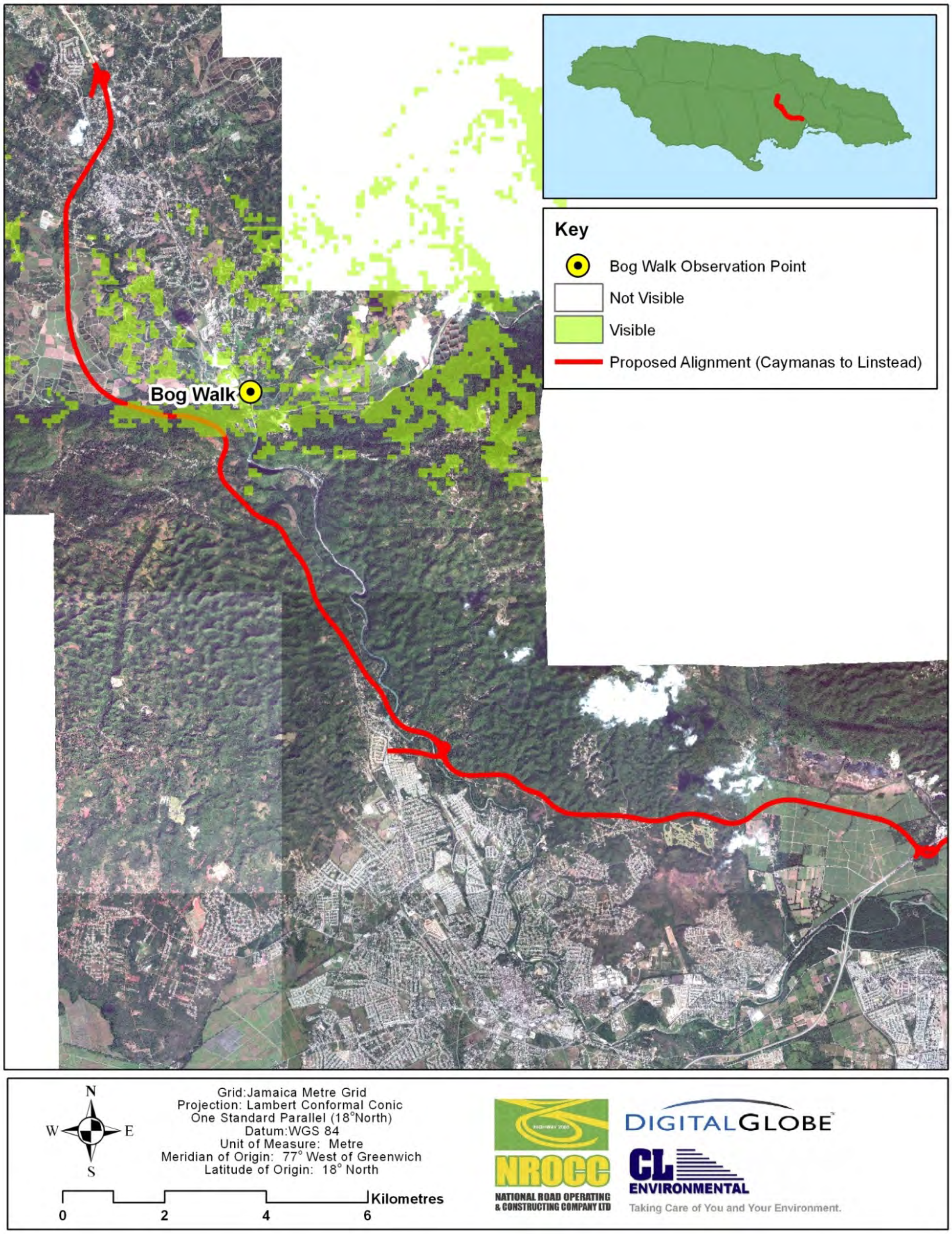


Figure 5-6 - Viewshed from Bog Walk observation point, Caymanas to Linstead alignment

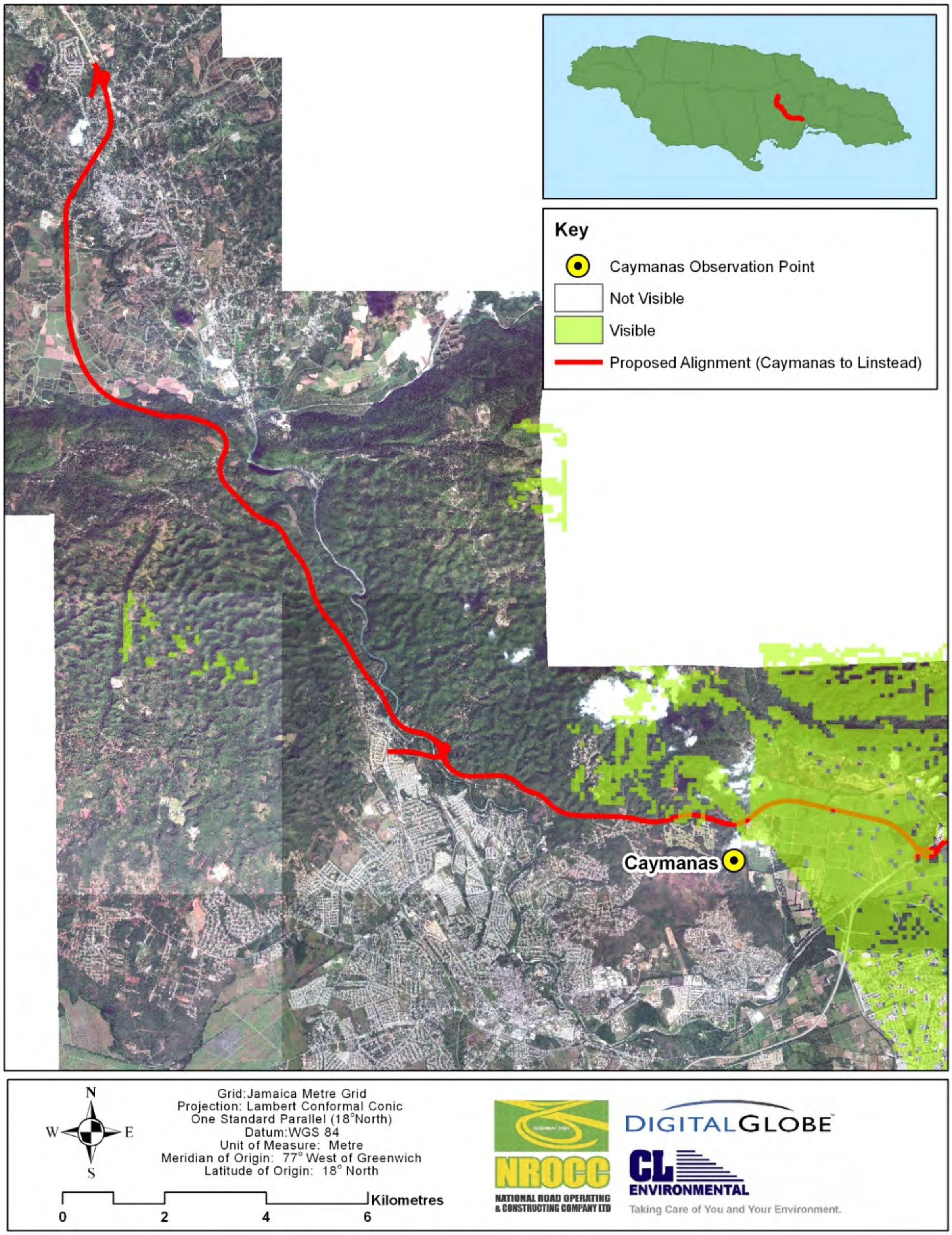


Figure 5-7 - Viewshed from Caymanas observation point, Caymanas to Linstead alignment

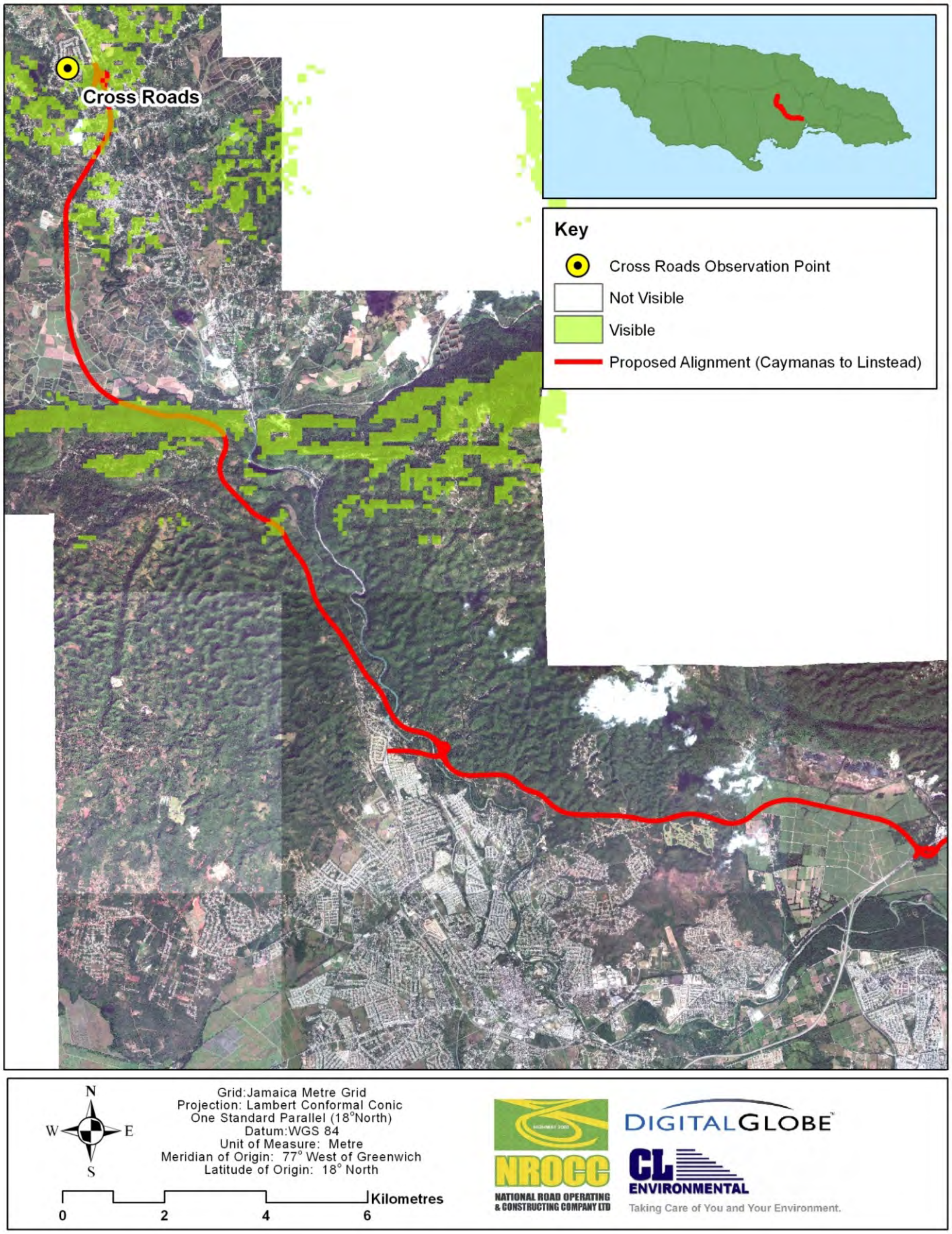


Figure 5-8 - Viewshed from Cross Roads observation point, Caymanas to Linstead alignment

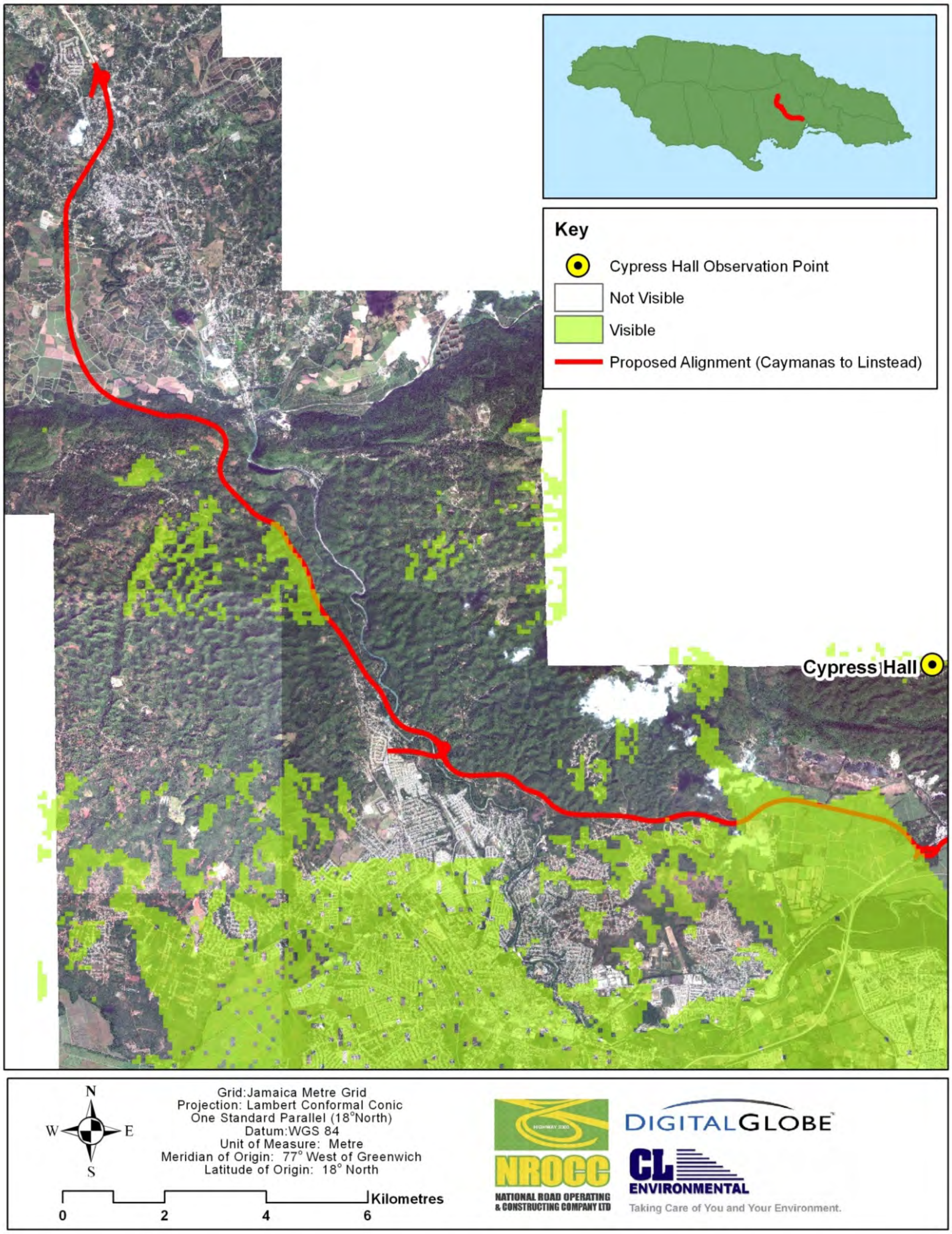


Figure 5-9 - Viewshed from Cypress Hall observation point, Caymanas to Linstead alignment

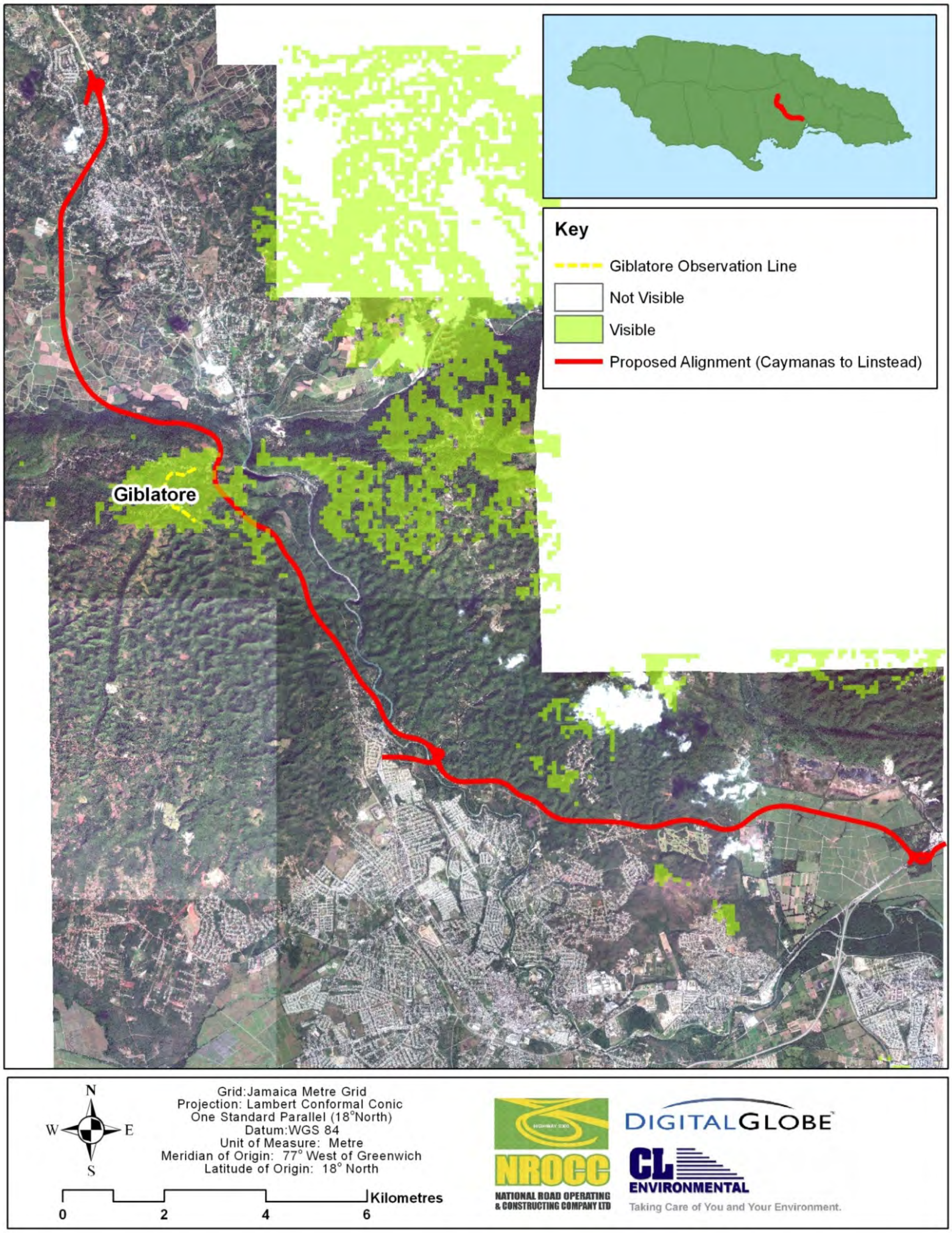


Figure 5-10 - Viewshed from Giblatore observation line, Caymanas to Linstead alignment

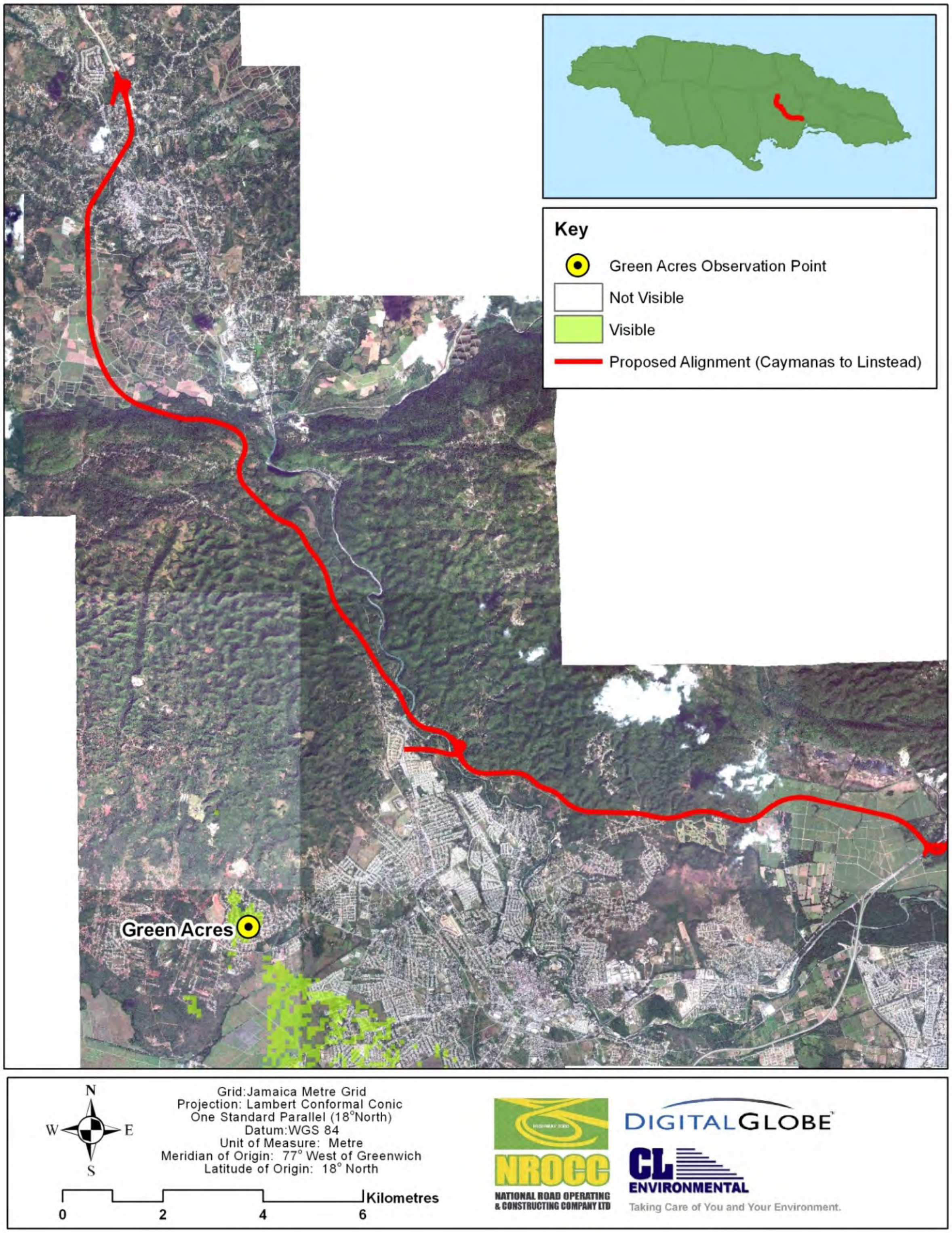


Figure 5-11 - Viewshed from Green Acres observation point, Caymanas to Linstead alignment

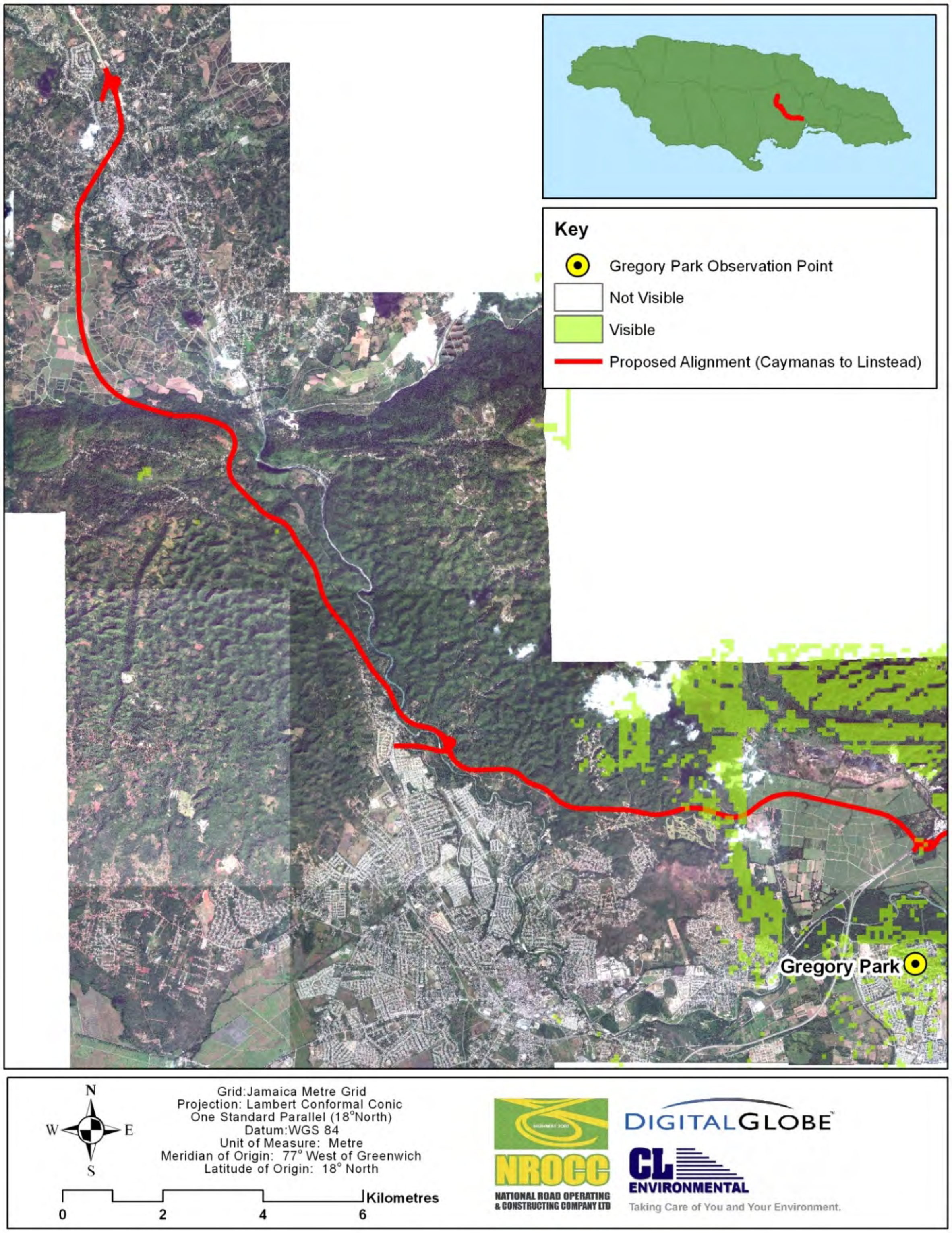


Figure 5-12 - Viewshed from Gregory Park observation point, Caymanas to Linstead alignment

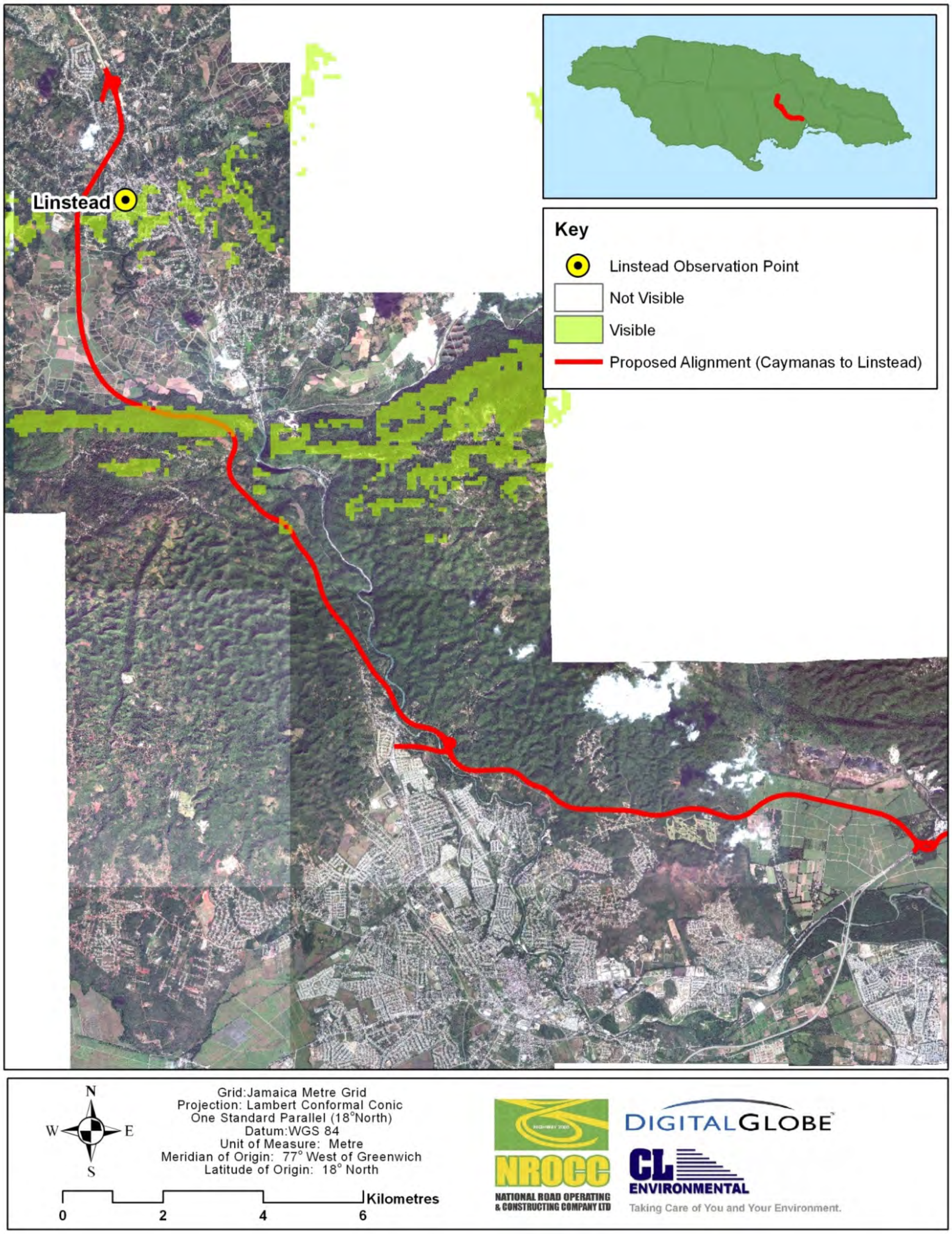


Figure 5-13 - Viewshed from Linstead observation point, Caymanas to Linstead alignment

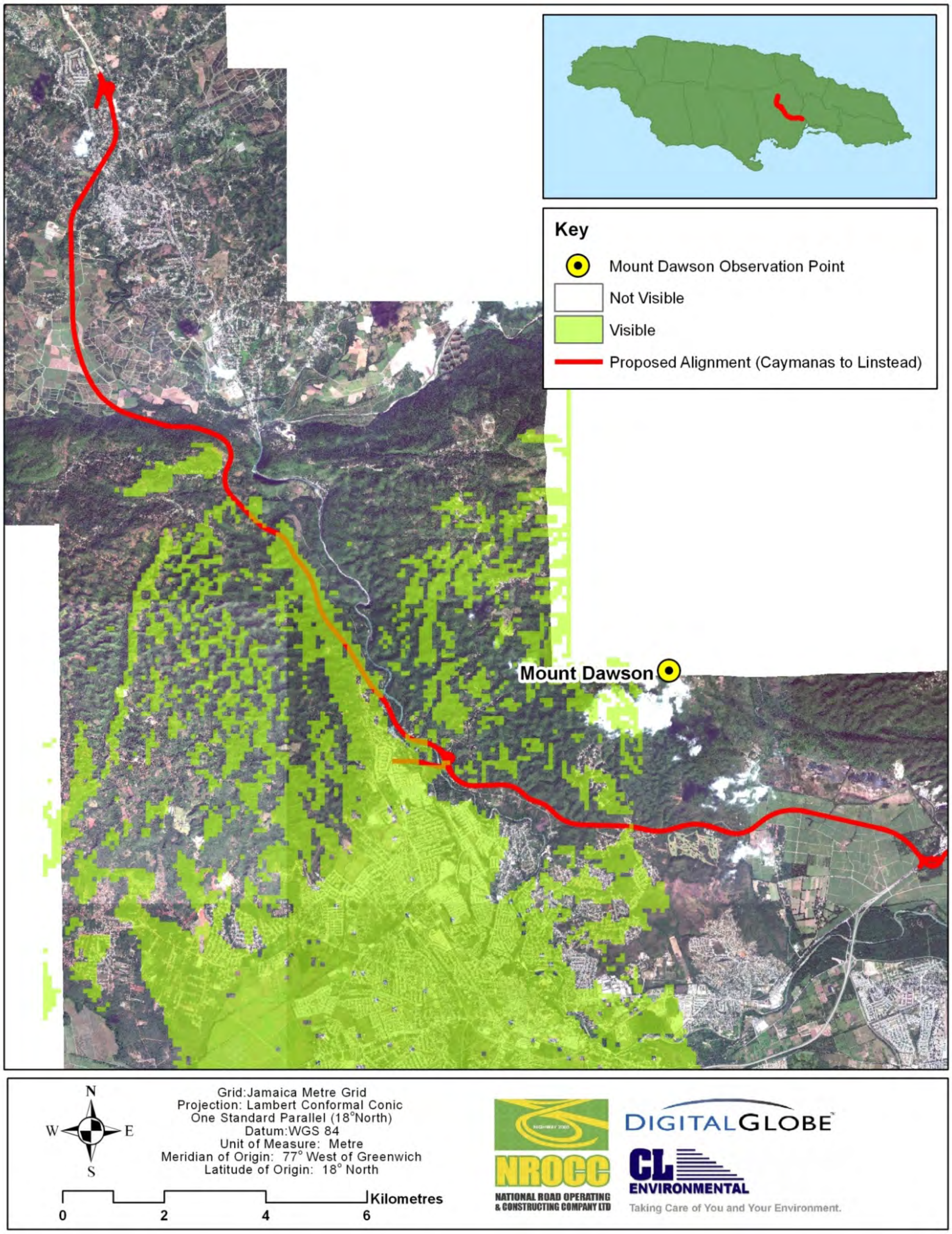


Figure 5-14 - Viewshed from Mount Dawson observation point, Caymanas to Linstead alignment

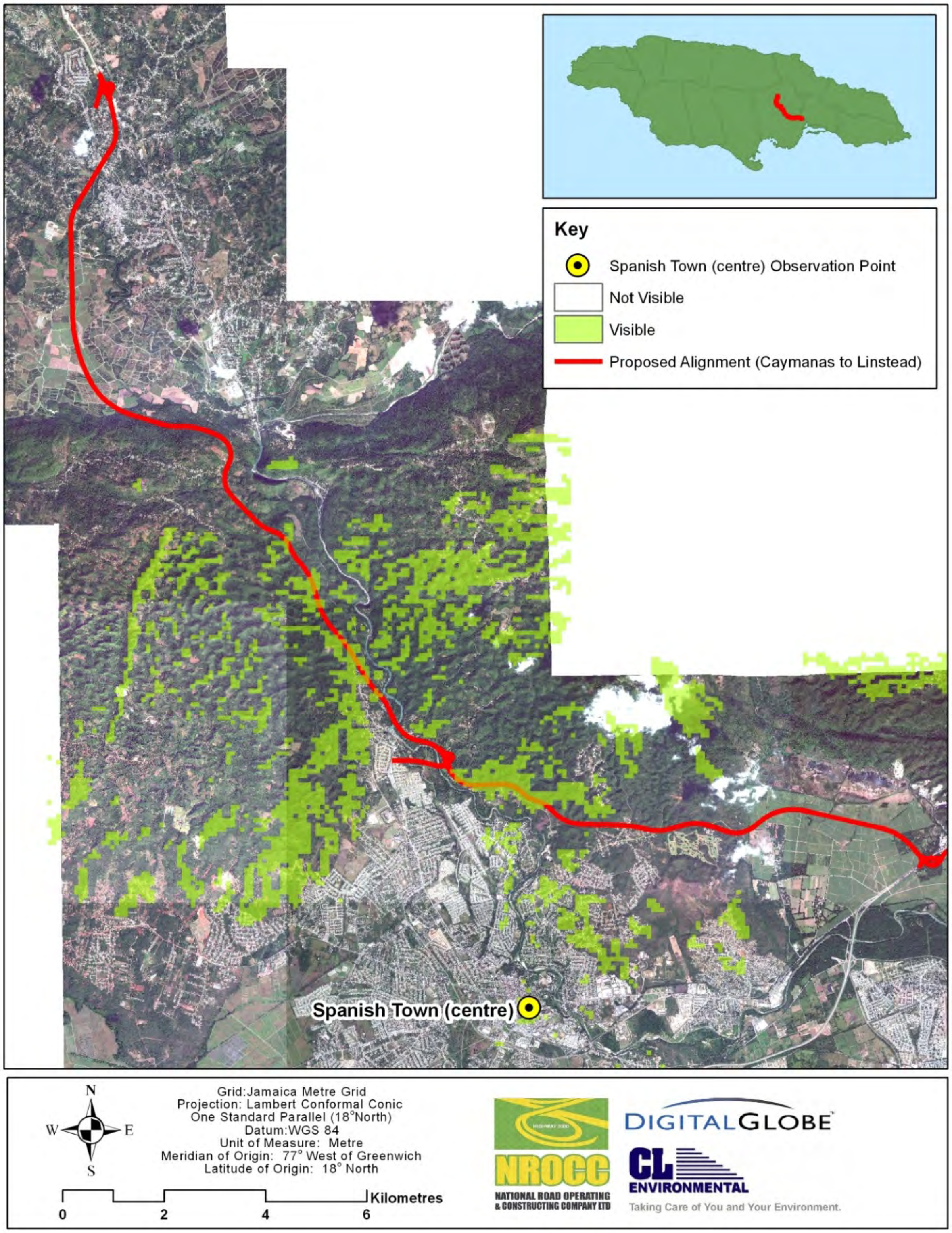


Figure 5-15 - Viewshed from Spanish Town observation point, Caymanas to Linstead alignment

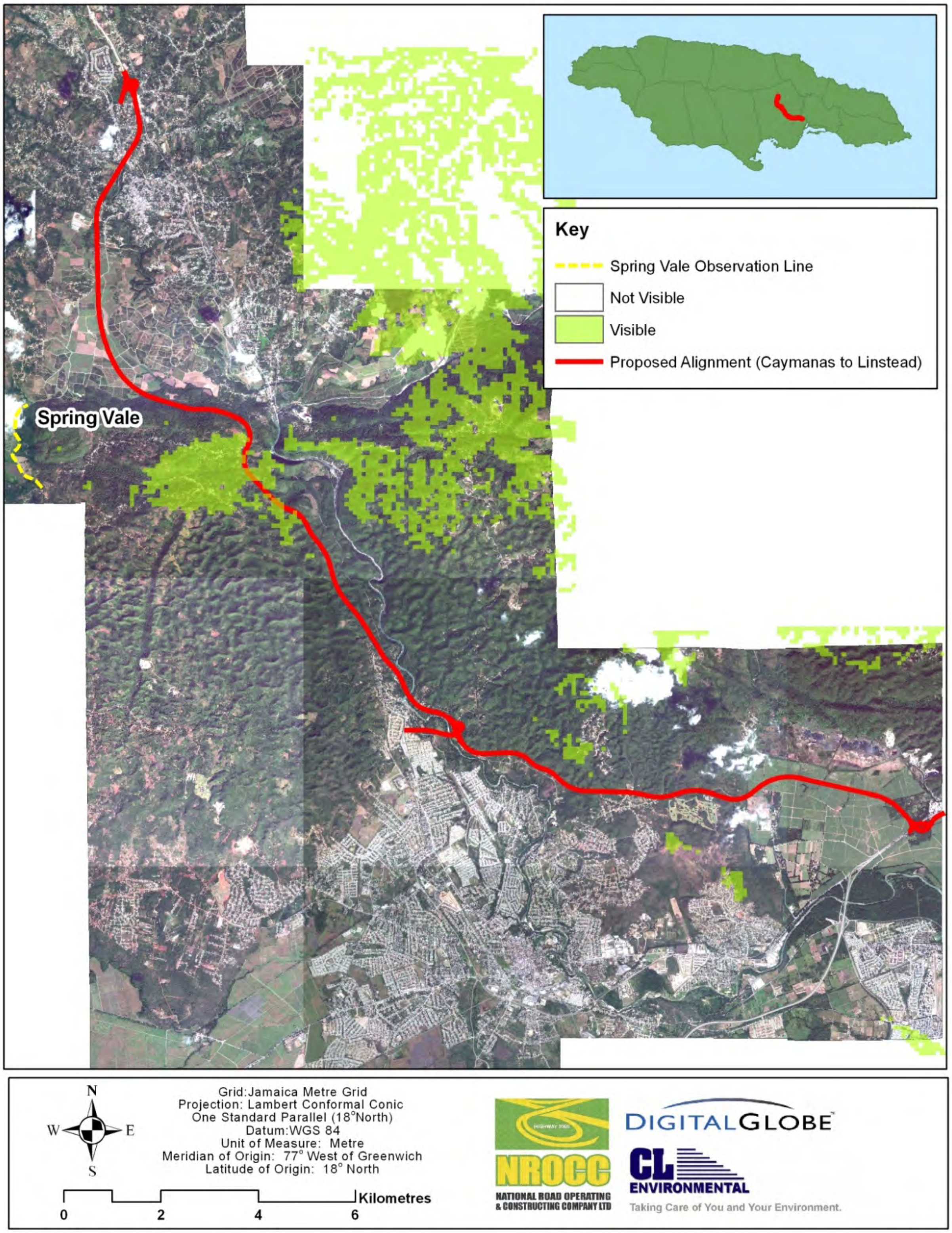


Figure 5-16 - Viewshed from Spring Vale observation line, Caymanas to Linstead alignment

5.2 3D VISUALISATION

Solely for visualisation purposes, the proposed alignment was superimposed on a 3D DEM of the study area (Figure 5-17).

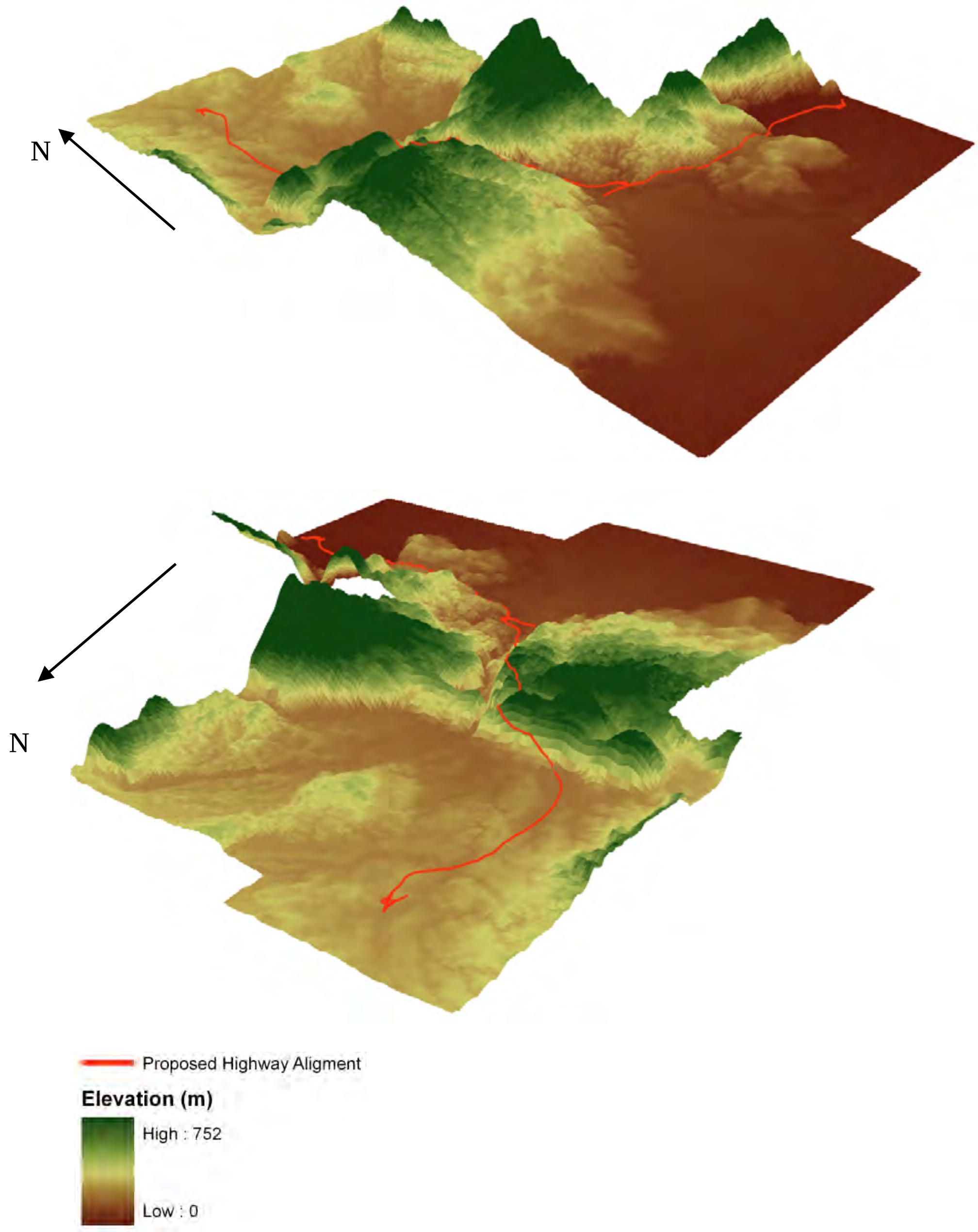


Figure 5-17 – 3D visualizations of the study area and proposed alignment from two varying angles, using a vertical exaggeration of 4.4

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

In this case, some soil and bedrock excavation may be necessary, prior to construction work. In practice, this excavation may involve a variety of methods one of which is controlled blasting. Insensitive blasting (i.e. controlled or otherwise) has the potential of resulting in unpredictable and unstable rock fissures and cracks within White Limestone bedrock formations.

Blasting is expected to be concentrated mainly between Caymanas and Bog Walk. 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

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.

The Fresh River located at the end of the H2K alignment in Ferry will be affected by the affected by the implementation of the highway. Debris generated during the site clearance and preparation may infiltrate the natural freshwater system of the river by means of runoff. In addition, excavation may play a major role in the contamination of the river due to dust and sheet flow runoff.

6.1.4 Flora and Fauna

6.1.4.1 Vegetation and Habitat Removal/Disturbance

Perceived Impacts to the Lowland Areas:

The vegetation located in the lowland areas exhibited signs of noticeable human modification (with several agricultural and residential developments) and as such, 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 Highland Areas:

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 into previously untouched areas.

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 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 exotic and native pest species as well as diseases.

Accidental or Intentional Removal of Important Plant Species

Over 80 plant species were encountered, including several fern and Agavaceae species, during the field excursion: seven 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 the surrounded protected area.

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 and more importantly into the surrounding protected area.

6.1.4.2 Fauna

Avifauna

The proposed development will not have a major negative effect on the bird community in the area. The birds which are going to be displaced during the development will migrate to the adjacent vegetation outside of the property. The cane field and the residential area have already been modified and the species found in cane field and the residential areas will continue to coexist with the human activity.

The construction of the road creates a potential for a negative impact on the forest. The road might create easy access to sections of the forest which was not accessible. This will cause degradation of the forest, which will have an indirect effect on forest specialist. However, there is a significant amount of forest in the area and forest specialists can migrate to the adjoining forest. It should be noted that a construction of a highway in forest usually will have a great impact on flightless birds, but none occur in Jamaica.

The construction of the highway will not have great effect impact on the bird population because the birds can migrate to other forest habitat, while the other species are already co-habiting with human activity. In addition, the construction of a highway does not require large acreage of lands such as a housing development, which will have negative impacts on the bird's habitat.

Freshwater Bodies

Freshwater habitats are particularly sensitive to contamination from development work occurring in the immediate vicinity. While by no means exhaustive, the list below indicates the primary factors emanating from a development of the proposed type, which are likely to have a negative impact on freshwater bodies:

(1) Inorganic contamination due to increased run-off resulting from vegetation removal /soil instability.
(2) Increased temperature due to removal of shade vegetation.
(3) Increased sedimentation due to construction /earth moving creating the potential for soil erosion.
(4) Hydrocarbon contamination due to vehicle /plant operation in the area of development.

1 and 3 listed above is likely to be the most serious source of contamination during site clearance.

Provided reasonable precautions are taken to minimize contamination and to stabilize construction to minimize increased sediment loading due to bankside erosion, while attempting to minimize removal of vegetation cover at these locations, it is fully expected that the community will return to its current composition within a few months of the cessation of construction activities.

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 6.3. The noisiest periods of highway construction are typically the ground clearing and earthwork phases.

Table 6.3 – 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 220 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 – Caymanas to Linstead.

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 especially in the Spanish Town areas and
- 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 (Caymanas, Cross Pen, Content, Crescent, Dignum/Mount Pleasant, Harker and Wakefield), Old Works for March's Bog and European artefacts (Caymanas Estate), A Great House Compound (Cross Pen) and the historic Rio Cobre pipeline (Content). 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

- 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 Linstead are particularly vulnerable as these areas are densely populated areas.

6.2.2 Water Resources

- Recharge paths for surface run-off may be traversed by the alignment, decreasing the volume of run-off reaching the sinkholes.
- Surface run-off may become contaminated due to oil spills. This problem may be more prone in areas where fuel stations are located.
- The H2K alignment does not traverse the Fresh River itself but does cross its tributaries and is contained within the catchment itself. Due to the presence of the alignment within the catchment, a small volume of runoff might not be able to

flow freely across the highway. Furthermore, the area surrounding Ferry is relatively flat, proving more difficult for the runoff to discharge into the Fresh River.

6.2.3 Natural Hazards

Natural hazards such as flooding, hurricane and earthquake has the potential to impact negatively on the structural integrity of the highway and its furniture.

6.2.3.1 Earthquake Hazard

From the catalogue of earthquakes impacting Jamaica over the past 300 years, most of the larger earthquakes recorded/reported were offshore. The earthquakes occurring on land tend to be of low magnitude. From a historical seismic perspective, the site is no more prone than any other area on the island.

6.2.3.2 Landslides

- The sections of the highway which traverses the mountainous environs north of Lime Walk and south of Bog Walk were determined most vulnerable to landslides.
- Approximately 3.1km of the alignment which traverses east to west through the mountains north of Lime Walk is determined to have slight to high vulnerability of landslides.
- 2.2km of the highway is determined to have slight to high vulnerability in the region of Content where the alignment intersects the Rio Cobre.
- A small segment of the highway which passes through Caymanas Bay is moderately susceptible to landslides.

6.2.3.3 Debris Flow

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:

$$\boldsymbol{A = R \times K \times LS \times C \times P}$$

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:

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

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:

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

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.

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 6-1) concluded that the alignment traverses moderate soil loss zones north-west of Flat Bridge and within close proximity to Waterloo Valley. More importantly, high loss regions are crossed north of Lime Walk and south-west of Kent Village. It is apparent that the Thomas River and associated tributaries which ultimately discharges into the Rio Cobre are more likely to have high sediment loads causing the Rio Cobre to have an elevated sediment load. 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 6-2 illustrates the recommended culvert/bridge openings along the proposed H2K Caymanas alignment.

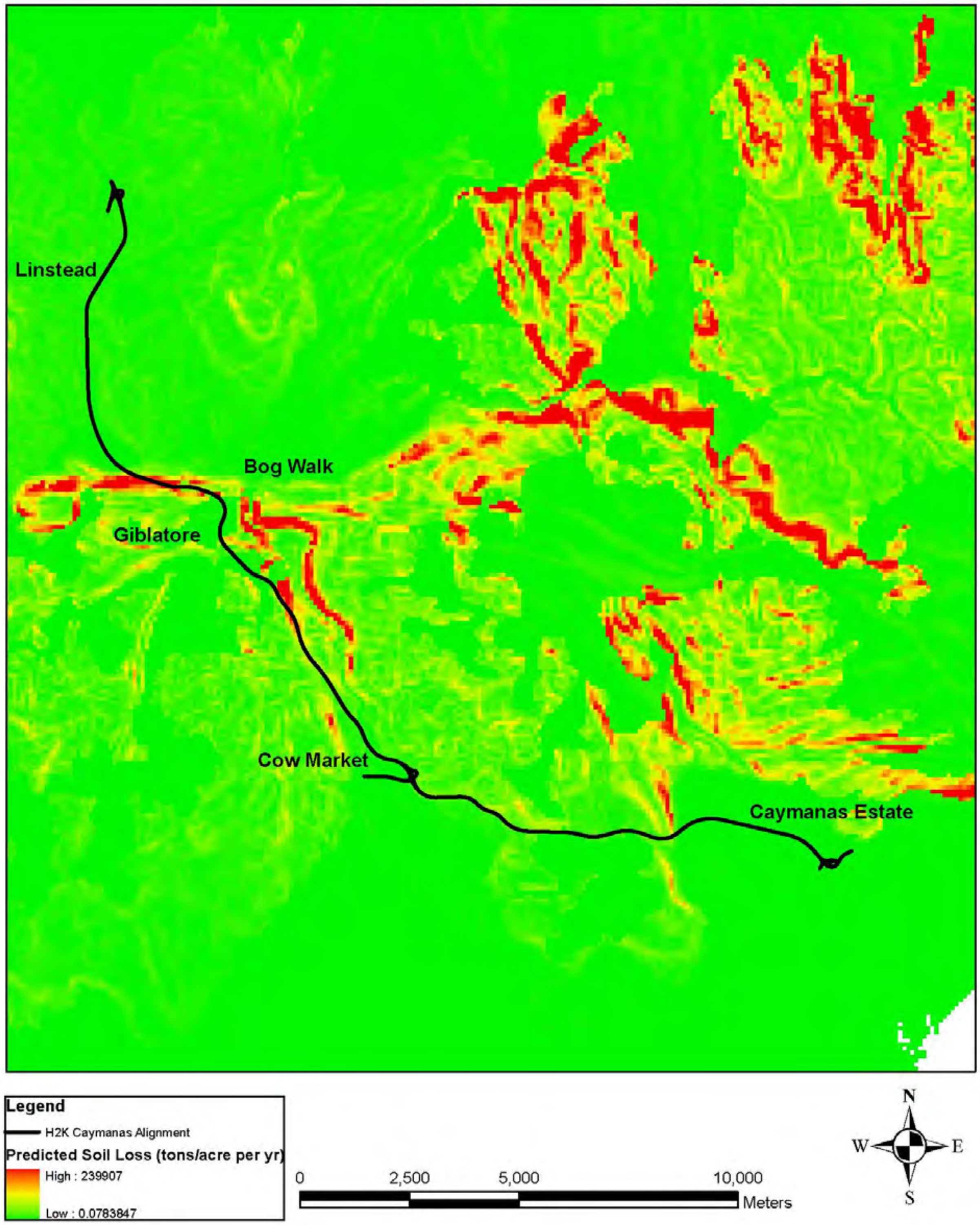


Figure 6-1 - Predicted soil loss (T/acre.hour) along the alignment

6.2.4 Runoff Impact

The following impacts are expected when the highway is constructed:

1. The peak flows will increase by 0.70 - 1.12 % from the current scenarios.
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. The catchments that will be most impacted are the Jordan Spring, Thomas River, Springvale River and Rio Cobre. There are numerous tributaries which also cross the proposed alignment and will need culvert openings as shown in Figure 6-2. Numerous areas identified as flood prone areas by the Office of Disaster and Emergency Management (ODPEM) are within close proximity to the alignment.
3. Moses Lake located within the plains of Caymanas acts as a retention pond for runoff from the surrounding areas (Figure 6-3). The routing of H2K through the Caymanas will cut off some of the runoff raising the need for culverts along H2K in these areas. The soils in the area consist of Clay Loam and Silty Clays which are not very permeable earths.

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.

Table 6.4 indicates the runoff expected from the proposed highway.

Table 6.4 - Runoff from proposed highway

Hydrology	Units	Location					
		Jordan Spring	**Thomas River 1**	**Thomas River 2**	**Springvale River**	**Rio Cobre**	**Fresh River**
Catchment area	HA	8767	406	534	4007	46140	6329
Return period	Years	100	100	100	100	100	100
Tc	min	50	30	10	32	87	165
Peak runoff							
Existing Condition	m^3/sec	1481.3	110.1	145.7	512.1	3954.6	339.3
Existing Condition plus Highway	m^3/sec	1491.8	111.0	147.0	522.3	3999.2	343.9
Difference		0.70%	0.84%	0.90%	1.95%	1.12%	1.33%

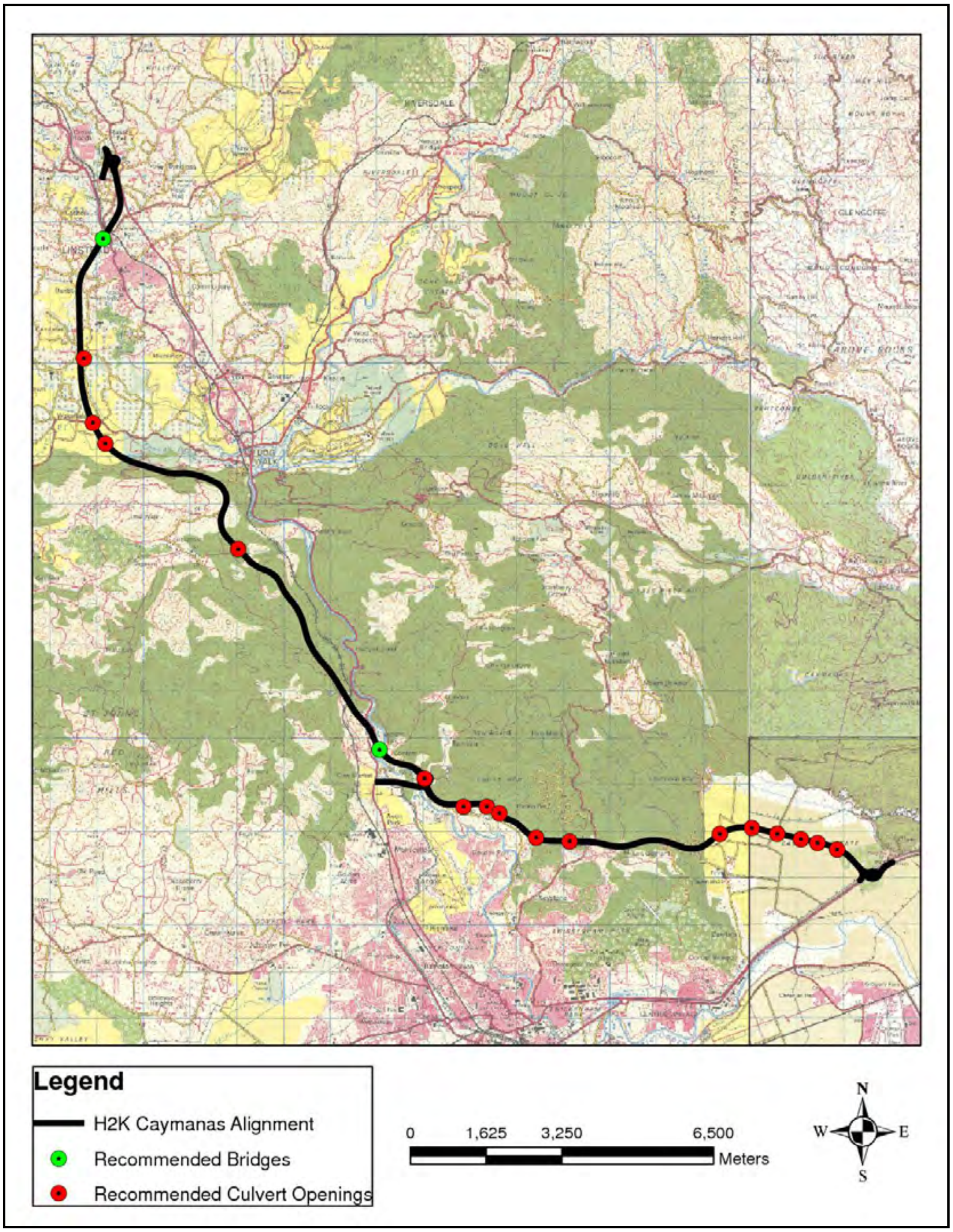


Figure 6-2 - Proposed culvert openings and bridges along the alignment

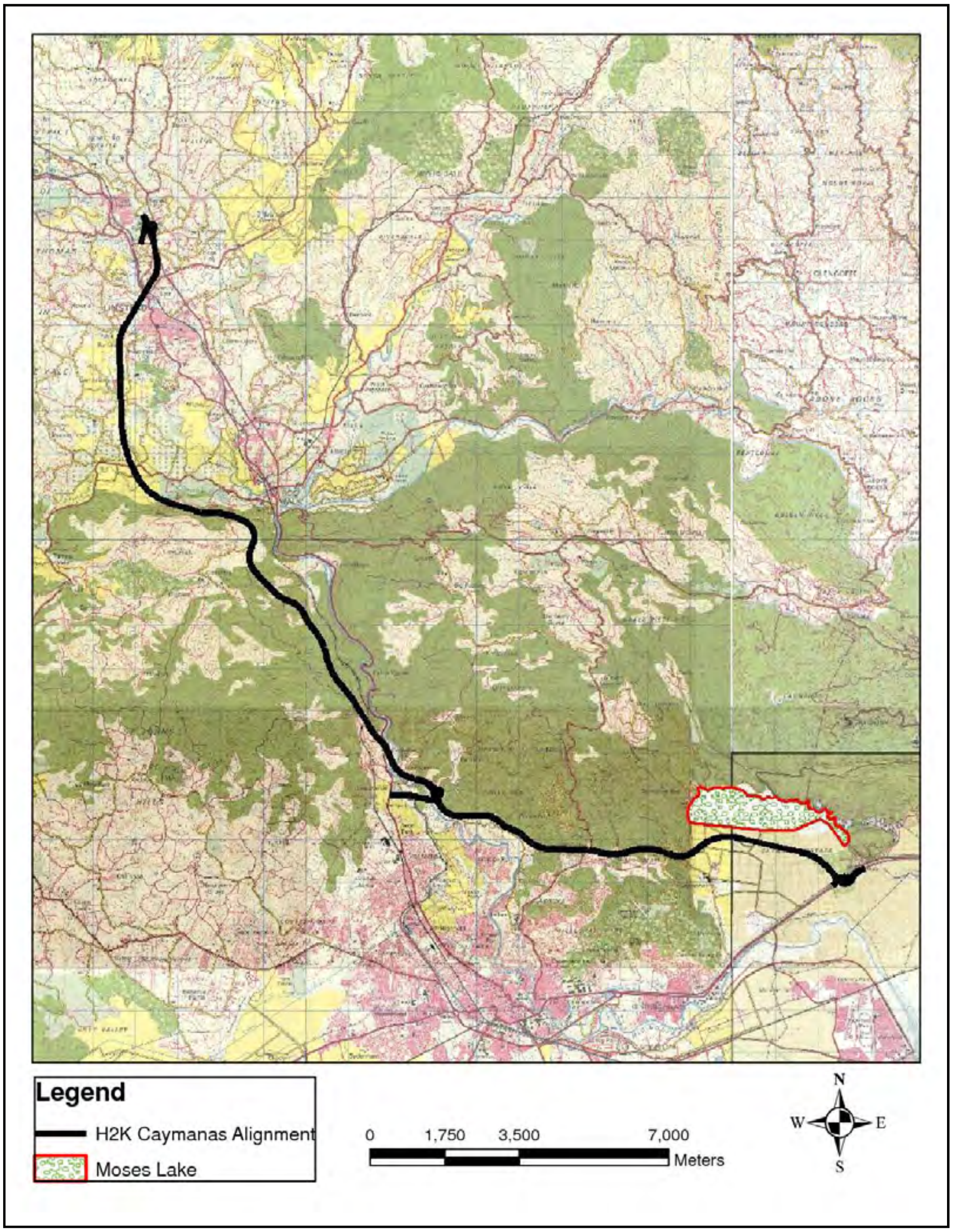


Figure 6-3 – Moses Lake in relation to alignment

6.2.5 Noise

The predicted noise impact from the operation of the North South Link (Spanish Town to Linstead) 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 80% relative humidity, 30oC temperature and pressure of 1013.25 mbar.

Comparison with NEPA Guidelines

Stations 8, 9 and 10 will be non -compliant with the NEPA day time guidelines (Table 6.5) and Figure 6-4. Whilst non–compliant, the baseline noise levels at Stations 5, 9 and 10 were already exceeding the NEPA day time guidelines.

Stations 2, 4, 5, 8, 9 and 10 will be non-compliant with the NEPA night time guidelines (Table 6.5) and Figure 6-5. Whilst non-compliant, the baseline noise levels at Stations 8, 9 and 10 were already exceeding NEPA night time guidelines.

Table 6.5 – Comparison 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	Caymanas Bay	Residential	53.1	ND	55	45.4	ND	50
2	Waterloo	Residential	50.7	52.4	55	52.1	**51.0**	50
3	Obama Heights	Residential	52.6	44.6	55	51.0	43.2	50
4	Content	Residential	54.6	52.2	55	49.8	**50.7**	50
5	Dam Head	Residential	61.1	54.2	55	49.3	**52.7**	50
6	Wakefield	Commercial	50.4	50.2	65	45.6	48.8	60
7	Cambria Farms	Commercial	52.4	48.9	65	42.3	47.5	60
8	Banbury	Residential	52.8	**72.2**	55	54.8	**70.8**	50
9	Vanity Fair	Residential	60.9	**59.0**	55	60.3	**57.5**	50
10	Giblatore	Residential	60.0	**58.8**	55	56.8	**57.3**	50

NB: Noise levels in red exceeded the NEPA guidelines

ND – Not done because this station is located approximately 800m away from the proposed highway alignment and therefore noise from the highway is expected to be minimal.

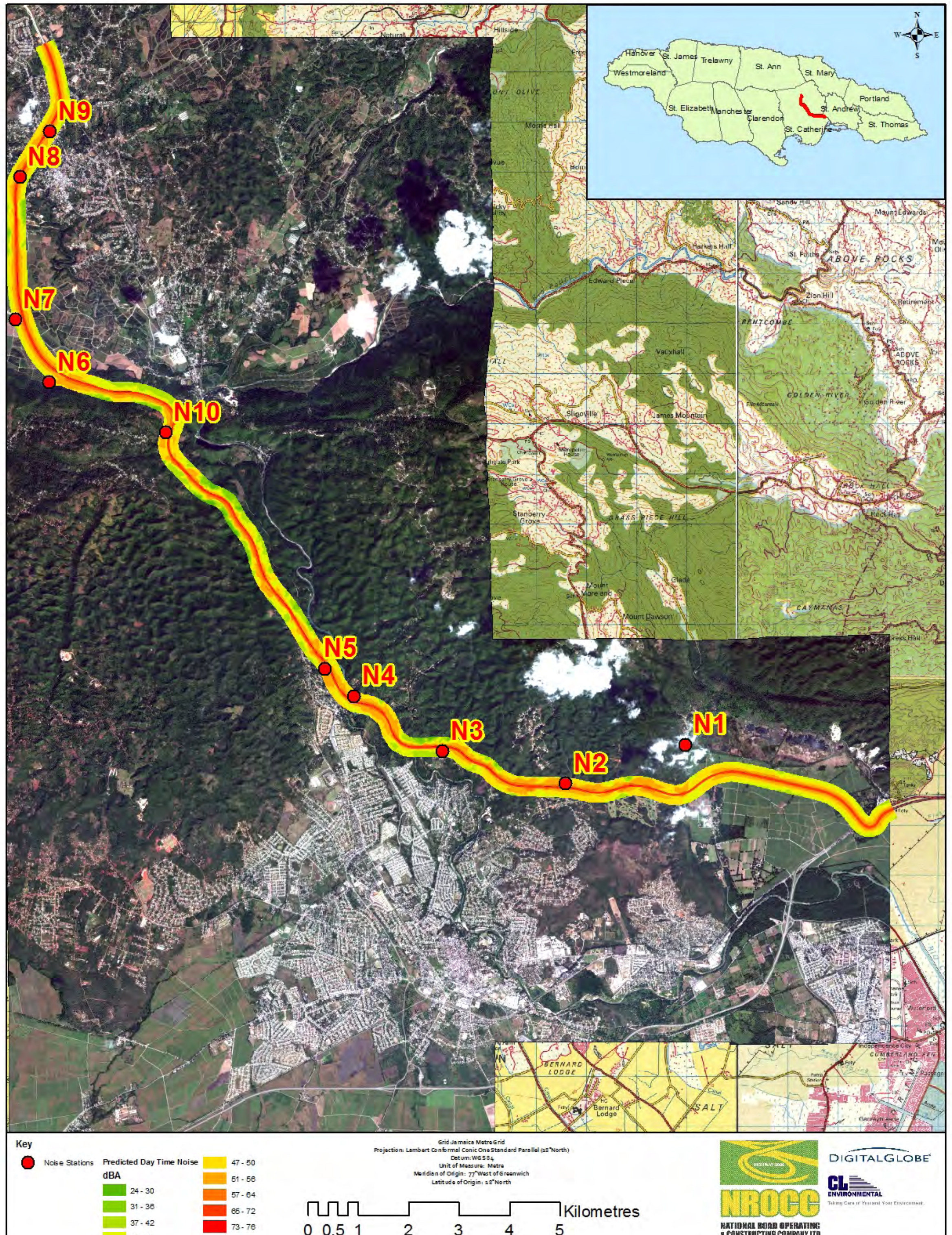


Figure 6-4 – Modelled Day Time noise levels along the proposed alignment

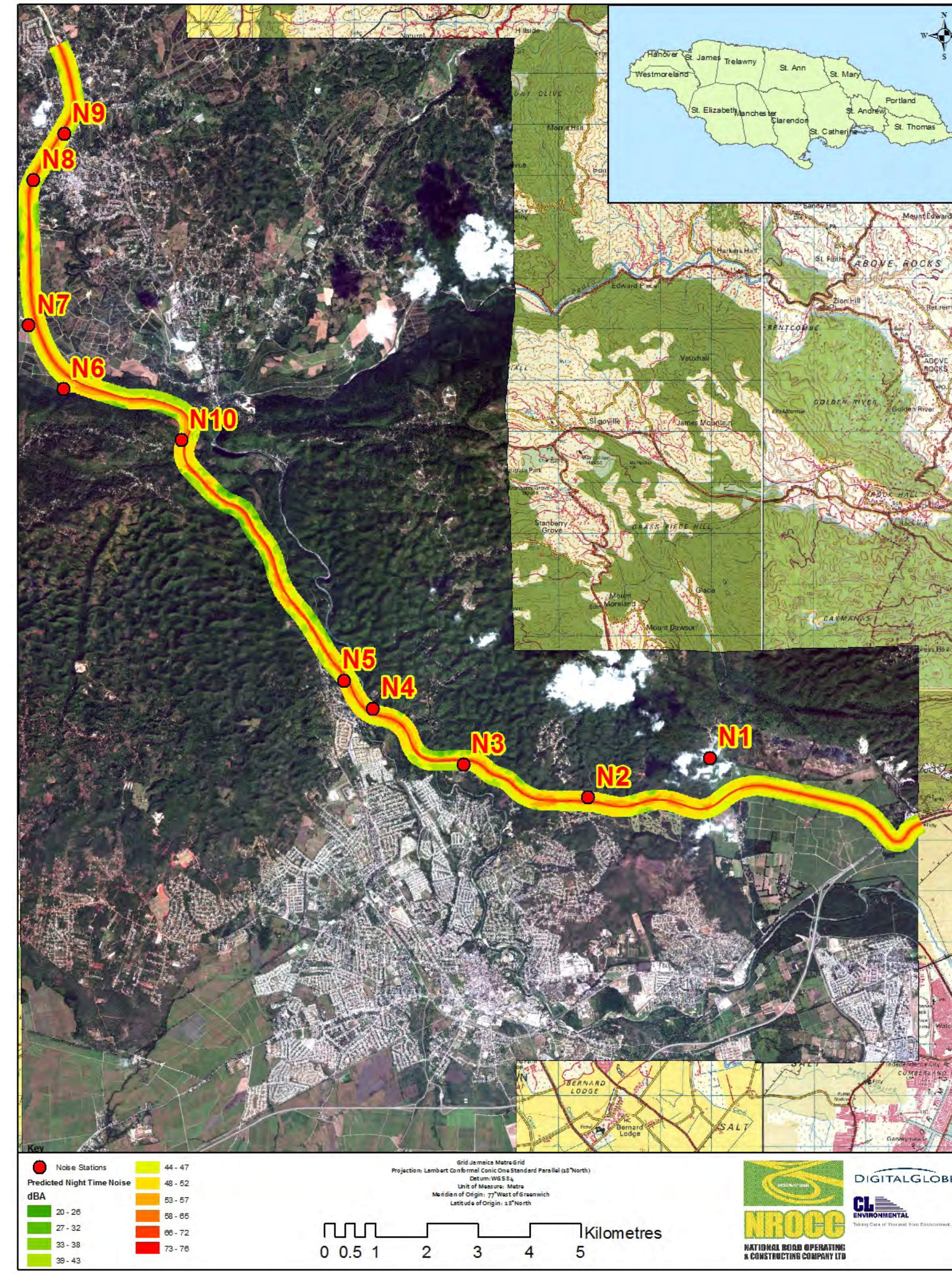


Figure 6-5 – Modelled Night Time noise levels along the proposed alignment

6.2.6 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).

6.2.7 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.

6.2.8 Traffic

Negative impacts on traffic are expected during the construction stages, they will include:

- Disruptions in traffic especially in the areas surrounding Linstead and the Caymanas interchange; 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

6.2.9 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 Stations 2, 3, 6 and 7 would be compliant with the NEPA day time guidelines and Stations 6 and 7 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 4 and 8 (day time) and Stations 4 and 5 (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	Caymanas Bay	Residential	53.1	ND	55	45.4	ND	50
2	Waterloo	Residential	50.7	54.6	55	52.1	**51.5**	50
3	Obama Heights	Residential	52.6	53.2	55	51.0	**51.7**	50
4	Content	Residential	54.6	**56.6**	55	49.8	**53.3**	50
5	Dam Head	Residential	61.1	**61.9**	55	49.3	**54.3**	50
6	Wakefield	Commercial	50.4	53.3	65	45.6	50.5	60
7	Cambria Farms	Commercial	52.4	54.0	65	42.3	48.6	60
8	Banbury	Residential	52.8	**72.2**	55	54.8	**71.0**	50
9	Vanity Fair	Residential	60.9	**63.1**	55	60.3	**62.1**	50
10	Giblatore	Residential	60.0	**62.5**	55	56.8	**60.1**	50

NB: Noise levels in red exceeded the NEPA guidelines

ND – Not done because this station is located approximately 800m away from the proposed highway alignment and therefore noise from the highway is expected to be minimal.

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

Table 7.2 indicates the predicted flows within the catchment when the highway is operational.

Table 7.2 - Predicted flows from within the catchment area including impacts from the proposed highway

Hydrology	Units	Location					
		Jordan Spring	Thomas River 1	Thomas River 2	Springvale River	Fresh River	Rio Cobre
Catchment area	HA	8767	406	534	4007	6329	46140
Return period	Years	100	100	100	100	100	100
Tc	min	50	30	10	32	165	87
Peak runoff							
Existing Condition	m^3/sec	1481.3	110.1	145.7	512.1	339.3	3954.6
Future Flows (fully developed catchment with highway)	m^3/sec	1714.5	128.1	171.3	661.9	565.4	4829.3

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:

- No user fees for motorists travelling from Linstead;
- Destruction of natural habitats will be avoided from the cutting and filling operations required during construction.

The following Negative impacts are anticipated:

- Continued long delays can be experienced in the Spanish Town areas during morning and evening peak hours for commuters;
- Continued delays may be experienced in the bog Walk Gorge and Spanish Town bypass during morning and evening peak hours;
- Long detours are required through Sligoville and Barry whenever the Gorge is blocked. These routes, and Sligoville in particular, are currently in disrepair and have high accident risks associated with their use;
- 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 proposed highway will provide a tolled alternative to the existing Bog Walk Gorge which is subjected to seasonal flooding as well as congestion prone areas of Spanish town and the bypass;

- The construction of this alternative will reduce the travel times, from urban centres and residential settlements in St. Catherine and other northern and western parishes, to and from Kingston;
- Reduced maintenance and fuel costs associated with better quality roads;
- Reduced traffic will be experienced through Spanish Town and on the Spanish Town bypass during peak hours;
- 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 Bog Walk and Caymanas Bay 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:

i. 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 of Linstead, Angels and Caymanas. 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.
ii. In keeping with the recommendation for a water resource risk management plan, a dedicated mapping exercise should be undertaken to identify all vulnerable sinkholes.
iii. 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.
iv. 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.
v. 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 and Fauna

9.1.4.1 Habitat Fragmentation

i. 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.
ii. 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). They would also 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.
iii. It is understood, however, that fencing may be a necessary feature of this development so as 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

i. The removal of the endemic species should be avoided.
ii. Trees with DBH>15cm should be preserved.
iii. If removal is necessary, a nursery should be established for the maintenance and propagation of these and other naturally occurring plants. These plants may later be reintroduced into the forest or used for landscaping and other aesthetic purposes.
iv. The development should be fenced to impede human and livestock access to the adjacent vegetation through which the highway runs.
v. Since some of the Guango (*Samanea saman*) with God Okra (*Hylocereus triangularis*) fall within the interchange, this may require the realignment of the south-eastern section around the aforementioned stand of trees.
vi. Relocation of the highway, alternate to Location L, should be considered.

9.1.4.3 Human Encroachment, Urban Sprawl and Control of Invasive Species

i. A proper plan should be developed concerning transportation routes and storage for equipment and material.
ii. The proposed post construction or operation road network should be kept simple as well as be used throughout the preparation and construction phases of the project.
iii. A buffer area should be established and maintained between the project area and the surrounding limestone forest.
iv. Fencing of exposed points to human and ruminant entry should reduce their intrusion.
v. Proper planning regarding access points to the construction site should be established.
vi. Further planning will be required for the establishment of development zones within nearby lands, villages and towns. This should direct controlled or prohibited development of nearby areas.

9.1.4.4 Increased Human and Invasive Species Access

i. A buffer area should be established and maintained between the project area and the surrounding limestone forest. Fencing will most likely be necessary.
ii. Fencing of exposed points to human and ruminant entry should reduce their intrusion.
iii. Proper planning regarding access points to the construction site should be established.
iv. Further policy planning will be required for the establishment of development zones within nearby lands, villages and towns. This should direct controlled or prohibited development of nearby areas.

9.1.5 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.

9.1.6 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.

9.1.7 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.

9.1.8 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.

9.1.9 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.

9.1.10 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.

9.1.11 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.

9.1.12 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 the 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.

9.1.13 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.

9.1.14 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.

9.1.15 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.

9.2.2 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

9.2.3 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.

9.2.4 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.

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

10.1SITE 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$60,000 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. Catherine 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$ 85,000 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$112,000.

- 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$60,000.

- 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. Catherine 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.

11.2AIR 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 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:

(A) 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 facilitate 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.

(B) 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.

(C) 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.

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
• Damion Whyte	Avifauna
• Dr Philip Rose	Flora
• 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
• 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)

HACH

Certificate of Instrument Performance

Company Name: CL ENVIRONMENTAL

Certification for Job# 491126

Part/Model Number: MiniSonde 5	Serial Number: 49186

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#): N.I.S.T. - traceable glass thermometer (H-B Thermometer, Serial 2Z9208) and a Cole-Parmer "*PolyStat*" Constant Temperature Circulator

Environmental Conditions:

Actual Temperature	Instrument Reading	Error
10 °C	10.03 °C	.03 °C
20 °C	20.01 °C	.01 °C
30 °C	29.99 °C	.01 °C

Hach Company does hereby certify that the above listed equipment meets or exceeds all Manufacturers' Service Specifications (unless limited conditions apply). Test equipment used for performance verification are calibrated using standards traceable to the National Institute of Standards and Technology (NIST). Where such standards do not exist, the basis for calibration is documented. The proper operation of the above instrument was established at the time of certificate issuance. To insure continued performance, user must adhere to all requirements listed in the instrument manual.

Certified by: J K Barton   Title: Instrument Service Technician

Certification Date: 7-6-11

5600 Lindbergh Drive • Loveland, CO 80538
(800) 227-4224 / FAX (970) 461-3924

Doc# 19773-01 Rev. 1

Appendix 5 – Calibration Certification (Quest QC)

3M

3M Occupational Health and Environmental Safety Division

Quest Technologies
1060 Corporate Center Drive
Oconomowoc, WI 53066-4828
www.questtechnologies.com
262 567 9157 800 245 0779
262 567 6149 Fax

QUEST TECHNOLOGIES
now part of 3M
An ISO 9001 Registered Company

Page 1 of 1

Certificate of Calibration

Certificate No: 1084042QII050083

Submitted By: IEES SUB. PROV. DE RIESGOS DE

Serial Number: QII050083
Customer ID:
Model: QC-10 CALIBRATOR
Test Conditions:
Temperature: 18°C to 29°C
Humidity: 20% to 80%
Barometric Pressure: 890 mbar to 1050 mbar

Date Received: 6/28/2011
Date Issued: 7/5/2011
Valid Until: 7/5/2012
Model Conditions:
As Found: IN TOLERANCE
As Left: IN TOLERANCE

SubAssemblies:
Description: **Serial Number:**

Calibrated per Procedure: 56V981

Reference Standard(s):

I.D. Number	Device	Last Calibration Date	Calibration Due
ET0000556	B&K ENSEMBLE	7/21/2010	7/21/2011
T00230	FLUKE 45 MULTIMETER	2/3/2010	2/3/2012

Measurement Uncertainty:
+/- 1.1% ACOUSTIC (0.1DB) +/- 1.4% VAC +/- 0.012% HZ
Estimated at 95% Confidence Level (k=2)

Calibrated By: SHAWN VANHEMERT, Service Technician — 7/5/2011

This report certifies that all calibration equipment used in the test is traceable to NIST, 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

Appendix 6 - Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme Rainfall

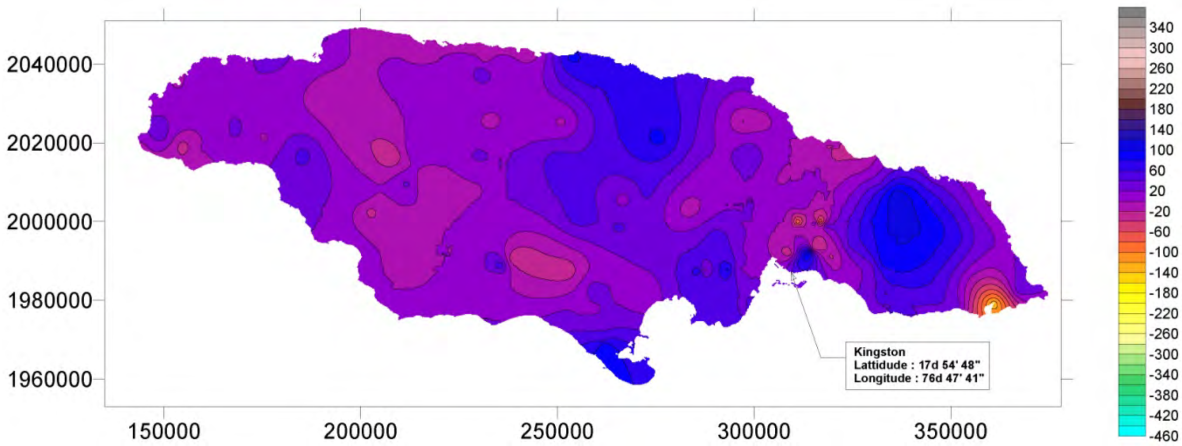


Figure 12-1 - Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 2 Year Return Period Event

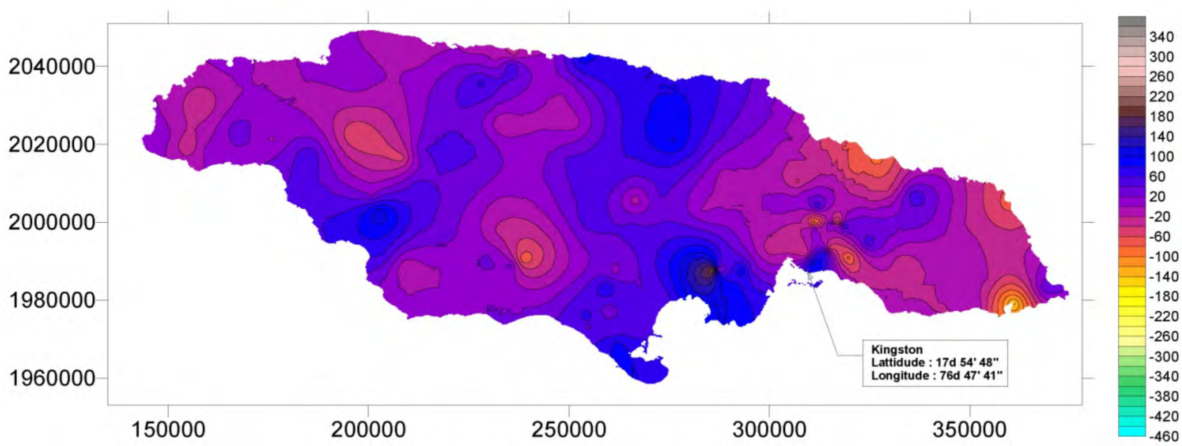


Figure 12-2 - Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 5 Year Return Period Event

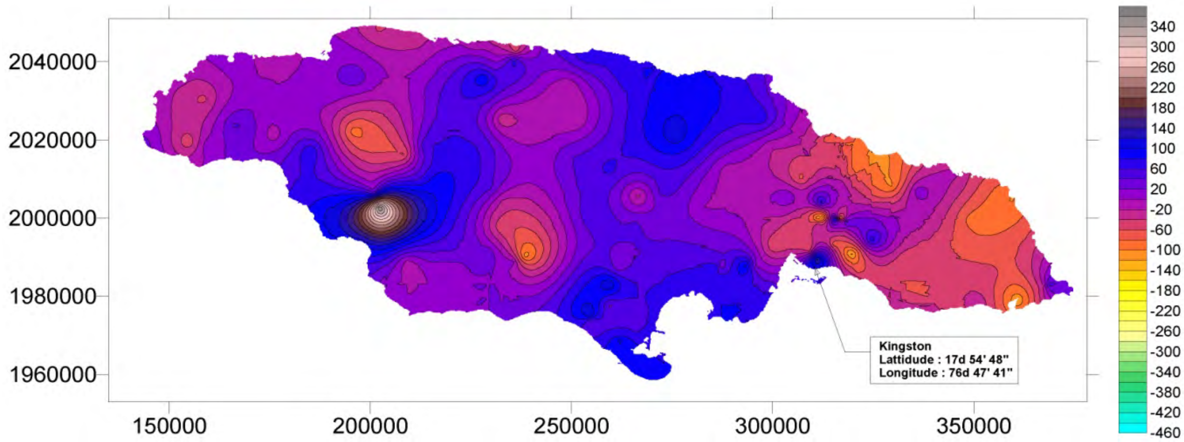


Figure 12-3 - Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 10 Year Return Period Event

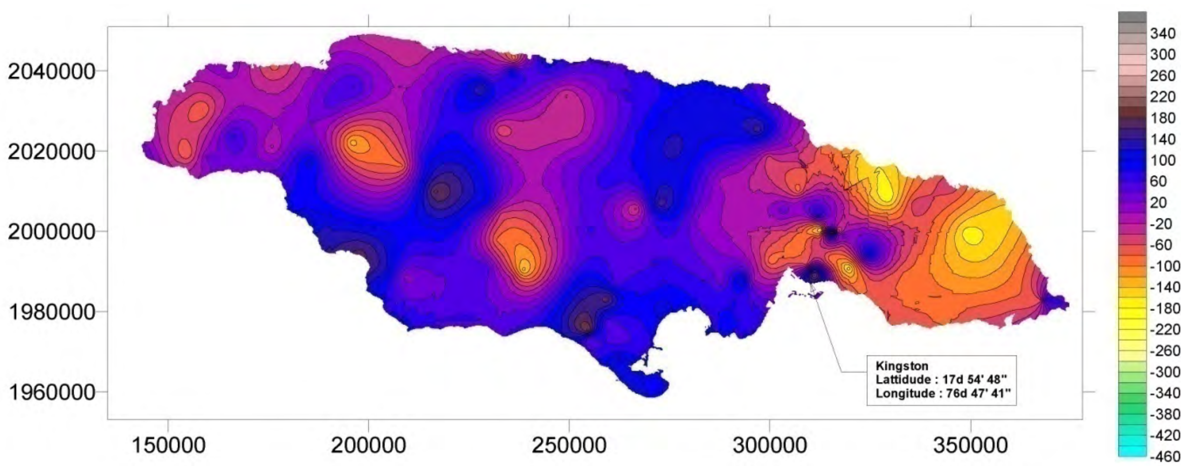


Figure 12-4 - Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 25 Year Return Period Event

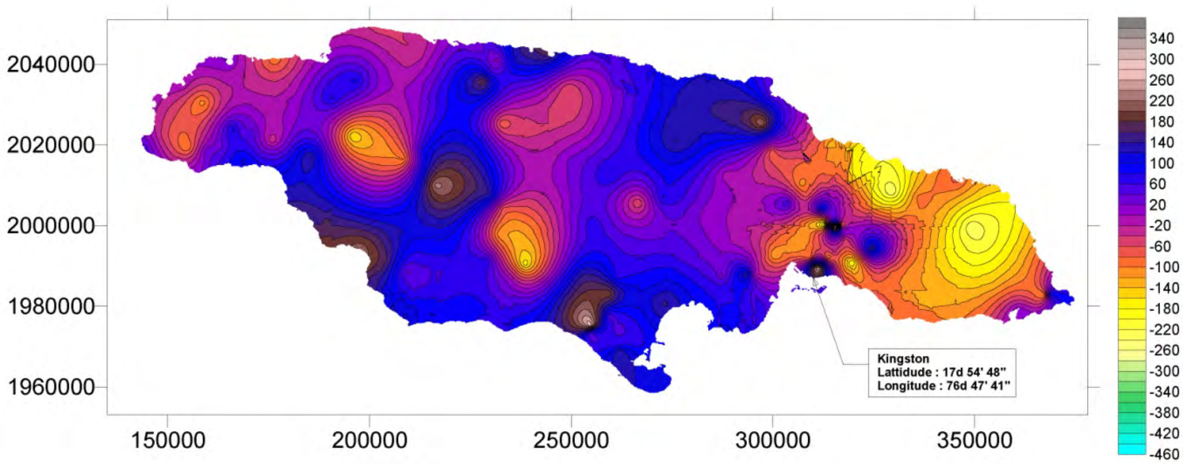


Figure 12-5 - Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 50 Year Return Period Event

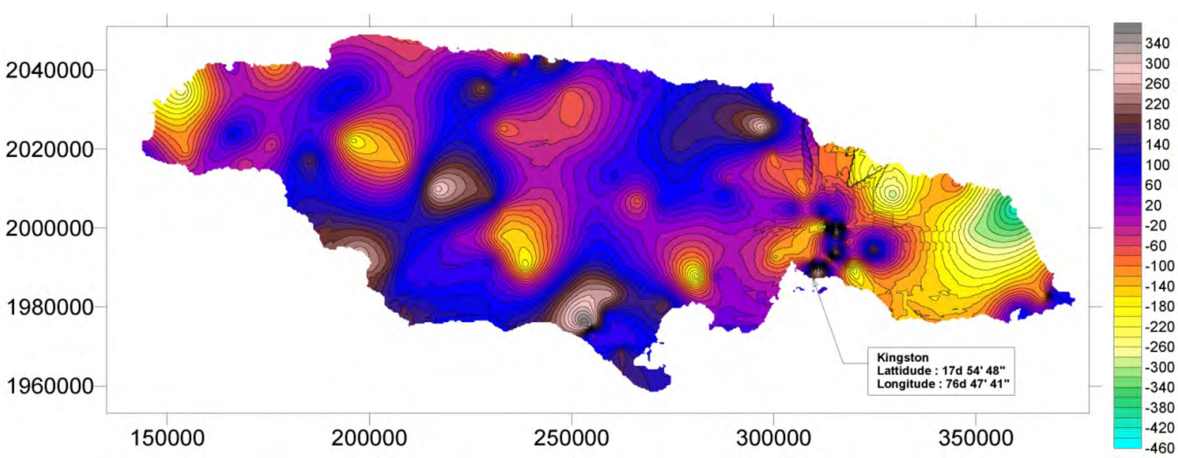


Figure 12-6 - Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 100 Year Return Period Event

Appendix 7 – Soil Properties

Soil Name	Landslide Probability	Susceptibility Class
BS	0.0%	1
M	0.0%	1
SW	0.0%	1
Bundo Clay	0.0%	1
Frontier Clay	0.0%	1
Newell Loam	0.0%	1
Chudleigh Clay loam	0.0%	1
MONTEGO BAY	0.0%	1
Crane Sand	0.0%	1
C	0.0%	1
Cave Valley Clay loam	0.0%	1
St. Toolies Clay	0.0%	1
Guilsboro Clay loam	0.0%	1
Linstead Clay loam	0.0%	1
Tilston Clay	0.0%	1
Gales Valley Clay	0.0%	1
Brysons Clay loam	0.0%	1
Boghole Clay	0.0%	1
Windsor Stony clay	0.0%	1
Agualta Silty clay loam	0.0%	1
Gales Valley Cherty clay	0.0%	1
Effort Loam	0.0%	1
Wildcane Sandy loam	0.0%	1
Gales Valley Cherty sandy clay loam	0.0%	1
Rosehall Clay	0.0%	1
Dunn's River Sandy clay loam	0.0%	1
MW	0.0%	1
Palm Clay	0.0%	1

Soil Name	Landslide Probability	Susceptibility Class
Bachelors Hall Clay	0.0%	1
Salt Island Clay	0.0%	1
Whim Clay loam	0.0%	1
Lodge (non-saline) Clay loam	0.0%	1
Horsecave Clay	0.0%	1
New Yarmouth Loam	0.0%	1
Ramage Silty clay loam	0.0%	1
Sandy Bank Sandy loam	0.0%	1
Clifton Hill Clay	0.0%	1
Bundo Sandy loam	0.0%	1
Halse Hall (red phase) Clay	0.0%	1
Bodles Gravelly clay loam	0.0%	1
Style Hut Clay	0.0%	1
Pera Clay	0.0%	1
MORANT BAY	0.0%	1
New Yarmouth Clay loam	0.0%	1
Agualta Clay loam	0.0%	1
Not used	0.0%	1
Lucky Hill Clay loam	0.0%	1
Diamonds Clay loam	0.0%	1
Deepdene Clay	0.0%	1
St. Ann Clay loam	0.0%	1
Airy Castle Clay	0.0%	1
Wirefence Clay loam	0.0%	1
MA	0.0%	1
Point Clay	0.0%	1
Fellowship Clay	0.1%	1
Harbour Head Clay	0.1%	1

Soil Name	Landslide Probability	Susceptibility Class
Shoothill Clay	0.0%	1
Agualta Silty loam	0.0%	1
Cave Valley Clay	0.0%	1
Roaring River Clay	0.0%	1
Fish River Clay loam	0.0%	1
Wallens Clay	0.0%	1
Heartease Gravelly loam	0.0%	1
Tulloch Silty clay loam	0.0%	1
BC	0.0%	1
Agualta Clay	0.0%	1
Kraal Clay	0.0%	1
Four Paths Clay	0.0%	1
Pennants Clay loam	0.0%	1
Four Paths Loam	0.0%	1
Norris Clay loam	0.0%	1
Morass Peat	0.0%	1
Wallens Silty clay loam	0.0%	1
Knollis Clay	0.0%	1
Shettlewood Clay loam	0.0%	1
Tulloch Sandy loam	0.0%	1
Lluidas Gravelly sandy loam	0.0%	1
Anglesey Clay loam	0.0%	1
Rosemere Fine sandy loam	0.0%	1
Sterling Silty loam	0.0%	1
B3	0.0%	1
RIV	0.0%	1
SAL	0.0%	1
Kildare Gravelly loam	0.0%	1

Soil Name	Landslide Probability	Susceptibility Class
Marymount Clay	0.1%	1
Bonnygate Stony loam	0.1%	1
Shrewsbury Ball Clay	0.2%	1
Nonsuch Clay	0.2%	1
Union Hill Stony clay	0.2%	1
Fontabelle Stony clay loam	0.2%	1
Waitabit Clay	0.2%	1
Seawell Stony clay	0.2%	1
Sunbury Clay	0.2%	1
Breastworks Clay loam	0.3%	1
Sansan Clay	0.3%	1
Agualta Sandy loam	0.3%	1
U	0.4%	1
Leith Hall Clay	0.4%	1
0	0.4%	1
Cuffy Gully Stony sandy loam	0.4%	1
P	0.5%	1
Silverhill Clay loam	0.5%	1
Cuna Cuna Gravelly sandy clay	0.5%	1
Lagoon Peaty loam	0.5%	1
Golden Grove Clay loam	0.5%	1
Salt Bay Gravelly clay loam	0.6%	1
Yallahs Stony loam	0.6%	1
Serge Island Fine sandy clay loam	0.7%	1
Yallahs Loam	0.7%	1
Hall Head Gravelly clay	0.7%	1
Serge Island Gravelly sandy clay loam	0.7%	1
Carron Hall Clay	0.8%	1

Soil Name	*Landslide Probability*	*Susceptibility Class*
Donnington Gravelly clay loam	0.0%	1
Morelands Gravelly sandy clay	0.0%	1
Blackhill Stony clay loam	0.0%	1
Berkshire Sandy loam	0.0%	1
Raheen Clay	0.0%	1
Deepdene Sandy loam	0.0%	1
Berkshire Stony sandy loam	0.0%	1
Boghole Sandy loam	0.0%	1
Vauxhall Clay loam	0.0%	1
Raheen Clay loam	0.0%	1
Holland Clay	0.0%	1
Tydixon Loamy sand	0.0%	1
Trout Hall Sandy clay	0.0%	1
Cashew Clay loam	0.0%	1
Morass (drained) Peat	0.0%	1
Milk Pen Clay	0.0%	1
Harkers Hall Loam	0.0%	1
Hodges Sand	0.0%	1
Pindars Clay	0.0%	1
Hall's Delight Moretown	0.0%	1
Caymanas Sandy loam	0.0%	1
Rhymesbury Clay	0.0%	1
Whim Sandy loam	0.0%	1
Four Paths Stony clay	0.0%	1
Sydenham Sandy loam	0.0%	1
Ferry Silty clay	0.0%	1

Soil Name	*Landslide Probability*	*Susceptibility Class*
Clifton Mount Clay loam	0.9%	1
Water Valley Silty clay	0.9%	1
Fontabelle Clay	1.0%	2
Belfield Association	1.0%	2
Llandewey Clay loam	1.1%	2
Bito Sandy loam	1.1%	2
Halifax Clay	1.1%	2
Flint River Sandy loam	1.2%	2
Hall's Delight Association	1.3%	2
Danvers Pen Gravelly sandy clay loam	1.3%	2
Agualta Loam	1.4%	2
Cuffy Gully-Diamonds Association	1.4%	2
Maverley Loam	1.4%	2
Mears Sandy loan	1.4%	2
Donnington Gravelly loam	1.4%	2
Agualta Stony sandy loam	1.5%	2
Williamsfield Clay loam	1.7%	2
RW	1.7%	2
Rochester Park Gravelly sandy loam	1.7%	2
Spring Gravelly sandy clay loam	2.2%	2
Highgate Clay	2.2%	2
Riverhead Gravelly loam	2.3%	2
Valda-Cuffy Gully Association	2.3%	2
Mocho Clay loam	2.3%	2
Killancholly Clay	2.8%	2
Island Head-Arntully	3.4%	2

Soil Name	Landslide Probability	Susceptibility Class
Caymanas Clay loam	0.0%	1
Halse Hall Clay	0.0%	1
Sydenham Clay	0.0%	1
Cottontree Sandy loam	0.0%	1
Springfield Clay	0.0%	1
SAL/BS	0.0%	1
Lodge (saline) Clay loam	0.0%	1
Bath Association	0.0%	1
Spring Gravelly clay	0.0%	1
Innswood Clay loam	0.0%	1
Churchpen Clay	0.0%	1
Morgans Clay loam	0.0%	1
Rhymesbury Loam	0.0%	1
Serge Island Clay	0.0%	1
Bodles Clay loam	0.0%	1
Hartland Clay	0.0%	1
Colbeck Sandy loam	0.0%	1
St. Jago Clay loam	0.0%	1
Smallwood Sandy loam	0.0%	1

Soil Name	Landslide Probability	Susceptibility Class
Association		
Konigsberg Clay	3.7%	2
Bloxburgh Silty loam	3.7%	2
Bath Gravelly clay loam	3.7%	2
Cuffy Gully Gravelly sandy loam	4.1%	2
Hall's Delight Channery clay loam	4.6%	2
Bolo Clay loam	4.7%	2
Belfield Clay	4.8%	2
R	4.8%	2
Mooretown Clay loam	5.2%	2
Rhine Gravelly clay loam	5.4%	2
Valda Gravelly sandy loam	5.4%	2
Kildare Clay	6.5%	2
Irish Towm Loam	8.0%	2
Arntully Stony loam	9.6%	2
Cuffy Gully Association	10.1%	3
Haldane Sandy loam	10.4%	3
Island Head Clay loam	10.9%	3
Lloyds Clay loam	26.6%	3
Barracks Slity loam	59.5%	3

Appendix 8 – Flora Survey Results

Species Encountered on South-Eastern Lowland Areas

Species	*Common name*	*DAFOR Rank*	*Growth form*
Achyranthes indica	Devil's Horse-whip	O	Herbs
Crotalaria sp.		O	
Cyperus sp.		O	
Emilia javanica	Cupid's Shaving Brush	O	
Euphorbia cyathophora		O	
Euphorbia heterophylla		O	
Heliotropium angiospermum	Dog's Tail	F	
Musa sapientum	Banana	R	
Panicum maximum	Guinea Grass	A	
Paspalum sp.		A	
Priva lappulacea	Clammy Bur	O	
Rivina humilis	Bloodberry	F	
Saccharum officinarum	Sugar Cane	D	
Stachytarpheta jamaicensis	Vervine	F	
Tridax procumbens		F	
Typha domingensis	Reedmace	R	
Vernonia cinerea		O-F	
Antigonon leptopus	Coralita	F	Scramblers/Twiners/Climbers
Centrosema virginianum		F	
Clitoria ternatea	Blue Pea	O-F	
Hylocereus triangularis[8]	God Okra	R-O	
Ipomoea sp.		F	
Mikania micrantha	Guaco	F	
Passiflora maliformis	Sweet Cup	R	
Phaseolus sp.		O	
Phaseolus vulgaris	Red Peas	O	
Tournefortia sp.		O	
Trichostigma octandrum	Basket Withe	O-R	
Allamanda cathartica	Yellow Allamanda	F	Shrubs
Lantana camara	White/Wild Sage	F	
Pisonia aculeata	Cockspur	F	
Plumbago sp.		F-A	
Sida acuta	Broomweed	A	
Solanum erianthum	Wild Susumber	R	

[8] Endemic

Species	*Common name*	*DAFOR Rank*	*Growth form*
Solanum torvum	Susumber	R	
Urechites lutea	Nightshade	R	
Yucca aloifolia	Spanish Dagger	R-O	
Cassia occidentalis	Dandelion	O	Shrubby Herbs
Cathranthus roseus	Periwinkle	R	
Mimosa pudica	Shame-o-lady	O	
Urena lobata	Ballard Bush	A	
Waltheria indica	Raichie	R	
Acacia tortuosa	Wild Poponax	F	Trees
Alchornea latifolia	Dovewood	R	
Annona sp.		R	
Bambusa vulgaris	Bamboo	O	
Bauhinia divaricata	Bull Hoof	O	
Bauhinia variegata	Poor Man's Orchid	R	
Blighia sapida	Ackee	O	
Cassia emarginata	Senna Tree	O	
Cassia sp.		O	
Cecropia peltata	Trumpet Tree	R	
Ceiba pentandra	Silk Cotton Tree	O	
Citrus spp.	Orange	R	
Cocus nucifera	Coconut	F	
Cordia alba	Duppy Cherry	O-F	
Delonix regia	Poinciana	R	
Ficus maxima		R	
Guazuma ulmifolia	Bastard Cedar	O	
Leucaena leucocephala	Lead Tree	F	
Melicoccus bijugatus	Guinep	R	
Nectandra sp.		R	
Pithecellobium unguis-cati	Privet	O	
Psidium guajava	Guava	R	
Samanea saman	Guango	F	
Spathodea campanulata	African Tulip Tree	O	
Terminalia catappa	West Indian Almond	O	
Ziziphus mauritiana	Coolie Plum	R-O	

Species Encountered on Eastern Highland Areas

Species	*Common name*	*DAFOR (Stite C)*	*DAFOR (Sites D-G)*	*DAFOR (Sites H-I)*	*Growth form*
Amaranthus crassipes				R	Herbs
Asclepias curassavica	Red Top		R		
Bromelia penguin	Pingwing	O	F		
Bryophyllum pinnatum	Leaf-of-Life			O	
Commelina diffusa	Water Grass	R-O			
***Cyperus* sp.**			O		

Species	Common name	DAFOR (Stite C)	DAFOR (Sites D-G)	DAFOR (Sites H-I)	Growth form
Euphorbia heterophylla			O		
Heliotropium angiospermum	Dog's Tail			R	
***Hyptis* sp.**			O		
Leonotis nepetifolia	Christmas Candlestick		O		
Musa sapientum	Banana		R	R	
Panicum maximum	Guinea Grass	A	A	O-R	
Rhynchelytrum repens	Natal Grass		O-F		
Rivina humilis	Bloodberry		F		
Saccharum officinarum	Sugar Cane		O-R	O-R	
Sansevieria trifasciata	Tiger Cat	F	A	F-A	
Stachytarpheta jamaicensis	Vervine	A	F	F	
Vernonia cinerea				R	
Abrus precatorius	Crab Eyes	F	F	F	Scrambler/Twiner/ Climbers
Centrosema virginianum			F		
***Hylocereus triangularis*[9]**	God Okra, Prickle Withe		O		
***Ipomoea* sp.**			F		
Mikania micrantha	Guaco		F	O	
Mucuna pruriens	Cowitch	R			
***Tournefortia* sp.**			O		
Trichostigma octandrum	Basket Withe	O			
Urechites lutea	Nightshade, Nightsage	O	F	F	
***Agave* sp.**		O			Shrubs
Allamanda cathartica	Yellow Allamanda	F			
Ateramnus lucidus	Crab Wood		O-F		
Cajanus cajan	Gungo Pea		O		
Chromalaena (Eupatorium) odoratum	Christmas Bush		O		
***Clerodendrum* sp.**			O-F		
Croton linearis			R	R-O	
Euphorbia nudiflora			O		
Hibiscus rosa-sinensis	Hibiscus			O	

[9] Endemic

Species	Common name	DAFOR (Stite C)	DAFOR (Sites D-G)	DAFOR (Sites H-I)	Growth form
Jatropha gossypiifolia	Belly-ache Bush		O		
Jatropha integerrima				O	
Jatropha podagrica	Coral Plant			O	
Lantana camara	White Sage, Wild Sage		F	F	
Lantana jamaicensis?[10]		R-O			
***Malpighia* sp.**		O			
Piper amalago******	Black Jointer			R	
Pisonia aculeata	Cockspur	O	F	F	
***Plumbago* sp.**			F	F	
Punica granatum	Pomegranate			R	
Ricinus communis	Castor Oil Plant, Oil Nut		O-F		
Sida acuta	Broomweed	A	F	A	
Solanum erianthum	Wild Susumber		R		
Solanum torvum	Susumber		O		
Tecoma stans			O	O	
Mimosa pudica	Shame-o-lady			O-F	Shrubby Herbs
Rhynchospora nervosa	Star Grass		O		
Waltheria indica	Raichie		F		
Acacia tortuosa	Wild Poponax		D		Trees
Adenanthera pavonina	Red Bead Tree	O			
Albizia lebbeck	Woman's Tongue Tree		F		
Alchornea latifolia	Dovewood		O-R		
Annona muricata	Sour sop		O		
Annona squamosa	Sweet Sop		O	O	
Artocarpus altilis	Breadfruit		O		
Bambusa vulgaris	Bamboo		R	R	
Bauhinia divaricata	Bull Hoof	O	O	F	
Blighia sapida	Ackee		O	O	
Bursera simaruba	Red Birch	R-O	O	O	
Cassia emarginata	Senna Tree, Yellow Candle Wood		O-F		
***Cassia* sp.**		O			
Casuarina equisetifolia	Willow			R	
Catalpa longissima	French Oak			O	

[10] Endemic

Species	***Common name***	***DAFOR (Stite C)***	***DAFOR (Sites D-G)***	***DAFOR (Sites H-I)***	***Growth form***
Cecropia peltata	Trumpet Tree			R	
Chrysophyllum cainito	Star Apple			R	
***Citrus* spp.**	Orange		O	O	
Cocus nucifera	Coconut		R	O	
Cordia collococca	Clammy Cherry		R-O		
***Cordia* sp.**		R			
Crescentia cujete	Calabash Tree		O		
Delonix regia	Poinciana	F	O	F	
Guazuma ulmifolia	Bastard Cedar	F	O	O	
Haematoxylum campechianum	Logwood	F-A	A	F-A	
Kigelia africana	Sausage Tree			R	
Leucaena leucocephala	Lead Tree	D	A	D	
Malpighia glabra	Wild Cherry		O		
Mangifera indica	Mango		O-F	O	
Manilkara zapota	Naseberry			R	
Melicoccus bijugatus	Guinep			O-R	
Morinda citrifolia	Noni	R	R		
***Nectandra* sp.**		F			
Piscidia piscipula	Dogwood	O	F		
Pithecellobium unguis-cati	Privet		F	F	
Psidium guajava	Guava			O	
Pterocarpus officinalis	Dragon's Blood Tree			R	
Samanea saman	Guango		O	O	
Simarouba glauca	Bitter Damson			R	
Tamarindus indica	Tamarind			R	
Terminalia catappa	West Indian Almond			O	
Thrinax parviflora[11]	Broom Thatch	O-F	O-F	O	

Species Encountered in Intermediate Areas

Species	***Common name***	***DAFOR***	***Growth form***
Bidens pilosa	Spanish Needle	F	Herbs
Emilia javanica	Cupid's Shaving Brush	F	
Leonotis nepetifolia	Christmas Candlestick	F	

[11] Endemic

Species	***Common name***	***DAFOR***	***Growth form***
Musa sapientum	Banana	F	
Panicum maximum	Guinea Grass	D	
***Paspalum* sp.**		A	
Rivina humilis	Bloodberry	O	
Saccharum officinarum	Sugar Cane	R	
Sansevieria trifasciata	Tiger Cat	O-R	
***Sporobolus* sp.**		A	
Tribulus cistoides	Kingston Buttercup	F	
Xanthosoma sagittifolium	Coco	O-F	
Antigonon leptopus	Coralita	F	Scrambler/Twiner/Climber
Thunbergia alata	Black-Eyed Susan	O	
Allamanda cathartica	Yellow Allamanda	F	Shrubs
Cajanus cajan	Gungo Pea	O	
Croton linearis		O	
Lantana camara	White Sage, Wild Sage	F	
Pisonia aculeata	Cockspur	O	
***Plumbago* sp.**		F	
Punica granatum	Pomegranate	R	
Ricinus communis	Castor Oil Plant, Oil Nut	O	
Solanum erianthum	Wild Susumber	R	
Solanum torvum	Susumber	R	
Tecoma stans		F	
Cassia occidentalis	Dandelion	R	Shrubby Herb
Alchornea latifolia	Dovewood	O	Trees
Annona muricata	Sour sop	O	
Blighia sapida	Ackee	F	
Catalpa longissima	French Oak	R	
Cocus nucifera	Coconut	O	
Delonix regia	Poinciana	F	
Mangifera indica	Mango	F	
***Nectandra* sp.**		O	
Psidium guajava	Guava	R	
Samanea saman	Guango	O	
Spondias dulcis	Jew Plum	R	
Terminalia catappa	West Indian Almond	O	
Thrinax parviflora[12]	Broom Thatch	R-O	

[12] Endemic

Species Encountered along Western Highland Areas

Species	Common Name	DAFOR	Growth Form
Adiantum sp.	Maiden Hair Fern	R	Ferns
Nephrolepis sp.		F	
Thelypteris dentata		O	
Agave sp.		O	Herbs
Aloe vera	Sinkle Bible	R	
Anthurium sp.		R	
Bidens dissecta[13]		R	
Bidens pilosa	Spanish Needle	O-F	
Bromelia pinguin	Ping Wing	O	
Bryophyllum pinnatum	Leaf-of-Life	R	
Colocasia esculenta	Dasheen	R	
Mimosa pudica	Shame weed	R	
Panicum maximum	Guinea Grass	O	
Paspalum sp.		R-O	
Rhoeo spathacea	Oyster Plant	R-O	
Sida sp.		F-A	
Stachytarpheta jamaicensis	Vervine	O	
Tridax procumbens		R	
Centrosema pubescens		O	Scrambler/Twiner/Climber
Cissus sicyoides	Snake Withe	O	
Clitoria sp.		O	
Cromolaena odorata	Christmas Bush	O	
Ipomoea spp.		A	
Merremia dissecta	Know You	R	
Mucuna puriens	Cowitch	R	
Vitis tiliifolia	Wild Grape	R-O	
Ateramnus lucidus	Crab Wood	O	Shrubs
Bambusa vulgaris	Bamboo	O	
Bastardia bivalvis		O	
Bixa orellana	Anatto	R	
Bocconia frutescens	John Crow Bush	O	
Byrsonima coriacea	Hogberry	R	
Caesalpinia major	Yellow Nickal	R-O	
Cordia bullata[14]		O	
Croton linearis	Rosemary	O-F	
Dracaena sp.		R	
Eupatorium heteraclinium§		R	
Gossypium barbadense	Sea-Island Cotton	R	

[13] Endemic (Adams 1972; Parker 2003)
[14] Endemic (Adams 1972; Parker 2003)

Species	***Common Name***	***DAFOR***	***Growth Form***
Lisianthus longifolius§	Jamaican Fuchsia	R	
Malvaviscus arboreus var. Penduliflorus	Sleeping Hibiscus	R	
Piper amalago§	Black Jointer	O	
Pisonia aculeata	Cockspur	F	
Randia aculeata	Indigo Berry	R-O	
Ricinus communis	Castor Oil	O	
Vernonia divaricata	Fleabane	O	
Cassia ligustrima		R	Shrubby Herbs
Lantana camara	Wild Sage	O-F	
Sida acuta	Broomweed	F	
Sida glutinosa		O-F	
Sida urens		O-F	
Triumfetta lappula		R	
Turnera ulmifolia	Ram-Goat Dashalong	O	
Urena lobata	Ballard Bush	F-A	
Watheria indica	Raichie	O-F	
Acacia tortuosa	Wild Poponax	F	Trees
Alchornea latifolia	Dovewood	O	
Annona squamosa	Sweet Sop	O	
Artocarpus altilis	Breadfruit	R-O	
Bauhinia divaricata	Bull-Hoof	R-O	
Blighia sapida	Ackee	F	
Bumelia sp.	Bully Tree	R	
Bursera simarouba	Red Birch	O-F	
Caesalpinia pulcherrima	Barbados Pride	R	
Cassia emarginata	Yellow Candle Wood	O	
Cecropia peltata	Trumpet Tree	R	
Citrus aurantifolia	Lime	R	
Clusia flava	Tar Pot	R	
Cocus nucifera	Coconut	R	
Commocladia pinnatifolia	Maiden Plum	F	
Commocladia velutina§	Velvet-leaved Maiden Plum	O	
Crescentia cujete	Calabash Tree	R	
Delonix regia	Poincianna	F	
Fagara martinicensis	Prickly Yellow	O	
Guazuma ulmifolia	Bastard Cedar	F	
Haematoxylum campechianum	Logwood	F	
Malpighia sp.		O	
Manilkara zapota	Naesberry	R	
Melicoccus bijugatos	Guinep	R	
Miconia sp.		R	

Species	Common Name	DAFOR	Growth Form
Nectandra sp.		O	
Pimenta dioica	Allspice	O	
Syzigium jambos	Otaheite Apple	R	
Thrinax parviflora[15]	Broom Thatch	F-A	

[15] Endemic (Adams 1972; Parker 2003)

Species Encountered on Nothern Face of Western Highlands and the plains of the North-Western Lowland Areas

Scientific name	Common name	Growth form	Location	DAFOR
Abrus precatorius	Crab Eyes	Climbers/Twiners	N	F
Asystasia gangetica			N	O
***Dioscorea* sp.**	Yam		Flats	O
Mikania micrantha	Guaco		N & O	F
Mucuna pruriens	Cowitch		O	F
Paulinia jamaicensis	Supple Jack		N	O
Syngonium auritum	Five Finger		O	F
Thunbergia alata	Black-Eyed Susan		N	F
Thunbergia fragrans	White Nightshade		N & O	O
***Adiantum* sp.**	Maiden Hair Fern	Fern	O	O
***Asplenium* sp.**			N	O
***Nephrolepsis* sp.**			N & O	O
Thelypteris dentata			N	O
Bidens pilosa	Spanish Needle	Herbs	N & O	O
Borreria laevis	Buttonweed		O	O
Catharanthus roseus	Periwinkle		N	O
Colocasia esculenta	Dasheen		N & O	R
Commelina diffusa	Water Grass		N	O-R
Emilia javanica	Cupid's Shaving Brush		N	R
***Hyptis* sp.**			N	R
Leonotis nepetifolia	Christmas Candlestick		N	O-R
Musa sapientum	Banana		O	R
Oeceoclades maculata			N	O
Panicum maximum	Guinea Grass		N	A
***Paspalum* sp.**			N	O
Rivina humilis	Bloodberry		N	O
Ruellia tuberose	Duppy Gun		N	R
Saccharum officinarum	Sugar Cane		Flats	A
Stachytarpheta jamaicensis	Vervine		N	O-R
Vernonia cinerea			N	R
Bambusia spp.	Bamboo	Shrubs	N	R
Cajanus cajan	Gungo Pea		Flats	O
Chromalaena (Eupatorium) odoratum	Christmas Bush		N	R
Gossypium barbadense	Sea Island Cotton		O	R
Hibiscus rosa-sinensis	Hibiscus		Flats	R
Jatropha divaricata	Wild Oil Nut		Flats	R
Lantana camara	White/Wild Sage		N	O

Scientific name	Common name	Growth form	Location	DAFOR
Malpighia glabra	Wild Cherry		N	O
***Miconia* sp.**	Melastome		N	R
***Piper amalago*[16]**	Black Jointer		N	R
Pisonia aculeata	Cockspur		N	O
Sida acuta	Broomweed		O	O
Solanum torvum	Susumber		Flats	O
Yucca aloifolia	Spanish Dagger		Flats	R
Adenanthera pavonina	Red Bead Tree	Trees	N & O	A
Amyris plumieri	Candlewood		N	O
Artocarpus altilis	Breadfruit		Flats	O
Bauhinia divaricata	Bull Hoof		N	R
Blighia sapida	Ackee		Flats	R
Brosmimum alicastrum	Breadnut		O	O
Bursera simarouba	Red Birch		N	O
***Cassia* sp.**			N	R
Cecropia peltata	Trumpet Tree		N	O
Chrysophyllum cainito	Star Apple		Flats	R
***Citrus* sp.**	Orange		Flats	A
Cocus nucifera	Coconut		Flats	O
Comocladia pinnatifolia	Maiden Plum		N	O
Cordia gerascanthus	Spanish Elm		N	O-A
Cupania americana	Wild Ackee		O	O
Delonix regia	Poinciana		N	O
Fagara martinicensis	Prickly Yellow		N	O
***Ficus* sp.**			O	R
Guazuma ulmifolia	Bastard Cedar		N	O
Haematoxylum campechianum	Logwood		N	O
Mangifera indica	Mango		Flats	O
Manilkara zapota	Naseberry		Flats	R
***Nectandra* sp.**			N	O
Pimenta dioica	Pimento		N	R
Piscidia piscipula	Dogwood		N	O
Pouteria multiflora	Bully Tree		O	O-R
***Roystonea altissima*[17]**	Mountain Cabbage		N	O-A
***Schefflera* sp.**			O	O-A
Spathodea campanulata	African Tulip Tree		N	D
***Thrinax parviflora*[§§§]**	Broom Thatch		N	O-A
Trophis racemosa	Ramoon		N	F

[16] Endemic (Adams 1972; Parker 2003)
[17] Endemic (Adams 1972; Parker 2003)

Appendix 9 – Avifauna Survey Results

Table 12.1 - DAFOR scale used to categorized the birds identified in the study

	Total number of birds observed during the survey (2 days)
Dominant	≥ 20
Abundant	15 – 19
Frequent	10 – 14
Odd	5- 9
Rare	< 4

Table 12.2 - Birds observed from the transects for the propose highway during the assessment.

Common Name	Scientific Name	Status	Tran 1	Tran 2	Tran 3	Tran 4	Tran 5
American Kestrel	*Falco sparverius*	*Resident*	R			R	
American Redstart	*Setophaga ruticilla*	*Migrant*		O	R	O	
Antillean Palm Swift	*Tachornis phoenicobia*	*Resident*	O				
Arrow-headed Warbler	*Dendroica pharetra*	*Endemic*				R	
Bananaquit	*Coereba flaveola*	*Resident*	A			A	R
Barn Swallow	*Hirundo*	*Migrant*				R	
Black and White Warbler	*Mniotilta varia*	*Migrant*	R	R		R	
Black-faced Grassquit	Tiaris bicolor	*Resident*	R			R	O
Black-Whiskered Vireo	*Vireo altiloquus*	*Resident*	O		O	O	R
Caribbean Dove	*Leptotila jamaicensis*	*Resident*	O		O	O	
Cattle Egret	Bubulcus ibis	*Resident*				O	D
Cave Swallow	*Petrochelidon fulva*	*Resident*			O	F	F
Chestnut Mannikin	*Lonchura atricapilla*	*Resident*				R	
Common Ground Dove	*Columbina passerina*	*Introduce*	O		R	A	A
Glossy Ibis	*Plegadis falcinellus*	*Resident*					F
Greater Antillean Bullfinch	*Loxigilla violacea*	*Resident*	R			R	
Greater Antillean Grackle	*Quiscalus niger*	*Resident*	O			F	A
Jamaica Tody	*Todus todus*	*Endemic*	O	O	R	R	
Jamaican Elania	*Myiopagis cotta*	*Endemic*	R				
Jamaican Euphonia	*Euphonia Jamaica*	*Endemic*	F			R	R
Jamaican Lizard-	*Saurothera vetula*	*Endemic*	O		R	O	

Common Name	Scientific Name	Status	Tran 1	Tran 2	Tran 3	Tran 4	Tran 5
cuckoo							
Jamaican Mango	*Anthracothorax mango*	*Endemic*	O			R	
Jamaican Oriole	*Icterus leucopteryx*	*Endemic*	O	R	R	R	
Jamaican Pewee	*Contopus pallidus*	*Endemic*	R	O			
Jamaican Vireo	*Vireo modestus*	*Endemic*	R	R		O	
Jamaican Woodpecker	*Melanerpes radiolatus*	*Endemic*	O			O	
Loggerhead Kingbird	*Tyrannus caudifasciatus*	*Resident*	R		O	D	D
Mangrove Cuckoo	*Coccyzus minor*	*Resident*	R			R	
Nothern Mockingbird	*Mimus polyglottos*	*Resident*		O	O	A	
Olive-throated Parakeet	*Aratinga nana*	*Resident*	F	O	O	O	
Orange Bishop	*Euplectes franciscanus*	*Introduced*					F
Ovenbird	*Seiurus aurocapillus*	*Resident*	R				
Prairie Warbler	*Dendroica discolor*	*Migrant*				R	
Red-billed Streamertail	*Trochilus polytmus*	*Endemic*	O			R	
Red-tailed Hawk	*Buteo jamaicensis*	*Resident*				R	
Sad Flycatcher	*Myiarchus barbirostris*	*Endemic*	R			R	
Saffron Finch	*Sicalis flaveola*	*Resident*					R
Smooth-billed Ani	Crotophaga ani	Resident	F			A	A
Stolid Flycacther	*Myiarchus stolidus*	*Resident*	R			R	
Turkey Vulture	*Carthartes aura*	*Resident*	O		O	O	O
Vervain Hummingbird	*Mellisuga minima*	*Resident*	O	R		F	O
White Crowned Pigeon	*Columba leucocephala*	*Resident*	O			A	
White-chinned Thrush	*Turdus aurantius*	*Endemic*	R		R	R	
White-Collared Swift	*Streptoprocene zonaris*	*Resident*				O	
White-Winged Dove	*Zenaida asiatica*	*Resident*	O			F	
Yellow-faced Grassquit	*Tiaris olivacea*	*Resident*	O	O	O	A	D
Yellow-shouldered Grassquit	*Loxipasser anoxanthus*	*Endemic*	R			O	
Zenaida Dove	*Zenaida aurita*	*Resident*				F	A

Appendix 10 – Invertebrate Fauna Survey Results

Site 1

Phylum: Mollusca

FAMILY	GENUS & SPECIES	DAFOR RATING	COMMENTS
Pleurodontidae	*Pleurodonte sp.*	D	Pulmonate, endemic
Sagdidae	*Sagda spei*	O	Pulmonate, endemic
Neocyclotidae	*Cyclochittya chittyi*	O	Operculate,endemic
Camenidae	*Zachrysia provisoria*	O	Introduced by humans
	Annularia mitis	O	Operculate

Phylum: Arthropoda

Class: INSECTA

ORDER & FAMILY	GENUS & SPECIES	COMMON NAME	DAFOR RATING
LEPIDOPTERA Nymphalidae	*Mestra dorcas*	Dorcas	R
Heliconiidae	*Dryas iulia delia*	Julia	O
Satyridae	*Calisto zangis*	The Jamaican Satyr	O
Pieridae	*Eurema messalina messalina*	Fabricius's Small White Sulphur	O
	Phoebis sennae	Cloudless sulphur	
Hesperidae	*Urbanus proteus*		
HYMENOPTERA	*Polisties crinitus*	Red wasps, paper wasps	O
	Apis melifera	Honey bee	O
ISOPTERA	*Nasutitermes nigriceps*	Termites, duck ants	O

Site 2

Phylum: Mollusca

FAMILY	GENUS & SPECIES	DAFOR RATING	COMMENTS
Orthalicidae	*Orthalicus undatus jamaicensis*	O/R	Endemic subspecies
Pleurodontidae	*Pleurodonte sp.*	D	Pulmonate,
	Dentellaria invalida	O	??
Sagdidae	*Sagda spei*	F	Pulmonate, endemic
	Hyalosagda arboreioides	O	Pulmonate, endemic
Urocoptidae	**Urocoptis aspera*	A	Pulmonate,endemic
Neocyclotidae	*Cyclochittya chittyi*	O	Operculate,
Helicinidae	*Eutrochatella pulchella*	O	Operculate, endemic
Annularidae	*Annularia* sp.	O	Operculate
	Parachondria fecunda	O	Operculate, endemic
	Lucidella aureola	O	Operculate, endemic
Helicinidae	*Helicinia neritella neritella*	R	Operculate, endemic
Oleacinidae	*Varicella dominicensis*	R	Pulmonate, endemic

* Live specimens seen

Phylum: Arthropoda

Class: INSECTA

ORDER & FAMILY	GENUS & SPECIES	COMMON NAME	DAFOR RATING
LEPIDOPTERA			
Heliconiidae	*Dryas iulia delia*	Julia	O
Hesperidae	*Urbanus proteus*		
HYMENOPTERA	*Polisties crinitus*	Red wasps, paper wasps	O
	Apis melifera	Honey bee	O
ISOPTERA	*Nasutitermes nigriceps*	Termites, duck ants	O
ODONATA			

Site 3

Phylum: Mollusca

FAMILY	GENUS & SPECIES	DAFOR RATING	COMMENTS
	Zachrysia provisoria	D	Introduced by humans
Camaenidae	*Dentellaria invalida*	O	
Pleurodontidae	*Pleurodonte lucerna*	A	Pulmonate (2 teeth)
	Pleurodonte sp.	R	Pulmonate , *1 tooth, large shell, old*
	Cyclochittya chittyi	R	Operculate
Urocoptidae	*Urocoptis brevis*	R	Pulmonate, endemic
Helicinidae	*Helicinia neritella*	R	Operculate, endemic
Bulimulidae	*Drymaeus immaculatus*	R	Pulmonate, endemic
Subulinidae	*Lamellaxis sp.*	R	Pulmonate

Phylum: Arthropoda

Class: HEXAPODA

ORDER & FAMILY	GENUS & SPECIES	COMMON NAME	DAFOR RATINGS
LEPIDOPTERA			
Papilionidae	*Papilio thersites*	Thersites Swallowtail	O
Peridae	*Phoebis sennae*	Cloudless sulphur	
Nymphalidae	*Mestra dorcas*	Dorcas	O
Heliconidae	*Dryas iulia delia*	Julia	O

Site 4

Phylum: Mollusca

FAMILY	*GENUS & SPECIES*	*DAFOR RATING*	*COMMENTS*
Orthalicidae	*Ortahlicus undatus jamaicensis*	R	Pulmonate; Endemic subspecies
Pleurodontidae	*Pleurodonte* sp.	D	Pulmonate; 2 teeth;
Camenidae	*Zachrysia provisoria*	F	Introduced by human
	Dentellaria valida	A	
Sagdidae	*Sagda spei*	R	Pulmonate, endemic
Urocoptidae	*Urocoptis aspera*	O	Pulmonate, endemic
Neocyclotidae	*Cyclochittya chittyi*	O	Operculate, endemic
Helicinidae	*Lucidella aureola*	F	Operculate, endemic

Phylum: Arthropoda

Class: HEXAPODA

ORDER & FAMILY	*GENUS & SPECIES*	*COMMON NAME*	*DAFOR RATINGS*
COLEOPTERA Cerambycidae	*Eburia tetrastalcata*		R
LEPIDOPTERA Hesperiidae	*Agura asander*		R
Papilionidae	*Papilio thersites*	The Thersites Swallowtail	O
Peridae	*Phoebissennae*	Cloudless sulphur	
Nymphalidae	*Mestra dorcas*	Dorcas	O
Heliconidae	*Dryas iulia delia*	Julia	O
DIPTERA Bombilidae	*Poecilanthrax lucifer*		R

Class: ARACHNIDA

Order: Scorpiones: one large, unidentified

Site 5 Cane Fields

Phylum: Arthropoda

Class: INSECTA

ORDER & FAMILY	GENUS & SPECIES	COMMON NAME	DAFOR RATING
LEPIDOPTERA			
Pieridae	*Eurema nise nise*	Cramer's Little Sulphur	F
	Ascia monuste	Cabbage White	F
	Phoebis sennae sennae	Cloudless sulphur	F
Nymphalidae	*Junonia (Precis) evarete*		O
Heliconiidae	*Dione vanillae*		O
Lycaenidae	*Leptotes perkinsae*		F
COLEOPTERA			
Coccinellidae	*Brachyacantha bistripustulata*		O
Curculionidae	*Cosmopolites sordidus*	Banana Root weevil	R
HYMENOPTERA		Mud wasp	R
Sphecidae	*Sceliphron assimile*		
Vespidae	*Poliste crinitus*	Paper wasp	O
Apidae	*Apis melifera*	Honey bee	
ODONATA			
	Erythemis plebja	Dragon fly	F/A
HEMIPTERA			
Pentatomidae	*Euschistus sp.*		O
DIPTERA			
Syrphidae	*Toxomerus pulchellus*		R

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