Environmental Impact Assessment

MONTEGO BAY PERIMETER ROAD, LONG HILL BYPASS AND WEST GREEN AND BARNETT STREET UPGRADE, ST. JAMES

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Submitted by:	CL ENVIRONMENTAL ENVIRONMENTAL CONSULTANTS
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ENVIRONMENTAL IMPACT ASSESSMENT FOR THE MONTEGO BAY PERIMETER ROAD, LONG HILL BYPASS AND WEST GREEN AND BARNETT STREET UPGRADE, ST. JAMES

Submitted to:

NATIONAL ROAD OPERATING AND CONSTRUCTING COMPANY LIMITED

4th Floor DBJ Building

11a Oxford Road

Kingston 5

Submitted by:

CL ENVIRONMENTAL CO. LTD.

20 Windsor Avenue

Kingston 5

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A	AADT	Annual average daily traffic
	ACGIH	American Conference of Industrial Hygienists
	AASHTO	American Association of State Highway and Transportation Officials
	AMC	Antecedent moisture conditions
	amsl	Above mean sea level
B	BA	Basal area
C	C	Celsius
	CH	Chainage
	CBD	Convention on Biological Diversity
	CCCL	Caribbean Cement Company Limited
	CDMP	Caribbean Disaster Mitigation Project
	CN	Curve number
	CO	Carbon Monoxide
	CO2	Carbon Dioxide
D	DAFOR	Dominant, Abundant, Frequent, Occasional, Rare
	dBA	A-weighted sound level (decibel)
	DBH	Diameter at breast height
	DCR	Design Concept Report
	DEM	Digital elevation model
	DO	Dissolved oxygen
E	E	East/ Easting
	EB	Eastbound
	EIRR	Economic Internal Rate of Return
	EAM	Environmental Assessment Memorandum
	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
	LOS	Level of service
M	m	Metre
	m/s	Metres per second
	m3/sec	Cubic metres per second
	mg/l	Milligrams per litre
	mg/m^3	Milligrams per cubic metre
	min	Minute (s)
	mm	Millimetre
	mm/24 hr	Millimetres per 24 hour period
	mS/cm	milli Siemens per cm
	MSDS	Material Safety Data Sheets
	MCE	Multi criteria evaluation
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
	NPV	Net present value
	NRCA	Natural Resources Conservation Act
	NSWMA	National Solid Waste Management Authority
	NTU	Nephelometric turbidity units
	NWA	National Works Agency
	NWC	National Water Commission
O	ODPEM	Office of Disaster Preparedness and Emergency Management
	OSHA	Occupational Safety and Health Administration
P	PCQ	Point-Centred Quarter
	PEL	Hearing Conservation and Permissible Exposure Limit
	PIF	Project Information Form
	PM10	Particulate matter smaller than 10 microns in diameter, respirable particulate matter
	PM2.5	Particulate matter smaller than 2.5 microns in diameter, fine particulate matter
	ppm	parts per million
	ppt	parts per thousand
	PSMP	(Jamaica) Public Sector Modernization Project
Q	QSP II	Quest suite Professional II

R	RADA	Rural Agriculture Development Agency
	ROW	Right of Way
S	s	Second
	SCHIP	Southern Coastal Highway Improvement Project
	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
	TWSC	Two-way-stop-controlled
U	USEPA	United States Environmental Protection Agency
V	vpd	Vehicles per day
W	WHO	World Health Organization
	WRA	Water Resources Authority
	WB	Westbound
Y	yr.	Year

EXECUTIVE SUMMARY

PROJECT BACKGROUND

Montego Bay, Jamaica's second largest City, is located in the parish of St. James along Jamaica's north coast. It is Jamaica's premier tourist destination, home of Jamaica's busiest airport and welcomes cruise ships to its port two days per week. Montego Bay is also the only city in the western region of Jamaica, and therefore provides major governmental services to neighbouring parishes. The commercial centre with all its amenities lies at the heart of the city with its main thoroughfare along the coast.

Traffic congestion in the city has been a longstanding issue as there is essentially one main thoroughfare connecting the east to the west of the city. Apart from the typical morning and evening peak hour traffic, the city often becomes gridlocked during times of heavy rainfall due to flooding, and on cruise ship days or other major activities or incidents, and productivity is lost because of the lengthy delays caused by traffic. The National Road Operating and Constructing Company Limited (NROCC), working through the Ministry of Economic Growth and Job Creation (MEGJC), has acquired funding for the development of an alternative route around the central business district (CBD) in Montego Bay to reduce congestion in the city and to spur economic benefit.

It was decided that an Environmental Impact Assessment (EIA) and the specific tasks outlined in the approved TORs were executed by CL Environmental Co. Ltd. This report serves to compile and present the findings of the EIA.

PROJECT DESCRIPTION

Overview and Project Location

The following four components are included in the proposed project

1 - **Montego Bay Perimeter Road** - approximately 15.4 km, starting at Alice Eldemire Drive and Howard Cooke Highway with the end point at the Intersection with the A1 North Coast Highway at Ironshore. It traverses the communities of Coral Gardens, Salt Spring, Montego Hill, Porto Bello, John's Hall, Bogue, Catherine Mount, Irwin, Fairfield and Norwood.

2 - **Long Hill Bypass** - encompasses the construction of approximately 10.5 kilometres of 2-lane, rural arterial highway leading from Montpelier intersection of B8 Road and B6 Road to Temple Gallery Road. The implementation of this road section will essentially connect the Montego Bay Perimeter Road with the western end of the Phase 2B corridor of the East West Highway. Bogue, Fairfield, Anchovy, Mount Carey and Bickersteth are the communities in which this alignment is located.

3 - **Barnett Street Upgrade** - located in Mount Salem, West Green and Catherine Mount (Figure 1 2). It involves is the dualization of 1.06 km of the existing two-lane road section from the intersection of West Green and Fairfield road in a northerly direction and ending at Cottage

road. The proposed works will involve the construction of an additional two-lane bridge over the Montego Bay River in the vicinity of the West gate Shopping Centre.

4 - **West Green Avenue Upgrade** - located in Bogue and is the dualization of the 0.82 km existing link road between Howard Cooke Boulevard and the Bogue Road at the Fairfield Road intersection.

Montego Bay Perimeter Road

Structures

Bridge structures have also been identified at locations where the proposed perimeter road alignments intersect existing roadways and connectivity across the new highway is required. In total there are ten locations identified as structural (bridge) crossings, 4 mainline structures and 6 crossroad structures. Superstructure types considered include cast-in-place (CIP) conventionally reinforced concrete slab spans, precast/pre-stressed (PC/PS) concrete girders, and composite steel girders.

Drainage structures of less than 6.0m in length will be spanned by culverts or RCBCs. The following sections are highlighted owing to special drainage conditions that exist:

1 - Chainage 10+500 to 11+400: Highway passes through wetland area close to the sea.
2 - Chainage 13+600 to 14+000: Realignment of the Montego River.
3 - Chainage 13+730: Major box culvert where the highway crosses the Tucker Spring (tributary to the Montego River).
4 - Chainage 17+160: Bridge structures where the highway and an access road (connecting the Porto Bello and Irwin communities) crosses the Montego River.

Main Technical Parameters

ITEM	UNIT	VALUE (General road section)	VALUE (Tough road section)
Road grade		Arterial Roads	Arterial Roads
Design Speed	Km/h	90	60
Road Width	m	25.2	25.2
Number of bi-directional lanes	No.	4	4
Lane width	m	3.65	3.65
Width of medial strip	m	3.6	3.6
Width of hard shoulder	m	2.5	2.5
Min. circular curve radius	m	300	180
Min. length of transition curve	m	150	100
Max. longitudinal slope	%	8	8
Pavement type		Asphalt concrete	Asphalt concrete
Camber crosswise slope	%	2.0	2.0

Long Hill Bypass

Structures

Seven (7) bridges are planned for Long Hill Bypass, all of which are overpasses.

Main Technical Parameters

Item	Unit	Value
Road grade		Arterial Road
Design speed	Km/h	95
Road width	m	10.9
Number of bi-directional lanes	No.	2
Lane width	m	3.65
Width of medial strip	m	0
Width of hard shoulder	m	1.5
Min. circular curve radius	m	400
Min. length of transition curve	m	150
Max. longitudinal slope	%	8
Pavement type		Asphaltic concrete
Camber crosswise slope	%	2.0

Barnett Street Upgrade

Main Technical Parameters

Item	Unit	Value
Road grade		Arterial Roads
Design speed	Km/h	60
Road width	m	24.8
Number of bi-directional lanes	No.	4
Lane width	m	3.65
Width of medial strip	m	3
Width of hard shoulder	m	2.5
Min. circular curve radius	m	300
Min. length of transition curve	m	150
Max. longitudinal slope	%	8
Pavement type		Asphaltic concrete
Camber crosswise slope	%	2.0

West Green Avenue Upgrade

Main Technical Parameters

Item	Unit	Value
Road grade		Arterial Roads
Design speed	Km/h	60
Road width	m	24.8
Number of bi-directional lanes	No.	4
Lane width	m	3.65
Width of medial strip	m	3
Width of hard shoulder	m	2.5
Min. circular curve radius	m	300
Min. length of transition curve	m	150
Max. longitudinal slope	%	8
Pavement type		Asphaltic concrete
Camber crosswise slope	%	2.0

Project Schedule

- Design Phase (land acquisition and other similar activities): 9 months

- Construction Phase (site preparation and general construction): 26 months
- Defects Liability Period (any issues related to the defects etc.): 2 years

IMPACTS AND MITIGATION

Site Preparation and Construction

CATEGORY		IMPACT	DIRECTION			MAGNITUDE	EXTENT
			POSITIVE	NONE	NEGATIVE		
Physical	Geotechnical (Mobay Perimeter Road)	Differential settlement and seismic induced liquefaction in coastal alluvial plain (Montego Bay Perimeter Road).			X	M	L
		Undercutting of fill slopes by Montego River and subsequent failure of embankment (Montego Bay Perimeter Road)			X	M	L
		Flooding and scouring where the road is located in the drainage channel of the Salt Spring Gut and its tributaries.			X	M	L
		Exposing the gypsum material to the elements could result in excessive erosion and degradation of the road slopes, embankment, and structure foundations.			X	M	L
		Rock falls in tall road cuts			X	M	L
		Differential settlement in association with karst solution features			X	M	L
		Potential for flooding upstream from the road and collapse of the road embankment			X	M	L
		Multiple organic and/or contaminated soil layers			X	M	L
	Geotechnical (Long Hill Bypass)	Flooding and scouring in area traversing the escarpment to the north of Anchovy			X	M	L
		Rock falls in tall road cuts			X	M	L
		Differential settlement in association with karst solution features			X	M	L
		Potential for flooding upstream from the road and collapse of the road embankment			X	M	L
		Multiple organic and/or contaminated soil layers			X	M	L
	Geotechnical (Barnett Street)	Erosion at 173+600 and 173+750 as a result of the proposed realigned section of the Montego River between 13+600 and 14+000			X	M	L
	Soil	Erosion and sediment loss resulting from vegetation removal			X	M	L
		Contamination from leaked hydraulic fuels, oils, etc.			X	M	L
	Drainage (Sinkholes)	Plugging of sinkholes in close proximity to alignments			X	M	R
		Recharge paths for surface run-off may be traversed by the alignment, decreasing the volume of run-off reaching the sinkholes.			X	M	R
		Surface run-off may become contaminated due to oil/fuel spills			X	S	R

CATEGORY		IMPACT	DIRECTION			MAGNITUDE	EXTENT
			POSITIVE	NONE	NEGATIVE		
	Water Quality	Pollution of Montego River from siltation, spillage, runoff etc.			X	S	R
	Noise	Noise impact on surrounding communities and construction workers			X	S	L
	Air Quality	Pollution generated from construction equipment and transportation of materials			X	S	L
		Fugitive dust from the construction areas and raw materials stored on or transported to site			X	S	L
	Vibration (West Green Ave.)	Vibration impact on persons residing nearby			X	M	L
		Vibration impact on houses/structures nearby			X	M	L
	Vibration (Mobay Perimeter Road and Long Hill bypass)	Vibration impact on persons residing nearby			X	S	L
		Vibration impact on houses/structures nearby			X	S	L
	Hazards - Flooding	Increased runoff volume downstream			X	M	L
		Increased erosion and scour			X	M	L
		Increased debris flow and sediments deposits downstream			X	M	L
		Increased concentration of contaminants			X	M	R
Biological	Terrestrial Flora	Habitat fragmentation and associated destructive issues (barriers to movement, division of continuous populations, increased incidence of fire and vulnerability to invasion by exotic and native pest species and diseases).			X	S	L
		Habitat Loss			X	M	L
		Accidental or intentional removal of important plant species and resulting decrease in diversity.			X	S	L
		Human encroachment, Urban Sprawl and Invasive resulting from land clearance			X	M	L
		Dusting and emissions from raw material storage and transportation				S	L
	Fauna	Habitat fragmentation			X	S	L
		Habitat Loss and Degradation			X	M	L
		Noise displacement			X	S	L
	Mangrove Community	Mangrove Loss from land clearance			X	M	L
		Sediment Loading			X	M	L
		Mangrove Prop Root Community degradation			X	S	L
	Benthic Community	Seagrass			X	S	R
		Meiofauna, filter feeders and fish			X	S	R
Human/ Social	Housing/ Residents	Displacement, relocation and resettlement of residents within cut and fill areas.			X	S	R
	Educational Facilities	Displacement of two schools within alignment			X	S	R

CATEGORY		IMPACT	DIRECTION			MAGNITUDE	EXTENT
			POSITIVE	NONE	NEGATIVE		
		Noise and dust nuisance on nearby schools within 100m of alignment			X	S	L
		Reduced Access			X	S	L
	Employment	Direct, indirect and induced job opportunity	X			M	N
	Water Supply	Groundwater (well) Contamination from roadway construction			X	M	R
		Groundwater contamination from on-site wastewater disposal			X	M	R
	Water Supply - NWC Distribution Network	Destruction of existing water supply pipelines			X	M	R
		Disruption of water supply			X	S	R
	Sewerage/Wastewater	Destruction of sewerage pipelines			X	M	R
		Disruption of sewerage services			X	S	R
	Solid Waste	Waste generation from on-site activities			X	S	R
	Telecommunications	Potentially impacted Infrastructure within 100m buffer from alignment			X	S	N
	Transportation	Existing road wear and tear from trucks			X	S	L
		Traffic disruption and congestion from trucks			X	S	R
		Dust pollution from trucks carrying material			X	S	L
		Accident/damage risk to other vehicles			X	M	L
	Health and Emergency	Occupational Health and safety of workers			X	M	L
		Community health and safety of residents			X	M	L
		Noise and dust pollution to health care facilities			X	S	L
		Disruption of access to health care facilities from road works			X	S	L
		Disruption of construction activities due to safety and security issues in volatile areas through which the alignment runs			X	M	N
	Recreational and Social	Displacement of two churches within alignment			X	S	R
		Noise and dust nuisance on nearby facilities within 100m of alignment			X	S	L
	Industry and Economy	Increased commercial activity	X			M	N
		Decreased commercial activity			X	M	N
		Displacement of shops/stalls and other commercial entities within alignment			X	M	R
	Tourism	Noise, dust and traffic nuisance			X	S	L
	Land Use	Southwestern end of Mobay Perimeter Road alignment traverses the Bogue Lagoon Creek Game Reserve			X	M	L
		West Green road works footprint touches eastern boundary of the Bogue Lagoon Creek Game Reserve		X		N	None
		Total of 573 land parcels impacted by proposed alignments			X	S	L
	Aesthetics	Reduced visual quality			X	S	L

CATEGORY		IMPACT	DIRECTION			MAGNITUDE	EXTENT
			POSITIVE	NONE	NEGATIVE		
Heritage and Archaeological	Historic Sites	Impact to historic houses/structures at Anchovy and Taíno site, Barnett Old Bridge, house and ruins at Providence.		X		N	None
		Impact to Fairfield Hotel			X	S	L
		Impact at Rocklands Bird Sanctuary.			X	S	L

Operation

CATEGORY		IMPACT	DIRECTION			MAGNITUDE	EXTENT
			POSITIVE	NONE	NEGATIVE		
Physical	Drainage and Stormwater	Blockage of drainage crossings may result in localized flooding or inundation			X	S	L
		Erosion and scouring of riverbed resulting from increased flow velocity from Montego River Realignment			X	S	L
		Sediment deposition around meanders of river channel resulting from erosion from Montego River Realignment			X	S	L
		Stormwater peak flows reduced upon reaching Bogue wetland			X	S	L
		Contamination and destruction of sinkholes and groundwater network			X	S	L
	Noise (Mobay Perimeter Road)	Proposed UWI Western Campus would have noise levels from the traffic (2021 and 2041) using the highway, above the NRCA day time noise standard (along the Mobay Perimeter Road)			X	S	L
	Noise (Long Hill bypass)	Six schools along the Long Hill bypass would have noise levels from the traffic (2021 and 2041) using the highway, above the NRCA day time noise standard			X	S	L
		Two churches along the Long Hill bypass had noise levels non-compliant with the NRCA night time standards for both the 2021 and 2041 traffic			X	S	L
	Noise (Barnett Street)	Three schools would have noise levels from the traffic (2021 and 2041) using the road above both the NRCA day and night time noise standards and One school non-compliant with the NRCA night time noise standard (in the vicinity of the Barnett Street road works)			X	S	L
		Catherine Hall Health Centre had noise levels non-compliant with the NRCA day and night time standards for the 2041 traffic (in the vicinity of the Barnett Street road works)			X	S	L
		Two churches had noise levels non-compliant with the NRCA night time standards 2041 traffic and once church had noise levels			X	S	L

CATEGORY		IMPACT	DIRECTION			MAGNITUDE	EXTENT
			POSITIVE	NONE	NEGATIVE		
		non-compliant with the NRCA night time standards for both the 2021 and 2041 traffic (in the vicinity of the Barnett Street road works)					
	Noise (West Green Ave.)	Five (5) schools had noise levels from the traffic (2021 and 2041) using the road above both the NRCA day and night time noise standards (in the vicinity of the West Green Ave. road works)			X	S	L
		Only Catherine Hall Health Centre had noise levels non-compliant with the NRCA Day and Night time standards for both the 2021 and 2041 traffic (in the vicinity of the West Green Ave. road works)			X	S	L
		Holiness Born Again Church of Jesus Christ had noise levels non-compliant with the NRCA Day and Night time standards for both 2021 and 2041 traffic (in the vicinity of the West Green Ave. road works)			X	S	L
	Occupational Noise	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.			X	S	L
	Air Quality	Vehicular emissions effect on nearby residential population			X	S	L
		Exposure of toll booth workers to vehicle emissions throughout the course of their work shifts.			X	S	L
	Vibration (West Green Ave.)	Vibration impact on persons residing nearby			X	M	L
		Vibration impact on houses/structures nearby			X	M	L
	Vibration (Mobay Perimeter Road)	Vibration impact on persons residing nearby		X		N	None
		Vibration impact on houses/structures nearby		X		N	None
	Vibration (Long Hill bypass)	Vibration impact on persons residing nearby			X	S	L
		Vibration impact on houses/structures nearby		X		N	None
	Hazards - Landslides	The mid-section segment between chainages 12+800 and 18+000 is the most vulnerable length to landslides			X	S	L
	Climate Change and Flooding	Three (3) main channels contribute to flooding in their respective areas: Salt Spring Gully, North Gully and South Gully.			X	S	L
		Increased river velocity as a result of river realignment may lead to sediment deposition in the meanders of the river channel resulting in potential flooding.			X	S	L
Biological	Terrestrial Flora	Increased access resulting in Invasive plants and animal intrusion			X	M	R
		Increased access resulting in logging			X	S	L
	Fauna	Habitat Fragmentation			X	S	L
		Habitat Degradation			X	S	L
	Mangrove	Mangrove degradation from improper drainage design resulting in poor hydrological conditions			X	M	L

CATEGORY		IMPACT	DIRECTION			MAGNITUDE	EXTENT
			POSITIVE	NONE	NEGATIVE		
		Mangrove prop root community degradation			X	M	L
	Benthic Community	Seagrass			X	M	L
		Meiofauna, filter feeders and fish			X	M	L
Human/ Social	Housing/Residents	Improved access for development (residential, educational, recreational etc.)	X			M	N
		Noise and dust pollution of nearby existing residents			X	S	L
		Decreased aesthetics			X	S	L
	Employment	Direct, indirect and induced job opportunity	X			S	N
		Increased investment from new traffic infrastructure	X			L	N
	Transportation	Improved Level of Service	X			M	R
		Reduced traffic and delays	X			M	R
		Turning volumes may still result in some traffic build up on Howard Cooke Blvd.			X	S	L
	Health and Emergency	Increase in traffic accidents as a result of speeding			X	S	L
		Light pollution impacts on nearby residences in the vicinity of Toll Plazas and Exit Ramps			X	S	L
		Natural hazards such as earthquakes, floods, fires			X	S	L
		Miscellaneous hazards such as stray animals, dead animals, fallen tree limbs, accumulation of dirt, gravel or other granular materials, oil spills etc.			X	S	L
	Industry and Economy	Improved infrastructure to boost Agriculture industry	X			L	N
		Increased tourism opportunity from access to new points of interest	X			L	N
		Increased recreational opportunity from access to new points of interest	X			L	N
		Increased efficiency of movement of goods and services island-wide	X			L	N
		Increase in jobs and additional GDP and tax take	X			L	N
	Land Use	Community Fragmentation and Accessibility			X	S	L
	Aesthetics	Disruption of scenic landscape for Montego Bay Perimeter Road			X	S	L
		Disruption of scenic landscape for Long Hill Bypass			X	S	L
	Impacted Structures	489 structures were mapped and deemed as impacted			X	M	N

ENVIRONMENTAL MONITORING AND MANAGEMENT PLANS

Environmental Management System

As part of the Environmental Management System (EMS), it is recommended that several parameters be monitored before, during and after the project implementation to record any negative construction impacts and to propose corrective or mitigation measures. The suggested parameters include but not limited to the following:

1. Noise
2. Dust
3. Traffic and Transportation
4. Water Quality
5. Solid Waste and Wastewater
6. Raw Material Storage and Transport
7. Health and Safety
8. Equipment Maintenance
9. Drainage
10. Community Management

Other Related Studies and Plans

<u>Risk Analysis Study</u>

The first step in Risk Assessment is identifying the major hazards; that is, gathering and analysing data on meteorological, hydrological and geological hazards in terms of their nature, frequency and magnitude. Overall assessed risk levels result from a combination of low, medium and high severity of occurrence and probability of occurrence. Priority hazards include: Flooding, Landslide, Earthquake, Accidents.

<u>Emergency Response Plan</u>

The Emergency Response Plan will be designed to describe the organizing, coordinating and directing of available resources in order to respond to various natural and man-made disasters and situations. These will include the following:

- Natural Disasters
- Civil Unrest and Riots
- Bomb Threats and Acts of Sabotage
- Acts of Terrorism and Armed Attacks
- Diesel and Hazardous Material Stockpiling
- Security and Safety Information
- Medical Emergency Information
- Technological Emergencies
- Occupational Health and Safety

Water Resources Risk Management Plan

A detailed assessment of the water resources along the final alignments and preparation of a Water Resource Risk Management Plan must be undertaken. This must be done in conjunction with Water Resources Authority's approval of the measures to mitigate against adverse effects during both the construction and operational phases. Reference must also be made to the drainage guidelines, "Guidelines for preparing hydrologic and hydraulic design reports for drainage systems of proposed developments", jointly developed by the NWA, ODPEM and the WRA.

Resettlement and Relocation Plan

All resettlement activities carried out by NWA will be sustainable in nature by providing sufficient resources or alternatives to those who are displaced. All persons affected will be consulted and given the opportunity to participate in the planning and implementation of their own resettlement. Assistance will be provided in helping individuals to restore their standard of living or to raise it, but no individual's standard of living should be lowered as a consequence of the project. The legal tenure of affected persons will determine the type of compensation and resettlement assistance to be received.

Restoration and Rehabilitation Plan

The rehabilitation will start with the restoration of the locations of the construction campsites and other cleared areas associated with the road works. This area will be backfilled with material removed during campsite construction and supplemented with layers of topsoil also removed during clearance activities. The surface will be stabilized according to an active planting program and a plant nursery will be setup to ensure that sufficient, suitable plant material is available to allow a timely re-vegetation of the site. The vegetation planted will be monitored over a minimum five-year period.

CONCLUSIONS

The safety and functional deficiencies that exists, plus overall capacity needs within Montego Bay, are prohibiting growth and development in the second city. The proposed road works outlined within this report will certainly provide the desirable capacity to the road network in and around the city of Montego Bay, as well as offer the possibility of opening up new areas to development along the newly created corridors (Montego Bay Bypass and Long Hill). From an economic feasibility standpoint, the base case with Gloucester Avenue being restricted is almost feasible, with an EIRR of 11.6%, NPV of -3.0 million US dollars, and a high FYRR of 14.6%; therefore the project should not be delayed.

The implementation of mitigation measures as well as the various management and monitoring programmes should assist in reducing the potential negative impacts of the project (degradation of natural habitats that support ecologically important species; costly and disruptive right-of-way acquisitions, relocation of residents, businesses and utilities; and the adverse effects on noise, air quality and water resources).

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

1.1.1 Context and Relevance

Montego Bay, Jamaica's second largest City, is located in the parish of St. James along Jamaica's north coast. It is Jamaica's premier tourist destination with possibly the largest concentration of tourist attractions on the island. It is also the home of Jamaica's busiest airport and welcomes cruise ships to its port two days per week. Montego Bay is also the only city in the western region of Jamaica, and therefore provides major governmental services to neighbouring parishes. The commercial centre with all its amenities lies at the heart of the city with its main thoroughfare along the coast. The city of Montego Bay is a very important contributor to Jamaica's economic growth and development.

Traffic congestion in the city has been a longstanding issue as there is essentially one main thoroughfare connecting the east to the west of the city. There have been many calls over the years for a perimeter road to be constructed or other creative solutions to ease the traffic congestion in Montego Bay. Over the years there has been attempts to address the problems of traffic and the road network that significantly impacts traffic in the city. Past efforts to improve the traffic congestion included improvement to the existing road infrastructure such as the Bogue Road Improvement Project, the dualization of the Howard Cooke Boulevard, and extensive traffic signal installations through the town centre. Notwithstanding these improvements, traffic congestion continues to be a major issue and in the opinion of many, is stifling growth and development of the City.

Apart from the typical morning and evening peak hour traffic, the city also often becomes gridlocked during times of heavy rainfall due to flooding, and on cruise ship days or other major activities or incidents, and productivity is lost because of the lengthy delays caused by traffic related to flooding. The problem of flooding was addressed with the expansion of the North and South gullies and the installation of trash racks to prevent garbage from being washed into the sea and beach areas. While the trash racks protect the beach from being polluted with garbage, the most recent flooding in November 2017 (Plate 1-1) shows that unless proper garbage disposal practices are adopted by the surrounding communities, garbage disposed in the gullies can clog the trash rack and cause flooding in the city and on the streets. These infrastructure developments therefore have not adequately addressed the flooding and flooding-related traffic problem in the city, hence, the continued calls for a perimeter road to be constructed.

Plate 1-1 Severe flooding in Montego Bay in November 2017

The National Road Operating and Constructing Company Limited (NROCC), working through the Ministry of Economic Growth and Job Creation (MEGJC), has acquired funding for the development of an alternative route around the central business district (CBD) in Montego Bay to reduce congestion in the city and to spur economic benefit. The feasibility of the proposed project hinges on the losses incurred by the Montego Bay CBD, as a result of the issues previously mentioned due to the current road network. Significant travel time delays are experienced as main roads run through the central business district (CBD) whose capacity to handle current traffic volumes are below acceptable levels. The proposed bypass road connects to the A1 North Coast highway and runs on the outskirts or 'perimeter' of the city circumventing traffic, signalised stops and pedestrian activity.

1.1.2 Project Rationale

1.1.2.1 Tourism Industry

Tourism in Jamaica accounts for 15% of the national gross domestic product (GDP). Montego Bay is often referred to as the tourism capital of Jamaica and therefore has a significant impact on the economy of Jamaica. The larger international airport in Jamaica, namely the Sangster International Airport is situated here and is the leading tourism gateway to the island. There is also a high concentration of hotels and tourist destinations in and around the city centre. With the tourism sector expected to grow at 3.8% per annum (Jamaica Tourist Board, 2015), there is also expected to be a continued growing demand on the transportation infrastructure. Growth in the tourism sector will result in additional traffic being generated by the airport and seaports. This traffic increase will ultimately result in: (1) Additional traffic through the city as the visitors try to access different attractions in and around Montego Bay and (2) Increase in traffic intending to bypass the city of Montego Bay as visitors seek access to attractions in other tourist destinations located in Negril and Ocho Rios.

1.1.2.2 Transportation Infrastructure

The main coastal corridor in Montego Bay carries over 30,000 vehicles per day but operates as a major urban arterial with closely spaced signalized intersections to provide access to the city centre. Along the North Coast Highway (Elegant Corridor) traffic signals are spaced every 1 km while Howard Cooke Boulevard and Alice Eldemire Drive traffic signals are spaced 300m – 500m apart. The closely spaced signals on Howard Cooke Boulevard in particularly have serious capacity constraints with high turning volumes headed into the city centre. Even with modest traffic projects around the city, the main coastal roads have existing capacity constraints and limited right-of-way for expansion. Currently, the coastal roads must provide access to the city, as well as provide access through the city with limited viable alternatives.

1.1.2.3 Project Benefits

Historically, it is well documented that in developing countries investment in transportation infrastructure generates economic benefits by reducing transportation costs for existing activities, providing access to new areas with economic development potential and creating investment activities. This proposed highway will meet international standards and requirements of projects of this nature and will alleviate the current traffic problems in the poorly built and insufficient road infrastructure in Montego Bay and its environs. The following are examples of the generalized benefits/justification of the project which are given in Vision 2030 (see Section 4.2.1.10):

- Reduce traffic
- Reduce travel time
- Reduce accident potential for both vehicular and pedestrian traffic
- Stimulate economic growth
- Create jobs

The construction of Montego Bay Bypass will provide significant benefits to the travelling public. The benefits include travel time savings (possible increase productivity and lower transportation costs), vehicle operating cost savings, public safety savings (reduced accident costs), rehabilitation and maintenance cost savings on the existing highway network and savings related to other externalities (primarily air pollution related). The proposed road improvements and alignments will not only provide additional capacity to the road network, but also offer the possibility of opening up new areas to development along the corridor. Based on the economic assessment conducted during the preliminary design and feasibility study, the economic indicators show an Economic Internal Rate of Return (EIRR) of 11.6%, net present value (NPV) of -3.0 million US dollars, and a high First Year Rate of Return (FYRR) of 14.6%.

1.2 PROJECT LOCATION

The following four components are included in the proposed project (Figure 1-1):

1 - Montego Bay Perimeter Road
2 - Long Hill Bypass

3 - Barnett Street Upgrade
4 - West Green Avenue Upgrade

The length of the **Montego Bay Perimeter Road** corridor is an approximately 15.4 km, 4-lane highway starting at Alice Eldemire Drive and Howard Cooke Highway with the end point at the Intersection with the A1 North Coast Highway at Ironshore. It traverses the communities of Coral Gardens, Salt Spring, Montego Hill, Porto Bello, John's Hall, Bogue, Catherine Mount, Irwin, Fairfield and Norwood (Figure 1-2).

The **Long Hill Bypass Alignment** component encompasses the construction of approximately 10.5 kilometres of 2-lane, rural arterial highway leading from Montpelier intersection of B8 Road and B6 Road to Temple Gallery Road. The implementation of this road section will essentially connect the Montego Bay Perimeter Road with the western end of the Phase 2B corridor of the East West Highway. Bogue, Fairfield, Anchovy, Mount Carey and Bickersteth are the communities in which this alignment is located (Figure 1-3).

Barnett Street road improvement is located in Mount Salem, West Green and Catherine Mount (Figure 1-2). It involves is the dualization of 1.06 km of the existing two-lane road section from the intersection of West Green and Fairfield road in a northerly direction and ending at Cottage road. The proposed works will involve the construction of an additional two-lane bridge over the Montego Bay River in the vicinity of the West gate Shopping Centre.

West Green Avenue improvement is located in Bogue (Figure 1-2) and is the dualization of the 0.82 km existing link road between Howard Cooke Boulevard and the Bogue Road at the Fairfield Road intersection.

Collectively, the four road sections pass through a total of 15 communities in the parish of St. James:

1. Anchovy
2. Bickersteth
3. Bogue
4. Catherine Mount
5. Coral Gardens
6. Fairfield
7. Irwin
8. John's Hall
9. Montego Hill
10. Mount Carey
11. Mount Salem
12. Norwood
13. Porto Bello
14. Salt Spring
15. West Green

Figure 1-1 Location map showing all proposed project components (Barnett Street, Long Hill Bypass, Monetgo ay Periemter and West Green Avenue)

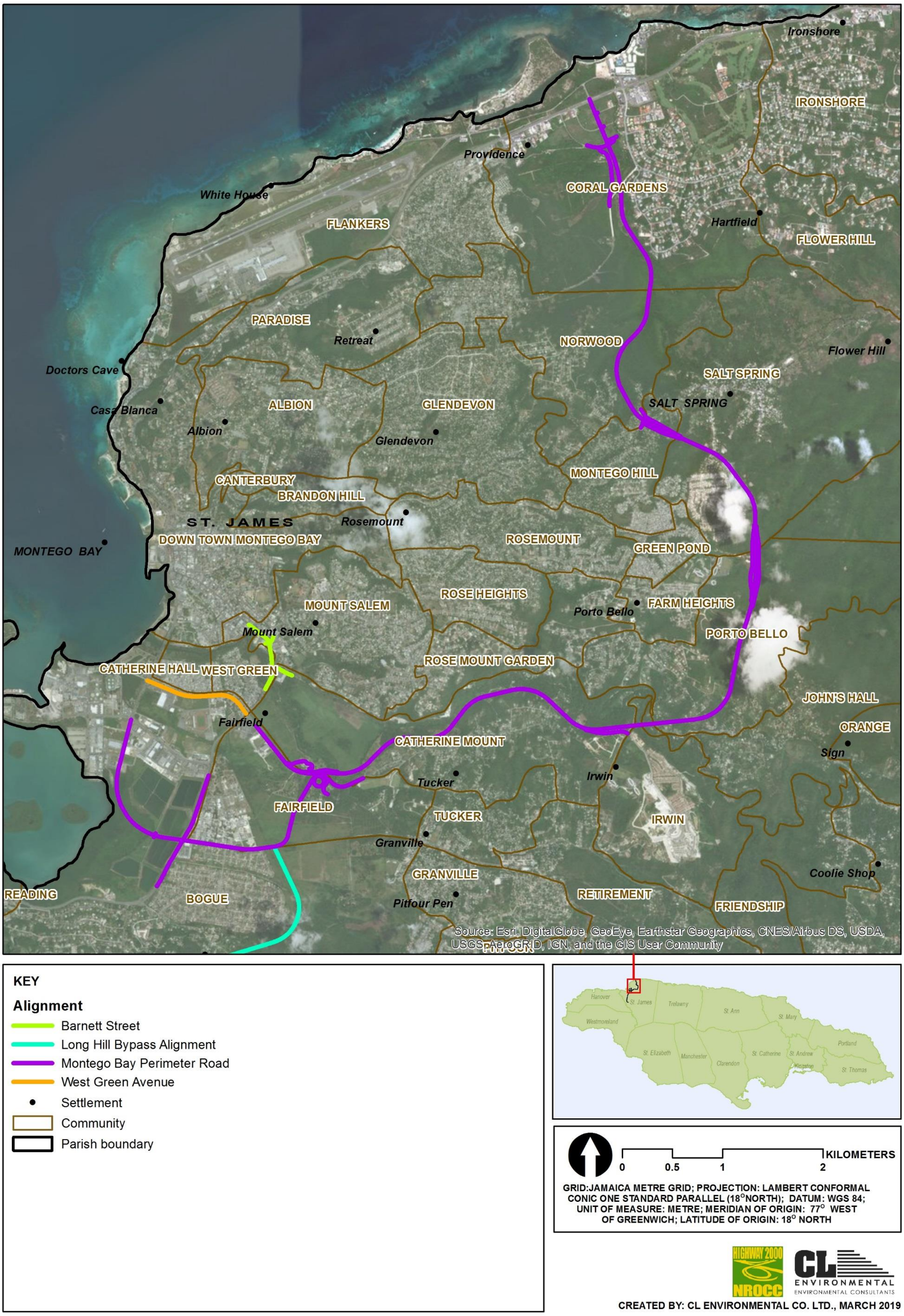


Figure 1-2 Location map showing proposed project components (Barnett Street, Montego Bay Perimeter and West Green Avenue) and communities through which each pass

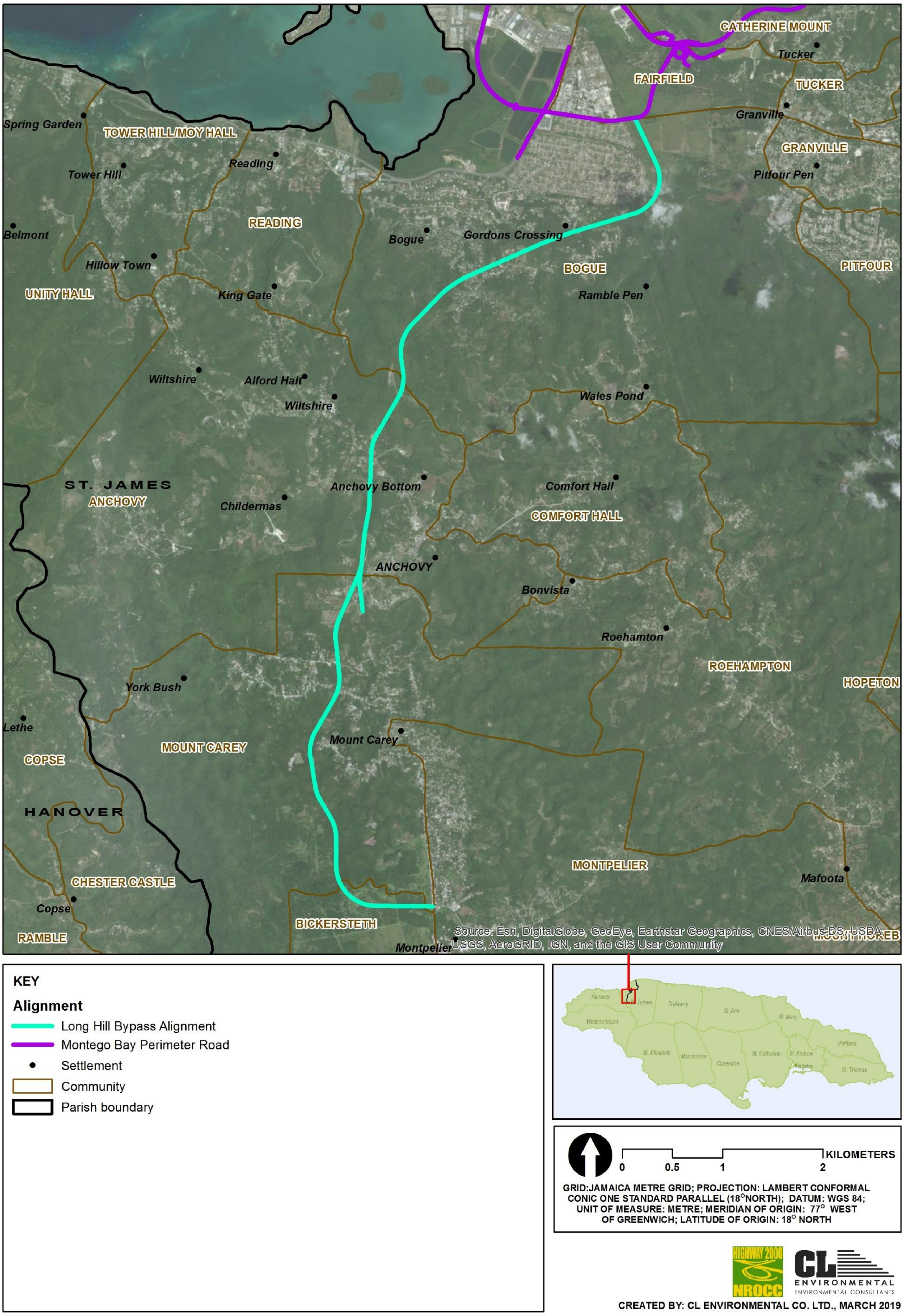


Figure 1-3 Location map showing Long Hill Bypass proposed project components and communities through which it passes

1.3 ORGANISATIONAL PROFILES

The proponent for this project, as well as the environmental consultant are listed in Table 1-1. Additional background information for each are given in subsequent sections.

Table 1-1 Contact information for the project proponent and project consultant

Company and Role	Address	Telephone	Website and Email
National Road Operating and Constructing Company Limited (NROCC) *Proponent*	4th Floor DBJ Building, 11a Oxford Road Kingston 5, Jamaica	Support: +1 (876) / 926-7830/4808/ 929-1581	https://h2kjamaica.com.jm/home info@h2kjamaica.com.jm
Ministry of Economic Growth and Job Creation (MEGJC) *Employer*	25 Dominica Drive Kingston 5	Tel: 876.926.1590 Fax: 876.926.4449	info@megjc.gov.jm http://www.mwh.gov/#!/
Stanley Consultants, Inc. *Implementing organisation*	Unit #27 Seymour Park 2 Seymour Avenue Kingston 6	Tel: 876.622.7398 Fax: 876.622.7411	http://www.stanleyconsultants.com/
C. L. Environmental Company Limited *Project consultant*	20 Windsor Avenue Kingston 5	Tel/Fax: 876.756.0338	info@clenvironmental.com http://www.clenvironmental.com/

1.3.1 The Proponent

The **Ministry of Economic Growth and Job Creation (MEGJC)** is considered the Employer of the proposed project. The MEGJC was created in March 2016, with the change of the political administration. The Ministry is charged with drafting the blueprint to drive economic growth and sustainable development in Jamaica. It has responsibility for seven (7) critical portfolio areas: Land, Environment, Climate Change, Investment, Water and Wastewater, Housing and Works. Under its portfolio areas, the Ministry has oversight for some 48 Agencies, Departments and Divisions, which are responsible for approximately 68 subject areas.

The **National Road Operating and Constructing Company Limited (NROCC)**, also known as the Grantor, is a public company formed to represent the Government of Jamaica's interest under a Concession Agreement signed in 2001 for the establishment, development, financing, operation and maintenance of a tolled highway.

NROCC entered into an arrangement with the Developer, Trans Jamaican Highway Limited (TJH) for the design, construction, operation and maintenance of the Highway 2000 toll road. The project was conceived as a public-private partnership and implemented as a build‑finance-operate and transfer (BFOT) 35-year concession scheme. NROCC also has the responsibility for monitoring the performance of the Developer to assure compliance with the requirements of the existing Concession Agreement and for monitoring new tolled roads which are added to the network. NROCC purchases properties affected by the Highway alignment on behalf of the Government of Jamaica and also provides partial funding to the project.

In 2012 NROCC signed a second Concession for the implementation of Phase 2 of the Highway 2000 project from Caymanas to Ocho Rios under a 50-year BFOT concession with Jamaica North South Highway Company (JNSHC).

1.3.2 Implementing Organisation

Stanley Consultants Inc. serves clients globally, assisting with complex challenges in power, transportation, water and environmental for utility, industrial, higher education and local, state, federal and foreign government agencies. They are ranked #76 among ENR's Top 500 Design Firms and #129 among the Top 225 International Design Firms. Founded in 1913, Stanley Consultants has nearly 1,000 members in 30 offices worldwide and has worked in all 50 states and more than 100 countries around the world. Services provided include planning, design, permitting, environmental analysis, construction management, program management and alternative project delivery.

1.3.3 Project Consultant

C. L. Environmental Company Limited has been incorporated in Jamaica as a Limited Liability Company since August 2000. The Company provides consultancy services to both governmental and non-governmental agencies, local and overseas. The company comprises a range of professional skills and includes environmental scientists, marine ecologists, environmental engineers, waste management specialists, planners, industrial hygienists, environmental management systems specialists, environmental educators and quality Consultants. The team of Consultants and Scientists associated with C.L Environmental Company have over the years, worked on numerous environmental projects of which some were of national importance such as the Highway 2000 North South Link: Caymanas to Linstead and Moneague to Ocho Rios legs, National Programme of Action for Land Based Sources and Activities that Impact the Marine Environment, the Remediation of the American Airlines Flight 331 Accident Site at Norman Manley International Airport, the Ausjam Gold Mine Cyanide Spill in Clarendon, Environmental Assessment Road Rehabilitation Works for the Moneague Lake Flooding in St. Ann for Bouygues Travaux Publics and the Environmental Monitoring of the Falmouth Cruise Pier Development in Falmouth, Trelawny for the National Environment and Planning Agency (NEPA) to name a few.

The environmental impact assessment capabilities of the company are built on a multidisciplinary group of professional associates who collectively have over eighty years of experience in environmental management. In addition, to their experience, the depth and diversity of the team provides us with strengths in policy development, organisational evaluation operational management, project management, noise modelling, water quality assessments, solid waste and medical waste management and waste treatment design and implementation. The combined inter disciplinary strength of this team and their regional and international experience, makes them highly suitable to undertake the proposed project.

1.4 SCOPE OF WORK

Sections of the proposed alignment development fall under the category of "New Highways", and specifically may be described as a roadway providing means of travel and transportation for passengers and goods. The proposed corridors will connect various destinations and is intended for motorised traffic. Environmental impacts from the construction and operation of the proposed alignments will potentially arise and it was considered imperative to evaluate these likely impacts, recommend mitigation strategies and potentially viable alternatives to the proposed project.

The Permit Application for the proposed project, *the Environmental Impact Assessment for the Montego Bay Perimeter Road, Long Hill Bypass and West Green and Barnett Street Upgrade, St. James* was submitted on 1 March 2018. It was decided that an Environmental Impact Assessment (EIA) was required and the Terms of Reference (TORs) (Appendix 1) were established by the National Environment and Planning Agency (NEPA) in order to outline the various aspects of the EIA. The specific tasks outlined in the approved TORs were executed by CL Environmental Co. Ltd.; the study team may be seen in Appendix 2. This report serves to compile and present the findings of the EIA and ultimately provide a comprehensive evaluation of the proposed project.

2.0 COMPREHENSIVE DESCRIPTION OF THE PROPOSED PROJECT

2.1 PROJECT DEVELOPMENT AND PRELIMINARY STUDIES

In 2017, the National Road Operating and Constructing Company Limited (NROCC) contracted Stanley Consultants Inc. (SCI), to conduct a feasibility study for an alternative route around the central business district (CBD) in Montego Bay to reduce congestion in the city and to spur economic benefit. The feasibility study undertaken by SCI comprised an amalgamation of various supporting studies and reports generated contain detailed information regarding the respective aspect of the project. These supporting documents are as follows.

- Origin-Destination Study
- Structures Assessment Memorandum
- Engineering Geological Survey Report (Volume 1)
- Preliminary Geotechnical Design Memorandum
- Environmental Report
- Economic Feasibility Report
- Traffic Report
- Alignment Alternatives Report
- Drainage Report
- Design Concept Report
- Preliminary Plans

2.1.1 Alignment Alternatives

Using the available digital elevation model (DEM), several alignments for the perimeter road were modelled and optimized. The alignment options were segmented and further developed to generate four optimal alignments for each of three identified segments. These segments were studied to determine the environmental, socio-economic and engineering attributes and potential impacts. Conceptual costs were developed for all alignment alternatives, including preliminary land acquisition costs. The preferred alignment was chosen by NROCC in June 2017 based on the costs and socioeconomic impacts. Section 7.0 provides further detail about the alignment alternatives.

2.1.2 Design Concept

The results of the alignment alternative selection were carried forward into a design concept. The development of a design concept for the Montego Bay Perimeter Road included various studies and reports. Studies began in 2016 with an origin-destination study and continued through to September 2017 with traffic, alternative alignment and geotechnical studies. The Origin-Destination (OD) Study was conducted in the Greater Montego Bay Metropolitan Area to inventory the travel patterns and trip attributes of the motoring public travelling into or passing through Montego Bay from the west (Bogue Road), the south (Fairfield Road, Salt Spring Road and Adelphi/Porto Bello Main Road) and the east (Highway A1/Elegant Corridor). The objective of the OD study was to record vehicle travel patterns during the workweek by capturing internal and external traffic commuting patterns, travel times, identify trip purposes and vehicle classes, etc.

The alignment and profile for the selected alignment was adjusted based on preliminary structural, geotechnical, and drainage criteria. Connections to the existing road network were conceptualized and modelled, and proposed locations identified for toll plazas. Value engineering was added in order to optimize the design. Conceptual plans were prepared that included road geometry, drainage features, bridge structures and required right-of-way. Additionally, Design Cost costs were developed.

2.1.3 Drainage Report

Based on the design concept, a hydrologic assessment and hydraulic analysis was conducted to determine the design discharges and determine optimal sizes for drainage structures. The drainage report also includes climate change considerations, highway impact on wetlands, the realignment of the Montego River among others.

2.1.4 Geotechnical Study

Based on the location of the preferred alignment, geotechnical investigations began in July 2017. The geotechnical study included borehole logs from 26 locations with borehole depths of 3 metres along the proposed roadway and 40 metres at bridge locations and high cut areas.

2.1.5 Structures Report

The structures report identifies and evaluates various structure alternatives along the proposed Montego Bay Perimeter Road alignment. Potential structure locations are based on the proposed perimeter road alignments, crossroad alignments, and drainage features.

2.1.6 Environmental Report

A desk review of environmental impacts was conducted for the preferred alignment of the Montego Bay Perimeter Road. The environmental report presents the available baseline/desktop information for the physical, biological and social elements in the surrounding environs of the perimeter road, along with a listing of legislation relevant to the project.

2.1.7 Economic Feasibility Report

The economic feasibility report contains a brief explanation of economic indices used in the analysis, followed by the methodology, data inputs for each part of the model, and a presentation of the results, including various sensitivity analyses, as summarized in the economic conclusions derived from the model.

2.2 PROJECT CRITERIA AND STANDARDS

The standards used to govern the proposed project shown in Table 2-1 in priority order. The design controls used for the alignments are presented in Table 2-2.

Table 2-1 Governing project standards

Source: (Stanley Consultants Inc., 2018)

PRIORITY	AGENCY	DOCUMENT
1	Government of Jamaica (GOJ)	Manual for Traffic Control Devices (MTW)
2	American Association of State Highway and Transportation Officials (AASHTO)	A Policy on Geometric Design of Highways and Streets
3	AASHTO	Roadside Design Guide
4	AASHTO	Standard Specifications for Highway Bridges, 16th Ed.
5	Federal Highway Administration (FHWA)	Manual for Uniform Traffic Control Devices for Streets and Highways (2003 Edition) (MUTCD)
6	Ministry of Transport and Mining (MTW)	Standard Details

Table 2-2 Design controls

Source: (Stanley Consultants Inc., 2018)

ELEMENT	VALUE	REFERENCE
Roadway Classification a. Type of Facility b. Area c. Highway System	 a. Arterial Roadway (Highway) b. Urban & Rural c. "A" Class Main Road	Terms of Reference
Design Vehicle	WB 15 (Turning Movements) Passenger Car (Sight Distance)	Terms of Reference
Level of Service	LOS C-Rural; LOS D-Urban	Traffic Report
Number of Travel Lanes	Minimum 2 Lanes – (1 in Each Direction) or based upon traffic demand or truck speed reduction	Terms of Reference
Design Traffic Volumes	To Be Determined	Traffic Report
Pedestrian & Bicycle Requirements	1.36m Sidewalks and Pedestrian Ramps in urban areas	Terms of Reference Typical sections

The proposed alignments are expected to have both urban and rural sections, the criteria for which are shown in Table 2-3 and Table 2-4. The proposed typical sections used for rural areas in the concept includes 4-3.65 lanes, paved shoulder and median barrier as shown in the typical section in Figure 2-1. Urban cross-sections have the addition of kerbs and sidewalks as needed. A typical urban section is shown in Figure 2-2.

Table 2-3 Rural Roadway Design Criteria

Source: (Stanley Consultants Inc., 2018)

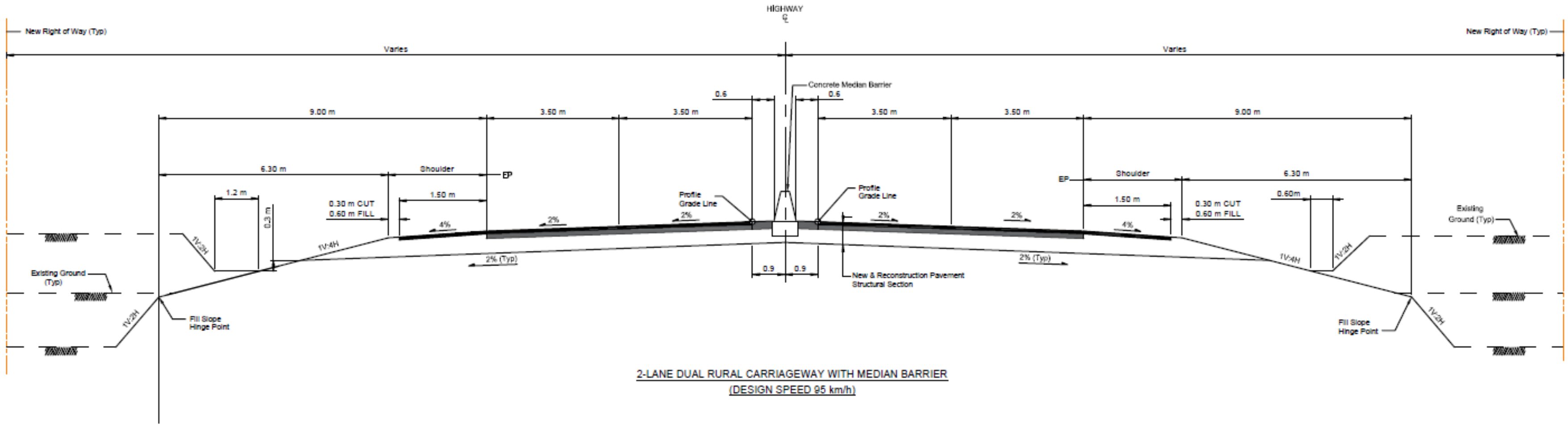
ELEMENT	VALUE	REFERENCE
1) Design Speed	95 kilometers per hour	Terms of Reference
2) Lane Width	3.65 meters	Terms of Reference
3) Shoulder Width	2.7 meters (2.4m Paved)	Terms of Reference
4) Grades a. Level b. Rolling c. Mountainous	a. 3.5% b. 4.5% c. 6.0%	AASHO Table 7-2 (2011 Edition)
5) Cross Slope a. Travel Lanes b. Shoulders	a. 2% b. 4%	Terms of Reference; Typical Sections
6) Horizontal Alignment a. Max. Super elevation (e) b. Min. Radius (e-max) c. Min. Radius (NC) d. Max. Deflection w/o curve	a. 6% b. 387 m curve c. 3195 m curve d. 0.95 Degrees	AASHTO Table 3-9 (2011 Edition)
7) Vertical Alignment a. K value – Crest VC b. K value – Sag VC c. Minimum length of curve d. Max. change in grade w/o vertical curve	a. K = 46 b. K = 42 c. 57m d. 0.4%	AASHTO Table 3-34 (Crest); Table 3-36 (Sag) (2011 Edition)
8) Minimum sight distance a. Stopping b. Passing	a. 173 meters b. 643 meters	AASHTO Table 7-1 (2011 Edition)
9) Horizontal Clearance (Recoverable Terrain)	9 meters	
10) Roadside Slopes a. Front Slope b. Back Slope c. Transverse Slopes	a. 1:4 Within Clear Zone b. 1:4 (1:3 w/Trap Ditch) c. 1:10 or Flatter	
11) Criteria for Grade Datum	0.6 meters clearance – Roadway Base above Seasonal High-Water Table or ditch design flows	

Table 2-4 Urban Roadway Design Criteria

Source: (Stanley Consultants Inc., 2018)

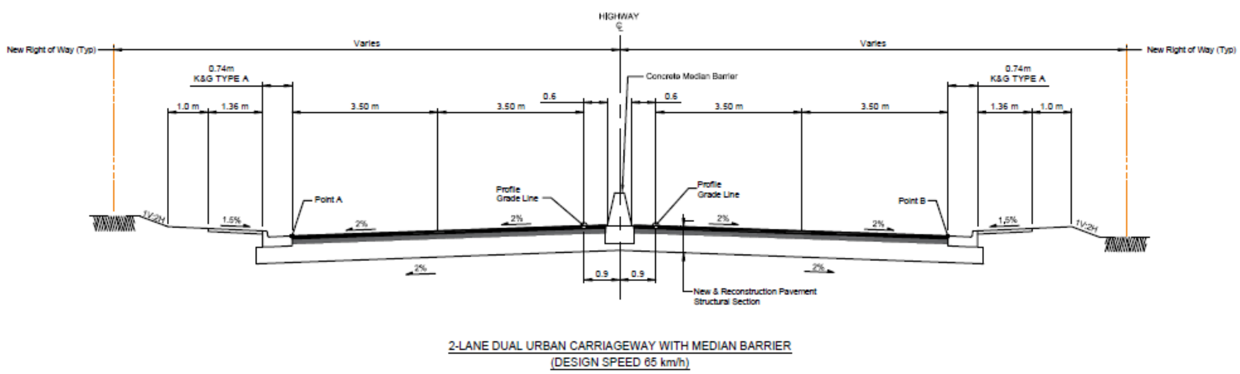
ELEMENT	VALUE	REFERENCE
1) Design Speed	65 kilometres per hour	Terms of Reference
2) Lane Width	3.65 meters	Terms of Reference
3) Shoulder Width Desirable / Minimum	Not Applicable (kerb)	Roadway Typical Sections
4) Grades a. Level b. Rolling c. Mountainous d. Minimum (kerb & gutter)	a. 6.0% b. 7.0% c. 9.0% d. 0.3%	AASHTO Table 7-4 (2011 Edition)

ELEMENT	VALUE	REFERENCE
5) Cross Slope a. Travel Lanes b. Shoulders	a. 2% b. 4%	Terms of Reference; Roadway Typical Sections
6) Horizontal Alignment a. Max. Super elevation (e) b. Min. Radius (e-max) c. Min. Radius (NC) d. Max. Deflection w/o curve	a. 6% b. 154m curve c. 243m curve d. 2.0 Degrees	AASHTO Table 3-13a (2011 Edition) Low Speed Urban
7) Vertical Alignment a. K value - Crest VC b. K value - Sag VC c. Minimum length of curve d. Max. change in grade w/o vertical curve	a. K = 14 b. K = 21 c. 39m d. 0.8%	AASHTO Table 3-34 (Crest); Table 3-36 (Sag) (2011 Edition)
8) Minimum Sight Distance a. Stopping b. Passing	a. 95 meters b. 195 meters	AASHTO Table-7-1 (2011 Edition)
9) Horizontal Clearance a. Poles & Above Ground Fixed objects b. Trees	a. 1.2m from face of kerb (minimum) b. 1.2m from face of kerb (minimum)	
10) Roadside Slopes	1:4 behind kerb	Roadway Typical Sections
11) Criteria for Grade Datum	0.3 meters' clearance – Roadway Base above Seasonal High Water Table	



Source: (Stanley Consultants Inc., 2018)

Figure 2-1 Typical rural road section



Source: (Stanley Consultants Inc., 2018)

Figure 2-2 Typical urban road section

2.3 PROJECT FEATURES AND DESIGN

2.3.1 Montego Bay Perimeter Road

2.3.1.1 Road Segments

2.3.1.1.1 Segment 1 – Alice Eldemire to Bogue Road (10+000 to 11+600)

Alice Eldemire Drive to Bogue Road consists of an urban section and a rural section. The Urban section extends from Alice Eldemire Drive to the end of the existing commercial area from chainage 10+000 to 10+520 and utilizes the existing divided corridor. The existing corridor contains a grass median with two median openings. It is proposed that one of the median opening be closed and the remaining median opening be upgraded to provide exclusive right-turn lanes.

Between chainage 10+520 and 11+600, a rural cross-section is proposed since the road is through virgin lands and sewer ponds. Barriers will need to be installed along sections of the road that are adjacent to the sewer ponds. Grades along this segment are relatively flat with maximum grades of 0.28%. The segment ends at the grade separated interchange with Bogue Road.

2.3.1.1.2 Segment 2 - Bogue Road to Fairfield Road (11+600-13+400)

Bogue Road to Fairfield Road consists of urban and rural sections. The urban section begins at chainage 11+600 and goes to 12+560 where the alignment utilizes the existing Temple Gallery/Clarence Nelson Drive through commercial and industrial land uses. At the end of this area is the proposed University of the West Indies (UWI) western campus, and the Montego West Village residential development. Between 12+560 to the end of the segment at Fairfield Road chainage 13+400, the alignment goes through mostly virgin land at the boundary of the Fairfield Estate. The grades for this segment are relatively flat with the exception of the overpass at Fairfield Road that has a maximum grade of 6.5%.

2.3.1.1.3 Segment 3 - Fairfield to Porto Bello/Irwin (13+400 to 17+000)

The section from Fairfield Road chainage 13+400 to Porto Bello/Irwin chainage 17+000 is a rural section along the river, north of Fairfield and Irwin. It intersects the Adelphi main road in the vicinity of Porto Bello as well as a local road through Irwin. The interchange in this location was therefore designed as a split diamond to accommodate traffic on both sides of the river. Maximum grade in this area is 6.6%.

2.3.1.1.4 Segment 4 - Porto Bello/Irwin to Cornwall Courts (17+000 to 19+400)

Porto Bello/Irwin (17+000) to Cornwall Courts (19+400) is a rural section through the mountainous outskirts of Porto Bello and Green Pond. Maximum grade in this area is 8.3% for a maximum distance of 284m.

2.3.1.1.5 Segment 5 – Cornwall Courts to Salt Spring (19+400 t0 21+400)

Cornwall Courts (19+400) to Salt Spring (21+400) is a rural section through the mountainous outskirts of Salt Spring and Cornwall Courts. Maximum grade in this area is 8.0% for a distance of 207 m.

2.3.1.1.6 Segment 6 – Salt Spring to Ironshore (21+400 to 24+000)

Salt Spring (21+400) to Ironshore (24+000) is a rural section through the mountainous terrain between Salt Spring and Ironshore. Maximum grade in this area is 8.0% for a distance of 1,375 m.

2.3.1.1.7 Segment 7 – Ironshore to North Coast Highway 24+000 to 24+900

Ironshore (24+000) to North Coast Highway (24+900) is an urban section through proposed residential, industrial and commercial subdivisions. Maximum grade in this area is 7.6% for a distance of 205 m. This segment goes through proposed commercial and residential subdivisions; therefore, a roundabout is proposed in the middle to accommodate internal traffic circulation.

2.3.1.2 Intersections

With the exception of the urban sections of the alignment, all intersections with the local road network are grade separated. The proposed alignment contains five interchanges for the grade separated portions. The signalized intersections along the alignment are the existing intersections at the start (Howard Cooke Boulevard and Alice Eldemire Drive) and end (North Coast Highway and the Bypass). The following details the major intersections and interchanges along the Bypass.

2.3.1.2.1 Alice Eldemire Drive and Howard Cooke Boulevard

This intersection is an existing 4-leg signalized intersection. The proposed Bypass will utilize the current cul-de-sac, Industrial Road, as access to the highway. In order to mitigate against changes in the traffic patterns and volumes at this intersection, the Industrial Road leg is recommended to be modified as shown in below. The modifications include exclusive left-turn and right-turn lanes.

2.3.1.2.2 Global Gateway and Fairview Shopping Centre

Along the Industrial Road there are two existing median openings. It is proposed that one of the median openings be formalized to include right-turn lanes for the Global Gateway property and a secondary entrance to the Fairview Shopping Centre.

2.3.1.2.3 Bogue Road and Temple Gallery Road

Bogue Road and Temple Gallery intersection is proposed to be grade separated. The grade separation can be accomplished with a tight diamond interchange that accommodates two right turn lanes on the northbound off-ramp and double right-turn lanes from the westbound Temple Gallery leg.

2.3.1.2.4 University of the West Indies and West Village Residential Development

The intersection with the proposed UWI campus and the West Village residential development was designed to allow for a signalized intersection to accommodate both properties. This intersection was designed to have exclusive left and right-turn lanes.

2.3.1.2.5 Fairfield Road

A trumpet interchange is proposed for the intersection of the Bypass and Fairfield Road. This trumpet will facilitate access to and from the future developments in Barnett Estate.

2.3.1.2.6 Riverside Drive

The Riverside Drive local road lies in close proximity to the proposed Montego Bay Bypass. In order to reconnect the community, an underpass is proposed in the vicinity of 15+900 to allow access to the severed pieces of Riverside Drive.

2.3.1.2.7 Irwin/Porto Bello/Adelphi

The communities of Irwin and Porto Bello are currently separated by the Montego River, therefore an interchange in this area would only provide access to one community without a connection across the river. The proposed interchange addresses the connectivity between these communities with an access road across the river that also accesses the proposed Bypass.

2.3.1.2.8 Cornwall Courts/Green Bond Interchange

The proposed interchange at Cornwall Courts is a simple diamond interchange which is anticipated to also be the connection to future phases of the Montego Bay Bypass.

2.3.1.2.9 Cottage Road Overpass

The proposed Bypass crosses Cottage Road in Salt Spring, however Cottage Road is not proposed to have access to the Bypass since the Bypass crossing the Salt Spring main road is in close proximity. This intersection would therefore be just grade separated with no ramp connections.

2.3.1.2.10 Salt Spring Road

The proposed interchange in Salt Spring posed a challenge since the alignment north of the interchange has a long grade of 8.0%. The main line alignment in this area cuts through the Salt Spring ridge in order to reduce the maximum grade, ramps on the north side of this interchange would therefore be greater than 8%. In order to have reasonable grades on the ramps, all ramps would need to be on the south side of the interchange, and this can be achieved with a partial clover-leaf interchange. Unfortunately, this interchange configuration requires more right-of-way than a standard diamond.

Alternatives considered include:

- Limiting access at this interchange location, that is removing the ramps north of the interchange and in doing so eliminate trips between Ironshore to Salt Spring. The footprint of this half diamond interchange was used to develop the land acquisition areas and costs.
- Eliminate the inter-change due to the potential impact on residential structures and create an alternate connection to the highway via the Cornwall Courts Inter-change, which is in proximity to Salt Spring.

2.3.1.2.11 Quebec Avenue

Where the proposed Bypass crosses Quebec Avenue, it is proposed that Quebec Avenue be diverted north to connect to existing local roads. This will aid in access management as well as provide accessibility between the future developments in Ironshore and the residential communities in Retreat and beyond. Based on the level of the Montego Bay Bypass where it crosses Quebec Avenue, an underpass can also be added to facilitate a direct connection from Quebec Avenue to Morgan Road.

2.3.1.2.12 Subdivision Road

Between Quebec Avenue and the North Coast Highway, commercial and residential developments are expected to occur. A roundabout is therefore proposed in this area to provide some traffic calming and access for these developments.

2.3.1.2.13 North Coast Highway

In order to accommodate projected traffic from the proposed Bypass and the intersection with the North Coast Highway, a signalized intersection is recommended. The current intersection already has exclusive right-turn lanes, therefore, to accommodate the bypass, the eastbound right-turn lane would just need to be extended and a westbound left-turn lane added.

2.3.1.3 Toll Plaza

Toll plazas have not been included in the design plans or estimate; however, areas have been identified where toll plazas can be located. Based on dialogue with NROCC, the ideal maximum grade for a toll plaza is 2.5%. At the eastern end of the project, a section of the profile was flattened to 2% to provide an option for a toll plaza in the east. This flattening was achieved by having approximately 15 metres of fill above Quebec Avenue. This, however, results in a steeper grade into Ironshore. If a toll plaza is not placed in this area, the fill can be reduced, and grades flattened beyond Quebec Avenue. At the potential location in Ironshore, the 2% grade goes from 23+400 to 24+070 and therefore provides 670 metres for vehicles to decelerate from the previous 8% grade. In the Fairfield area between 14+636 and 17+280, grades are 0.9% to 2.4%, therefore a toll plaza can be located along this 2.6 km section.

2.3.1.4 Drainage

2.3.1.4.1 Design Guidelines

The following design guidelines were used to determine the capacity of the drainage structures:

- Bridges crossing the Montego River were designed to convey flows associated with the 100-year, 24-hour frequency storm.
- The minimum freeboard used was 1000 mm or 25% of the depth of flow, whichever is greater. The freeboard was measured from the bottom chord of the girder to the 100-year flow hydraulic grade line (water level).

- All other hydraulic structures were designed to convey the 25-year return period storm without surcharging and the 100-year storm with a maximum surcharge of 1000 mm above the top of the culvert.
- Minimum culvert sizes were 900mm diameter.
- All other stormwater drainage systems (roadside ditches, swales, storm sewers, catch basins, gutters, pavement) were designed for the 10-year storm. The hydraulic grade line (water level) for roadside ditches and swales was designed to be below the roadway pavement structural section.

2.3.1.4.2 Hydraulic Assessment, Drainage Structures and Conveyance Capacities

The culverts were modelled using the Bentley Culvert Master Software v3 which was developed specifically for modelling culverts. The culverts were designed to convey the 25-year design discharge without surcharge and the 100-year discharge with maximum surcharge of 1.0m. The bridge structures crossing the Montego River and the tucker Spring were analysed using the HY-8 Culvert Hydraulic Analysis Program v7.4. A summary of the required drainage structures and their conveyance capacities are presented in Table 2-6.

An overview of the hydrological analysis conducted for input to the hydraulic assessment may be found in section 3.1.5.1.

Table 2-5 Proposed drainage structures and conveyance capacities

MONTEGO BAY PERIMETER ROAD - DRAINAGE STRUCTURES													
BASIN	DRAINAGE AREA	CHAINAGE	PIPE	RCBC		BARRELS	BARREL LENGTHS	Q_D (25YR)	Q_D (100YR)	DESIGN SLOPE	CAPACITY	SURCHARGE (25YR)	SURCHARGE (100YR)
	(HA)		D (MM)	W (MM)	H (MM)	NO.	M	(M^3/S)	(M^3/S)	(M/M)	(M^3/S)	(M)	(M)
		K10+460	1500				45						
		K10+700	1500				45						
		K11+000	1500				45						
		K11+300	1500				50						
B05	28.02	K12+500		1520	1520	1	33	4.8	7.1	0.002	4.9	0.0	0.6
B06	19.98	K12+700	1650			1	40	3.5	5.2	0.002	3.6	0.0	0.6
B07	41.04	K12+850		3050	1520	1	24	8.1	12.1	0.002	8.9	0.0	0.4
B08	2.08	K13+130	900			1	65	0.6	0.8	0.002	0.7	0.0	0.1
B09	4.67	K13+300	900			2	65	1.4	1.8	0.05	1.6	0.0	0.1
B10	910.25	K13+725		5000	4500	2	30		140.7	0.002	170	0.0	0.0
B11	3.26	K13+990	900			1	35	1.0	1.2	0.01	0.9	0.0	0.3
B12	2.12	K14+200	900			1	45	0.8	0.9	0.05	0.9	0.0	0.0
B13	6.51	K14+710	1350			1	100	2.1	2.6	0.05	2.4	0.0	0.1
B14	3.76	K14+970	1050			1	80	1.3	1.8	0.05	1.3	0.0	0.2
B15	3.25	K15+210	900			1	50	1.1	1.4	0.01	0.9	0.2	0.7
B16	10.69	K15+340	1350			2	80	2.6	3.3	0.05	2.4	0.1	0.3
B17	2.27	K15+535	900			1	50	1.0	1.2	0.05	0.9	0.1	0.2
B18	2.77	K15+700	900			1	55	1.0	1.2	0.01	0.9	0.1	0.2
B19	2.81	K15+840	900			1	80	1.0	1.3	0.01	0.9	0.1	0.3
B20	2.10	K16+100	900			1	40	1.0	1.2	0.01	0.9	0.1	0.2
B21	6.08	K16+280	1200			1	45	1.9	2.3	0.05	1.8	0.0	0.2
B22	5.67	K16+500	1200			1	100	2.0	2.4	0.01	1.9	0.1	0.3
B23	9,975.19	K17+100							1164.4	0.01	> 2000	0.0	0.0
B24	10.70	K17+380	1350			2	110	2.5	3.2	0.05	2.4	0.0	0.3
B25	3.52	K17+600	900			1	55	1.1	1.4	0.05	0.9	0.1	0.3
B26	2.14	K17+800	900			1	70	0.8	0.9	0.05	0.9	0.0	0.0
B27	4.68	K18+100	1200			1	40	1.5	1.9	0.002	1.5	0.0	0.2
B28	5.55	K18+270	1200			1	100	1.9	2.3	0.05	1.8	0.0	0.2

MONTEGO BAY PERIMETER ROAD - DRAINAGE STRUCTURES													
BASIN	DRAINAGE AREA	CHAINAGE	PIPE	RCBC		BARRELS	BARREL LENGTHS	Q_D (25YR)	Q_D (100YR)	DESIGN SLOPE	CAPACITY	SURCHARGE (25YR)	SURCHARGE (100YR)
	(HA)		D (MM)	W (MM)	H (MM)	NO.	M	(M^3/S)	(M^3/S)	(M/M)	(M^3/S)	(M)	(M)
B29	35.43	K18+470	1200			2	110	3.5	6.3	0.05	3.6	0.0	0.5
B30	5.97	k18+900	1200			1	100	1.9	2.3	0.05	1.8	0.0	0.2
B31	5.01	K19+450	1050			1	80	1.4	1.9	0.05	1.3	0.1	0.2
B32	1.33	K19+775	900			1	50	0.6	0.7	0.05	0.9	0.0	0.0
B33	1.53	K19+990	900			1	50	0.6	0.7	0.05	0.9	0.0	0.0
B34	1.42	K20+220	900			1	50	0.6	0.7	0.05	0.9	0.0	0.0
B35	1.00	K20+430	900			1	50	0.4	0.6	0.05	0.9	0.0	0.0
B36	7.68	K20+785	1200			1	85	2.0	2.5	0.05	1.8	0.1	0.3
B37	10.53	K21+030	1350			2	90	2.5	3.2	0.05	2.4	0.0	0.3
B38	4.60	K21+230	1050			1	90	1.3	1.8	0.05	1.3	0.0	0.2
B39	6.42	K21+840	1200			1	45	1.9	2.4	0.01	1.9	0.1	0.3
B40	0.99	K22+020	900			1	55	0.4	0.4	0.05	0.9	0.0	0.0
B41	48.38	K22+230		3050	1830	1	40	11.3	16.8	0.01	11.7	0.0	0.6
B42	3.40	K22+300	900			1	60	1.1	1.3	0.05	0.9	0.0	0.3
B43	1.95	K22+475	900			1	60	0.8	1.0	0.05	0.9	0.0	0.1
B44	116.32	K22+665		2440	2130	2	30	17.7	30.2	0.05	18.9	0.0	0.8
B45	0.93	K22+800	900			1	45	0.4	0.6	0.05	0.9	0.0	0.0
B46	132.09	K23+000		2440	2130	2	30	18.9	30.2	0.05	18.9	0.0	0.8
B47	302.34	K23+100		3050	3050	2	35	39.6	62.2	0.05	40.4	0.0	1.0
B48	317.84	K23+400		3050	3050	2	40	39.9	62.8	0.05	40.4	0.0	1.0
B49	8.07	K23+600	1350			1	55	2.2	2.8	0.01	2.5	0.0	0.1
B50	4.55	K23+960	900			1	60	1.1	1.4	0.01	0.9	0.0	0.3
B51	40.40	K24+200		1830	1520	1	40	4.8	7.9	0.01	5.3	0.0	0.6

2.3.1.4.3 Special Drainage Conditions

The following sections are highlighted owing to special drainage conditions that exist:

5 - Chainage 10+500 to 11+400: Highway passes through wetland area close to the sea at the start of the project.
6 - Chainage 13+600 to 14+000: Realignment of the Montego River.
7 - Chainage 13+730: Major box culvert where the highway crosses the Tucker Spring (tributary to the Montego River).
8 - Chainage 17+160: Bridge structures where the highway and an access road (connecting the Porto Bello and Irwin communities) crosses the Montego River.

WETLAND AREA (CH 10+500 – 11+400)

The highway passes through the wetland area as shown in Figure 2-3. The highway in this area will be raised between 2 to 3 meters above ground for road stability and to prevent flooding of the roadway. This would create a divide in the wetland and cause flooding and water stagnation on the upstream side of the highway. To mitigate this, four 1.5m diameter balancing culverts will be installed at approximately 300m intervals to allow for the mixing and movement of water to continue within the wetland. This will allow storm runoff to continue to be conveyed to the sea and to prevent water stagnation on the upstream side of the highway.

Figure 2-3 Placement of culverts in wetland area (CH 10+500 – 11+400)

MONTEGO RIVER REALIGNMENT (CH 13+600 – 14+000)

The Concept Plans calls for the realignment of a section of the Montego River in the Fairfield area. The proposed realignment is between chainage 13+600 and 14+000 (Figure 2-4) and is proposed for the following reasons:

- The highway crosses the river twice in this area and would require the construction of two major bridges.
- There is a major interchange connecting the highway and the Fairfield Road which would impact on one of the two major bridges outlined in bullet 1 above. This would require a very complex and expensive design.

The realignment could cause potential increase flow velocities, but this is expected to be insignificant given the size of the Montego River.

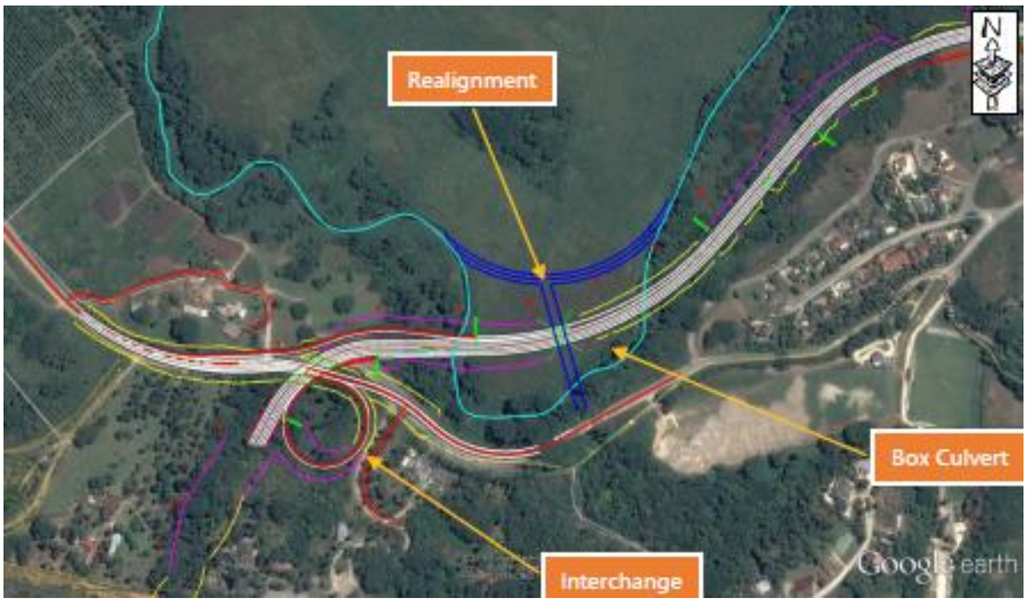


Figure 2-4 Proposed Montego River realignment and major box culvert for tributary crossing

BOX CULVERT

A major box culvert is required at chainage 13+730 where the highway crosses the Tucker Spring (Figure 2-4). The flow will be partly regulated by the existing bridge on the Fairfield Road. The box culvert is designed to convey the 100-year return period storm without surcharge. Saturated conditions within the watershed was represented by a CN value of 83. With a watershed area of approximately 910 ha, the design discharge was computed as 140.7 m3/s for the 100-year storm. Based on the hydraulic analysis, a double-cell 5.0m x 4.5m box culvert is proposed which has a flow capacity of approximately 170 m3/s. This flow capacity, being greater than the 100-year design flow, is sufficient to convey the 100-year design discharge without surcharge.

BRIDGE STRUCTURES

The Concept Plans call for two bridge structures across the Montego River as follows (Figure 2-5):

1. At the highway crossing at chainage 17+160
2. At the access road crossing.

The close proximity of the bridges means the required flow capacity for both structures are the same. The bridges are designed to convey the 100-year return period storm. Saturated conditions within the watershed was represented by a CN value of 84. With a watershed area of approximately 9,975 ha, the 100-year design discharge of 1,164 m3/s was computed. Based on the hydraulic analysis, a minimum flow area of 228 m2 is required. The flow area of the two bridges are as follows:

a. Highway crossing > 2,500 m^2
b. Access road crossing ~ 365 m^2

The flow areas, being much greater than the required flow area, are sufficient to convey the design discharge with adequate freeboard.

Figure 2-5 Bridge crossing of the Montego River

2.3.1.5 Structures

Drainage structures of less than 6.0m in length will be spanned by culverts or RCBCs, as discussed previously. Bridge structures have also been identified at locations where the proposed perimeter road alignments intersect existing roadways and connectivity across the new highway is required. In total there are ten locations identified as structural (bridge) crossings, 4 mainline structures and 6 crossroad structures, summarized in Table 2-6. Superstructure types considered include cast-in-place (CIP) conventionally reinforced concrete slab spans, precast/pre-stressed (PC/PS) concrete girders, and composite steel girders. All three types are viable and appropriate to the project and all three have been used successfully on previous Agency projects.

Table 2-6 Structure locations (bridges)

ALIGNMENTS	CHAINAGE	STRUCTURE TYPE	STRUCTURE LENGTH	SPANS
Bogue Rd over Montego Bay Perimeter road	200+525 11+620	PC/PS Concrete I-Girder	93.3 m	3
Montego Bay Perimeter road over Fairfield Rd	13+400 100+113	Welded Steel Plate Girder	49.0 m	1
Montego Bay Perimeter road over Fairfield Creek Connector	13+730 n/a	CIP Concrete Slab	18.0 m	2
Montego Bay Perimeter road over Riverside Drive	15+900 n/a	PC/PS Concrete I-Girder	33.2 m	1
Irwin Rd over Montego Bay Perimeter road	201+135 16+970	PC/PS Concrete I-Girder	65.4 m	2
Montego Bay Perimeter road over Montego Bay River & Adelphi Rd	17+140 n/a 201+210	Welded Steel Plate Girder	271.2 m	5
Irwin Rd over Montego Bay River	300+800 n/a	PC/PS Concrete I-Girder	33.2 m	1
Cornwall Courts Rd over Montego Bay Perimeter road	400+282 19+420	PC/PS Concrete I-Girder	33.2 m	1
Cottage Rd over Montego Bay Perimeter road	600+106 20+660	PC/PS Concrete I-Girder	33.2 m	1
Salt Spring Rd over Montego Bay Perimeter road	700+138 21+390	PC/PS Concrete I-Girder	33.2 m	1

2.3.1.6 Geotechnical Considerations

It should be noted that design parameters and recommendations presented here are preliminary; the investigation program was limited for a project of this size and importance with a relatively small number of widely spaced borings. In some cases, no borings were advanced in areas with difficult access. Additional investigations and field verification of geotechnical conditions during construction by the designer's geotechnical engineer/geologist is required to support and verify detailed design of the project features. The following geotechnical parameters are provided based on available geotechnical data and previous highway construction experience in the region.

2.3.1.6.1 *Material Parameters*

Table 2-7 and Table 2-8 present the recommended rock and soil parameters.

Table 2-7 Soil parameters

Soil Type	Color	SPT	γ (kN/m3)	$γ_{dry}$ (kN/m3)	ϕ	Cu (kPa)
Silty Clay	Grey	6	15.71	10.52	26	33.52
Sand	Grey	12	18.07	16.49	29	-
Silty Clay	Brown	9	18.07	13.82	28	83.79

Table 2-8 Rock parameters

Rock Type	Lump Density (kN/m3)	Natural Uniaxial Compressive Strength (MPa)	Saturated Uniaxial Compressive Strength (MPa)	ϕ
Limestone	26.23	24.99	18.89	30.0
Gypsum	17.28	6.31	3.79	8.0

2.3.1.6.2 *Embankment Slopes*

The proposed embankments are to be constructed of the locally available excavated rock and marl (silty clays) materials. Previous experience with embankment construction in the region has indicated stable marl embankment slopes of 1V:2H. However, based on the above soil parameters, an embankment slope of 1V:2.5H is recommended for the silty clay soils. Steeper slopes (1V:2H) may implemented if supported by additional investigations or construction observations indicating improved soil conditions.

2.3.1.6.3 *Excavation Slopes*

Most excavations in soil material will be relatively shallow, less than 5 m of depth. Based on recent experience in the region, soil excavation slopes of 1V:2H have successfully been constructed. However, based on the provided test data, an excavation slope of 1V:2.5H in the silty clay soils is recommended. Steeper slopes (1V:2H) may implemented if supported by additional investigations or construction observations indicating improved soil conditions.

Most of the project's excavations will be through bedrock (limestone or gypsum) layers, with some of the excavations as deep as 37 m. Regional experience excavating in the local bedrock has resulted in using rock slopes of 4V:1H, with 1.5 m benches every 15 m. The suggested rock material properties support a typical design section of 4V:1H slope with 1.5m benches at 15 m.

Bedrock conditions will vary along the alignment with zones of weathered and fractured rock being encountered. The designer's geotechnical engineer or geologist will need to assess the conditions during construction and make determination on slope adjustments or implementation of reinforcement or protection measures.

2.3.1.6.4 Bridges

There are nine proposed bridge locations for current alignment with many of the structures being within the gypsum bedrock zone. Based on the geological profile, the gypsum bedrock is shown from STA K14+600 to K24+900, with limestone from STA K10+000 to K14+600. Due to the corrosive potential of gypsum on steel, drilled concrete piers are recommended for support of project structures. Table 2-9 shows the drilled pier design parameters for gypsum and limestone supported foundations are recommended based on the data contained in the geotechnical report.

For concrete piers bearing in gypsum bedrock, additional measures are recommended to support design. Once bridge pier locations are established, it is recommended test borings be extended a minimum of 5 pier diameters below the proposed pier tip elevation to verify no cavities or voids are present. In addition, pier load testing should be performed to verify design capacities are achievable.

Table 2-9 Limestone and gypsum design parameters for drilled pier foundations

Rock Type	q_u design (MPa)	Ultimate End Bearing Capacity (MPa)	Side Friction (MPa)	E_{ri} (MPa)	k_{rm}
Limestone	5.00	20.00	0.037	7446	0.0005
Gypsum	1.26	2.93	0.019	1585	0.0005

2.3.1.7 Slope Protection Proposals

It is proposed to treat the side slopes with grass planting or skeleton grass planting to protect the slopes against erosion and achieve aesthetic appearance to blend in with the surrounding environment. For fill slopes with a height less than 10m, they will be protected with grass planting, while for fill slopes higher than 10 meters, they will be protected by grass planting along the slope face and the skeleton grass planting at the remaining slope areas.

For cut slopes with a height less than 10m, they will be protected by grass planting while for cut slopes with a height between 10 and 30m, they will be protected by grass planting at the slope top and skeleton grass planting at the remaining slope areas. For cut slopes higher than 30 m, they will be protected by grass planting to the top and berm of slope and anchor-Lattice beam grass planting to the remaining slope areas.

2.3.1.8 Main Technical Design Parameters

Taking traffic demand, existing road conditions and local needs in Jamaica into account, AASHTO standard (Arterial Roads) is applied for this project. According to American standard “A Policy on Geometric Design of Highways and Streets” (AASHTO, 6th Edition, 2011), combining different uses and trip modes along the road, the design speed along the route is 90 km/h and part of the road with difficult terrain adopts 60km/h. Both are bi-directional 4-lane roads. The main design parameters are summarized in Table 2-10.

Table 2-10 Design Parameters Montego Bay Perimeter Road

ITEM	UNIT	VALUE (General road section)	VALUE (Tough road section)
Road grade		Arterial Roads	Arterial Roads
Design Speed	Km/h	90	60
Road Width	m	25.2	25.2
Number of bi-directional lanes	No.	4	4
Lane width	m	3.65	3.65
Width of medial strip	m	3.6	3.6
Width of hard shoulder	m	2.5	2.5
Min. circular curve radius	m	300	180
Min. length of transition curve	m	150	100
Max. longitudinal slope	%	8	8
Pavement type		Asphalt concrete	Asphalt concrete
Camber crosswise slope	%	2.0	2.0

The design life of is 20 years for roadway pavements, 75 years for highway bridges and retaining structures, and 50 years for culvert structures.

2.3.1.9 Material Quantities

Table 2-11 shows the quantities estimated for various construction related activities.

Table 2-11 Estimated quantities for main works for Montego Bay Bypass

Source: (Stanley Consultants Inc., 2018)

ITEM	UNIT	QUANTITY
Subgrade Works		
Embankment	m^3	2174466
Excavation	m^3	3211933
Subgrade protection	m^3	86690
Pavement Works		
Asphalt concrete pavement (160 mm)	m^2	337196
Base course	m^3	355515
Subbase course	m^3	355515
Bridges and Culverts		
New bridges	m/Nr.	990/7
New culvert	Nr.	45

2.3.2 Long Hill Bypass Alignment

This component of the project encompasses the construction of approximately 10.5 kilometres of 2-lane, rural arterial highway with climbing lanes and escape ramps where required, leading from Montpelier intersection of B8 Road and B6 Road to Temple Gallery Road as described in the following sections. The implementation of this road section will essentially connect the Montego Bay Perimeter Road with the western end of the Phase 2B corridor of the East West Highway.

2.3.2.1 Road Sections

2.3.2.1.1 Section 1 - Temple Gallery Road to Ramble Hill Road

The Long Hill Bypass will begin at the intersection of the proposed Montego bay Bypass and the Temple Gallery/Clarence Nelson Drive, in the vicinity of the Bogue Village and Montego Bay West Village Housing Estates as an urban Intersection with “at-grade” crossing. The alignment will proceed in a general southerly direction through scrub land towards Bogue Hill crossing the Ramble Hill road with a grade separated overpass. The grades for this section will range from approximately 2% to 8%.

2.3.2.1.2 Section 2 - Ramble Hill Road to Bogue Hill Road

This section of the proposed highway traverses the densely populated area of Bogue Hill impacting a large number of residential and commercial structures. This includes at least three (3) churches and a basic school. The terrain is very steep in some sections and two major gullies are crossed. This section will include the construction of an overpass bridge over the Bogue Hill Drive and drainage structures as a major gully traverses the community in a south to north direction. The grades in the Bogue section is 8% for a distance of 1.5 km.

NROCC will consider a realignment in this area to avoid the churches and the basic school.

2.3.2.1.3 Section 3 - Bogue Hill to Anchovy Main Road

This is primarily a rural section of the proposed highway travelling south westerly in upland areas. The terrain in this section of the corridor is quite steep and will involve mainly cuts due to the terrain. The area is sparsely populated and ends with an interchange at the anchovy main road. The maximum grade in this area is 5.6% for approximately 500 meters.

2.3.2.1.4 Section 4 - Anchovy main Road to Mount Carey

This section of the proposed alignment traverses undulating landscape having a mixture of disturbed vegetation along with residential and farming activities. The residential areas show instances of informal as well as traditional rural settlements and the project will result in the relocation of sentiments of the community. At the northern end of this section, a Church and a school are currently in the proposed alignment. This section of the roadway will have maximum slopes of 2.87% for approximately 1.5 km.

2.3.2.1.5 Section 5 - Mount Carey to Montpelier

This section of the roadway traverses the communities of Mount Carey Village, York Bush and Mahogany. The former two areas will have direct impact on residential while the latter will be bypassed to the west. Of significance is the York Bush community where land tenure issues may arise. The community is less organized and the passage of the highway, will cause some amount of dislocation.

2.3.2.1.6 Section 6 - Mount Carey to Montpelier Road Section

This section of the alignment traverses mainly greenfield landscapes with cultivations spotted along various sections. There are no residences observed along this section. The landscape shows several hills and valleys which will results in maximum slopes towards the north, at 8.00% and slopes in the southern section between 1.00% and 3.41%. The final section crosses orange orchids and end at an intersection with the Montpelier main road.

2.3.2.2 Main Bridges

Seven (7) bridges are planned for the Long Hill Bypass, all of which are overpasses (Table 2-12).

Table 2-12 Main bridges

No	Chainage	Local Name	Type	Bridge Type
1	-	Ramble Hill road	Overpass	Local Road
2	-	Bogue Hill Road	Overpass	Local Road
3	-	Anchovy Main Road	Overpass	Local Road
4	-	Railway Crossing	Overpass	Local Road
5	3+065	York Bush	Overpass	Local Road
6	3+307	Mount Carey Village	Overpass	Local Road
7	3+981	Cotton Tree Heights	Overpass	Local Road

2.3.2.3 Main Technical Design Parameters

The main design parameters for the Long Hill Bypass are outlined in Table 2-13.

Table 2-13 Main Technical Design Parameters of Long Hill Bypass

Item	Unit	Value
Road grade		Arterial Road
Design speed	Km/h	95
Road width	m	10.9
Number of bi-directional lanes	No.	2
Lane width	m	3.65
Width of medial strip	m	0
Width of hard shoulder	m	1.5
Min. circular curve radius	m	400
Min. length of transition curve	m	150
Max. longitudinal slope	%	8
Pavement type		Asphaltic concrete
Camber crosswise slope	%	2.0

2.3.3 Barnett Street Dualization

Barnett Street improvement is the dualization of 1.06 km of the existing two-lane road section from the intersection of West Green and Fairfield road in a northerly direction and ending at Cottage road. The proposed works will involve the construction of an additional two-lane bridge over the Montego Bay River in the vicinity of the West gate Shopping Centre. The implementation of this section of road is designed to complement the Montego Bay Bypass by moving approximately 27,000 VPD in and out of the Central Business district.

The main design parameters for the Barnett Street Dualization are outlined in Table 2-14.

Table 2-14 Main Technical Design Parameters of Barnett Street

Item	Unit	Value
Road grade		Arterial Roads
Design speed	Km/h	60
Road width	m	24.8
Number of bi-directional lanes	No.	4
Lane width	m	3.65
Width of medial strip	m	3
Width of hard shoulder	m	2.5
Min. circular curve radius	m	300
Min. length of transition curve	m	150
Max. longitudinal slope	%	8
Pavement type		Asphaltic concrete
Camber crosswise slope	%	2.0

2.3.4 West Green Avenue Dualization

West Green Avenue improvement is the dualization of the 0.82 km existing link road between Howard Cooke Boulevard and the Bogue Road at the Fairfield Road intersection. The construction will result in the removal of the existing round-a-bouts and the creation of signalized intersections, construction of sidewalks, concrete median barrier and drainage improvement. The aim is to improve the capacity to convey traffic between these two busy corridors and by extension the proposed Montego Bay Bypass and reduce travel time.

The main design parameters for the dualization of West Green Avenue are outlined in Table 2-15.

Table 2-15 Technical Design Parameters of West Green Avenue

Item	Unit	Value
Road grade		Arterial Roads
Design speed	Km/h	60
Road width	m	24.8
Number of bi-directional lanes	No.	4
Lane width	m	3.65
Width of medial strip	m	3
Width of hard shoulder	m	2.5
Min. circular curve radius	m	300
Min. length of transition curve	m	150
Max. longitudinal slope	%	8
Pavement type		Asphaltic concrete
Camber crosswise slope	%	2.0

2.4 AUXILIARY PROJECT ACTIVITIES

2.4.1 Construction Camps and Infrastructure

The location of the construction camp/site(s) yard(s) have 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 projects should be taken into account, with regards to good housekeeping habits, conformance to permitting requirements, and adherence to audit procedures.

Water for the camp/site(s) yard(s) will be obtained either by connection to a NWC pipeline in proximity to the site or by water trucked to the site and stored in tanks. Wastewater generated from the camp/site(s) yard(s) will be collected and treated by plant. These will be designed to meet the NEPA sewage effluent and wastewater standards and the Ministry of Health requirements. Along the alignment of the highway construction, portable toilets will be strategically placed in the desired numbers. A guideline that should be used 1 portable toilet per 25 workers. Electricity for the campsite will be had either through connection to a JPSCo powerline or through the use of standby generators or a combination of both.

2.4.2 Waste Management Plan

2.4.2.1 Construction

Solid waste will be disposed of in a manner approved by National Solid Waste Management Authority (NSWMA). Removal and disposal of hazardous waste material shall be performed in accordance with all applicable government, county, parish, and local regulations. Submittal of documentation attesting to the method proposed for disposal of wastewater will need to be submitted.

Efforts will be made to avoid and minimize spillage of fuels, lubricants, cleaners, solvents, or other hazardous substances which may potentially contaminate surface water bodies and groundwater bodies. Maintenance of vehicles and equipment will be conducted on hardstands in designated areas designed to contain incidental spills of hydraulic or other fluids.

Secondary containment for all bulk storage tanks or drums will be provided. Secondary containment shall be of adequate size to contain the entire contents of the tank plus sufficient freeboard to allow for precipitation. All secondary containments shall be constructed of impermeable materials to prevent infiltration of spilled or leaked tank contents onto the ground. Disposal of concrete residue and wash water, water from aggregate washing and other operations resulting in sedimentation will be treated by filtration, settling basins, or other means sufficient to reduce the sediment concentration to applicable limits established by NEPA.

The Project Manager and/or his designated representative will have the responsibility to implement and monitor the Plan. Project Manager and/or his designated representative will be supported by work team of monitors who will ensure waste is stored in the designated areas and assist in litter control. The team will also ensure burning of solid waste does not take place on the construction site. In addition, proper signage will be established to identify interim storage areas on site.

Litter control will be a key part of the solid waste plan. Forty-five-gallon drums will be placed at strategic locations to collect litter. In addition, workmen will be given responsibility to control litter in their work area as part of monitoring programme.

The Site Manager will keep a log of the waste leaving the site. This will include; date, waste type, vehicle number, estimated quantity and disposal site. A ticketing system will be developed, and records of disposal will be kept ensuring effective management of 'cradle to grave' and verification of disposal at the correct site. The logbook/ticketing system will be in place where upon departure the license number, time of departure and drivers name will be logged. An authorized agent before departure of each truck trip from the construction site will sign this ticket in triplicate.

The drivers of trucks entering the disposal site must have a valid identification card and the ticket must be given to the respective agent located at the site. The time of arrival must be entered, and the ticket signed. The driver will receive a copy of the ticket as prove that the cargo he was carrying was delivered to the dumpsite. Monitoring of the transportation of solid waste from the construction site to the disposal site at will be done to ensure that no debris being transported is falling unto the roadway along the route. This will be done by an appointed agent. Spot checks should be conducted by NEPA and/or the Local Planning agencies.

2.4.2.2 Operation

The only expected solid waste to be generated during operations will come from littering by users of the roadway and/or accidental spillage of debris/material etc. from trucks transporting said items.

2.4.3 Utilities

Details regarding the utility infrastructure (e.g. JPS, DIGICEL, FLOW, NWC etc.) falling within the proposed alignments and to be relocated are to be finalised.

2.4.4 Site Access

Access to the project site will be through controlled ingress and egress along the existing main road. Flagmen and warning signs with cones will be in place during active construction zones.

The access plans have not been finalized; however, upon finalization the plans will be shared with the relevant Regulatory Authorities for approvals. Special consideration will be given to all socially sensitive areas (e.g. residential areas, schools, etc.) and ecologically sensitive areas (e.g. primary forest, endemic species etc.). These will be avoided where possible.

2.4.5 Decommissioning and Site Rehabilitation

The rehabilitation will start with the restoration of the locations of the construction campsites and other cleared areas associated with the road works. This area will be backfilled with material removed during campsite construction and supplemented with layers of topsoil also removed during clearance activities. The surface will be stabilized according to an active planting program. The establishment of a ground cover is of priority, after which, hardwood trees can/will be planted in the final rehabilitation phase. A plant nursery will be setup by the contactor to ensure that sufficient, suitable plant material is available to allow a timely re-vegetation of the site. Please see section 6.3.4 for further details.

2.4.6 Source of Raw Materials

Thirty-one (31) licensed quarries have been identified to be within 20km of the proposed project area (Figure 2-12 and Table 2-18). These quarries vary in material supplied with 29 supplying crushed limestone, 1 supplying river aggregate and 1 supplying Andesite. 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 contractor must apply from the relevant Government authorities' permits for mining and quarrying operation.

Table 2-16 Summary of quarries and their respective locations and materials supplied in proximity to the project areas

Quarry Operators	Location	Proximity (km)	Material Supplied
Jamaica Quarry Products	Chigwell, St. James	10.3	Limestone
Dante Foote	Webbers Valley	18.4	Limestone
Anthony Frank Beaumont	Gray's Mount, St.James	4.1	Limestone
Carlcord Construction	Wiltshire, St. James	1.4	Limestone
Ewen Corrodus	Childermas, St. James	0.7	Limestone
F.P.A Limited	Wiltshire, St. James	0.3	Limestone
Amrod Investment Co	Long Hill, St. James	1.0	Limestone
Amrod Investment Co	Long Hill, St. James	1.0	Limestone
WIHCON	Retirement, St. James	1.3	River Aggregate
Crichton Quarry	Retirement, St. James	3.0	Limestone
Western Wheels	Blackshop, St. James	7.3	Limestone
Danmore Ltd.	Retirement, St. James	4.0	Limestone
John's Hall Aggregates	John's Hall, St. James	5.0	Limestone
Henry Rhoden	Flower Hill, St. James	3.0	Limestone
Keiffer L. R. Singh and Associates Ltd	Kirkpatrick Hall, St. James	3.0	Limestone
George Anderson	Paisley, St. James	6.5	Limestone
Williams Quarry	Hogcrawl, St. James	7.2	Limestone
Leyden Investments	Lottery, St. James	11.1	Andesite
Spring Vale Farm	Spring Vale, St. James	18.8	Limestone
Errol Construction	Yorkland, St. James	10.2	Limestone
Trelawny Sugar Co.	Gales Valley, Hampden	13.8	Limestone
Ruel A. Barnett	Content, St.James	8.9	Limestone
Silbert Roy Romans	Chatham District, St.James	10.8	Limestone
Kent Industries Ltd.	Kent, St. James	13.2	Limestone

Quarry Operators	Location	Proximity (km)	Material Supplied
Spot Valley Sports, Ent. & Training Complex	Spot Valley, Rose Hall, St. James	10.1	Limestone
Garfield Dussard	Lilliput, St. James	12.3	Limestone
Jose Cartelloness CCSA	Hatfield Estate, St. James	0.3	Limestone
Jose Cartelloness CCSA	Ironshore, St. James	1.0	Limestone
Nationwide Design Co. Ltd.	Norwood, St. James	2.4	Limestone
Selvyn Smith	Wiltshire, St. James	1.4	Limestone
Cornwall Aggregates	John's Hall, St. James	10.1	Limestone

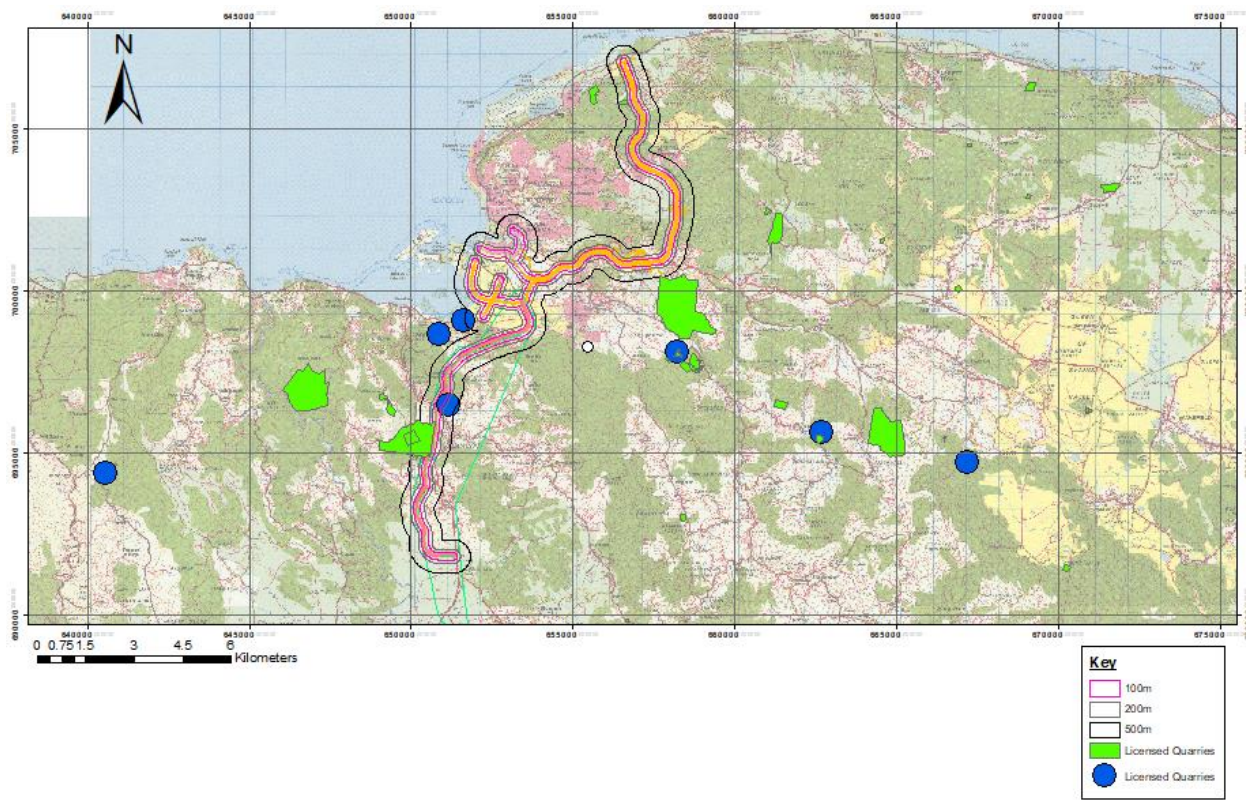


Figure 2-6 Map showing Licensed Quarries in relation to the proposed project area

2.4.7 Measures for Mitigating Environmental, Health and Safety Impacts

2.4.7.1 Design Phase

According to the regulations of design code of environmental protection for highway, environmental protection measures shall be incorporated at the design phase in the following aspects:

i) Rational utilization of land resources: The land resources along the route shall be investigated and studied in detail and developed rationally according to the local development planning.

Development of water, sewage and underground utilities shall be included in project design and facilitate land use planning and implementation.

ii) Protection of water bodies: Information on the distribution, flow, and major functions of the water source within a range of 200m at both sides of the road shall be investigated and collected. Water bodies shall be protected from excessive sedimentation during construction and operation. Runoff from rehabilitated roadways or new roadways shall be cleaned up before discharging into receiving water bodies near the road construction. The drainage of new roadways and rehabilitated roadway shall be managed to reduce contamination of water bodies into which they discharge. Sediment management and oil and grease management must be designed into the improved works. The construction and operation phases shall have water quality management facilities or mechanisms.

iii) Design of protection works/safety features of the route: The protection works of the road shall stabilize the subgrade, reduce the road hazards and improve driving safety, and also save the land resources and protect the environment. Protective works should assist in preventing water loss and soil erosion. Protective measures of this Project shall be designed according to the different forms of the side slope.

iv) Re-vegetation project of the route: Vegetation can play an important role in stabilizing the subgrade, protecting the slope and maintaining the water and soil. Vegetation also improves the road aesthetics. Vegetation can also filter runoff, adsorb dust, purify the air, conserve water source, reduce the noise, and beautify the road, therefore having the function of improving the road environment.

v) The widening of road will impact the original alignment vegetation; therefore, the re-vegetation design on both sides of the route shall give full considerations to the characteristics of the area, the local climate and environmental characteristics, and the protective measures of the project.

vi) Selection of borrow area: Aggregate for road construction shall not be obtained directly from the construction site in order to avoid the formation of ditches at the site of the road construction, which could destroy the natural drainage system. The borrow area for the road construction shall be determined through coordination with the NROCC and the Mines and Geology Division. The location shall be selected in combination with the local economic development planning in order to obtain aggregate centrally. In the process of obtaining the aggregate, special attentions shall be paid to the protection of the local water, soil resources and roads in the area.

vii) Spoil stockpiling: In the process of stockpiling the spoil from the construction, the spoil shall not destroy the vegetation, nor block the original discharge system nor pollute the water body. Stockpiling locations must be designated to enhance environmental protection.

viii) Effective Environmental Management Plan, Occupational Health and Safety Management Plan, Emergency Management Plan, Oil Spill Contingency Plan shall be developed for the Project. These shall be submitted to the relevant Authorities for review and comments before project implementation begin

ix) Environmental Permit shall be sought for the projects that fall into the category of activities that require environmental permits for implementation. The Permit and License System (P&L)

is the mechanism used by the Natural Resource Conservation Authority Act (NRCA) to ensure that all development within Jamaica meets required standards in order to minimize negative environmental effects. The P&L was established by the NRCA, which is the legal and institutional framework of the environmental assessment process in Jamaica. Under this system projects involving major road improvements extending over 10 km, construction of new roads and multi span bridges require environmental permits in order to be implemented.

2.4.7.2 Design of Soil and Water Conservation

The measures for the design of soil and water conservation are as follows:

i) Based on the different geological conditions, the rational protection mode shall be adopted for the cut-and-fill of the side slope of the subgrade to ensure the stability of the side slope.
ii) The existing water conservancy facilities and runoff system shall be retained as much as possible, the irrigation and drainage system changed due to the construction shall be rationalized to ensure smooth water flow and reduce the soil and water loss.
iii) A re-vegetation design/plan for the road works shall be properly produced. The implementation of the plan should not only beautify the environment and improve the driving conditions but also prevent the water loss and soil erosion effectively.
iv) Method statements for construction activities shall be submitted for approval before construction begins. The statements shall ensure that exposed areas along these routes are kept to manageable stretches in keeping with available budgets and dust control parameters.

2.4.7.3 Construction Phase

i) The sewage and wastewater generated during the construction shall be prohibited from being discharged randomly into the environment. The sewage and wastewater shall be treated in a designated central system or transported to a facility approved by the National Environment and Planning Agency (NEPA) to process and meet the discharge standard.
ii) During the construction, contamination of land by storage of material such as hazardous material (sewage, oil, waste) must be minimized with the implementation of appropriate storage measures and waste disposal methods. The construction equipment shall be checked in order to avoid the spilling and leakage of the oil to reduce the pollution of the land and water source along the route. During the construction, the waste and garbage shall be collected and treated in facilities approved by the NEPA in a timely manner.
iii) The concrete mixing area shall be located far away from the residential districts; night construction shall be reduced to the minimum and timely notice of activities shall be given. Work shall be done in the normal working hours (namely 8:00 am -5:00 pm) to reduce the impact of noise on the residents.
iv) If a batching plant is being used, the stabilized soil mixing with the fly ash, lime, cement, etc., shall be sprayed to stabilize the material, and the water shall be sprayed to prevent the pollution of the air by the flying ash and dust. Admixture shall be used to assist in pollution reduction.

v) If the permanent, temporary construction ground and borrow area in the project have destroyed the original vegetation, the re-vegetation work shall be performed after the completion of road construction to reduce the adverse impact on the environment.
vi) Heavy-duty vehicles transporting material to site must be covered to reduce dust nuisance.

A team of environmental professionals with adequate experience and qualification must be on board to monitor the implementation of the Environmental Management Plan that will be developed for the Project.

2.4.7.4 Operational Phase

i) Vehicles with emission exceeding the discharge standard shall be restricted from driving on the road;
ii) The traffic control and traffic movement shall be enhanced, and the vehicle shall maintain the minimum speed to reduce the tail gas emission;
iii) The vehicle shall be kept clean to reduce the pollution from dust;
iv) The timely maintenance shall be made to reduce the noise pollution due to the vibration of the vehicle;
v) The environmental monitoring shall be strengthened in order to prevent the environmental damage caused by the unexpected event.

2.5 PROJECT PHASES AND SCHEDULE

2.5.1 Project Timeline

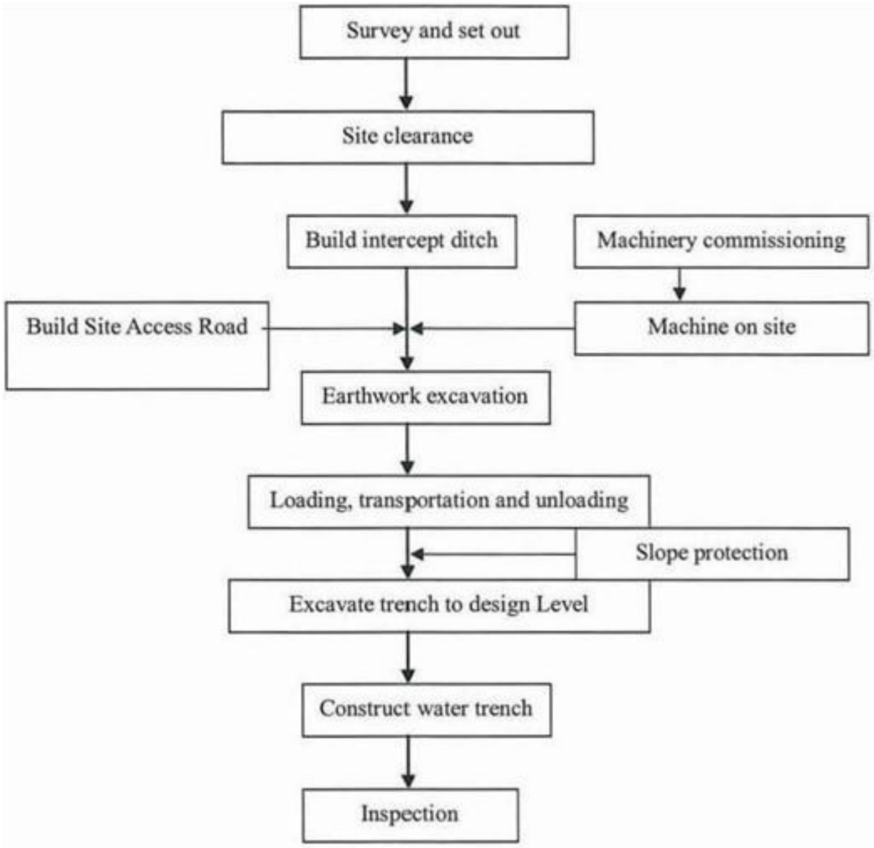
The estimated timelines for each phase are given in Table 2-17 below. It is anticipated that the project will commence in the year 2020.

Table 2-17 Table of proposed Project Timelines

Phase	Summary Description	Expected Duration
Design Phase	Land Acquisition and other similar activities	9 months
Construction Phase	Site preparation and general construction	26 months
Defects Liability Period	Any issues related to the defects etc.	2 years

2.5.2 Construction Methods

It is anticipated that the entire construction period for the project will last 26 months and will likely follow the procedures outlined in Figure 2-6.



Source: (CL Environmental Co. Ltd., 2013)

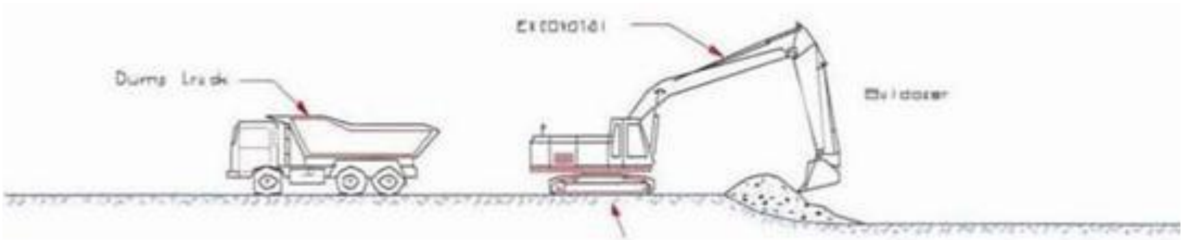
Figure 2-7 Roadbed construction procedure

2.5.2.1 Site Clearance and Removal of Vegetation

Site clearance will be carried out before commencing of any excavation and filling works. The scope of site clearance works comprises removal and disposal of vegetation, debris, contaminated soil, trees and brushes. The waste material will be deposited where appropriate, at the municipal waste disposal site. It is proposed to remove generally 30 cm deep topsoil. Topsoil generated from the project and free from petroleum products, construction waste, and debris will be reused for landscaping planting (Stanley Consultants Inc., 2018).

2.5.2.2 Excavation

Excavation of soft material shall be done in layers from the top downwards (Figure 2-7). Bulldozers and excavators with hydraulic breaker will be deployed to remove the rock.

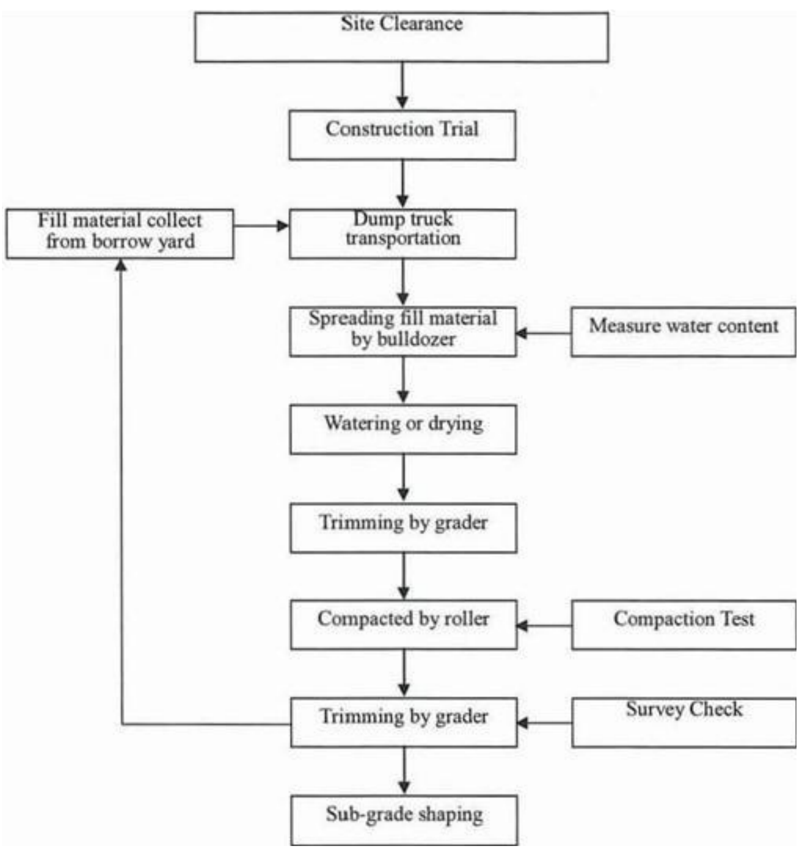


Source: (CL Environmental Co. Ltd., 2013)

Figure 2-8 Earthwork excavation

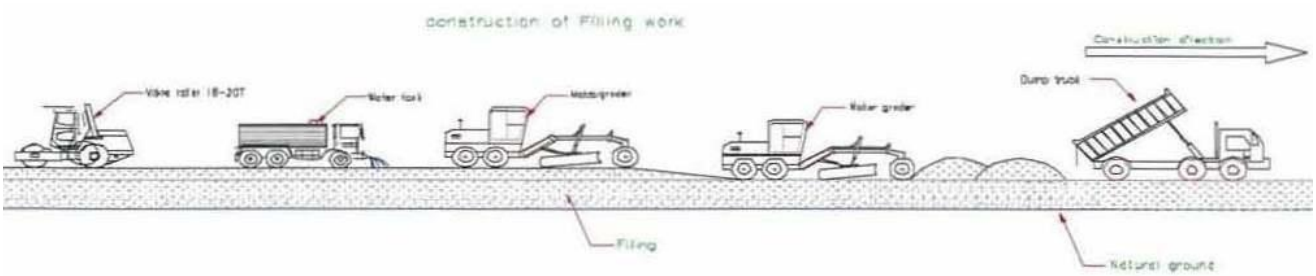
2.5.2.2.1 Roadbed Filling

Figure 2-8 outlines the procedures that will be employed to do roadbed filling. The filling material will be transported to the construction site from the borrow area and dumped in the site, then spread by bulldozer and trimmed to control the design level. Then roller will be deployed to compact. 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. In case of filling by sections and at different time, the first section shall be filled by bench method with gradient 1: 1.



Source: (CL Environmental Co. Ltd., 2013)

Figure 2-9 Construction procedure for roadbed filling



Source: (CL Environmental Co. Ltd., 2013)

Figure 2-10 The steps for transporting, spreading and compacting fill material

2.5.2.2.2 Subgrade Filling and Compaction

Formation of subgrade will be completed in layers not exceeding 30 cm in height. Adequate compaction will be carried out to achieve the required requirement for pavement structures. The requirements for compaction of subgrade and the size of fill materials are shown in Table 2-18.

Table 2-18 Subgrade compaction standard and particle size of fills

Source: (Stanley Consultants Inc., 2018)

Type	Subgrade level below finished grade (mm)	Degree of compaction / CBR (%)	Maximum size of fill material (mm)
Embankment	0～300	96/8	100
	300～800	96/5	100
	800～1500	94/4	150
	＞1500	93/3	150
Cut platform	0～800	96/8	100

2.5.2.2.3 Soft Ground Improvement

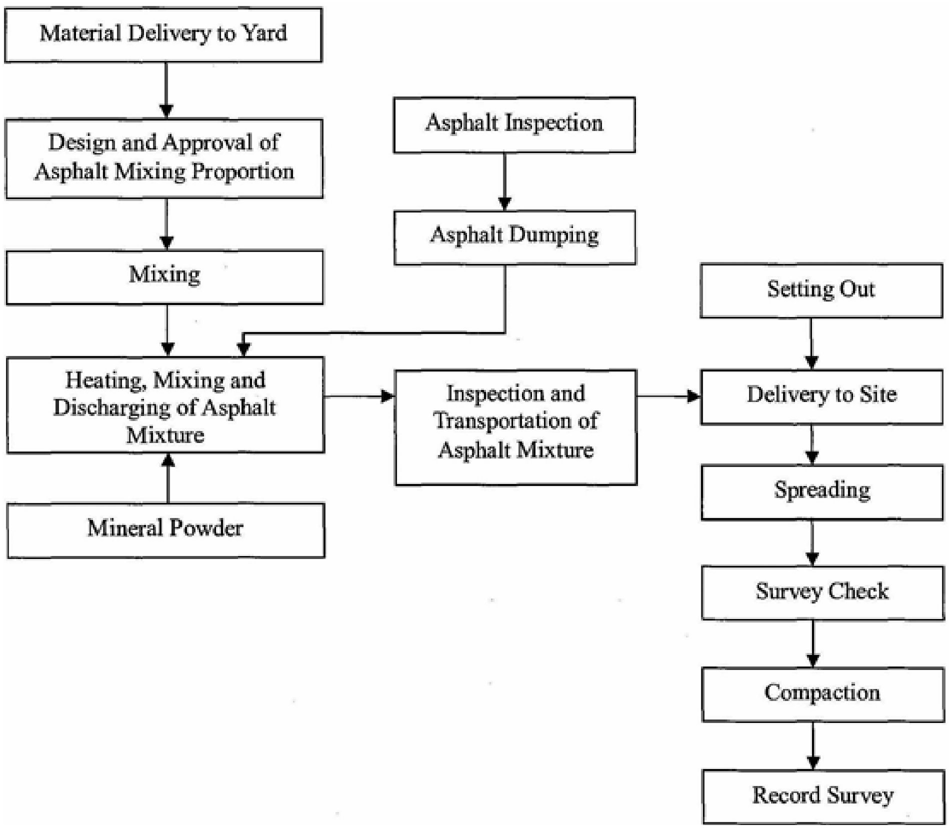
It is anticipated that there may be some soft ground encountered along the route of road widening or newly aligned road sections. For the superficial soft ground, the soft soil will be replaced by sand, coarse soil or other permeable materials, while for the deep soft soil, cement mixing piles or similar treatment solutions are recommended (Stanley Consultants Inc., 2018).

2.5.2.3 Drainage and Retaining Wall Construction

Forming the bedding with crushed stone after excavation, concreting to designed level. The reinforced concrete retaining wall will be constructed by employing backhoe, steel-fixer, carpenter and concreter.

2.5.2.4 Pavement Construction

The pavement works will follow the methodology outlined in Figure 2-10.



Source: (CL Environmental Co. Ltd., 2013)

Figure 2-11 Pavement Construction Schematic

2.5.2.4.1 Asphalt and Base Course Work

The thicknesses of the asphalt and base course are 90 mm and 430 mm respectively. The graded material will be graded by bulldozer, levelled and spread by a spreader and then compacted to required degree of compaction.

2.5.2.4.2 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).

Source: (CL Environmental Co. Ltd., 2013)

Plate 2-1 Asphalt Pavement Construction (Spraying)

2.5.2.4.3 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).

Source: (CL Environmental Co. Ltd., 2013)

Plate 2-2 Transportation of Asphalt Concrete

The asphalt concrete will be spread by three ABG-type Pavers equipped with auto-adjusting thickness devices and auto-levelling device and initially compacting device. The Paver will be adjusted to the best working condition to ensure the paving surface is even so as to reduce or to eliminate segregation.

The elevation control method guided by steel wire shall be applied to spreading. The spreading speed will keep up with the step of material supply and compactors to ensure the consecutive and even spreading without interruption as much as possible (Plate 2-3).

Source: (CL Environmental Co. Ltd., 2013)

Plate 2-3 Asphalt Concrete Spreading

2.5.2.4.4 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).

Source: (CL Environmental Co. Ltd., 2013)

Plate 2-4 Spreading and Compacting Asphalt Mixture

2.5.2.5 Bridge Construction

Bridge construction will be constructed concurrently with road construction.

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.

2.5.2.5.1 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.

2.5.2.5.2 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.

2.5.2.5.3 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. After jacking into position, cement mortar shall be applied to grout to seal the holes.

2.5.2.5.4 Precast Beam Storage

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

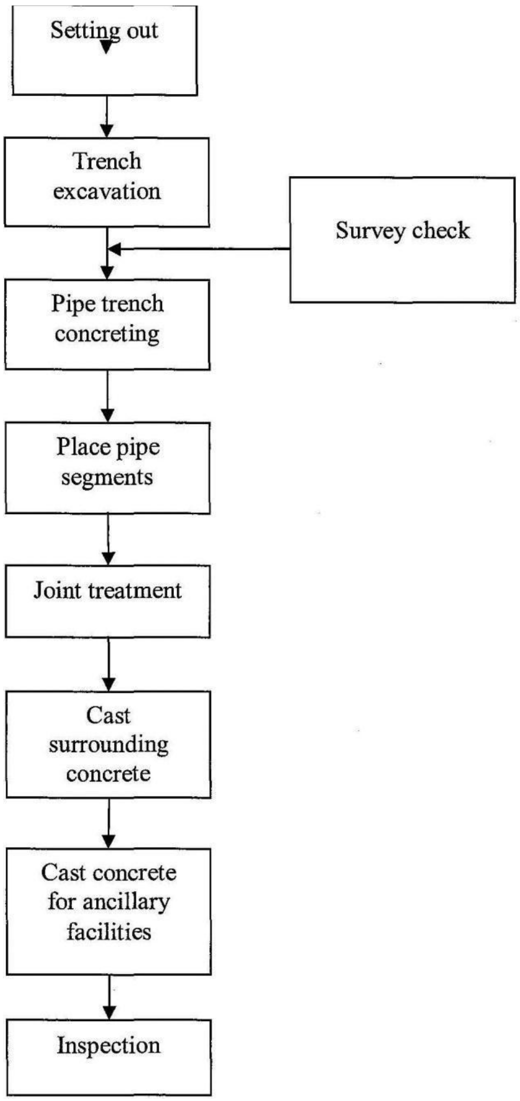
2.5.2.5.5 Beam Installation

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.

2.5.2.6 Culvert Construction

The construction procedure is set out in Figure 2-11. 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. 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.



Source: (CL Environmental Co. Ltd., 2013)

Figure 2-12 Culvert Construction Procedure

2.5.2.7 Transportation Considerations

2.5.2.7.1 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

2.5.2.7.2 Potential Road Diversions

Potential road diversions will be discussed and agreed upon by the proponent and relevant authorities and subsequently announced to the public.

2.5.2.7.3 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 Ministry of Transport and Mining (MTW).

2.5.2.8 Decommissioning and Abandonment of Works

Prior to the end of the project, a detailed decommissioning plan will be submitted to the relevant agencies. This will include but not limited to the following project features: batching plant, camp site (dormitories, sewage, canteen etc.) and fuelling and repairs stations.

2.5.2.9 Equipment and Machinery

The following types of equipment and plants are anticipated for the construction phase.

- Bulldozer
- Backhoe
- Asphalt Paver
- Dump Truck
- Frontend Loader
- Water Truck
- Crane
- Roller
- Excavator
- Grader
- Concrete Batching Plant
- Asphalt Batching Plant
- Concrete Mixer Truck
- Aggregate Crushing Plant

2.5.2.10 Employment

The proposed project is expected to employ local and expatriate persons during construction. The numbers are not yet known.

2.5.3 Operation

2.5.3.1 Activities

Toll plazas have not been included in the design plans or estimate; however, areas have been identified where toll plazas can be located (Section 2.3.1.3)

2.5.3.2 Employment

Approximate numbers are not yet known.

3.0 DESCRIPTION OF THE ENVIRONMENT

3.1 PHYSICAL ENVIRONMENT

3.1.1 Climate and Meteorology

The following climate data was taken from the Technical Report for the NFE North Holdings Ltd. Montego Bay Micro-LNG Receiving Terminal, 2016.

Montego Bay has a subtropical to tropical climate, with yearly minimum temperatures averaging 22.3 °C and maximum temperatures averaging 29.8 °C (Table 3-1). Mean monthly temperatures are lowest in January and February and highest between June and October.

The mean monthly relative humidity ranges between 71 and 84 percent. Relative humidity is low in the afternoon and high in the evenings. Mean monthly values of daily sunshine hours range between 7.0 and 8.5 (Table 3-1).

Winds impacting Montego Bay blow predominantly from the E and ENE throughout the greater part of the year. However, seasonal changes occur in the annual wind regime and may be described as follows:

- December to February: winds are primarily from the NE to ENE.
- March to May: winds are mainly from the East.
- June to August: winds are primarily from the E to ESE.
- September to November: winds are mainly from the E to SE.

Mean wind speed at Donald Sangster International Airport is typically 9 m/s (17 knots) and maximum sustained winds speeds are generally between 5 m/s (10 knots) and 12 m/s (25 knots) (Louis Berger International, Inc., 1996).

Table 3-1 Monthly Averages of Climatological Data for Montego Bay (Sangster International Airport)

Month	Maximum Temperature (ºC)	Minimum Temperature (ºC)	Rainfall (mm)	Number of Rain days	Relative Humidity - 7am (%)	Relative Humidity - 1pm (%)	Sunshine (hrs)
January	27.9	20.7	85.0	9	85	71	7.3
February	28.2	20.4	69.0	8	85	71	7.5
March	28.8	20.9	27.0	5	83	68	8.5
April	29.5	21.9	53.0	7	82	68	7.5
May	30.2	22.6	100.0	12	83	71	8.2
June	30.9	23.1	122.0	10	84	72	7.5
July	31.3	23.5	53.0	7	82	70	8.3
August	31.4	23.6	95.0	10	82	70	7.8
September	31.1	23.1	127.0	12	84	72	7.0
October	30.4	23.1	166.0	13	86	75	7.5
November	29.7	22.8	110.0	11	84	73	7.0
December	28.4	21.9	103.0	9	89	72	7.5
Maximum	31.4	23.6	166.0	13	89	75	8.5
Minimum	27.9	20.4	27.0	5	82	68	7.0
Mean	29.8	22.3	92.5	9	84	71	7.6

The Average Climatological data based on a 50-year return period monthly mean rainfall for Montego Bay ranges from a low of 27 mm in March to a high of 166 mm in October (Figure 3-1). The rainy season is from August to December and the dry season from January to July.

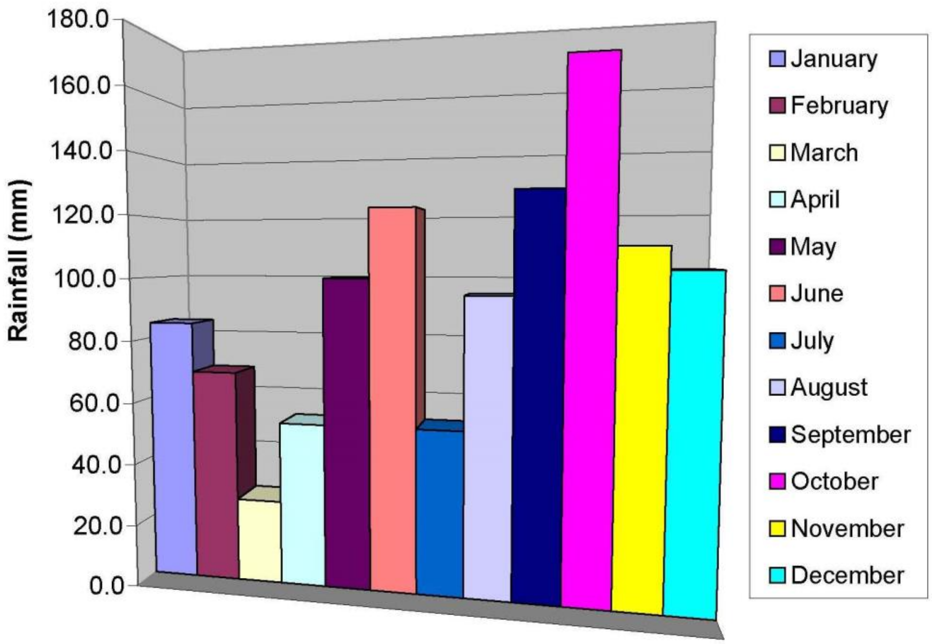


Figure 3-1 Monthly Rainfall Distribution (Sangster International Airport, Montego Bay)

3.1.1.1 Fog Formation

Fog is clouds of tiny water droplets that is at or near ground level (suspended in the atmosphere) and sufficiently dense to reduce horizontal visibility to less than 1,000 metres (3,281 feet). Fog also may refer to clouds of smoke particles, ice particles, or mixtures of these components. It is similar to mist, however with mist horizontal visibility is above 1,000 metres.

The air around us can hold a certain amount of water vapor, or water in a gaseous state. As more and more water fills the air, the air feels more humid. The amount of water vapor in the air is known as humidity. When the water vapor completely saturates the air, the water droplets start to condense, or turn from a gas back into a liquid. This temperature is known as the dewpoint. When the conditions are ideal (clear skies, particulates so that the water vapours can coalesce), light winds (<6.7ms^{-1}), humid air) and the difference between air temperature and dewpoint is 3 ^{o}C or less then fog will form.

The types of fog are separated into three main categories, and some of these categories have multiple types. These are:

1. Radiation fog: is fog that is due to the cooling of the earth's surface at night. In the evening, the earth radiates off heat absorbed from the Sun's light during the day. As the warm air rises,

the air near the earth's surface becomes cooler. Cold air can hold less water vapor than warm air, and the water vapor in the air near the surface condenses, forming radiation fog.

2. Advection fog: is the fog that appears due to cool air mixing with warm air. Warm, moist air flows into a cooler area. Since cold air can hold less water vapor than warm air, the water vapor condenses and forms fog.
3. Precipitation Fog: is fog that forms when rain is falling through cold air.

A Davis weather station was set April 11 – May 1, 2019 in Montpelier. The data indicated that between 7pm and 8 am during the time period, the difference between the air temperature and dewpoint were ≤ 3°C (Figure 3-2) and wind speed was below 6.7 ms^{-1}. This indicates that there is a potential for fog formation. Fog formation in the area was confirmed by personal communications during the structure survey.

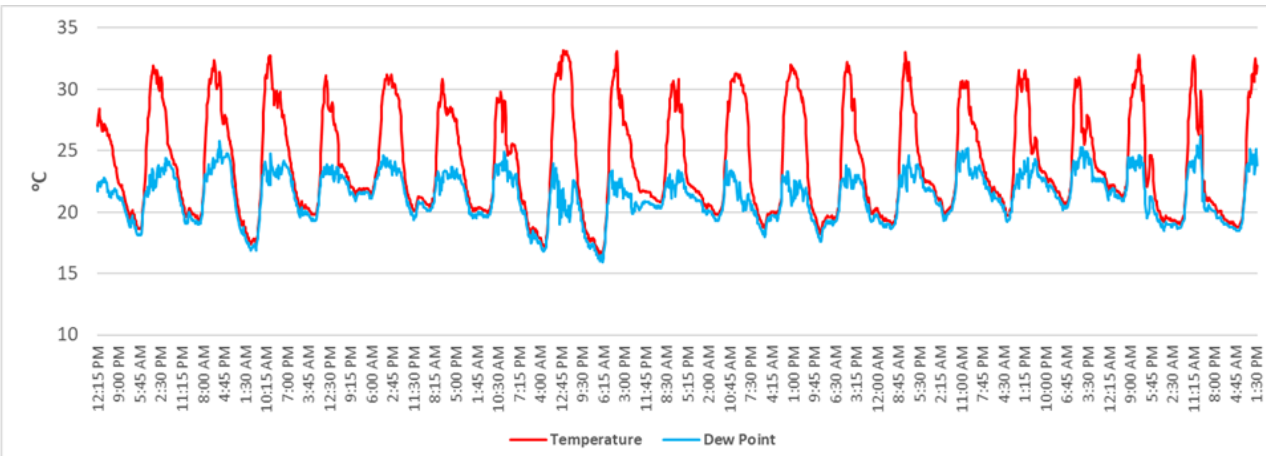


Figure 3-2 Temperature and dewpoint at Montpelier (April 11 – May 1, 2019)

3.1.2 Topography and Geomorphology

The topography and geomorphology is described in this section in reference to the milepost along the proposed road alignment. The mileposts are expressed in the format km+m. The locations in the descriptions are rounded to 50m.

3.1.2.1 Montego Bay Perimeter Road

The proposed Montego Bay Perimeter Road starts in the coastal alluvial plains of the Montego River at the intersection of the Alice Eldemire road and Howard Cook Boulevard (10+000) where it enters the Montego Bay Freezone and follows the existing road to the edge of the land reclamation. (10+500). The road enters at that point the morass area to the west of the sewage treatment plant. The topography is flat and about at sea level. The road will pass in between two sewage ponds to cross the Bogue Road (11+650). The road continues to the east crossing the urban area of Bogue Village up to the Montego West Village housing development (12+500) where the road crosses the old railroad embankment and turns to the north leaving the coastal alluvial plains of the Montego River.

At milepost 13+000 the road traverses a broad low ridge at an elevation of 30m A.M.S.L. which forms the watershed divide between the Montego Bay River and Retirement River (Figure 3-3 - Figure 3-8).

After crossing the Fairfield road (13+400) the Perimeter Road turns east where it enters back in the coastal alluvial plains of the Montego River and intersects with a meander of Montego River. The meander will be removed by straightening the river, shifting the Montego River and the confluent with Tucker Spring to the north (13+700). At milepost 14+200 the road leaves the coastal alluvial plains and enters the narrow valley the Montego River has cut into the limestone. The road is located on an erosional terrace level on the left bank of the Montego River, approximately 20m above the valley. The road continues in general easterly direction on the left bank of the river until it reaches the deep meander near Irwin/Porto Bello. The terrace level is there about 40m above the valley floor at an elevation of approximately 80m A.M.S.L. The road crosses the valley of the Montego River (17+100) and makes a sharp turn to the north to start the traversing of the E- W trending limestone plateau between the coastal plain of the north coast and the Montego River.

The limestone plateau has a hummocky, rolling, hilly immature karst topography of rounded hills and closed depression. The edge of the plateau has been deeply incised by ephemeral drainage systems in areas weakened by fractures and joints. One of these ephemeral drainage systems is the White Gut. The road runs parallel on the right bank of the White Gut, and crosses one of its tributaries at mile post 18+500 and a drain of the Green Pond High School area to the White Gut at 19+400. The Perimeter Road continues further to the north parallel to the White Gut until it reaches the watershed divide near Salt Spring at an elevation of approximately 230m A.M.S.L. where it crosses the Salt Spring main road (21+400). Before reaching the watershed divide, the road also crosses 3 minor tributaries of the North Gully at mile posts 20+800, 21+000 and 21+200 Figure 3-3 - Figure 3-8).

After the watershed divide the road descends to the north coast in the stream bed of a tributary of the Salt Spring Gut and further downstream in the Salt Spring Gut. The topography in this section of the road alignment is still rugged but lacks at least one of the distinctive large-scale features of a Karst landscape, the closed depression. The drainage pattern becomes in this section dendritic. At milepost 23+400 the valley widens as it enters the coastal plain on an erosional terrace level with an elevation of approximately 45m. The road shits here to the left of the Salt Spring Gut. At 24+200 the road crosses a tributary of the Salt Spring Gut. The road ends on the coastal plain on the alluvial fan of the Salt Spring Gut between 24+400 and 24+900 (Figure 3-3 - Figure 3-8).

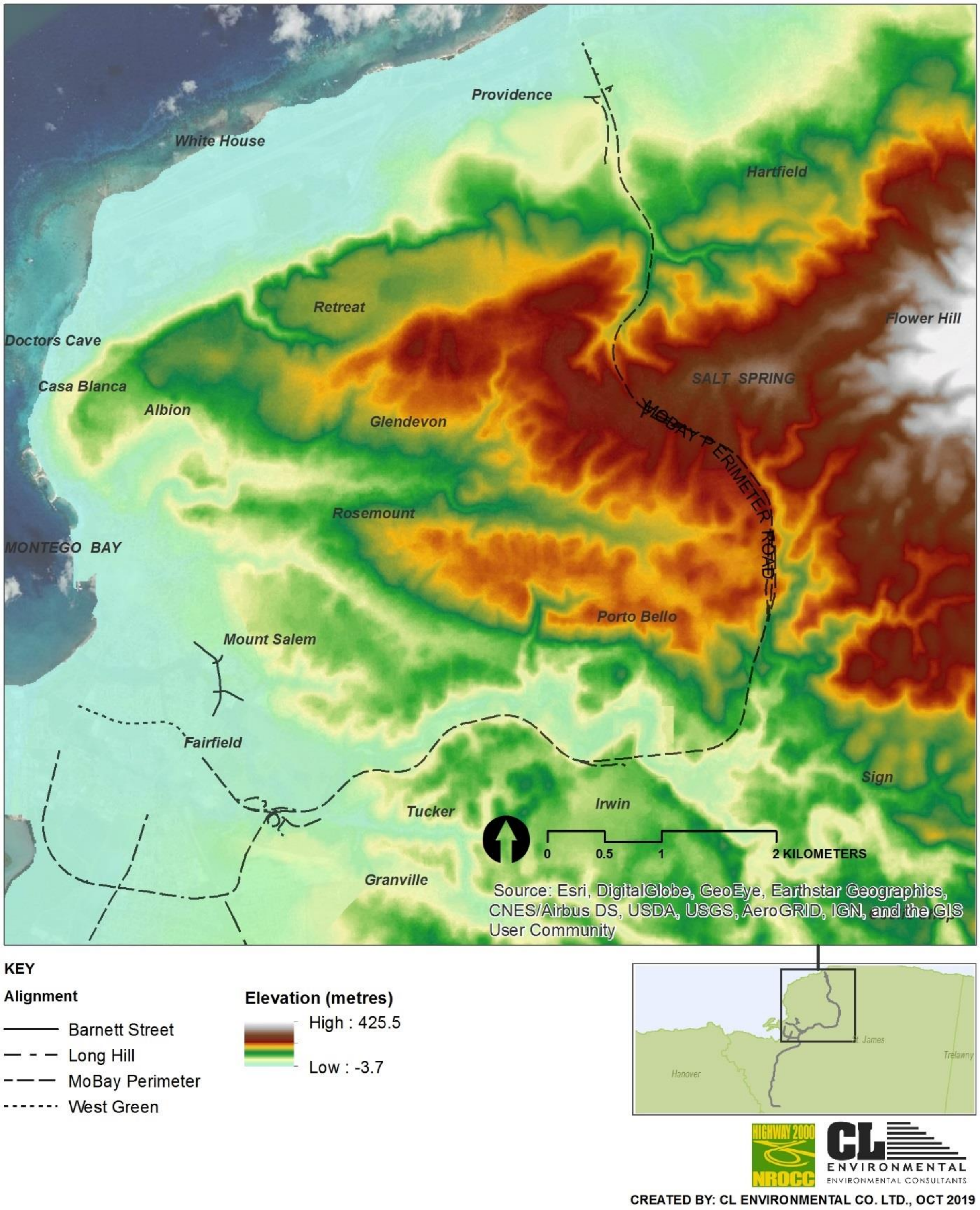


Figure 3-3 Digital elevation model for Montego Bay Perimeter Road, West Green and Barnett Street

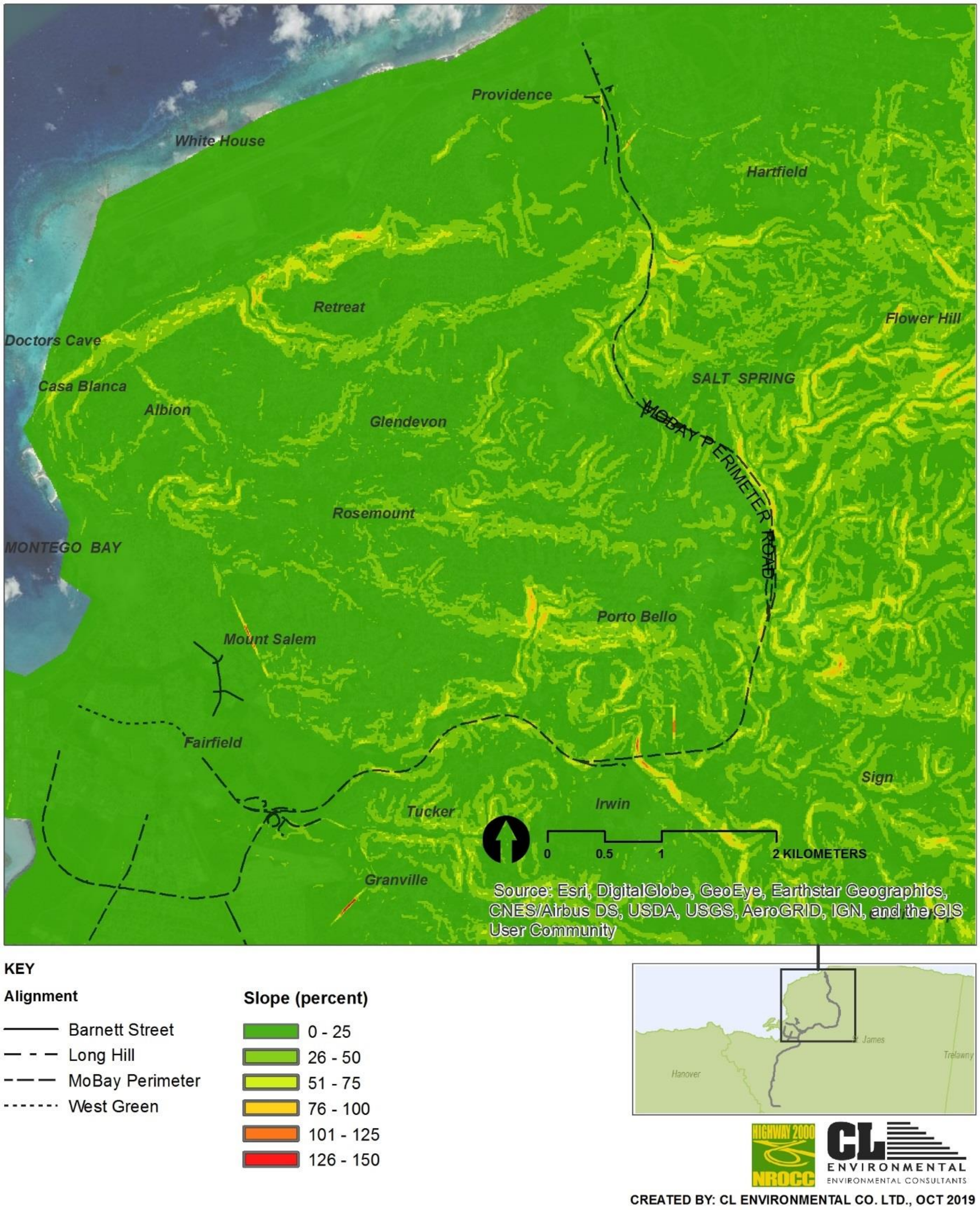


Figure 3-4 Slope, Montego Bay Perimeter Road, West Green and Barnett Street

Figure 3-5 Mile post location referenced in morphological description of Montego Bay Perimeter Road (entire alignment)

Figure 3-6 Mile post location referenced in morphological description of Montego Bay Perimeter Road (western segment of alignment)

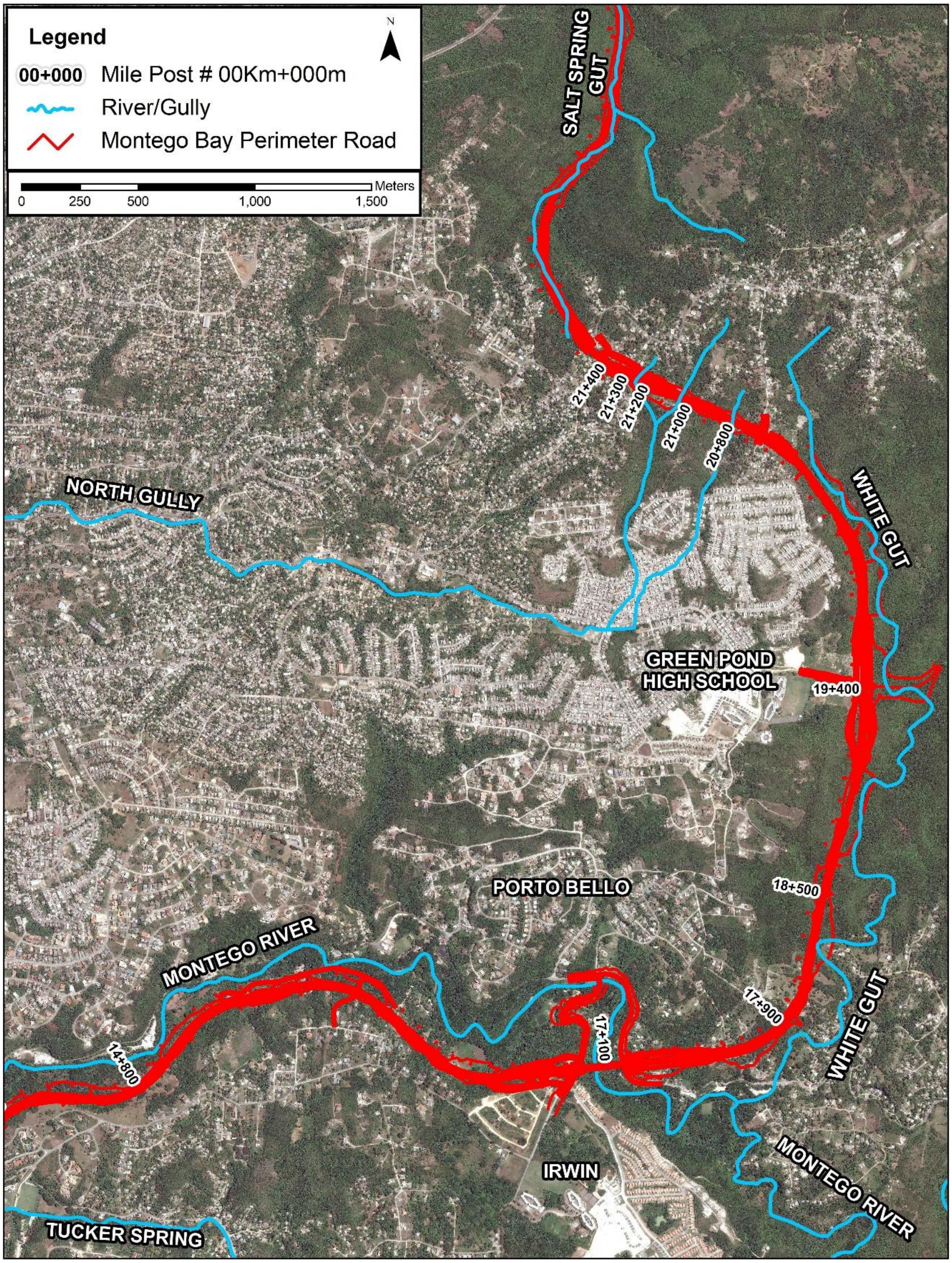


Figure 3-7 Mile post location referenced in morphological description of Montego Bay Perimeter Road (eastern segment of alignment)

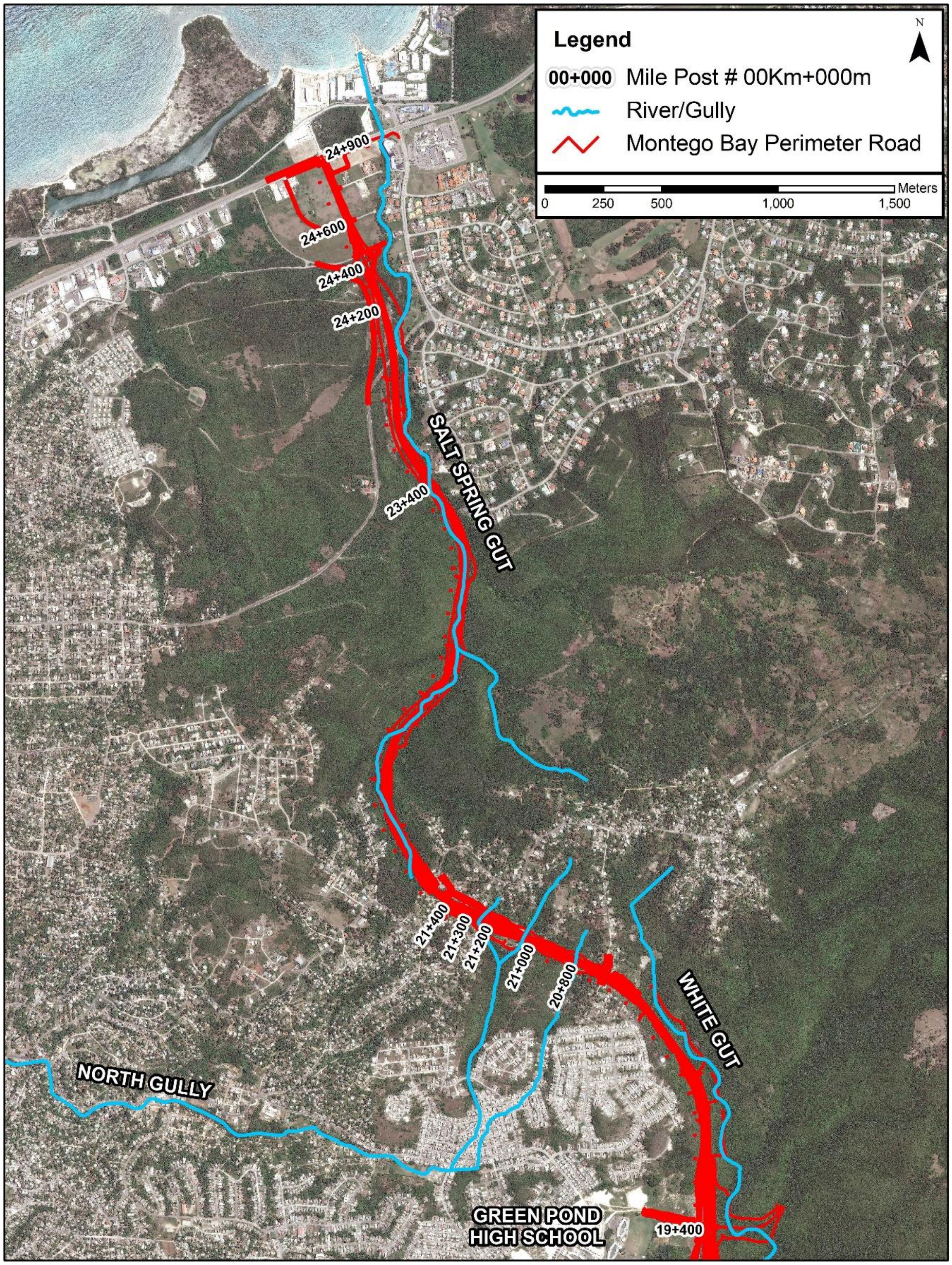


Figure 3-8 Mile post location referenced in morphological description of Montego Bay Perimeter Road (northern segment of alignment)

3.1.2.2 Long Hill Bypass

The Long Hill Bypass will start in the coastal alluvial plain of the Montego River. This section of the coastal alluvial plains is separated from the Montego River basin by the watershed divide that is formed by a low broad ridge south of Fairfield Avenue. The topography is very gentle sloping to near flat but has been heavily modified by recent housing developments. The topography increases from 15 m at the proposed intersection with the Montego Bay Perimeter Road (10+490) to 30 m at the foot limestone escarpment that borders the coastal alluvial plain to the south. The escarpment has an elevation between 300 to 350 m A.M.S.L and has an overall slope angle of 35 % (20 degrees). To achieve a more reasonable slope Long Hill Bypass traverses the escarpment oblique. It runs more or less parallel above the old railroad track but climbs at a slightly steeper angle (Figure 3-9, Figure 3-10). The escarpment has been incised by numerous very short parallel gullies which are mostly dry but can swell in minutes into torrential streams carrying not only large volumes of water but also large volumes of loose material. During the 1979 flood rains several of the cross drains of the railroad embankment were blocked. As the water back-up behind the embankment, the embankment failed catastrophically in several locations. The road embankment will be intersected by at least 6 parallel gullies in the escarpment at milepost 8+500, 8+400, 7+900, 7+500, 7+300 and 6+700 (Figure 3-11).

The proposed Long Hill Bypass will reach its maximum height at 6+200. The existing elevation is 259 metres, but the road will be cut into the ridge to maintain the road gradient. The topography is a fairly rugged karst topography of steep sided hills and deeply incised valleys. The steep sided hills vary from dome shaped to elongated raising between 30 to 60 m above the valley floor. The road gradient in this rugged terrain will be maintained by lowering the ridges and filling in the depressions. The cut and fill areas in shown in Figure 3-11.

The bypass traverses the Northern end of an elongated karst depression in which Anchovy, the old railroad embankment and the main road to Montpelier are located at 5+500. The valley floor of this depression has an elevation of 200m A.M.S.L. The road alignment does not follow the lower lying depression in which Anchovy is located but continues to west of it, following a narrow valley flanked by steep sided hills and crossing a sinkhole (4+500). The Long Hill bypass joins a wide elongated valley at 4+200 and continues to south along the foot of the escarpment on the western side of that valley. Between 3+200 and 3+000 the bypass will cross an 80 to 90 m high escarpment. To the south of the escarpment, the road enters a doline/sinkhole between 3+000 and 2+500 with a diameter of 400m and floor at 150m A.M.S.L. Leaving the sinkhole the Long Hill bypass traverses through a short valley and a few small sinkhole depressions to enter the large karst depression (1+900) near Montpelier. This karst depression or polje has a diameter of several km and is enclosed by steep limestone hills. At this particular location the escarpment is only 15m high. (1+900). The floor of the Polje is relative flat with an elevation of approximately 120m but is dotted with conical hill and semi-circular sinkhole depressions. The Anchovy Gully intersects the proposed road alignment at 2 locations, at 1+000 and at 0+100. It is an ephemeral drainage channel which comes from the east across the Montpelier main road and the old railroad embankment and ends to the west in the Great River. The road ends here where it intersects with the Montpelier main road (0+000) (Figure 3-11).

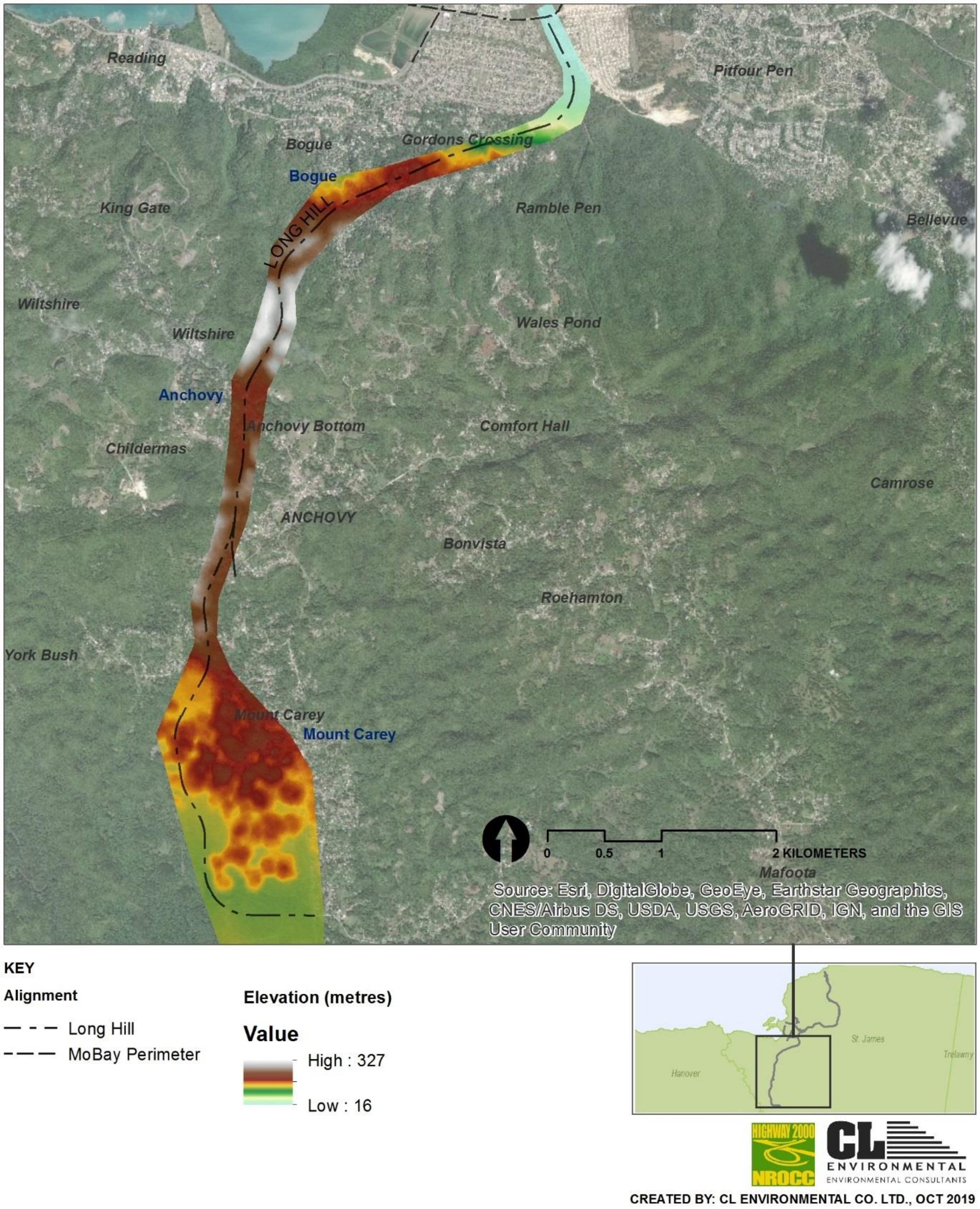


Figure 3-9 Digital elevation model for Long Hill Bypass

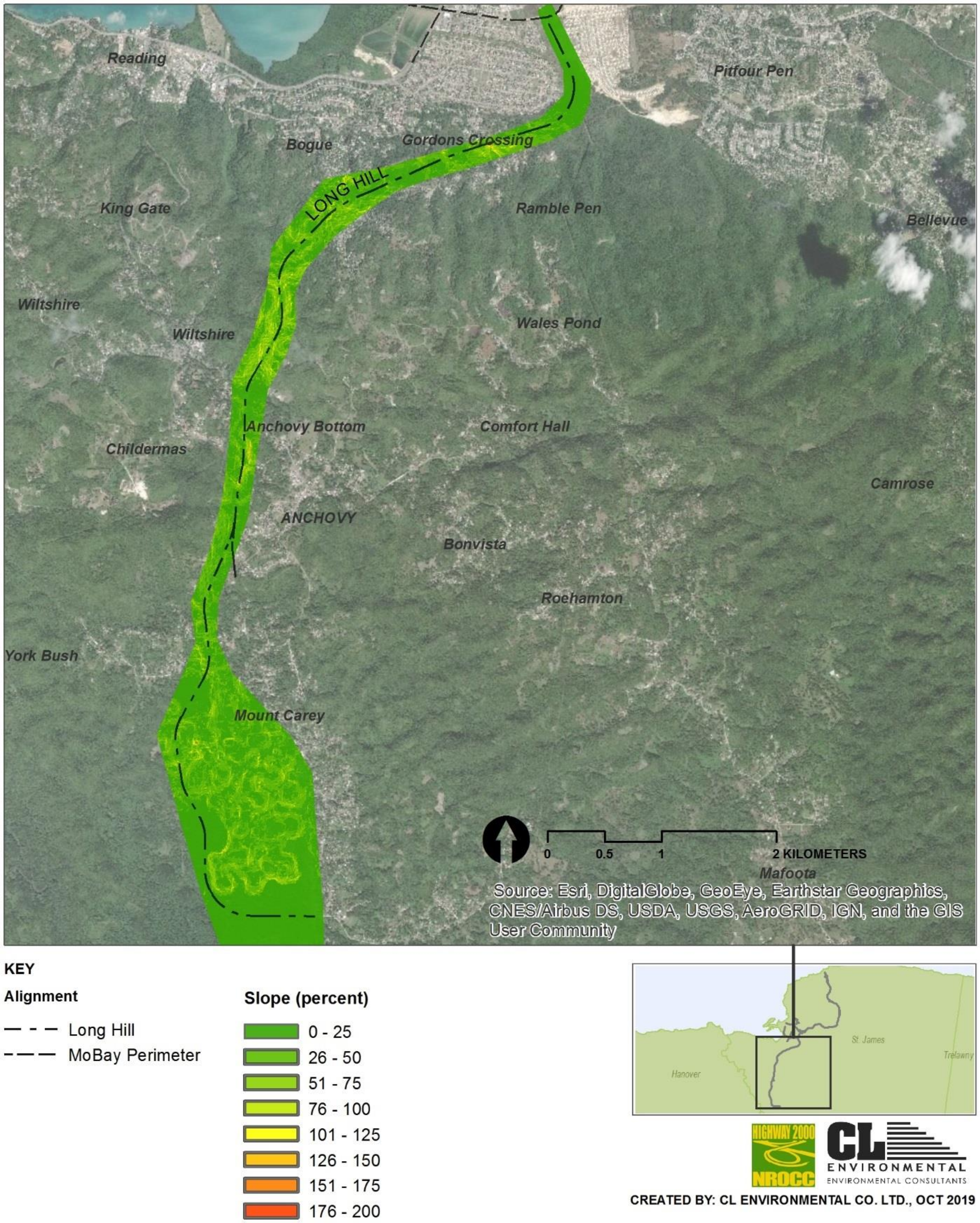


Figure 3-10 Slope, Long Hill Bypass

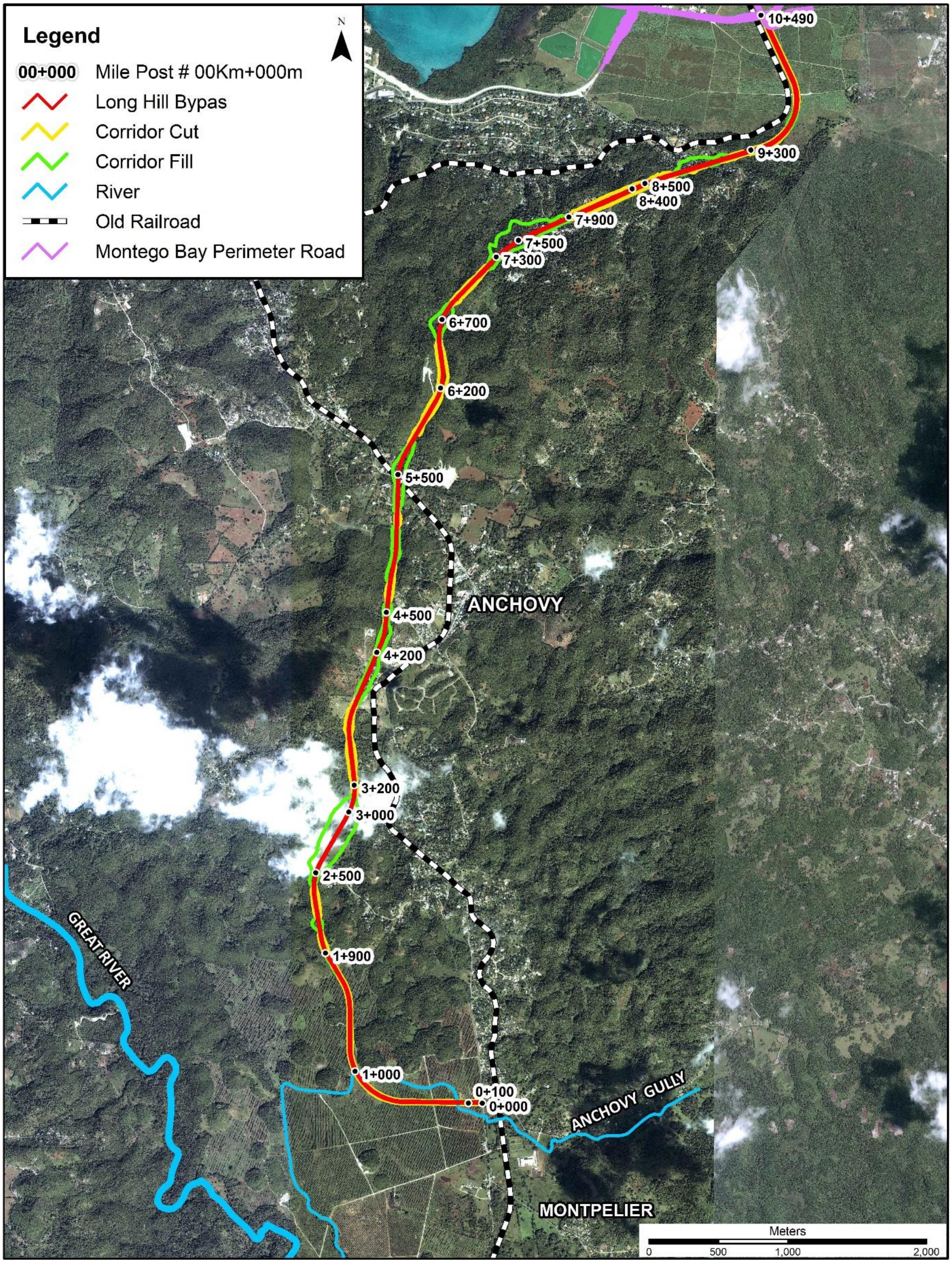


Figure 3-11 Mile post location referenced in morphological description of the Long Hill Bypass

3.1.2.3 Barnett Street Upgrade Works

The upgrade area begins at the bridge over the Montego River at milepost #173+400 and end just south of the intersection with Bevin Street near mile post #174+100. Between those mile posts, Barnett Street runs more or less parallel with Montego River. Before the bridge the Montego River flows from East to West. After the bridge the river makes a right angle turn to the north. Just before Bevin Street the river makes another sharp turn now to the west and continues in an East-West direction towards the sea parallel with Bevin Street. In that section Barnett Street is located on the edge of the coastal alluvial plan of the Montego River on the left bank of the River (Figure 3-12).

Between Bevin Street (post #174+100) and Miriam Way (post #173+900) Barnett Street is constructed on a fluvial terrace with an elevation of about 14m AMSL. At mile post# 173+750 Barnett Street move to a terrace level that is about 6m lower. The elevation of that terrace level ranges from 8m AMSL near mile post# 173+750 to 7m AMSL at the bridge (Figure 3-12).

Between the Bridge at West Gate and Bevin Street, the Montego River shows tendencies to shift. In particular between 173+750 and 173+600 the Montego River is very close to Barnett Street. The Horizontal Distance between the edge of the road as proposed and the stream is not more than 10m. The natural river processes are trying to shift the river edge further to the east and to undercut the slope that supports the road (Figure 3-12).

3.1.2.4 West Green Avenue Upgrade Works

The proposed West Green Avenue Upgrade begins at the intersection with Howard Cook Boulevard at mile post 10+000 (Figure 3-12). The road has a general west to east orientation and ends at the intersection with Barnett Street and Fairfield road at milepost 11+090. The topography is near flat and rises gently from approximately 3m AMSL at the intersection with Howard Cook Boulevard to approximately 7m at the intersection with Barnett Street (Figure 3-12).

West Green Avenue is located in the middle of the coastal alluvial plains of the Montego River to the south of the Montego River and is part of the Pies River sub-watershed. It is separated from the Montego River by a low watershed divide that corresponds more or less with Catherine Hall.

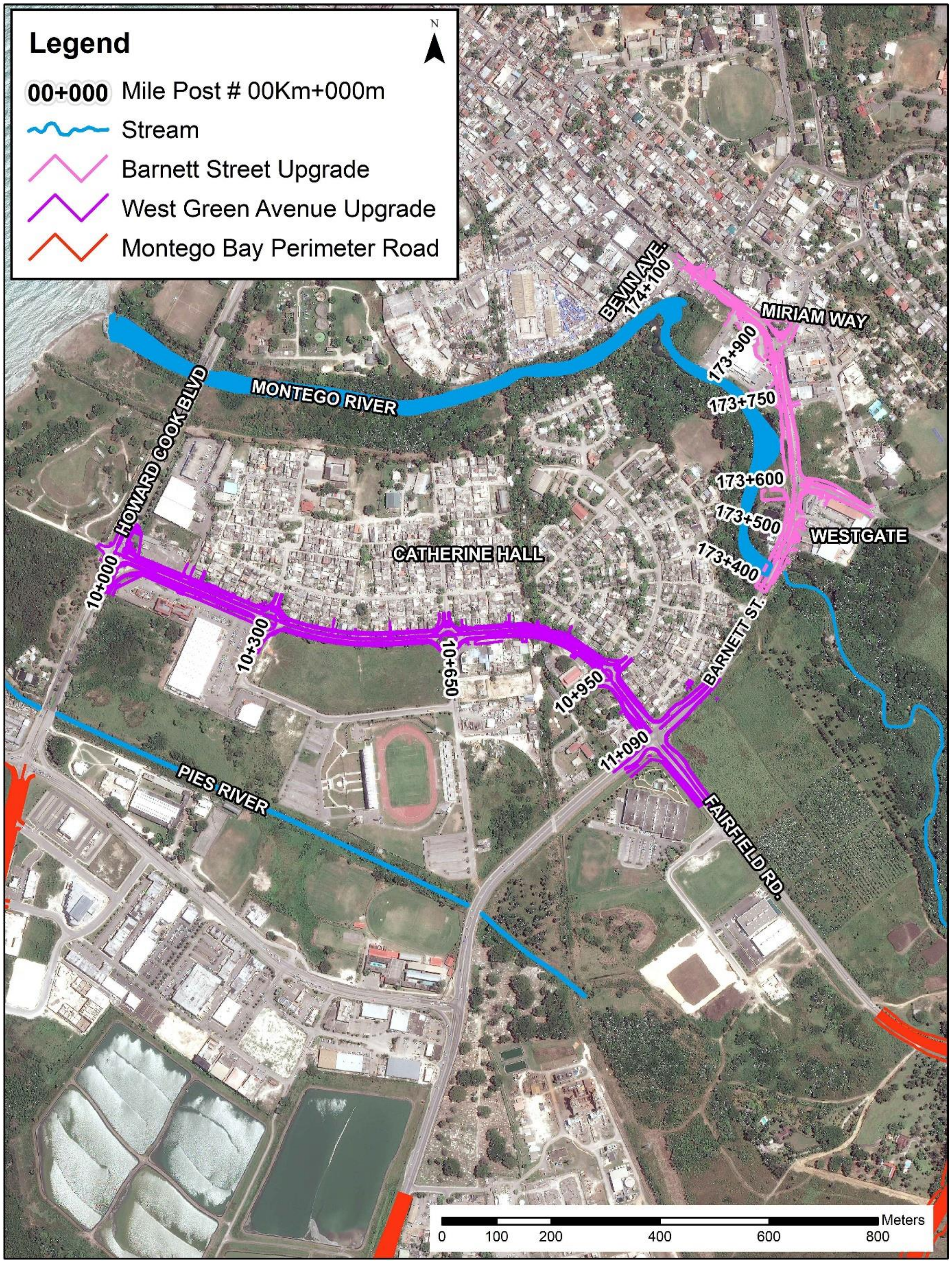


Figure 3-12 Mile post location referenced in morphological description of the Barnett Street and West Green Avenue Upgrades

3.1.2.5 Depressions and Caves

Data obtained from the Water Resources Authority (WRA) illustrated potential depressions across the island. Depressions were also mapped using 1:12,500 topography maps and later ground-truthed. Mapped depressions were identified adjacent to and along the proposed road alignment both in the northern and southern sections (Figure 3-13). There is a clustering of depressions south of Anchovy/west of Mount Carey (K1+500 to K4+500) and north of Irwin (K16+500). A total of five (5) depressions were identified within the 100m buffer of the proposed highway. Additionally, there are two (2) depressions and six (6) depressions found within the 200m and 500m buffers.

The Cave Society of Jamaica shapefile of caves, superimposed on the proposed highway alignment, indicated that several caves have been mapped in the general area. However, there was only one (1) cave identified within the highway buffers delineated, in the vicinity of Mount Salem. It should be noted that these caves may be an indication of additional fissures, caverns, sinkholes and other caves that are not mapped. These caverns and caves may be important hydrogeological features that can have regional importance. See also Section 3.1.5.5 for more information on sinkholes.

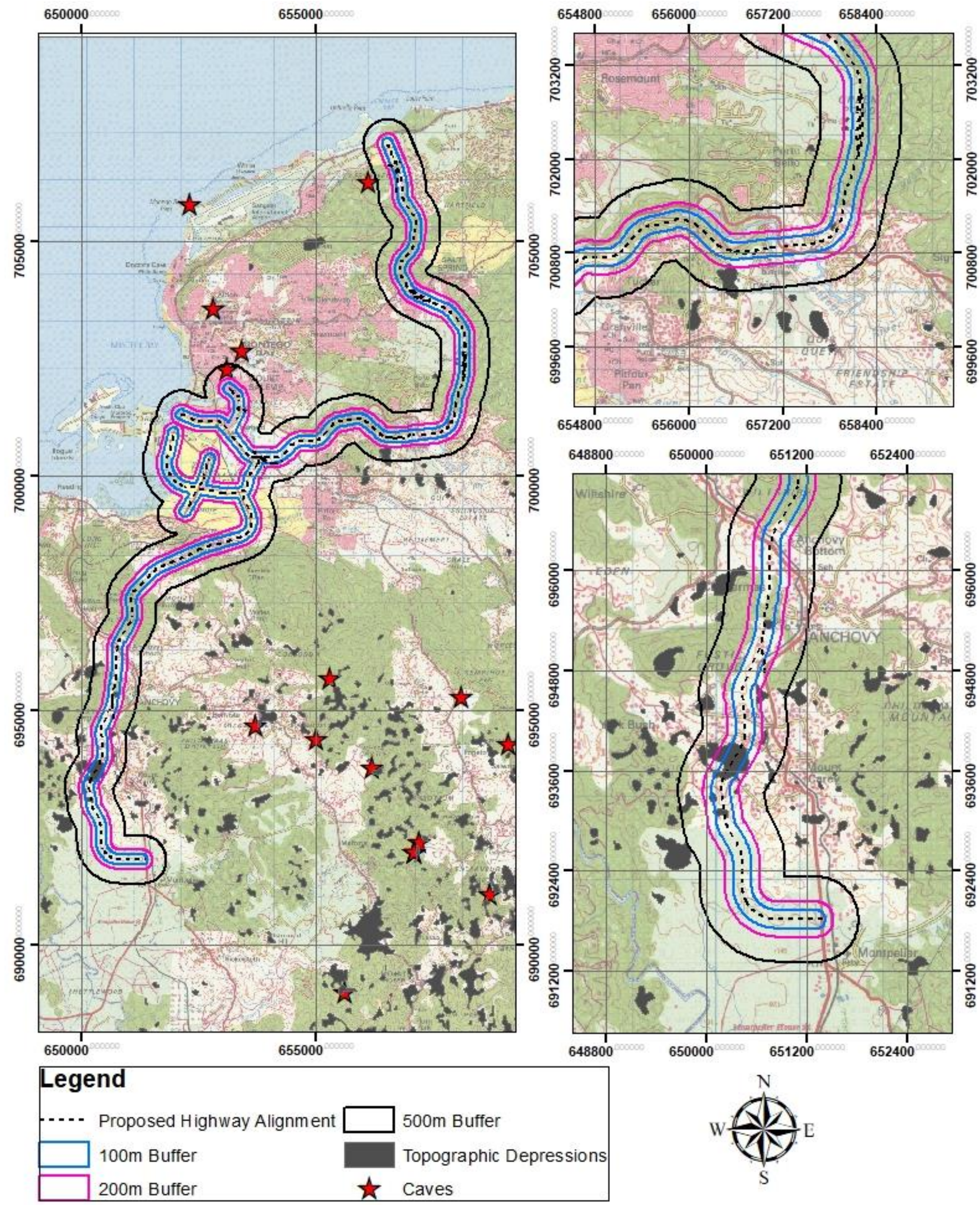


Figure 3-13 Limestone depressions and caves potentially to be impacted by construction of highway

3.1.3 Geology

3.1.3.1 Introduction

Figure 3-14 and Figure 3-15 show the general geology of the proposed Perimeter road (Alice Eldemire to Ironshore) and the proposed Long Hill Bypass (Bogue to Montpelier) respectively. The geology of the Barnett Street, Bogue road and West Green road improvements works is also presented in Figure 3-14 and displays the location of the 16 boreholes and 5 test pits which were made as a part of the feasibility study for the Montego Bay Perimeter Road by China Harbour Engineering Company Ltd. (China Harbour Engineering Company Ltd. (CHEC), 2017) Except for some minor modifications, the geology presented is based on the 1: 50,000 Geological Series (Metric Edition) sheet 2 Montego Bay, Mines and Geology Division.

The main geological units in the project area are the Montpelier Formation and the Gibraltar-Bonny Gate Formation on the hillsides and Raised Reefs deposit in the alluvial and coastal plains. The alluvial plain of the Montego River has also Quaternary alluvium, Swamp and Marsh deposit as well as a growing area of Fill/Reclaimed land as development continues to encroach on the swamp and marsh land around the bay.

The geology and geotechnical characteristics are described in this section in reference to the milepost along the proposed road alignment. The mileposts are expressed in the format km+m. The locations in the descriptions are rounded to 50m.

3.1.3.2 Geological Structure

The geological structure of the area can be described as a fault dissected east-west trending synclinal through (FAO, 1971) (Bateson, J.H., 2008). The depression in which the Montego River is located coincides with the syncline. A secondary anticline runs parallel to the north of the syncline which corresponds with the topographic high near Salt Spring. The structure of the project area is characterised by two main fault trends. The general E-W trending faults which are pronounced in the area of the proposed Montego Bay perimeter road and the NNW – SSE trending faults which dominate the Long Hill Bypass area. The E-W trending faults correspond with the Duanevale Fault zone which runs parallel to the North coast and the NNW – SSE trending faults correspond with the Montpelier-New-Market Fault zone. Map evidence indicate that the faults are near vertical or very steeply dipping.

3.1.3.3 Geological Units

The oldest deposits along the proposed road alignment are the limestones of the Gibraltar-Bonny Gate Formation. The Gibraltar-Bonny Gate Formation is Eocene, probably Mid to Upper Eocene. The Gibraltar-Bonny Gate Formation generally consists of cream-white indurated chalks interbedded with impure bioclastic limestones and frequent thin orange coloured clay partings. The proportion indurated chalk versus bioclastic limestones varies but near Salt Spring the indurated chalks dominate. The presumed bearing capacity of the Gibraltar-Bonny Gate formation is overall reasonably good, ranging from 2000 up to 4000 KN/m^2. Karst is not very mature well developed but sinks, closed depressions and underground drainage are common and often associated with faults and joints and zones of recrystallization.

The Montpelier formation occupies the largest part of the road alignment of the Montego Bay Perimeter Road and 97% of the Long Hill Bypass. The age range of the Montpelier formation is from Lower Miocene, possibly Upper Oligocene, to Upper Miocene. The Montpelier formation overlays unconformably the Gibraltar-Bonny Gate Formation. The unit consists primarily of a sequence of white to greyish chalks, with interbedded bioclastic beds and chaotically deposited blocks. This indicates deformation of the chalks during the depositional phase, possibly caused by submarine debris flow. Thick bedding is dominant but is often alternated with horizons of medium bedding. Clay partings are present but are less common then in the Gibraltar-Bonny Gate Formation. The bedding is particularly thick around Anchovy to Ramble where the bedding is in the order of several meters.

Raised Reefs deposits are generally poorly bedded to massive, rubbly and often vuggy limestones with coral debris making up the bulk of the rock. The Raised Reefs overlay unconformably the Montpelier formation. The thickness of these deposits varies as does the hardness. Some sections are recrystallized and are very hard. The rubbly, marly and poorly consolidated sections are soft although case hardened surface layers may make these deposits appear to be more competent than they really are. Raised Reefs deposits are present within most of the road reservation of Barnett Street upgrade beginning near the Bridge at West Gate (173+500) up to the end at Bevin Street (174+100) and under the Montego Bay Perimeter Road alignment near Tucker between mile posts 12+700 and 14+800.

The Quaternary Alluvium deposits underlie the entire length of the West Green Avenue, the Montego Bay Perimeter road in the Bogue area between milepost # 11+200 and 12+700, and the West Gate Bridge area on Barnett Street. The Quaternary Alluvium deposits are generally calcareous sands and gravels. These deposits are made up of horizontal layers of clayey and silty sands mixed with the erosional products brought down by the adjacent river system. It is common for organic material to be present within this horizon. The alluvial clay is known from boreholes to overlie marine clays which consist of greyish-brown dense sandy clays with gravel bands including abundant shell and plant fragments.

Quaternary Swamp and Marsh Deposits are waterlogged alluvial deposits consisting of alternating layers of very loose to lose sand and silty/clayey sand and very soft to soft sandy clay with significant, often extensive layers of organic soils and peat and water bodies with free water at the surface. The thickness of the Swamp and Marsh Deposits varies from 1 and 12m and includes generally a 0.2 to 1-m-thick layer of peat or plant material. The Quaternary Swamp and Marsh Deposits are unconformably overlaying the limestones of the Montpelier Formation or Raised Reefs.

The land reclamation of the Montego Bay Free Zone was placed over the in situ Quaternary Swamp and Marsh Deposits. It consists of hydraulic fill from the dredging of the harbour covered with uncontrolled fill from inland quarries and excavations. The land fill in the road alignment of the Montego Bay Perimeter Road was done after the Montego Bay Free Zone reclamation and consist probably only of 1 to 2 m uncontrolled fill on top of the Quaternary Swamp and Marsh Deposits. The fill material includes calcareous sands and gravel and stiff to hard sandy clay.

No alarming features were identified based on existing geotechnical information and data including information and data from published and unpublished consultancies for developments in the area, satellite imagery, aerial photography or topographical analysis that would require or justify major realignment of the road or render the project unfeasible. The Montpelier and Gibraltar Bonny Gate Formation are deposits that are very consistent in composition and in general do not pose significant geotechnical problems. There is always the potential of localized features affecting the stability. To pick-up on such issues early in the project it is recommended to have a geologist on site when the initial road cuts are made and also on standby during the construction phase. He/she should record in detail lithology, discontinuities, local ground water condition (seepage) and this information be used in the final slope design and to identify local conditions that need to be addressed.

A geological map of the Montego Bay Perimeter Road with Barnett Street and West Green Avenue works and the Long Hill Bypass are shown in Figure 3-14 and Figure 3-15 respectively.

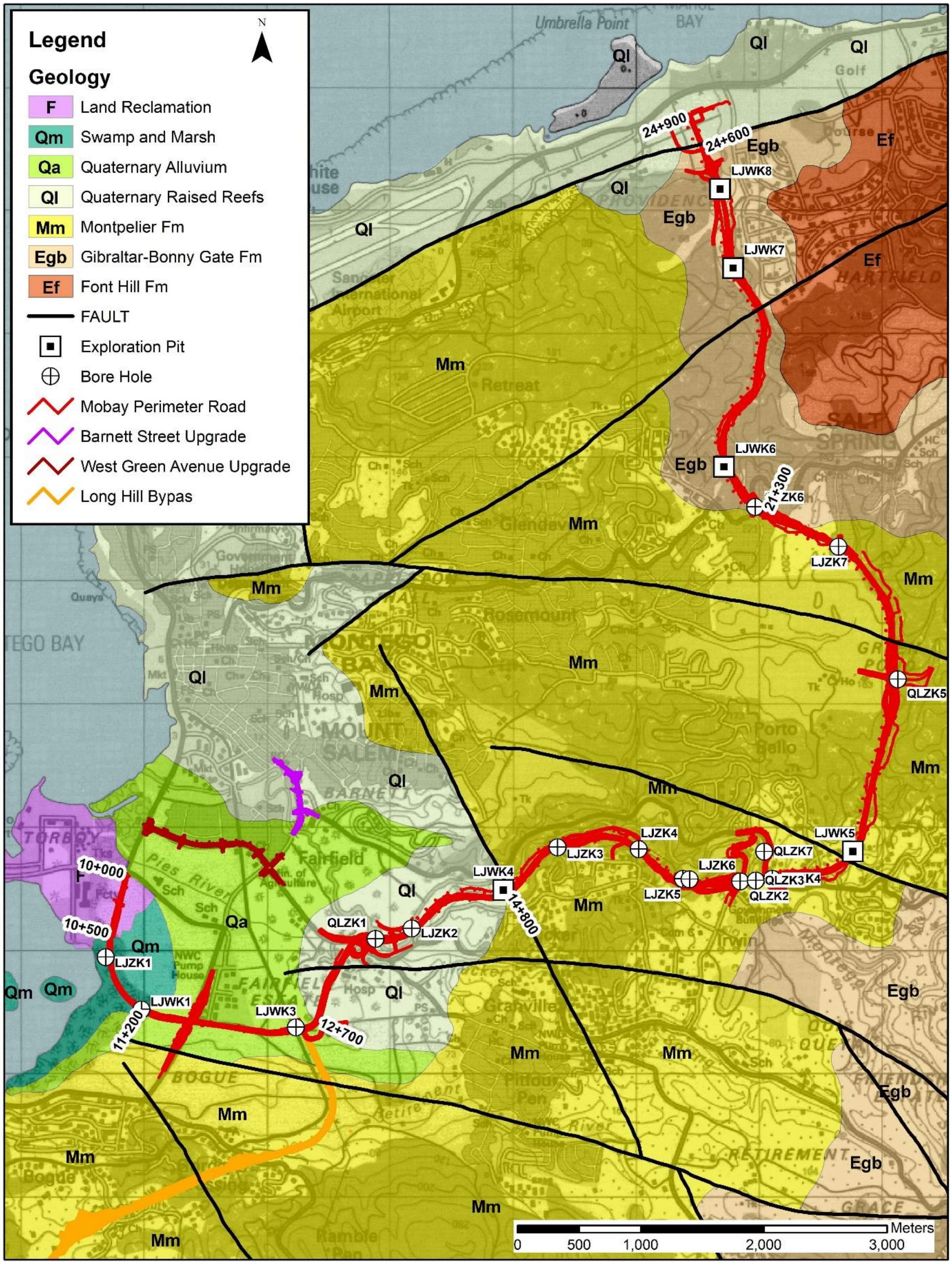


Figure 3-14 Geology of the Montego Bay Perimeter Road along with Barnett Street and West Green Avenue Upgrade works

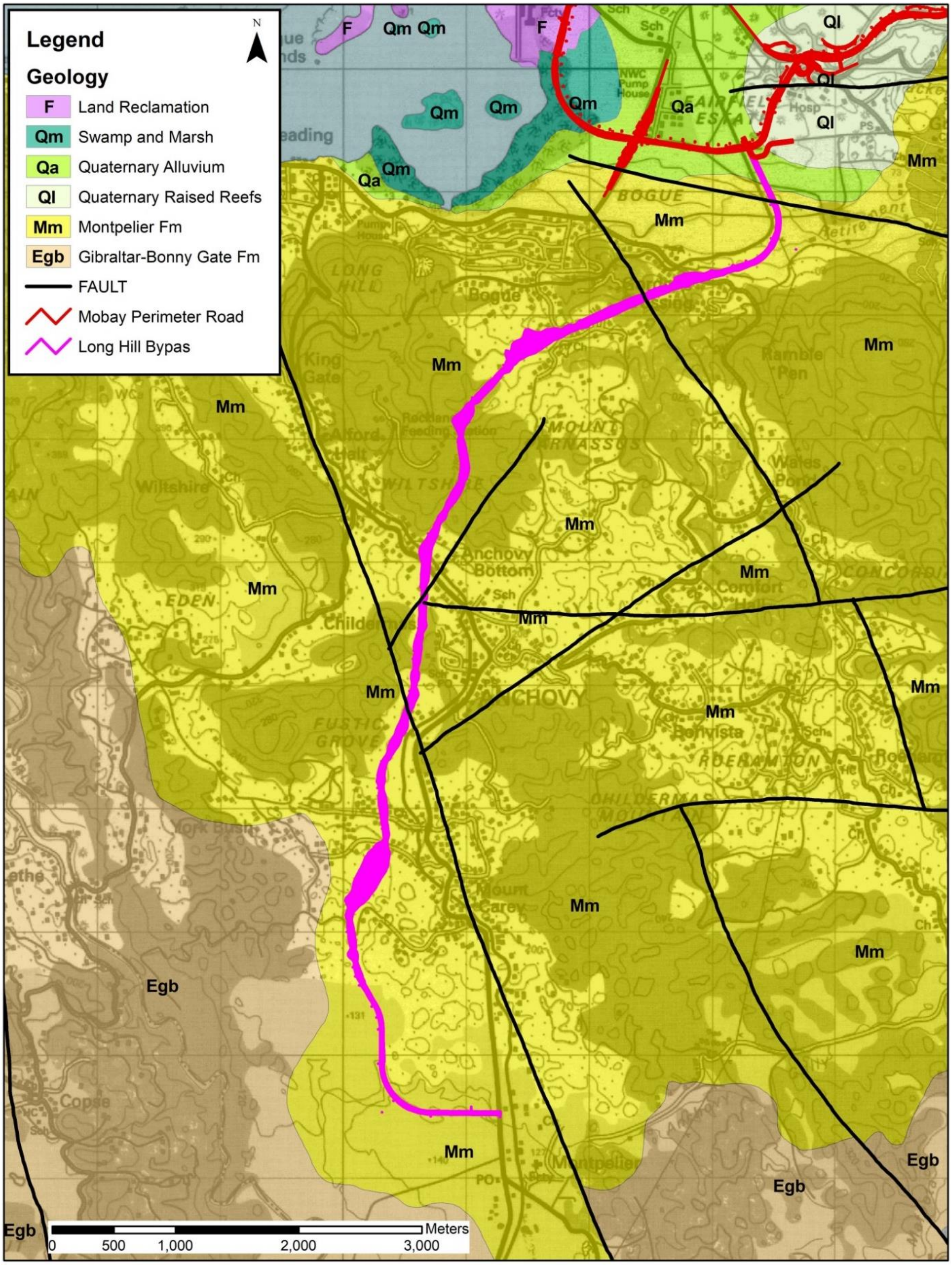


Figure 3-15 Geology of the Long Hill Bypass

3.1.3.4 Geotechnical Characteristics

3.1.3.4.1 Montego Bay Perimeter Road

ROAD SEGMENT 10+000 TO 10+500

This road segment is located in reclaimed land. This 1 to 2-metre-thick layer of calcareous sandy gravels is medium dense to dense and forms the subgrade of the existing four lane road, which currently serves local industrial traffic. The underlying Swamp and Marsh deposits have likely reached equilibrium under the current conditions, but they are still relatively loose and compressible and have a low bearing capacity. Minor subsidence was observed in this area. In association with the high-water table the sand layers have a high probability of liquefying during the major earthquake events. Such liquefaction could cause differential ground subsidence of the road during or shortly after an earthquake.

ROAD SEGMENT 10+500 TO 11+200

The geotechnical characteristics of this segment are in essence the same as those of the previous segment. The main difference between the two is that this segment has not been reclaimed and lacks the layer of calcareous sands and gravels fill raising the ground level above tidal influence. Reclamation will have to be part of the road construction. Waterlogged, with layers of loose sand, clays and partial decomposed organic material including peat, the allowable bearing capacity of Quaternary Swamp and Marsh Deposits is low (0.08MPa). Excessive settlements should be anticipated and addressed by the roadbed design. The highly compressible layer peat and partially decomposed organic material could be removed and replaced (Plate 3-1).

Plate 3-1 Waterlogged Swamp and Marsh deposits near milepost #10+500. Trash washed in by a drainage channel from the Montego Bay Freezone discharging in the morass.

ROAD SEGMENT 11+200 TO 12+700

The segment is located in Quaternary Alluvium which consist of a typically alternation of loose unconsolidated gravels, sand, clays and organic matter (Plate 3-2). The allowable bearing capacity is varying from moderate (0.3MPa) to a low of (0.08MPa) in particular where organic material is present. Between 11+300 and 11+600 the road alignment is located between 2 sewage ponds, which will have to be partially filled up to accommodate the road. Sludge layer which has likely over the years accumulated in it should be removed before filling it in. Between 11+600 and 12+500 a layer of gravelly marly man-made fill can be expected on top of the Quaternary alluvium. This layer was placed as part of the construction of the main traffic corridor for the recent urban developments in Bogue.

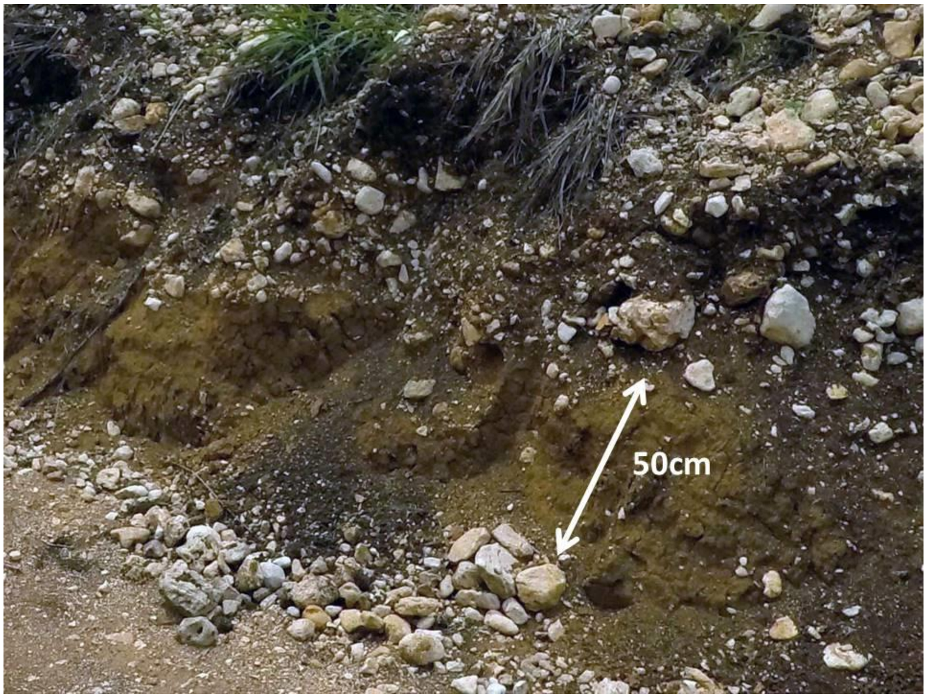


Plate 3-2 Quarternary Alluvium consisting of coarse calcareous gravels on top of layered sandy clay deposits near milepost #12+500

ROAD SEGMENT 12+700 TO 14+800

This segment has no major geotechnical issues. The slopes are very gently with gradient of 10% or less. Raised Reefs limestones are fairly competent with allowable bearing capacity ranging from 0.35MPa to 0.45 for the typical rubbly marly deposits. To accommodate the road, the Montego River will be realigned between13+600 and 14+000. This will require the cutting of a new river channel to straighten the river to remove the meander and also the construction and maintenance of river training works to stabilize the river in that position.

ROAD SEGMENT 14+800 TO 17+900

The road will be constructed by cutting and filling the slopes which form the left bank of the Montego River. The slopes along the river are about 15 degrees (27%). The cut slope will be in the Montpelier formation which consists of an alternation of fairly thick beds of chalk and bioclastic limestone and has an allowable bearing capacity ranging from 0.9 to 1.1 MPa (Plate 3-3). The slope stability of the Montpelier is generally good but rock falls must be anticipated to be on-going problem. A stepped slope excavation with a slope ratio of 1:1.00 to 1: 1.25 is proposed. The stepped slope design will help to control rock fall but other method to prevent rock falls may need to be applied. Where the fill slope reaches the river channel, river training works will have to be deployed to protect the base of the fill slope from lateral river erosion associated with from the Montego River.

At 15+300 the road alignment intersects with a small stream channel that drains the Irwin area. The cross drain will need to be installed that can not only manage the run-off but also bed-load associate with a major flash flood

At 17+100 the road will cross the Montego River. About 38m above the river, the bridge will span the 125m wide valley floor. The bedrock of the Montpelier formation is exposed in the valley walls but in the river channel the bedrock is covered by alluvial deposits which include clays and gravels and as indicated by the borehole data can be 7 to 10 metres thick (Plate 3-4). Small ephemeral stream draining the Porto Bello area intersect the road alignment at 17+400 and will have to be taken in account in the construction of the bridge and exit ramps.

Plate 3-3 Montpelier Formation typical exposure along the Montego River consisting ½ to 1m thick beds of chalks and micritic limestone.

Plate 3-4 Montego River near milepost #17+100. Montpelier limestone exposed in the left bank of the river, coarse alluvial gravels on the right bank

ROAD SEGMENT 17+900 TO 21+300

The road alignment traverses in this segment a relative rugged karst topography of steep hills and closed depressions. The Montpelier Formation, exposed over the entire length of this segment, has the same basic geotechnical characteristics as in the Montego River valley. To provide a consistent gradient for the construction of the road, the irregular karst topography will be cut and filled. The Slope stability is fairly good, but rock falls can be expected to be an on-going problem. The cut slopes proposed to be excavated as a stepped slope with a slope ratio of 1:1.00 to 1: 1.25.

Karst solution features are abundant but are not very well developed. Since the solution features are generally small in size, collapse of underground structures is not considered to be a major problem but cannot be ruled out. Construction and maintenance crews need to look out for the presence and development of solution features. When encountered these features need to be investigated and remediated as needed. While the drainage is mainly underground because of the high secondary permeability, several surface drainage channels do intersect with the road alignment at 18+500, 19+400, 20+800, 21+000 and 21+200. Although relatively small these drainage channels will have to be taken in account in the design of the road embankment.

ROAD SEGMENT 21+300 TO 24+650

The Gibraltar-Bonny Gate Formation is exposed in this segment. The lithology and by extend geotechnical characteristics of the Gibraltar-Bonny Gate formation are very similar as those of the Montpelier formations. The allowable bearing capacity of the Gibraltar-Bonny Gate formation is overall reasonably good (0.9 to 1.1 MPa.). The proposed road alignment runs in a small stream which starts near the watershed divide stream and has an average slope of approximately 10% (6 degrees) (Plate 3-5). The channel slope of the river reduces to 4% near the coast. The main geotechnical issue of this segment will be the drainage. The stream is ephemeral and carries only water during heavy rainfall. The drainage design will not only have to take in account the runoff but also the bed load under extreme rainfall condition. During extreme rainfall condition the secondary channel may deliver their load as high-density flow forcing the runoff to go where it is not intended to go.

Plate 3-5 Outcrop of the Gibraltar-Bonny Gate formation in the channel of the Salt Spring Gut

ROAD SEGMENT 24+650 TO 24+900

This road segment has no particularly significant geotechnical issues the average slope in this section of the propose alignment is 4% (2 degrees) Raised Reefs are fairly competent They consist typically of rubbly marly deposits with an allowable bearing capacity ranging from 0.35 to 0.45 MPa. There are also no noteworthy hydrological or hydrogeological features or issues.

3.1.3.4.2 Long Hill Bypass

No geotechnical study specific for the proposed Long Hill Bypass was available at the time of reporting. The geotechnical assessment in this report therefore is based an existing information on the geology and geotechnical characteristics of the area.

ROAD SEGMENT 10+490 TO 10+140

This road segment is located in Quaternary Alluvium and runs parallel with the old railroad. The terrain is near flat with a slope in the order of 1%. The deposit consists mainly of gravelly stiff silty clay with an allowable bearing capacity in the range of 0.13 to 0.35MPa. The main potential geotechnical issue is differential settlement.

ROAD SEGMENT 10+140 TO 6+200

Between 10+140 and the end of the road (0+000), the alignment of the Long Hill Bypass is set in the Montpelier formation. The lithology and geotechnical characteristic of the Montpelier formation are basically the same they are along in the Montego Bay Perimeter road. The Montpelier formation consists of an alternation of fairly thick beds of chalk and bioclastic limestone and has an allowable bearing capacity ranging from 0.9 to 1.1 MPa (Plate 3-6). The slope stability of the Montpelier is generally good but rock falls must be anticipated to be on-going problem where there are steep road cuts.

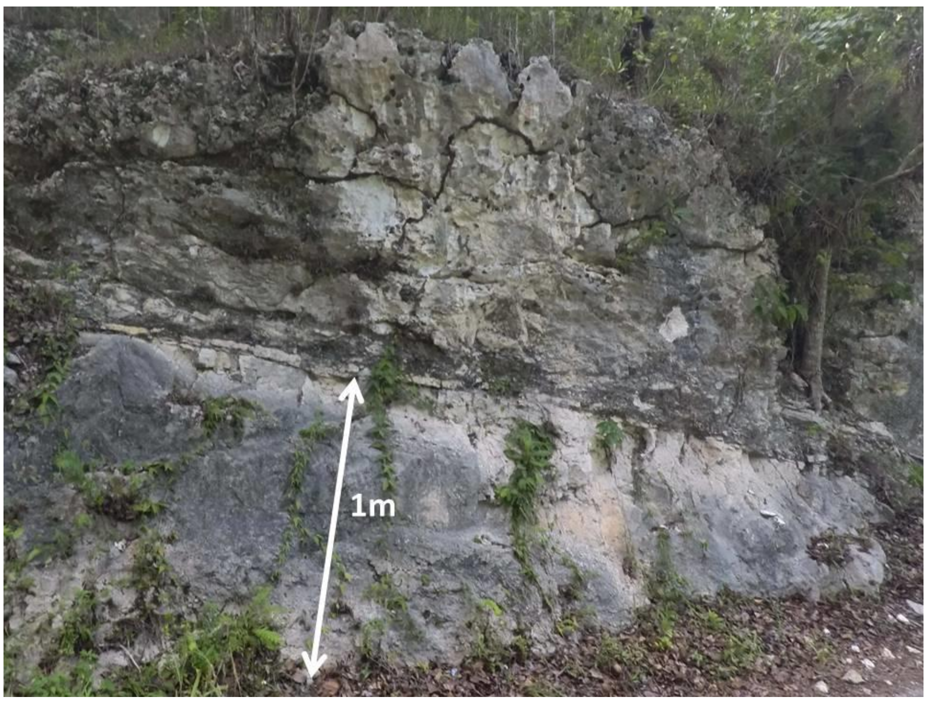


Plate 3-6 Montpelier formation along the Ramble Hill road in the vicinity of milepost # 9+000

The bypass segment in the Montpelier Formation between 10+140 and 9+300 slopes very gently with an overall gradient of 5%, increasing to 12% near the foot of the escarpment. Near the 9+300 mark the bypass road starts its steep climb across the 170m escarpment. The escarpment has an overall slope of 35 % (20°). If possible, the cut slope should be excavated as a stepped slope with a slope ratio between 1:1.00 to 1: 1.25. Although slopes in the escarpment are steep, major slope stability problem are not expected to happen because the Montpelier Formation has a good internal drainage. Rock falls are expected to be the most likely slope failure, although small shallow rotational landslide have been known to occur where very thick chalk layers are exposed. Karst solution features should be anticipated in the alignment but even though they maybe abundant, the features are expected to be too small to cause significant problems.

The road alignment intersects with several short gullies. To prevent a catastrophic collapse of the road embankment similar to the 1979 failure of the railroad embankment, cross drains will have to be designed to accommodate the runoff and the sediment load caused by extreme rainfall events. However the main geotechnical challenge will be to manage and control the drainage of the proposed Long Hill Bypass to prevent it to become another storm drain which deposits limestone debris at the foot of hill similar to what is now happens from time to time on the Anchovy to Reading main road.

ROAD SEGMENT 6+200 TO 1+900

This section of the proposed road alignment is characterized by an irregular topography of steep hills, narrow elongated depressions and semi-circular dolines or sinkholes. There are no streams; in fact, there is no apparent surface drainage or sign of ponding of runoff in the closed depressions. It has to be concluded therefor that the runoff drains freely to an underground drainage system.

The topography along the proposed road alignment gradually loses height from 240 m at the watershed divide near the escarpment to 150m at the edge of the large interior depression or polje. This works out to an average gradient of 2% to the south. Excavation above and backfilling below grade sections will create in some section steep slopes with a height in the order a few ten meters. Slope stability is in general not anticipated to be a significant problem in this section. The main geotechnical problems in this segment are related to the potential development of sinkholes and underground drainage in the fill areas causing differential settlement in the bypass road.

ROAD SEGMENT 1+900 TO 0+000

To the north of 1+000, the soil cover on top of the Montpelier formation is very thin ranging from a few centimetres to about 30cm, consisting of limestone gravel set in a matrix of clayey silt. To the south of the Anchovy Gully beginning at 1+000, the soils are significantly thicker, at least one to few meters and consist of clayey silt to plastic clay (Plate 3-7). The drainage of this soil is very poor. The main geotechnical issue in this section is the potential for differential settlement associate with the presence and potential development of karst features. The design of the bypass also has to take into account the ephemeral Anchovy Gully which intersects this road segment at 1+000 and at 0+100.

Plate 3-7 The Anchovy Gully intersecting the main road between Montpelier and Anchovy (100m south of milepost #0+000)

3.1.3.4.3 Barnett Street Upgrade Works

ROAD SEGMENT 174+100 TO 173+500

This section is located in Raised Reefs limestones which are fairly competent deposits with allowable bearing capacity ranging from 0.35MPa to 0.45 for the typical rubbly marly deposits. No major geotechnical issues are expected. The only cause of concern is the stability of the banks of the Montego River. Between mileposts 173+600 and 173+750 the river is very close to the road and tries to shift to east undercutting the slope which forms the right bank of the river. Special attention will have to be given to verify and ensure that the stability of these slopes cannot be affected during flood stages (Plate 3-8).

Plate 3-8 Undercutting of the right bank of the Montego River near milepost # 173+700

ROAD SEGMENT 173+500 TO 173+400

This road segment consists in mainly of the West Gate Bridge and the approaches to the bridge. The deposits in this road segment are Quaternary Alluvium. The geotechnical report for the bridge upgrade was not available when this report was prepared. The allowable bearing capacity of the Quaternary alluvium is estimated to range on average from a moderate 0.3MPa to a low of 0.08MPa in particular where organic material is present.

3.1.3.4.4 West Green Avenue Upgrade Works

West Green Avenue is located in Quaternary Alluvium which consists mainly of loose unconsolidated gravels, sand, clays and organic matter. The allowable bearing capacity can vary from a moderate 0.3MPa to a low 0.08MPa where organic material is present. A layer of gravelly marly man-made fill is expected to have been placed on top of the Quaternary alluvium as part of the construction of the road. No significant geotechnical problems are anticipated for these upgrade works.

3.1.4 Soils

3.1.4.1 Soil Type

Five (5) identified soil types are present along the various road alignments and upgrades and are illustrated in Figure 3-16. Three (3) different soil types are present along the Montego Bay Perimeter Road alignment (Stony Loam, Clay and Stony Clay), dominated by the presence of Stony Loam. Four (4) different soil types are present along the Long Hill bypass alignment (Stony Loam, Clay, Silty Clay Loam and Clay Loam), dominated by the presence of Stony Loam. Two (2) different soil types are present along the West Green Avenue upgrade section (Loam and Clay) dominated by the presence of Loam, while the Barnett Street upgrade section has unclassified soil types.

The erosion potential of the various soil types identified range from slight to high. Figure 3-17 illustrates the erosion potential rating of each soil type identified. Stony Loam, which is the dominant soil type along the Montego Bay Perimeter Road and the Long Hill bypass alignments, has a high erosion potential rating. Loam, which is the dominant soil type along the West Green Avenue upgrade section, has a slight erosion potential rating.

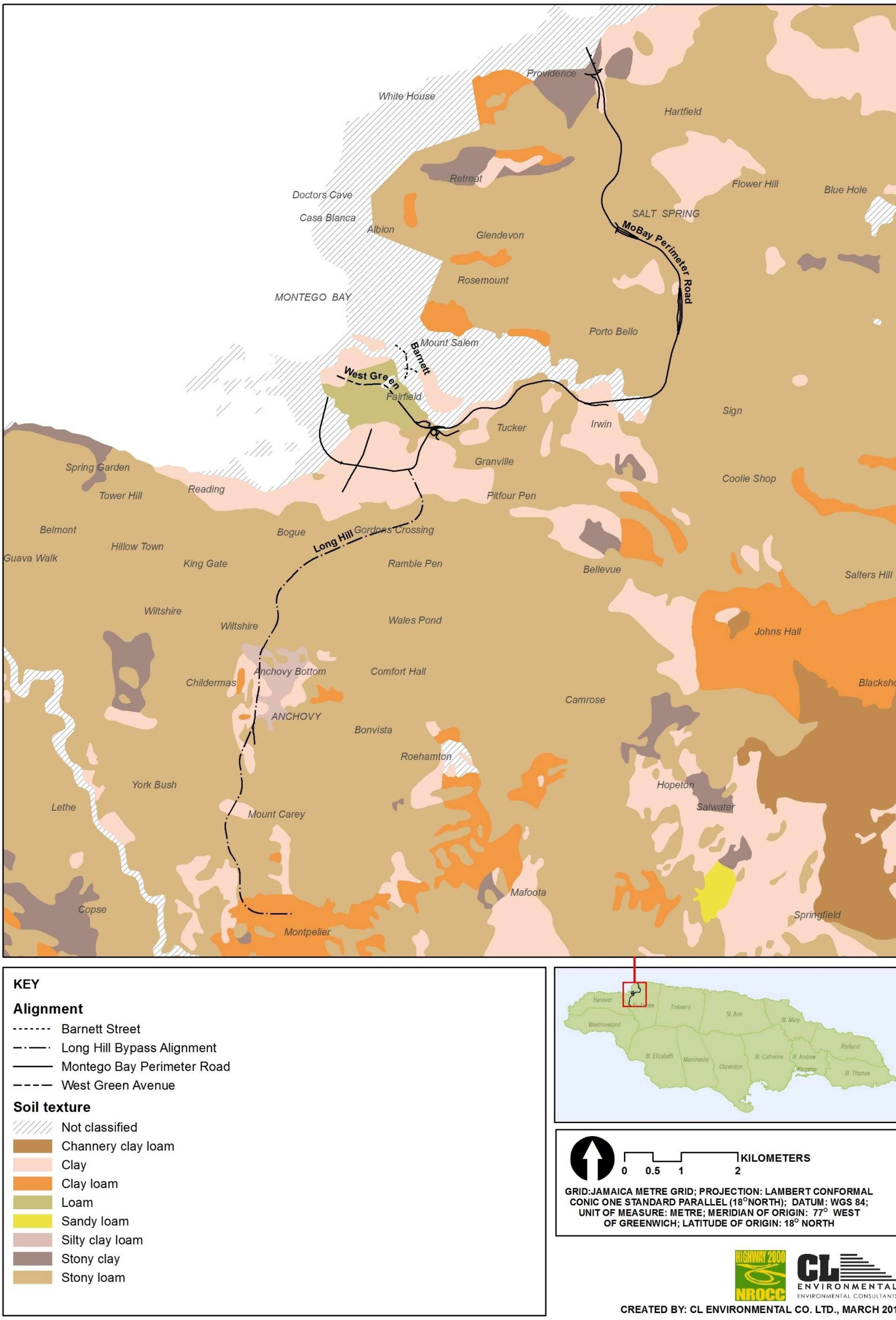


Figure 3-16 Soil Types along the various alignments

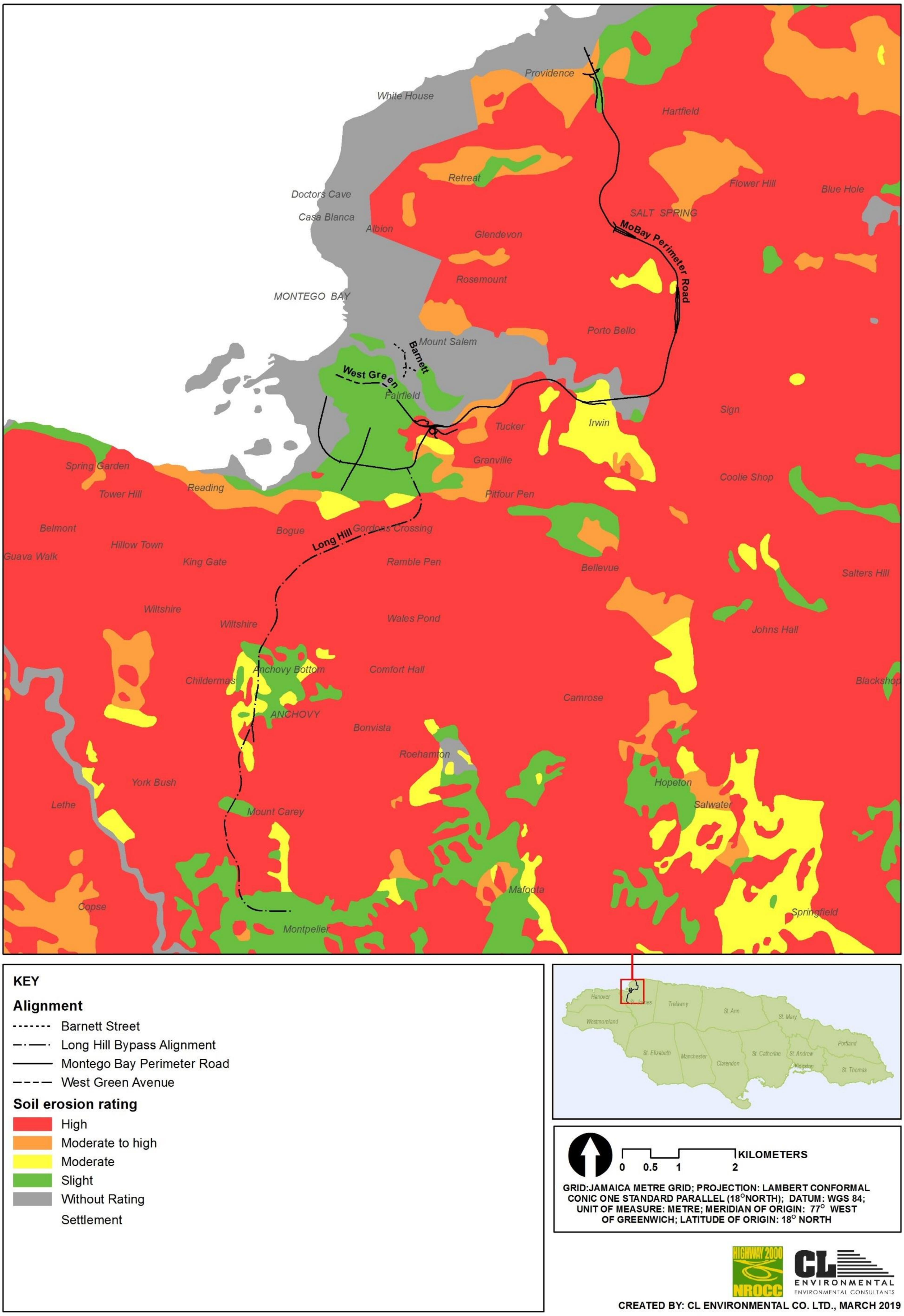


Figure 3-17 Erosion rating of soils identified along the various alignments

3.1.4.2 Debris Flows and Soil Loss

3.1.4.2.1 Methodology

The Universal Soil Loss Equation (USLE) predicts the long-term average annual rate of erosion on a field slope based on rainfall pattern, soil type, topography, crop system and management practices. USLE only predicts the amount of soil loss that results from sheet or rill erosion on a single slope and does not account for additional soil losses that might occur from gully, wind or tillage erosion. Five major factors are used to calculate the soil loss for a given site. Each factor is the numerical estimate of a specific condition that affects the severity of soil erosion at a particular location. The erosion values reflected by these factors can vary considerably due to varying weather conditions. Therefore, the values obtained from the USLE more accurately represent long-term averages.

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

A represents the potential long-term average annual soil loss in tonnes per hectare (tons per acre) per year.

R is the rainfall and runoff factor by geographic location. The greater the intensity and duration of the rain storm, the higher the erosion potential.

K is the soil erodibility factor. It is the average soil loss in tonnes/hectare (tons/acre) for a particular soil in cultivated, continuous fallow with an arbitrarily selected slope length of 22.13 m and slope steepness of 9%. ***K*** is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Texture is the principal factor affecting ***K***, but structure, organic matter and permeability also contribute.

LS is the slope length-gradient factor. The ***LS*** factor represents a ratio of soil loss under given conditions to that at a site with the "standard" slope steepness of 9% and slope length of 22.13 m. The steeper and longer the slope, the higher the risk for erosion.

C is the vegetation and management factor. It is used to determine the relative effectiveness of soil and vegetation management systems in terms of preventing soil loss. The ***C*** factor is a ratio comparing the soil loss from land under a specific crop and management system to the corresponding loss from continuously fallow and tilled land.

P is the support practice factor. It reflects the effects of practices that will reduce the amount and rate of the water runoff and thus reduce the amount of erosion. The ***P*** factor represents the ratio of soil loss by a support practice to that of straight row farming up and down the slope.

A qualitative soil loss analysis was conducted using GIS Datasets which capture the predicted soil loss in Tons/Acre per Year using the afore mentioned USLE. The analysis was conducted along the reservation of the proposed highway alignment along the Montego Bay Perimeter Road, Long Hill Bypass, and Barnett Street.

3.1.4.2.2 Model Predicted Results

SOIL LOSS ZONES

Analysis of the predicted soil loss map (Figure 3-18) concluded that the 54.7% of the alignment traverses very low soil loss zones, 19.4% traverses low soil loss zones, 23.7% traverses moderate soil loss zones and 2.2% traverses high soil loss zones. The alignment of the proposed Long Hill Bypass was observed to be more susceptible to soil loss than the remaining Perimeter Road, with several areas predicted to be affected. Table 3-2 details the areas to be affected and their associated soil loss.

Table 3-2 Summary of sections of the proposed highway and their associated estimated soil loss

Estimated Soil Loss (Ton.acre/yr)	Chainages	Percentage of Highway Traversing Sections
0 – 14.72	CH0+520 – CH1+980, CH2+640 – CH2+840, CH2+960 – CH3+150, CH4+000 – CH4+200, CH4+390 – CH4+480, CH4+760 – CH4+850, CH5+130 – CH5+700, CH8+540 – CH9+030, CH9+950 – CH10+489, CH10+000 – CH14+900, CH16+150, CH17+000 – CH18+250, CH20+660 – CH21+700, CH23+400 – CH24+901	54.7%
14.72 – 39.26	CH0+070 – CH0+530, CH2+170 – CH2+640, CH2+850 – CH2+960, CH3+150 – CH4+000, CH4+200 – CH4+390, CH4+480 – CH4+760, CH4+850 – CH5+130, CH7+640 – CH8+460, CH14+900 – CH16+100, CH16+200 – CH17+000	19.4%
36.26 – 70.34	CH1+980 – CH2+160, CH5+700 – CH7+640, CH9+310 – CH9+540, CH18+250 – CH20+600, CH21+700 – CH23+400	23.7%
70.34 – 96.80	CH9+220 – CH9+313, CH9+540 – CH9+970	2.2%

RIVER CATCHMENTS (SEDIMENT LOAD)

The catchments associated with the Flower Hill Gully and Norwood Gully were further investigated given majority of the highway peak runoff generated will enter either of the two catchments (Figure 3-19). The average soil loss estimates (sediment load) pre-development are as follows:

- Flower Hill Gully: 20.42 ton.acre/yr.
- Norwood Gully: 22.17 ton.acre/yr.

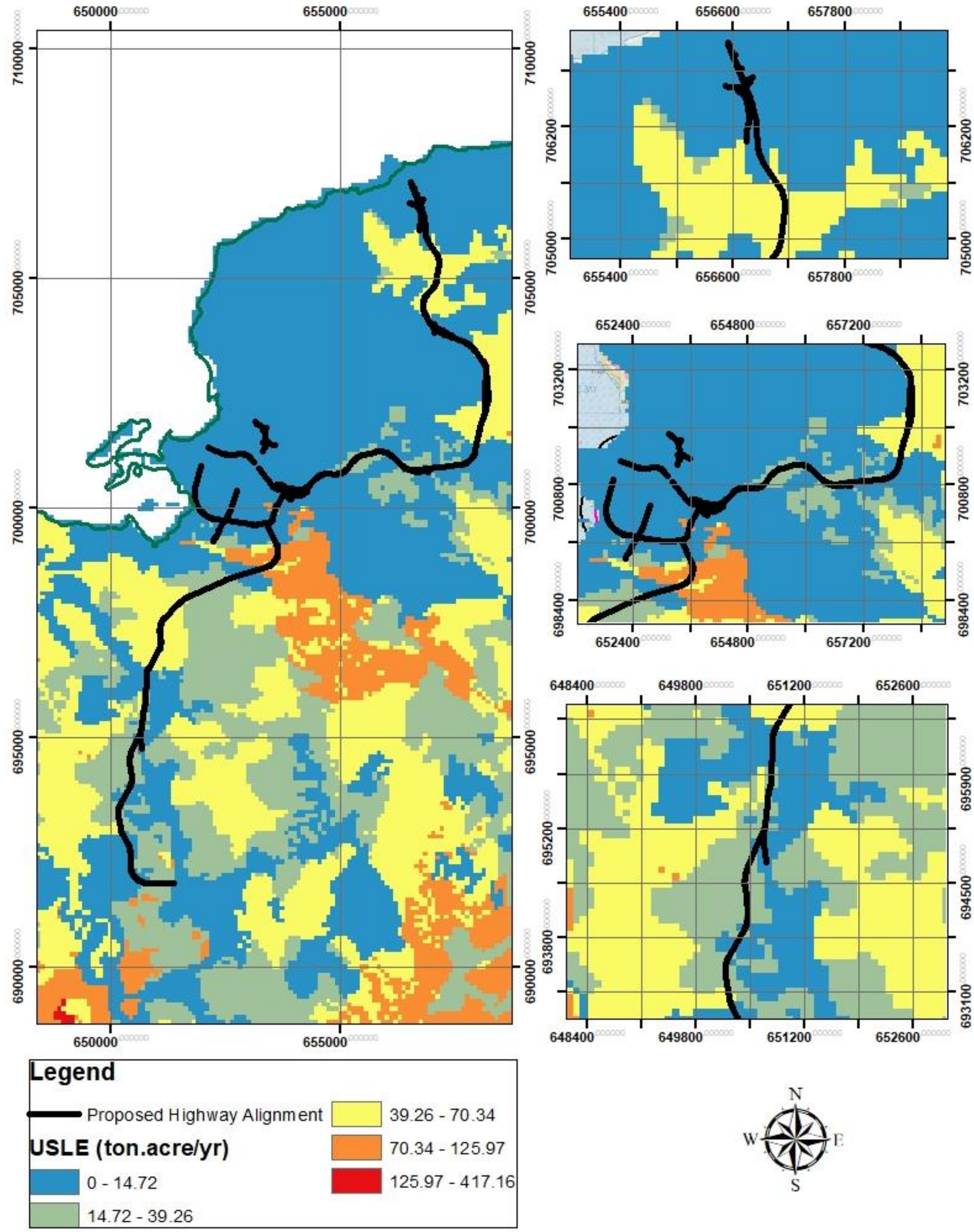


Figure 3-18 Proposed highway alignment superimposed on the estimated Soil Loss Map

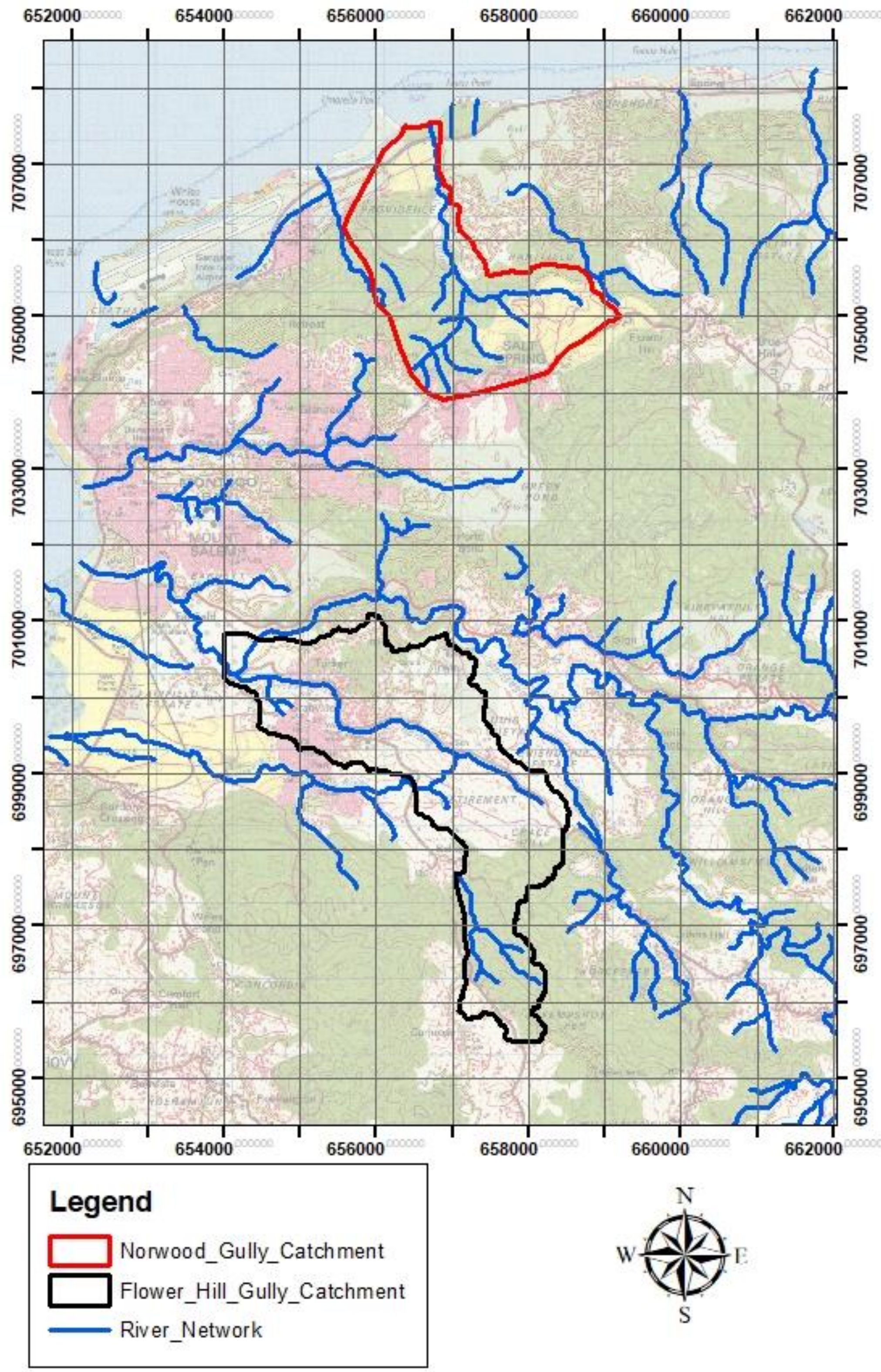


Figure 3-19 Flower Hill Gully and Norwood Gully catchments delineated

3.1.5 Drainage and Stormwater

3.1.5.1 Hydrological Assessment (Montego Bay Perimeter Road)

The information presented in this section was taken from (Stanley Consultants Inc., 2018) for the Montego Bay Perimeter Road alignment.

3.1.5.1.1 Methodology and Model Inputs

WATERSHED DELINEATION

The watersheds were delineated using the ArcHydro tool in ArcGIS using the island-wide digital terrain model (DTM), the 12,500 topographic maps and Google Earth images. The watersheds were edited manually to better define smaller watersheds which were not automatically delineated by the ArcHydro tool. Fifty-one (51) watersheds were delineated (Figure 3-20).

METHODS OF COMPUTATION

The design discharges were determined using the Jamaica 2 method (Imperial version) and the Rational Method of hydrologic calculations. The Jamaica 2 Method was used to determine the runoff hydrographs for catchment areas greater than 30ha, as recommended by the National Works Agency (NWA) for hydrologic calculations in Jamaica. The Rational Method was used to compute the peak flows for watersheds with catchment areas less than 30ha. The Rational Equation used is as follows:

Rational Equation: $Q = 0.0028ciA$

Where: *Q = Peak discharge (m^3/s)*

c = Rational method runoff coefficient

i = Rainfall intensity (mm/hour)

A = Drainage area (hectare)

The Velocity Method was used to estimate the time of concentration used in the Rational Method. The Velocity was estimated based on the TR-55 velocity versus slope for shallow concentrated flow diagram and that runoff is conveyed above ground in unpaved/grassed waterways. The design discharges were computed on the assumption that saturated conditions exist at the start of the storm event. The land-use and soil characteristics for the watershed areas were determined based on the Ministry of Industry, Commerce, Agriculture and Fisheries (MICAF) soil and land-use maps. Curve numbers (CN) were developed for each watershed based on a guide document developed by the Water Resources Authority (WRA) under the Trees for Tomorrow Project. A maximum CN value of 85 was used for saturated conditions.

CLIMATE CHANGE

To account for the potential impact of climate change, a surcharge of 10% was added to the peak discharges to arrive at the design discharge. This is in keeping with the recommendations of the NWA.

RAINFALL

Rainfall recorded at the Sangster's International Airport (SIA) was used in the analysis. The 24-hour rainfall depths are presented in Table 3-3. Rainfall intensities for the Rational Method was determined using the intensity duration frequency (IDF) curves developed under the Hydrological Support Unit Project, 1995.

Table 3-3 24-hour rainfall for Sangster's International Airport (SIA) rainfall station

24-HOUR RAINFALL (MM) (SIA)					
2yr	5yr	10yr	25yr	50yr	100yr
84	147	188	239	279	316

3.1.5.1.2 Discharge Calculations

The discharge calculations were performed for the 25-year and 100-year storm events and the resulting design discharges are presented in Table 3-4 along with the catchment characteristics and parameters used in the calculations.

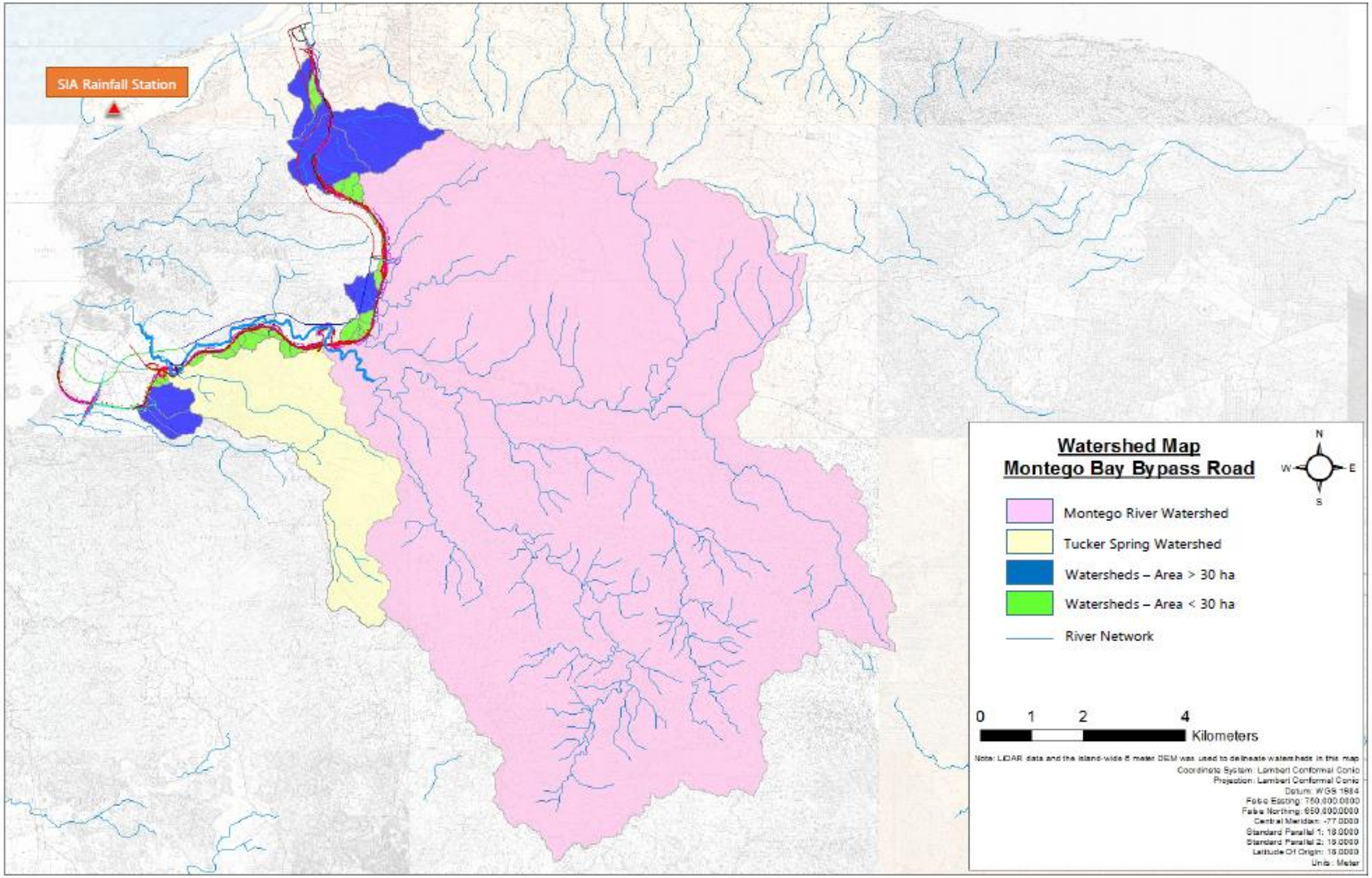


Figure 3-20 Watershed boundaries used for hydrological assessment

Table 3-4 Watershed characteristics and calculated drainage discharges

MONTEGO BAY PERIMETER ROAD - DESIGN DISCHARGE											
BASIN ID	DRAINAGE AREA	WATERCOURSE LENGTH	WATERCOURSE SLOPE	RUNOFF COEFFS.		TC	25YR RAINFALL INTENSITY	25YR PEAK DISCHARGE (Q_P)	25YR DESIGN DISCHARGE (Q_D)	100YR DESIGN DISCHARGE (Q_{D100YR})	METHOD OF COMPUTATION
	(HA)	(M)	(M/M)	CN	C	(MIN)	(MM/HR)	(M^3/S)	(M^3/S)	(M^3/S)	
B05	28.02	1456		85		59.4		4.4	4.8	7.1	JAM 2
B06	19.98	1365		85		57.0		3.2	3.5	5.2	JAM 2
B07	41.04	934		85		46.2		7.4	8.1	12.1	JAM 2
B08	2.08	201	0.0249		0.68	26.2	124.3	0.5	0.6	0.8	RM
B09	4.67	295	0.0475		0.68	22.4	136.0	1.3	1.4	1.8	RM
B10	910	17592		83		120.9		85.2	93.8	140.7	JAM 2
B11	3.26	328	0.1006		0.70	23.6	132.0	0.9	1.0	1.2	RM
B12	2.12	242	0.1364		0.70	19.0	149.5	0.7	0.8	0.9	RM
B13	6.51	308	0.1591		0.70	20.6	142.7	1.9	2.1	2.6	RM
B14	3.76	216	0.2222		0.69	16.1	164.4	1.2	1.3	1.8	RM
B15	3.25	256	0.1992		0.69	17.9	154.7	1.0	1.1	1.4	RM
B16	10.69	548	0.0839		0.70	31.3	112.2	2.4	2.6	3.3	RM
B17	2.27	157	0.2611		0.69	13.4	182.7	0.9	1.0	1.2	RM
B18	2.77	258	0.1899		0.69	18.2	153.2	0.9	1.0	1.2	RM
B19	2.81	224	0.2455		0.69	16.0	165.0	0.9	1.0	1.3	RM
B20	2.10	118	0.3051		0.69	11.3	201.5	0.9	1.0	1.2	RM
B21	6.08	330	0.1636		0.69	21.1	140.7	1.7	1.9	2.3	RM
B22	5.67	256	0.2070		0.70	17.8	155.2	1.8	2.0	2.4	RM
B23 – Montego River	9,975	17592		84		206.9			0.0	1164.4	JAM 2
B24	10.70	727	0.11		0.69	33.6	107.7	2.3	2.5	3.2	RM
B25	3.52	310	0.1710		0.69	20.3	143.9	1.0	1.1	1.4	RM
B26	2.14	285	0.1965		0.69	18.9	149.9	0.7	0.8	0.9	RM
B27	4.68	297	0.1650		0.69	20.1	144.7	1.4	1.5	1.9	RM
B28	5.55	293	0.2355		0.69	18.4	152.3	1.7	1.9	2.3	RM
B29	35.43	758		66		32.3		3.2	3.5	6.3	JAM 2
B30	5.97	368	0.2228		0.69	20.7	142.3	1.7	1.9	2.3	RM
B31	5.01	297	0.0875		0.69	23.3	132.9	1.3	1.4	1.9	RM
B32	1.33	181	0.2044		0.69	15.2	169.9	0.5	0.6	0.7	RM
B33	1.53	269	0.1338		0.69	20.1	144.7	0.5	0.6	0.7	RM
B34	1.42	197	0.1980		0.69	15.9	165.6	0.5	0.6	0.7	RM

MONTEGO BAY PERIMETER ROAD - DESIGN DISCHARGE												
BASIN ID	DRAINAGE AREA	WATERCOURSE LENGTH	WATERCOURSE SLOPE	RUNOFF COEFFS.		TC	25YR RAINFALL INTENSITY	25YR PEAK DISCHARGE (Q_P)	25YR DESIGN DISCHARGE (Q_D)	100YR DESIGN DISCHARGE (Q_{D100YR})	METHOD OF COMPUTATION
	(HA)	(M)	(M/M)	CN	C	(MIN)	(MM/HR)	(M^3/S)	(M^3/S)	(M^3/S)	
B35	1.00	191	0.1728		0.69	16.2	163.8	0.4	0.4	0.6	RM
B36	7.68	486	0.1049		0.69	28.1	119.4	1.8	2.0	2.5	RM
B37	10.53	611	0.0917		0.69	32.3	110.2	2.3	2.5	3.2	RM
B38	4.60	348	0.1293		0.69	22.9	134.3	1.2	1.3	1.8	RM
B39	6.42	387	0.1835		0.69	22.2	136.7	1.7	1.9	2.4	RM
B40	0.99	189	0.1587		0.69	16.4	162.7	0.4	0.4	0.4	RM
B41	48.38	760		85		34.0		10.3	11.3	16.8	JAM 2
B42	3.40	384	0.2135		0.69	21.3	140.0	1.0	1.1	1.3	RM
B43	1.95	189	0.3122		0.69	14.0	178.2	0.7	0.8	1.0	RM
B44	116	1227		77		40.1		16.1	17.7	30.2	JAM 2
B45	0.93	103	0.5243		0.69	9.3	216.2	0.4	0.4	0.6	RM
B46	132	1526		77		45.4		17.2	18.9	30.2	JAM 2
B47	302	2506		79		62.5		36.0	39.6	62.2	JAM 2
B48	317	2812		79		67.1		36.3	39.9	62.8	JAM 2
B49	8.07	480	0.1563		0.69	25.5	126.2	2.0	2.2	2.8	RM
B50	4.55	522	0.0670		0.69	32.3	110.2	1.0	1.1	1.4	RM
B51	40.40	1696		74		50.1		4.4	4.8	7.9	JAM 2

3.1.5.2 Hydrological Assessment (Long Hill Bypass)

An investigation was conducted to assess the pre-construction and post-construction hydrological features and impacts of the proposed roadway to determine the area's runoff and how it will affect highway operations and surroundings. This assessment will help guide the design to prevent flooding or storm-water accumulation.

3.1.5.2.1 Methodology

The general methodology adopted was as follows:

- Data Collection to include:
  - Topographic data
  - Soils data
  - Land Use data
  - Meteorological data
- Delineation and hydrological analysis of the drains within immediate catchment
- Delineating catchments and confirmation of streams/rivers
- Calculating runoffs using the US Soil Conservation Service (SCS) method
- Re-calculate runoffs implementing post-development (plus climate change consideration) changes throughout the catchments.
- Hydraulic analysis of the existing drains and drainage features
- Assess likely impacts of project on surrounding environs
- Formulate mitigation measures

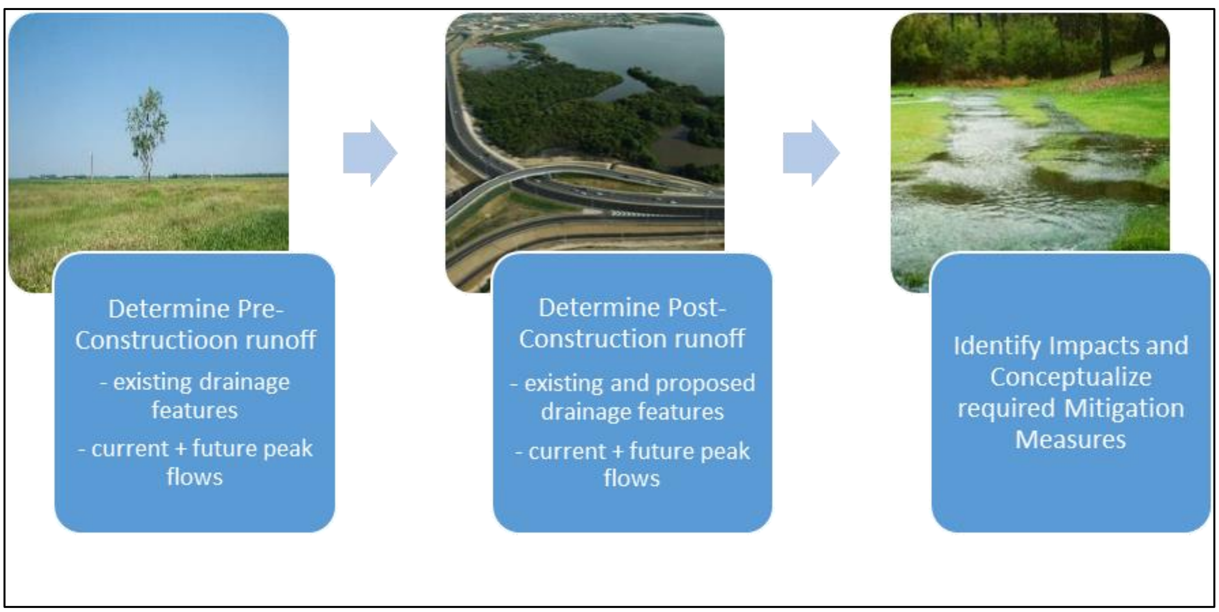


Figure 3-21 Hydrological assessment Investigation procedure

3.1.5.2.2 National Works Agency (NWA) Drainage Guidelines

The National Works Agency published "Guidelines for Preparing Hydrological and Hydraulic Design Reports for Drainage Systems of Proposed Development Applications (2015)" which was consulted to guide the assessment. According to the drainage requirements of the National Works Agency[1], minor drainage systems *(inlets, street/road gutters, roadside ditches, small channels/swales, small underground pipe systems*) and major drainage systems (*natural waterways, large impoundments, gullies and rivers*) should be sized to accommodate up to a 1:10 year storm event. For the purpose of this assessment, the 1:10, 1:25, 1:50, and 1:100-Yr Return Period storm events were investigated considering the scale and importance of the proposed infrastructure.

3.1.5.2.3 Soil Conservation Service (SCS)

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

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

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

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

Where, P = precipitation
I_a = initial abstraction
S = Potential retention which is a measure of the retention capacity of the soil.
The Maximum Potential retention, S, and the watershed characteristics are related through the Curve number CN.

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

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).

The peak runoffs are generally calculated using the Type III rainfall distribution for catchments in Jamaica. The primary inputs into the model are as follows:

- Drainage area size (A) in square miles (square kilometres);

[1] NWA - Guidelines for Preparing Hydrological and Hydraulic Design Reports for Drainage Systems of Proposed Development Applications (2015)

- Time of concentration (T_c) in hours;
- Weighted runoff curve number (RCN);
- Rainfall distribution (see Figure 4.1);
- Total design rainfall (P) in inches (mm).

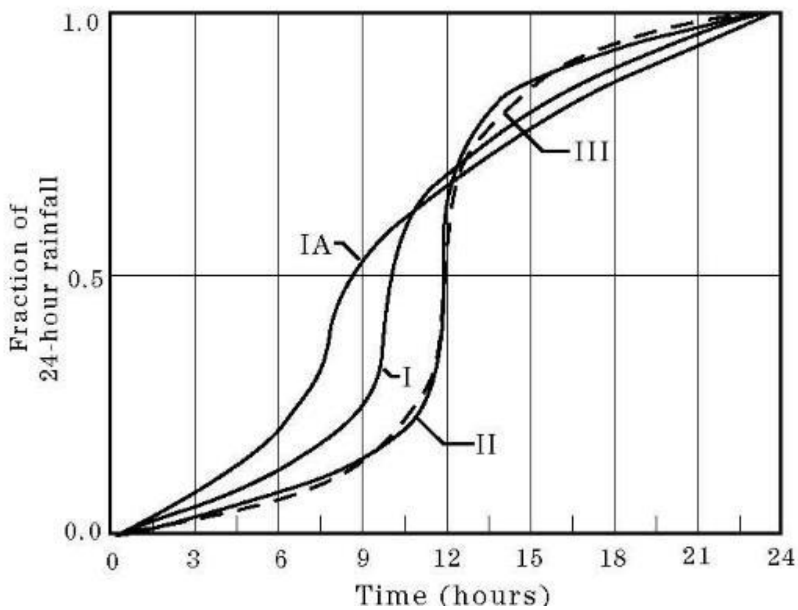


Figure 3-22 SCS 24-hour rainfall distributions

TIME OF CONCENTRATION

Time of concentration is an integral part of determining the design intensity for both the SCS method. The time of concentration is essentially the time it takes for the entire catchment to contribute simultaneously to the flows at the design point. This is also the point at which peak flow is achieved.

Time of concentration was estimated using the Manning's Kinematic equation (MKE) for time of entry and the NRCS method for the shallow concentrated flow.

Equation 1.1 Manning's Kinematic Equation for overland sheet flow

$$t_1 = \frac{5.48\,(nL)^{0.8}}{P^{0.5}\,S^{0.4}}$$

Equation 1.2 NRCS equations of shallow concentrated flow
V = 4.9178 S0.5 for an unpaved surface
V = 6.1960 S0.5 for a paved surface
t_2 = L/(60V)

3.1.5.2.4 Model Data Input

PRECIPITATION

The maximum 24-hour rainfall at the rainfall gauges within the vicinity of the watersheds was used to determine the precipitation to be applied to the model. The rainfall values were applied across each of the catchments was determined by creating rainfall fill map over the catchments.

Five Rainfall Stations were used to conduct the analysis as their proximity to the proposed project area will aptly represent of the rainfall and subsequent runoff in the project area. These stations are shown in Table 3-5 and Figure 3-23.

Table 3-5 Rainfall Station sin proximity to the assessment area

	Return Period (Year)					
Station	**2**	**5**	**10**	**25**	**50**	**100**
Kempshot	98	157.6	208.7	276.2	327.3	378.4
Montpelier	91	159	212.4	302.4	374.4	449.2
Mount Horeb	102.6	128.6	144.3	162.6	175	186.6
Pye River	98	138.1	165.7	200.2	225.1	249.3
Temple Galleries	103.9	190.9	269.6	386.1	482	583.7

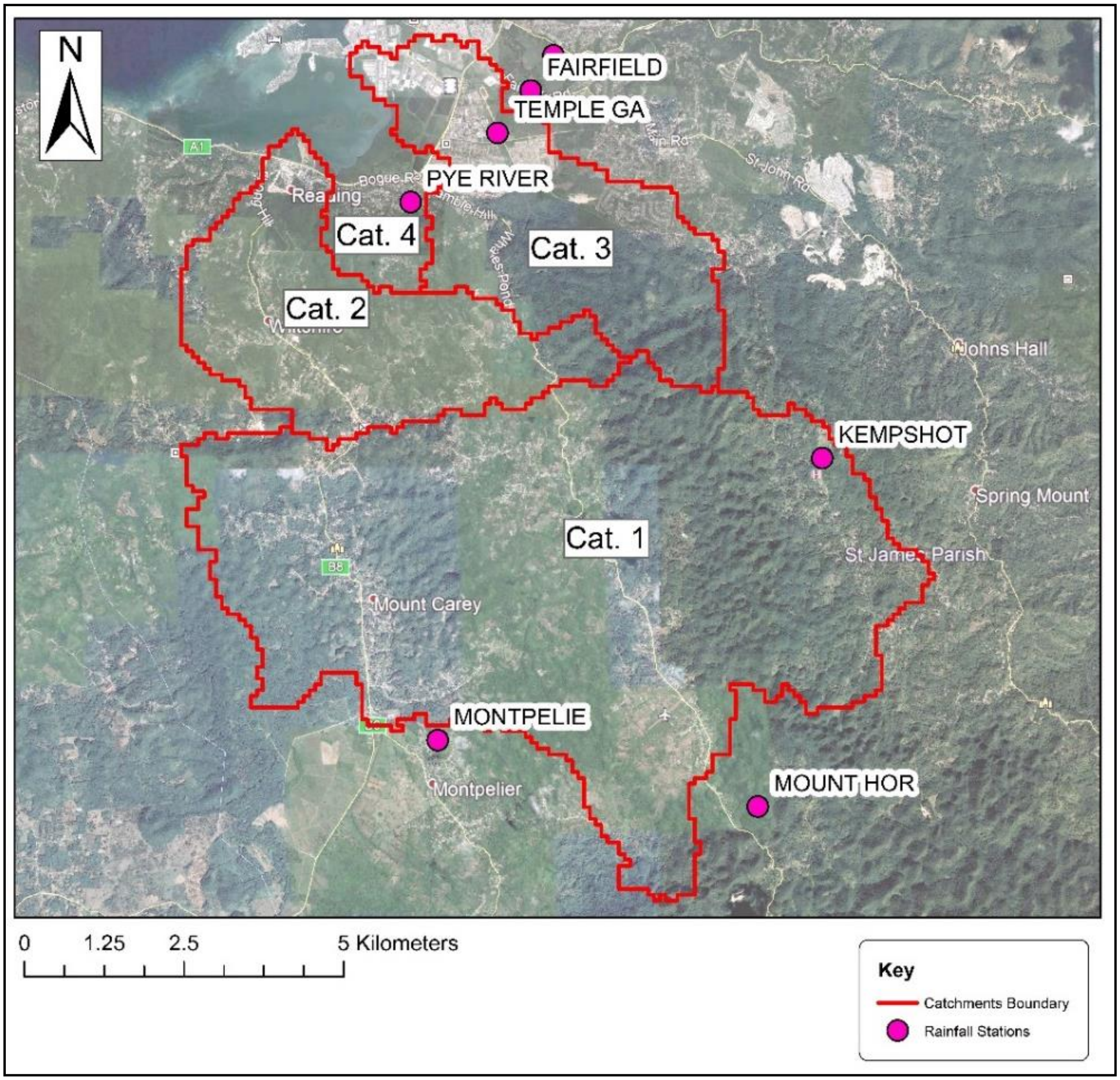


Figure 3-23 Rainfall Stations

SOILS

The catchments were superimposed on the Ministry of Agriculture's Soils Map of Jamaica to identify the soils distribution within each catchment (Figure 3-24). It was found that all the catchments had high proportions of Stony loam and Stony clay loam. The soil types are distributed across the catchments as follows:

1. Catchment 1 has over seventy percent (70%) Stony loam material with the remaining soils varying from Clay to Clay Loam.
2. Catchment 2 has over ninety percent (90%) Stony Loam material with the remaining soils varying form Clay to Silty Clay Loam.
3. Catchment 3 has over seventy-five percent (75%) Stony Loam material with the remaining soils varying from Clay to Loam.
4. Catchment 4 is predominantly Stony loam (70%) with the remaining soil being Clay.

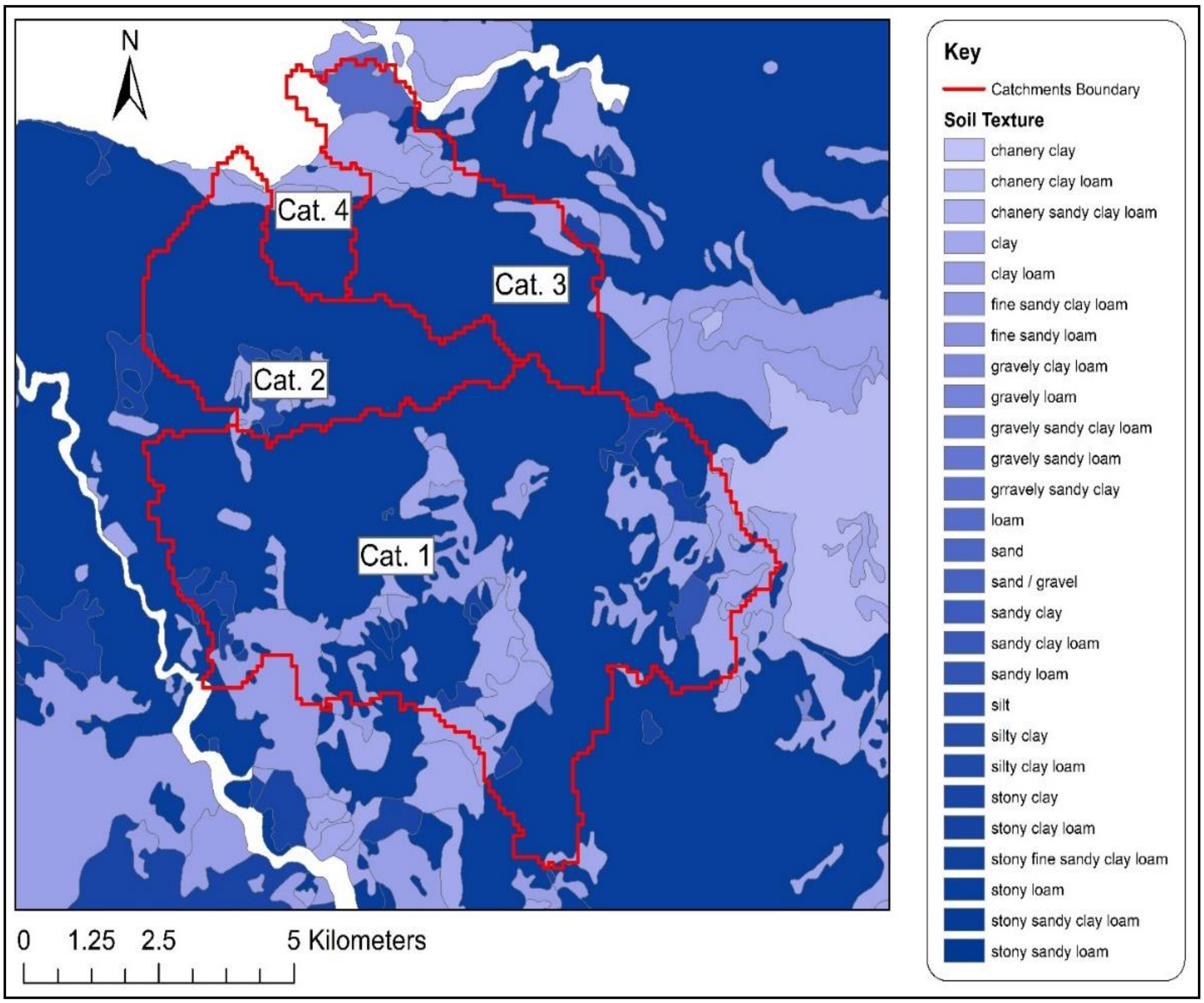


Figure 3-24 Catchment areas superimposed on Soils Map of Jamaica

LAND USE

The area through which the proposed highway alignment will traverse is currently undeveloped with highly vegetated regions with dense shrubs and trees. The proposed alignment area is also surrounded by sparsely developed areas which will have further influence on the runoff characteristics of each catchment. The land use for each catchment was determined from inspection of the Forestry Department land use map (Figure 3-25) as well as satellite imagery of the catchments.

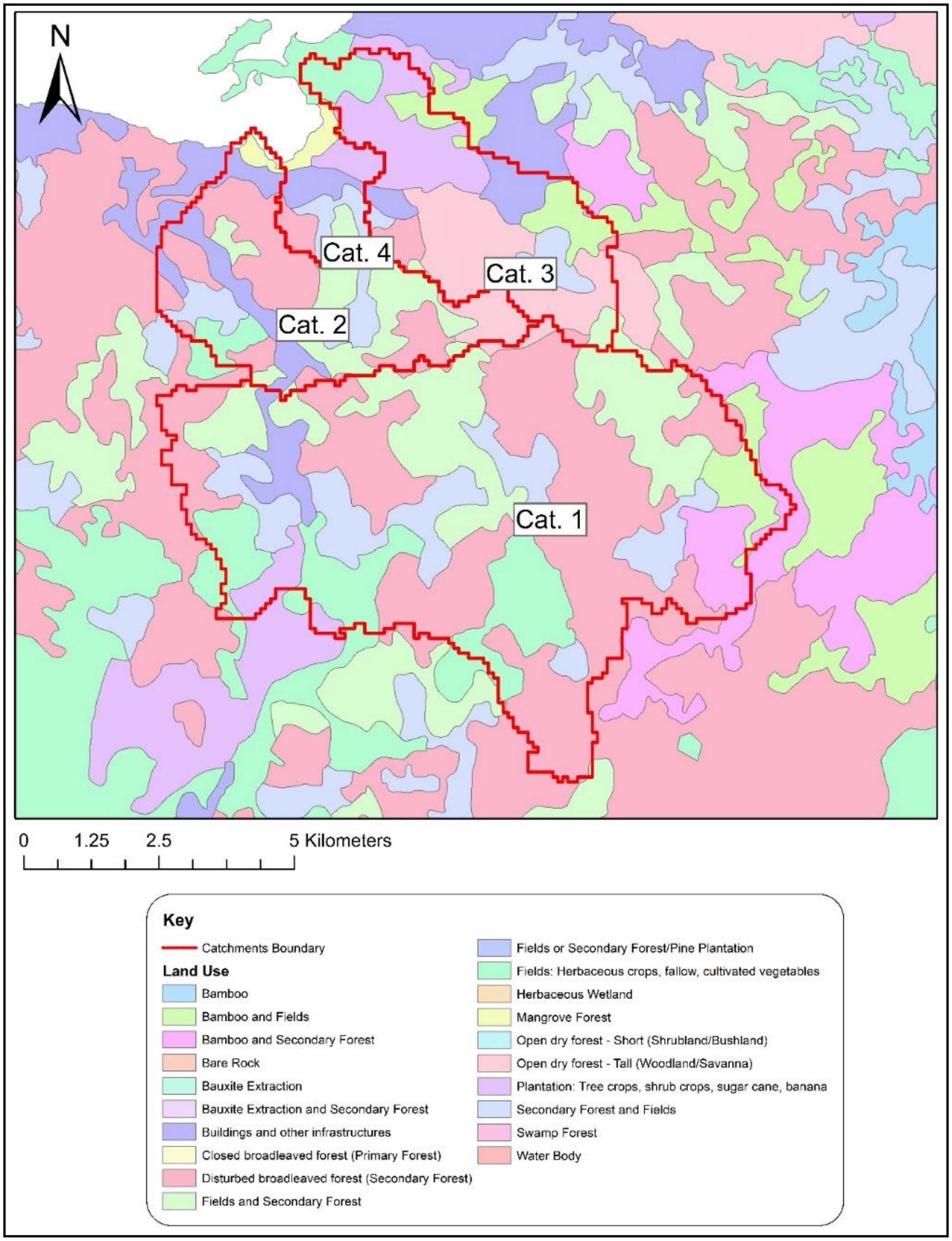


Figure 3-25 Land Use map of Jamaica with superimposed catchments and highway alignment

CURVE NUMBER

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. The curve numbers for existing conditions were selected for the catchments were as shown in Table 3-6

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 3-6 below. The development of the highway will impact the curve number and runoff by less than 0.1% 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 3-6 Curve Numbers used in SCS model

Curve Number (CN):	Watershed			
	Catchment 1	Catchment 2	Catchment 3	Catchment 4
Existing Conditions	72	75	70	72
Existing Conditions with Proposed Highway	73	76	72.6	72.3
Future w/ Proposed Highway	75	79	74	74

FUTURE CONDITIONS WITH CONSIDERATION FOR CLIMATE CHANGE

It is necessary to predict the increase in storm water runoff attributed to climate change that will be generated within each catchment. Climate change impacts are to be taken into consideration given that it is recognized from our analysis as well as other international organizations that there is an increase in rainfall intensities. The rainfall intensities were therefore changed to reflect the impacts of climate change in the future.

Table 3-7 Frequency analysis for stationary model (2010) and for parameters with temporal trends in the mean, standard deviation and skewness parameters for NMIA and SIA, up to 2100.

	Mean varying (2100)	Mean + std. dev. varying (2100)	Mean + std. dev. + skewness varying (2100)
NMIA [SIA]			
Time variable rates of increase			
Mean (mm/year)	−0.016 [0.091]	−0.054 [0.068]	−0.123 [−0.104]
Std. dev. (mm/year)		0.061 [0.016]	0.220 [−0.007]
Skewness (/year)			−0.001 [0.007]

24-h intensities (mm) for 2010 and 2100 period

Return period (years)	Stationary (2010)	Mean varying (2100)	Mean + std. dev. varying (2100)	Mean + std. dev. + skewness varying (2100)	Mean (2100) predictions	Average % increase
5	178.0 [132.6]	170.9 [132.8]	160.2 [133.1]	166.5 [120.8]	165.9 [128.9]	−7% [−3]
10	220.5 [163.6]	216.3 [166.2]	212.4 [172.4]	248.0 [157.4]	225.6 [165.3]	2% [1]
25	271.7 [202.7]	275.1 [209.0]	283.5 [229.2]	378.6 [224.3]	312.4 [220.9]	15% [9]
50	308.1 [231.7]	319.8 [241.1]	351.2 [280.0]	562.1 [292.0]	411.0 [271.0]	33% [17]
100	342.9 [260.5]	365.1 [273.3]	426.7 [336.9]	845.1 [381.2]	545.6 [330.5]	59% [27]

3.1.5.2.5 Results (Peak Runoff Calculations)

It is predicted that after construction of the highway has been completed, there will be more impermeable surfaces present including (potential) additional commercial and residential housing development. For pre-construction and post-construction flows, four (4) catchment areas were identified while determining the runoff flow for the areas that intersect with the proposed highway alignment. Table 3-26 shows the catchments delineated for the predevelopment and post development runoff analysis.

The hydrological model was then used to determine the pre-construction peak flows for the current conditions and post development conditions for 10, 25, 50 and 100-year return period events, including climate change considerations.

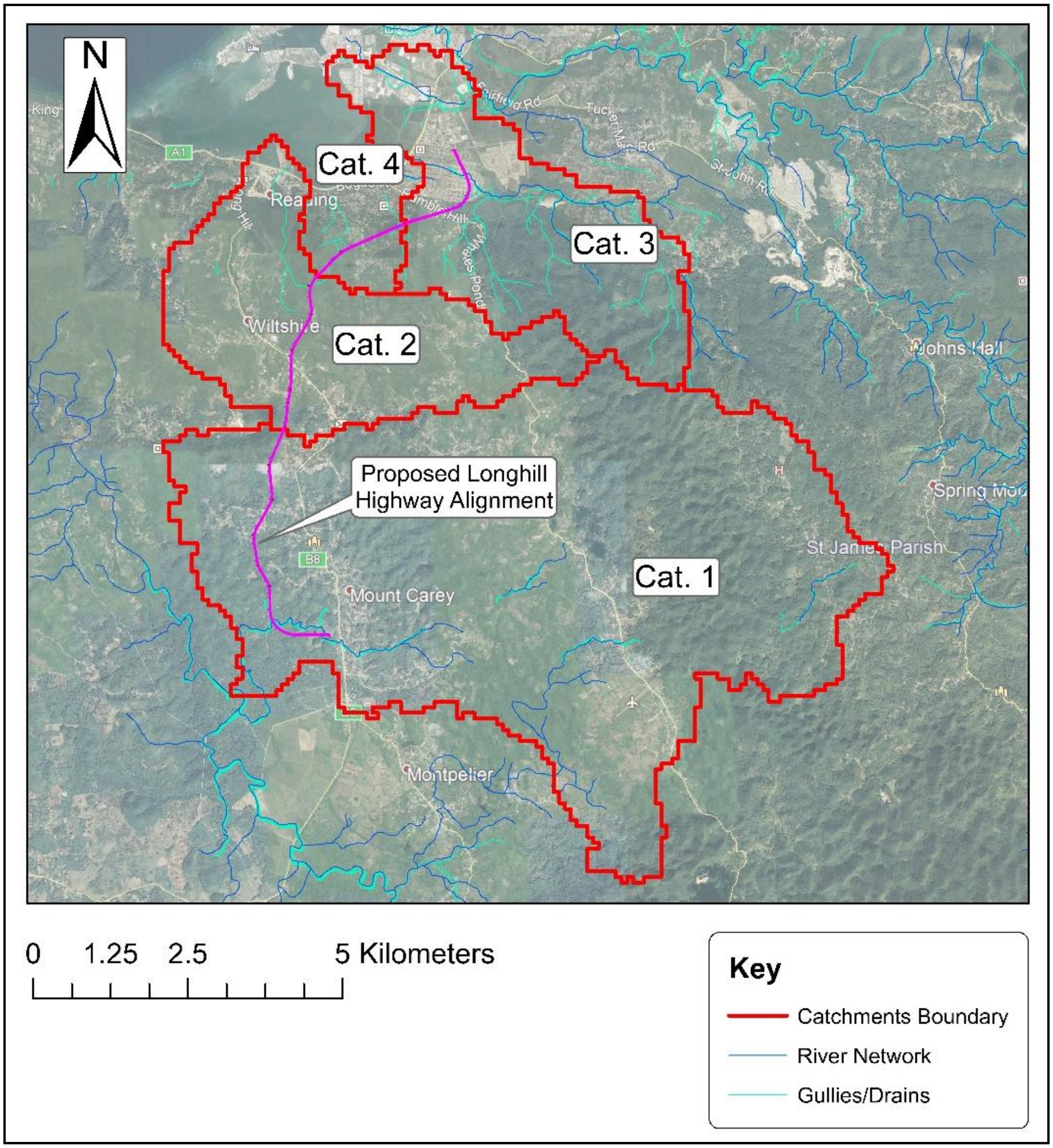


Figure 3-26 Catchment Areas

CATCHMENT 1

Catchment 1 is largely undeveloped and encompasses the Mount Carey area which comprises of very hilly and mountainous terrain which forms a large basin from which a significant portion of the runoff from the catchment concentrates its flow to the Great River.

For the 10-year return period pre-construction, the catchment had a concentrated flow of 108.4 m^3/sec. When compared to the Post-construction flows, an increase of 2.3% was observed as the Peak Runoff increased to 110.9 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 24.3% over Pre-construction flows with a peak flow of 134.7 m^3/sec (Table 3-8 and Figure 3-27).

For the 25-year return period pre-construction, the catchment had a concentrated flow of 167.8 m^3/sec. When compared to the Post-construction flows, an increase of 1.53% was observed as the Peak Runoff increased to 170.4 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 21.3% over Pre-construction flows with a peak flow of 203.5 m^3/sec (Table 3-8 and Figure 3-27).

For the 50-year return period pre-construction, the catchment had a concentrated flow of 214.8 m^3/sec. When compared to the Post-construction flows, an increase of 1.2% was observed as the Peak Runoff increased to 217.4 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 42.2% over Pre-construction flows with a peak flow of 305.4 m^3/sec (Table 3-8 and Figure 3-27).

For the 100-year return period pre-construction, the catchment had a concentrated flow of 262.9 m^3/sec. When compared to the Post-construction flows, an increase of 1.0% was observed as the Peak Runoff increased to 265.4 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 71.1% over Pre-construction flows with a peak flow of 449.7 m^3/sec (Table 3-8 and Figure 3-27).

Table 3-8 Peak Runoff Analysis (Pre-construction, Post-construction, & Post-Construction + Future) for Catchment 1

Parameter	Catchment 1	Unit
Area	54	km^2
Tc	0.68	Hours
Peak Runoff (Pre-Construction)		
1:10 Year Return Period	108.4	m^3/sec
1:25 Year Return Period	167.84	m^3/sec
1:50 Year Return Period	214.79	m^3/sec
1:100 Year Return Period	262.86	m^3/sec
Peak Runoff (Post-Construction)		
1:10 Year Return Period	110.9	m^3/sec
1:25 Year Return Period	170.41	m^3/sec
1:50 Year Return Period	217.37	m^3/sec
1:100 Year Return Period	265.41	m^3/sec
Peak Runoff (Post-Construction + Future)		
1:10 Year Return Period	134.7	m^3/sec
1:25 Year Return Period	203.52	m^3/sec
1:50 Year Return Period	305.43	m^3/sec

Parameter	Catchment 1	Unit
1:100 Year Return Period	449.72	m^3/sec

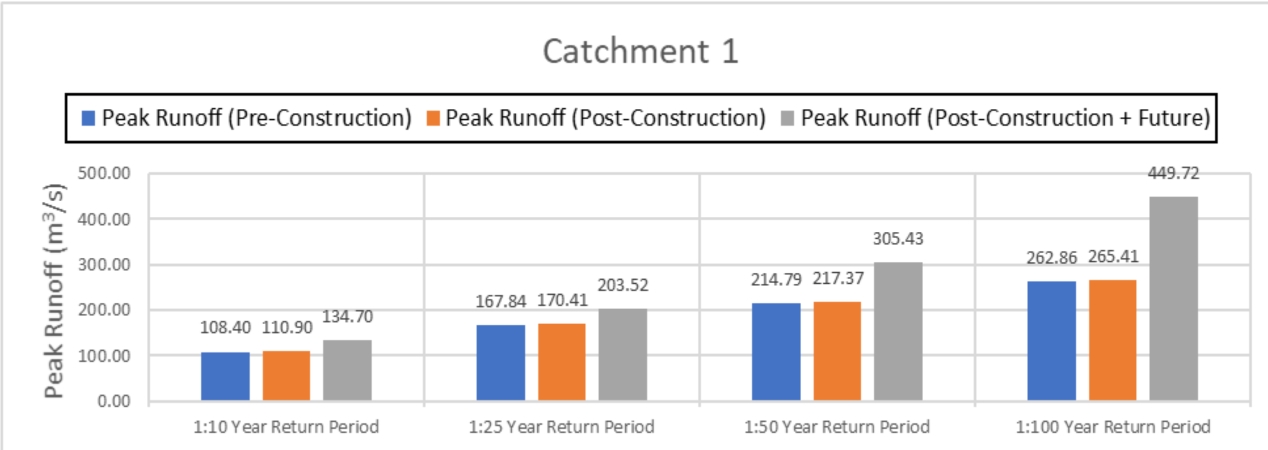


Figure 3-27 Flows associated with Catchment 1

CATCHMENT 2

As with Catchment 1, Catchment 2 is largely undeveloped, though to a lesser extent, and encompasses the Wiltshire area. This catchment primarily concentrates its flow a gully on the north of the catchment.

For the 10-year return period pre-construction, the catchment had a concentrated flow of 13.0 m^3/sec. When compared to the Post-construction flows, an increase of 2.7% was observed as the Peak Runoff increased to 13.4 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 139.7% over Pre-construction flows with a peak flow of 31.2 m^3/sec (Table 3-9 and Figure 3-28).

For the 25-year return period pre-construction, the catchment had a concentrated flow of 24.1 m^3/sec. When compared to the Post-construction flows, an increase of 1.7% was observed as the Peak Runoff increased to 24.53 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 130.7% over Pre-construction flows with a peak flow of 55.67 m^3/sec (Table 3-9 and Figure 3-28).

For the 50-year return period pre-construction, the catchment had a concentrated flow of 31.1 m^3/sec. When compared to the Post-construction flows, an increase of 1.3% was observed as the Peak Runoff increased to 31.5 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 171.3% over Pre-construction flows with a peak flow of 84.3 m^3/sec (Table 3-9 and Figure 3-28).

For the 100-year return period pre-construction, the catchment had a concentrated flow of 38.23 m³/sec. When compared to the Post-construction flows, an increase of 1.1% was observed as the Peak Runoff increased to 38.64 m³/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 226.9% over Pre-construction flows with a peak flow of 124.99 m³/sec (Table 3-9 and Figure 3-28).

Table 3-9 Peak Runoff Analysis (Pre-construction, Post-construction, & Post-Construction + Future) for Catchment 2

Parameter	Catchment 2	Unit
Area	8	km^2
Tc	2.94	Hours
Peak Runoff (Pre-Construction)		
1:10 Year Return Period	13.01	m^3/sec
1:25 Year Return Period	24.13	m^3/sec
1:50 Year Return Period	31.09	m^3/sec
1:100 Year Return Period	38.23	m^3/sec
Peak Runoff (Post-Construction)		
1:10 Year Return Period	13.37	m^3/sec
1:25 Year Return Period	24.53	m^3/sec
1:50 Year Return Period	31.5	m^3/sec
1:100 Year Return Period	38.64	m^3/sec
Peak Runoff (Post-Construction + Future)		
1:10 Year Return Period	31.19	m^3/sec
1:25 Year Return Period	55.67	m^3/sec
1:50 Year Return Period	84.34	m^3/sec
1:100 Year Return Period	124.99	m^3/sec

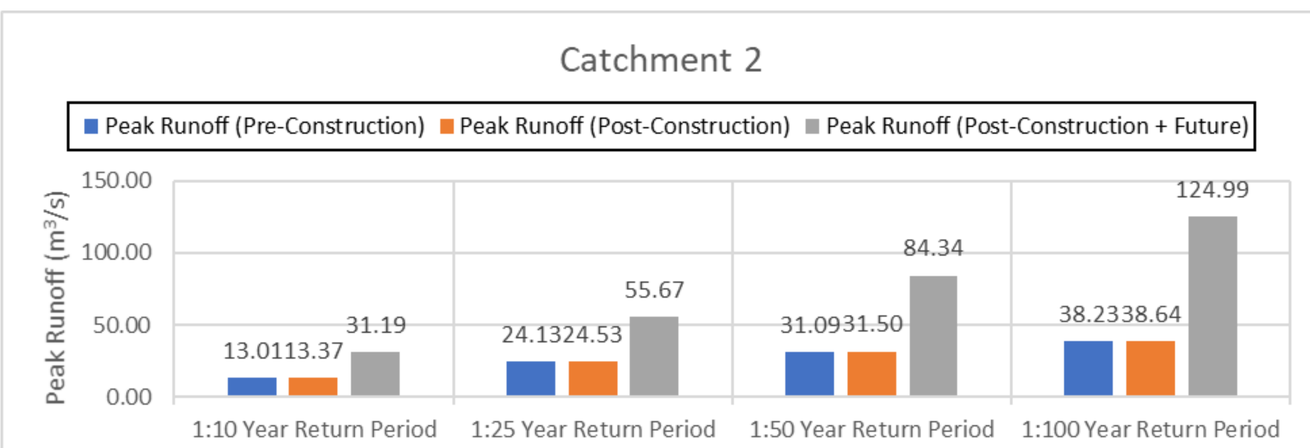


Figure 3-28 Flows associated with Catchment 2

CATCHMENT 3

Unlike Catchments 1 and 2, Catchment 3 is significantly more developed and encompasses a significant portion of Montego Bay, and primarily concentrates its flow to the Retirement River.

For the 10-year return period pre-construction, the catchment had a concentrated flow of 28.2 m^3/sec. When compared to the Post-construction flows, an increase of 4.6% was observed as the Peak Runoff increased to 29.46 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 84.6% over Pre-construction flows with a peak flow of 52.0 m^3/sec (Table 3-10 and Figure 3-29).

For the 25-year return period pre-construction, the catchment had a concentrated flow of 45.0 m^3/sec. When compared to the Post-construction flows, an increase of 1.1% was observed as the Peak Runoff increased to 46.3 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 78.9% over Pre-construction flows with a peak flow of 80.5 m^3/sec (Table 3-10 and Figure 3-29).

For the 50-year return period pre-construction, the catchment had a concentrated flow of 58.9 m^3/sec. When compared to the Post-construction flows, an increase of 2.2% was observed as the Peak Runoff increased to 60.2 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 107.4% over Pre-construction flows with a peak flow of 122.2 m^3/sec (Table 3-10 and Figure 3-29).

For the 100-year return period pre-construction, the catchment had a concentrated flow of 73.6 m^3/sec. When compared to the Post-construction flows, an increase of 1.7% was observed as the Peak Runoff increased to 74.9 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 101.6% over Pre-construction flows with a peak flow of 148.4 m^3/sec (Table 3-10 and Figure 3-29).

Table 3-10 Peak Runoff Analysis (Pre-construction, Post-construction, & Post-Construction + Future) for Catchment 3

Parameter	Catchment 3	Unit
Area	10.3	km^2
Tc	6.65	Hours
Peak Runoff (Pre-Construction)		
1:10 Year Return Period	28.16	m^3/sec
1:25 Year Return Period	44.98	m^3/sec
1:50 Year Return Period	58.9	m^3/sec
1:100 Year Return Period	73.63	m^3/sec
Peak Runoff (Post-Construction)		
1:10 Year Return Period	29.46	m^3/sec
1:25 Year Return Period	46.3	m^3/sec
1:50 Year Return Period	60.18	m^3/sec
1:100 Year Return Period	74.85	m^3/sec

Parameter	Catchment 3	Unit
Peak Runoff (Post-Construction + Future)		
1:10 Year Return Period	52	m^3/sec
1:25 Year Return Period	80.47	m^3/sec
1:50 Year Return Period	122.17	m^3/sec
1:100 Year Return Period	148.43	m^3/sec

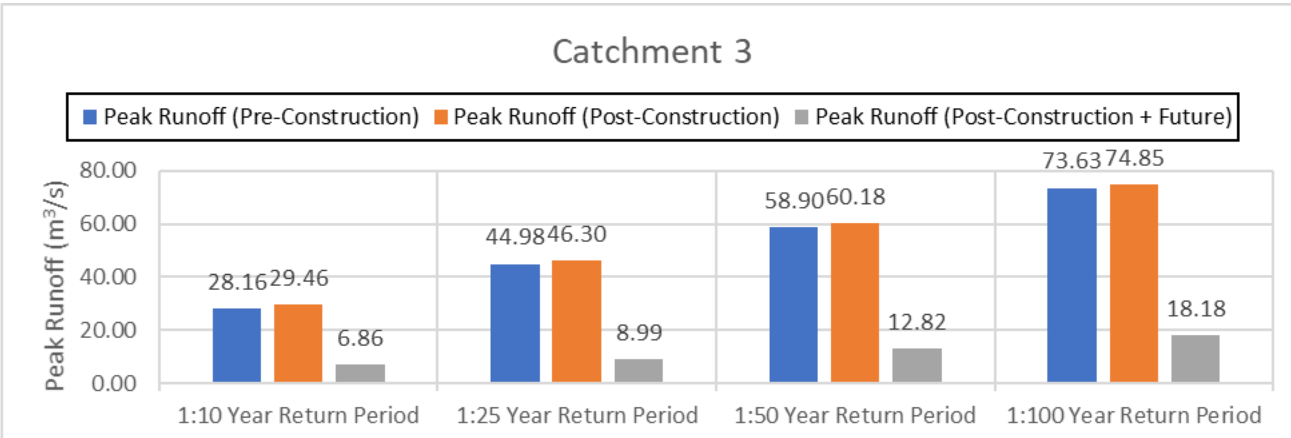


Figure 3-29 Flows associated with Catchment 3

CATCHMENT 4

Catchment 4 is the smallest of the catchments assessed and is significantly more developed. The catchment captures runoff from the Bogue communities and carries it to ocean with a peak run off through two channels.

For the 10-year return period pre-construction, the catchment had a concentrated flow of 1.29 m^3/sec. When compared to the Post-construction flows, an increase of 0.9% was observed as the Peak Runoff increased to 1.31 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 430.1% over Pre-construction flows with a peak flow of 6.86 m^3/sec (Table 3-11 and Figure 3-30).

For the 25-year return period pre-construction, the catchment had a concentrated flow of 1.72 m^3/sec. When compared to the Post-construction flows, an increase of 0.7% was observed as the Peak Runoff increased to 1.74 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 289.2% over Pre-construction flows with a peak flow of 8.99 m^3/sec (Table 3-11 and Figure 3-30).

For the 50-year return period pre-construction, the catchment had a concentrated flow of 1.96 m^3/sec. When compared to the Post-construction flows, an increase of 5.1% was observed as the Peak Runoff increased to 2.06 m^3/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 554.6% over Pre-construction flows with a peak flow of 12.82 m³/sec (Table 3-11 and Figure 3-30).

For the 100-year return period pre-construction, the catchment had a concentrated flow of 2.36 m³/sec. When compared to the Post-construction flows, an increase of 0.6% was observed as the Peak Runoff increased to 2.37 m³/sec. Furthermore, when compared to Post-Construction flows with future considerations, there was an increase of 671.7% over Pre-construction flows with a peak flow of 18.2 m³/sec (Table 3-11 and Figure 3-30).

Table 3-11 Peak Runoff Analysis (Pre-construction, Post-construction, & Post-Construction + Future) for Catchment 4

Parameter	Catchment 4	Unit
Area	0.9	km^2
Tc	3.29	Hours
Peak Runoff (Pre-Construction)		
1:10 Year Return Period	1.29	m^3/sec
1:25 Year Return Period	1.72	m^3/sec
1:50 Year Return Period	1.96	m^3/sec
1:100 Year Return Period	2.36	m^3/sec
Peak Runoff (Post-Construction)		
1:10 Year Return Period	1.31	m^3/sec
1:25 Year Return Period	1.74	m^3/sec
1:50 Year Return Period	2.06	m^3/sec
1:100 Year Return Period	2.37	m^3/sec
Peak Runoff (Post-Construction + Future)		
1:10 Year Return Period	6.86	m^3/sec
1:25 Year Return Period	8.99	m^3/sec
1:50 Year Return Period	12.82	m^3/sec
1:100 Year Return Period	18.18	m^3/sec

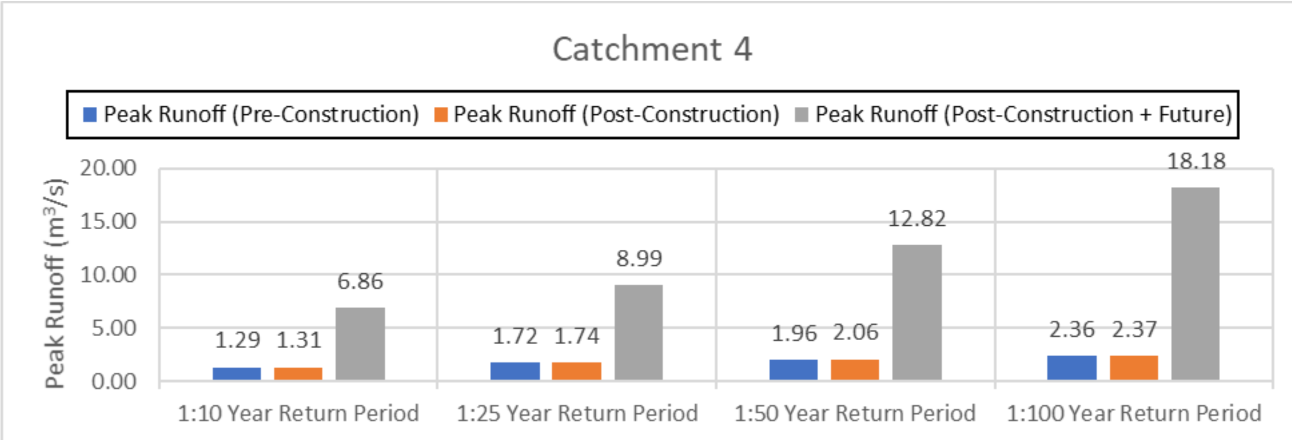


Figure 3-30 Flows associated with Catchment 4

3.1.5.3 Drainage Crossings

GIS datasets indicate that there are approximately thirty-eight (38) locations where rivers and gullies cross the proposed highway alignment. According to the 2018 Mobay Bypass Road Drainage Report (National Road Operating & Constructing Company Ltd., 2018), there are over fifty (50) designed drainage structures that seemingly coincide with crossings identified on maps. It should be noted that the designed drainage structures consist of a combination of circular pipes and reinforced concrete box culverts of varying sizes. The investigation of the drainage crossings was therefore focused on the Long Hill section of the proposed highway alignment as no drainage assessment has been conducted for this area to date. Of the twelve (12) identified crossings along the Long Hill section, six (6) were verified on foot while the other six (6) were inaccessible (Table 3-12).

Table 3-12 Drainage crossings identified along the Long Hill section

Feature	Chainage	Description	Status
River/Gully Crossing	10+085	Long Hill Bypass	Verified
River/Gully Crossing	9+680	Long Hill Bypass	Inaccessible
River/Gully Crossing	9+585	Long Hill Bypass	Inaccessible
River/Gully Crossing	8+505	Long Hill Bypass	Inaccessible
River/Gully Crossing	8+400	Long Hill Bypass	Inaccessible
River/Gully Crossing	7+480	Long Hill Bypass	Verified
River/Gully Crossing	7+360	Long Hill Bypass	Inaccessible
River/Gully Crossing	6+690	Long Hill Bypass	Inaccessible
River/Gully Crossing	1+140 – 1+060	Long Hill Bypass	Verified
River/Gully Crossing	1+020, 1+000, 0+980	Long Hill Bypass	Verified
River/Gully Crossing	0+990 – 0+980	Long Hill Bypass	Verified
River/Gully Crossing	0+100	Long Hill Bypass	Verified

The identified crossing located at 0+100 of the proposed alignment corresponded to a tributary of the Great River. This drainage crossing directly intersects the proposed alignment. The topography and the observed vegetation correlated with that of an area that experiences frequent water flows.

Between chainages 0+900 – 0+980 a river crossing directly intersects the proposed highway alignment. The topography and the observed vegetation correlated with that of an area that experiences frequent water flows. Further along the proposed alignment at chainages 1+000 and 1+020 the same river network continues and intersects the alignment again. The crossing located at 1+140 is much smaller than the previously identified segments, however, maintains similar characteristics of a natural water feature; this feature seems to be a stream. However, similarly topography and observed vegetation are characteristic of a natural water drainage path.

At 7+480 is another crossing that directly intersects the proposed alignment. This feature is a gully basin that slopes down from a gentle rocky hillslope. Vegetation identified in the basin is characteristic of that found in natural drainage paths. The crossing at 10+085 was identified as a river crossing This crossing was located on Barnett Estates property and in vicinity of an identified well. Currently it has large box culvert in place and is directly in line with the proposed alignment. It is of note that this crossing is also near to the Gore Development housing scheme being constructed.

Plate 3-9 River Crossing at 1+140

Plate 3-10 River Crossing at 1+060

Plate 3-11 River Crossing at 7+480

Plate 3-12 Identified Culvert Crossing at 10+085

Plate 3-13 Identified channel at 0+100

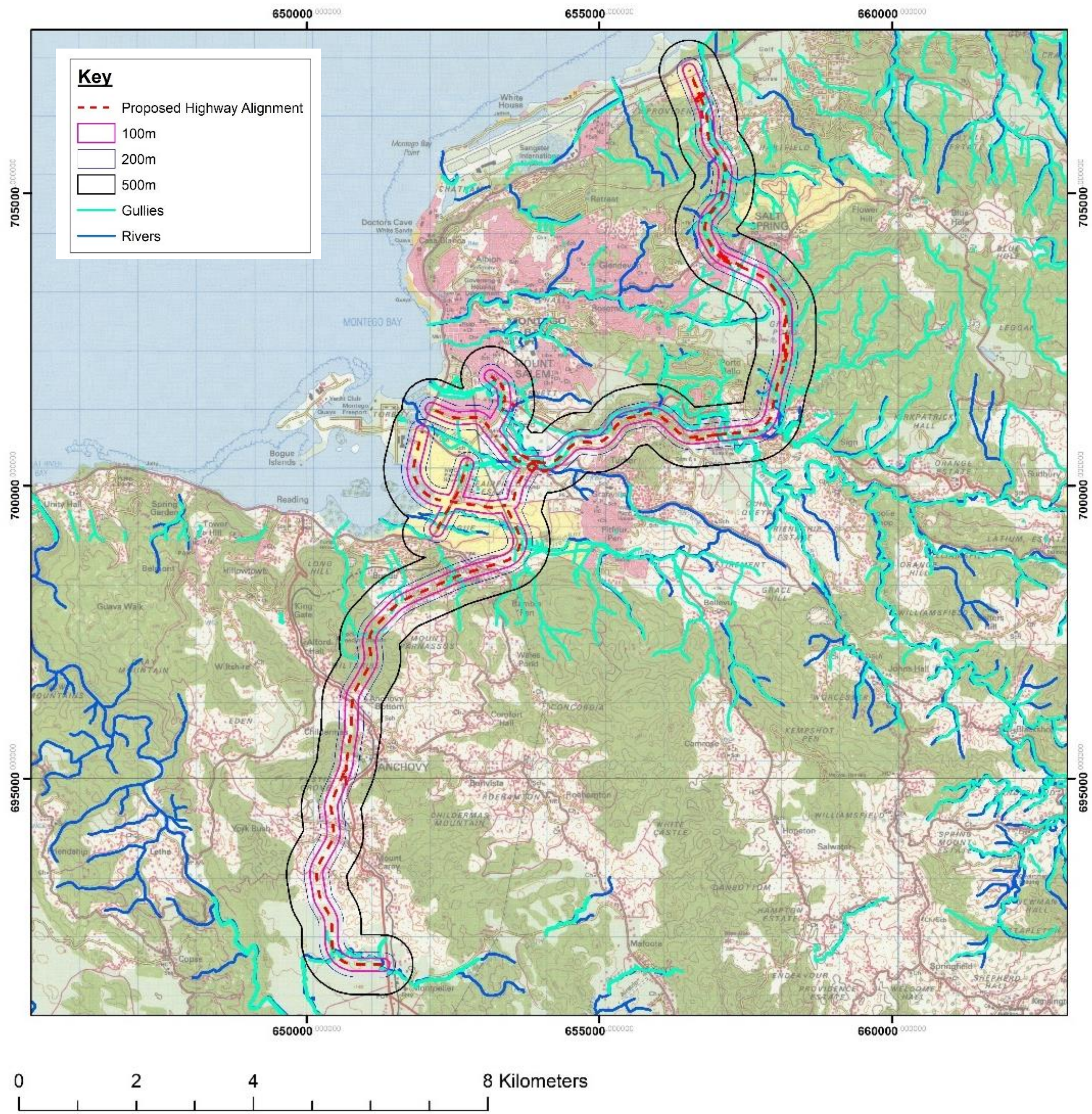


Figure 3-31 Map showing gully and river crossings along the proposed alignment

3.1.5.4 Montego River Realignment

3.1.5.4.1 Overview of Montego River and Historical Accounts

The Montego River is approximately 20 km long, with streams starting from the hills of Equity where is passes through or along the Porto Bello, Fairfield, and Catherine Hall communities and ends in Montego Bay, where it flows into the Caribbean Sea. Some areas of the river were noted to have depths as much as 3m, and widths exceeding 13m.

The river is known to swell and overflow its banks during heavy rainfall events, which results in significant damage to some of the afore mentioned communities. Several anecdotal interviews of residents were conducted within communities upstream, and downstream of the Montego River in order to fully appreciate the effects of previous events. Interviewees were asked how historic events affected the river and the communities and their responses recorded. Residents upstream of the proposed realignment area primarily recall the effects of Tropical Storm Nicole, where they vividly recall the river swelling and subsequently overflowing its banks.

Residents of the Riverside Drive, which is along the southern side of the river, were interviewed. They vividly recall the river exceeding the height of its banks of by up 0.3m, however they all stated that there was no damage as the community is much higher in elevation than the swollen river.

On the northern side of the river however, the residents and business owners lament damage due to erosion and flooding. An interview with the operator of the Block Factory adjacent the river revealed that he lost several blocks from the banks of the river due to erosion due to Tropical Storm Nicole. He stated that in that event, the water was approximately 0.6m above the banks on his property. Further upstream, the operator of a garage gave a similar recollection of the event as the block factory operator where the river overflowed its banks, however he was largely unaffected by the swell.

To further understand the current state and historic happenings within the area of the proposed realignment, Mark Kerr-Jarrett was interviewed as the proposed alignment is on his property, he stated clearly recalling that though the river overflowed its banks, there was no real damage. He however added that there was significant erosion as the banks have widened an additional 12m over the pass 20 years. An investigation of the river along the area of proposed realignment (13+600 – 14+000) was carried out, and findings confirmed what was said in the interview. Several areas of significant channel erosion, and sediment deposits at the meanders of the river.

Further downstream, the Montego River meanders towards Catherine Hall. Several interviews of residents were conducted in and around the community, including West Green, and vendors of the Charles Gordon Market. The persons interviewed shared their recollection of past events, namely Tropical Storm Nicole and Gilbert, as well as the period of heavy rainfall during November 2016. A majority of the interview respondents in the communities clearly recall the river overflowing its banks and flooding the common area of the Catherine Hall community. The effects on the Northern side of the river were much more severe as the vendors gave a clear recollection of severe erosion damaging the banks resulting in a large excavator and a Container shop being wash downstream.

3.1.5.4.2 River Network Simulation

As mentioned previously, it is proposed that a section of the Montego River be realigned (Figure 2-4). Both field assessment and the Mike 11 module were used to model and simulate the river network. The field data was collection included riverbed and bank composition, average channel depth and width, as well as the general shape of the channel. To estimate the inflows from the catchments delineated for the river network, the Soil Conservation Service (SCS) Method was used to estimate flows. This data was then used in conjunction with existing GIS Data to calibrate and prepare the river network model for simulation with a 50-year return period.

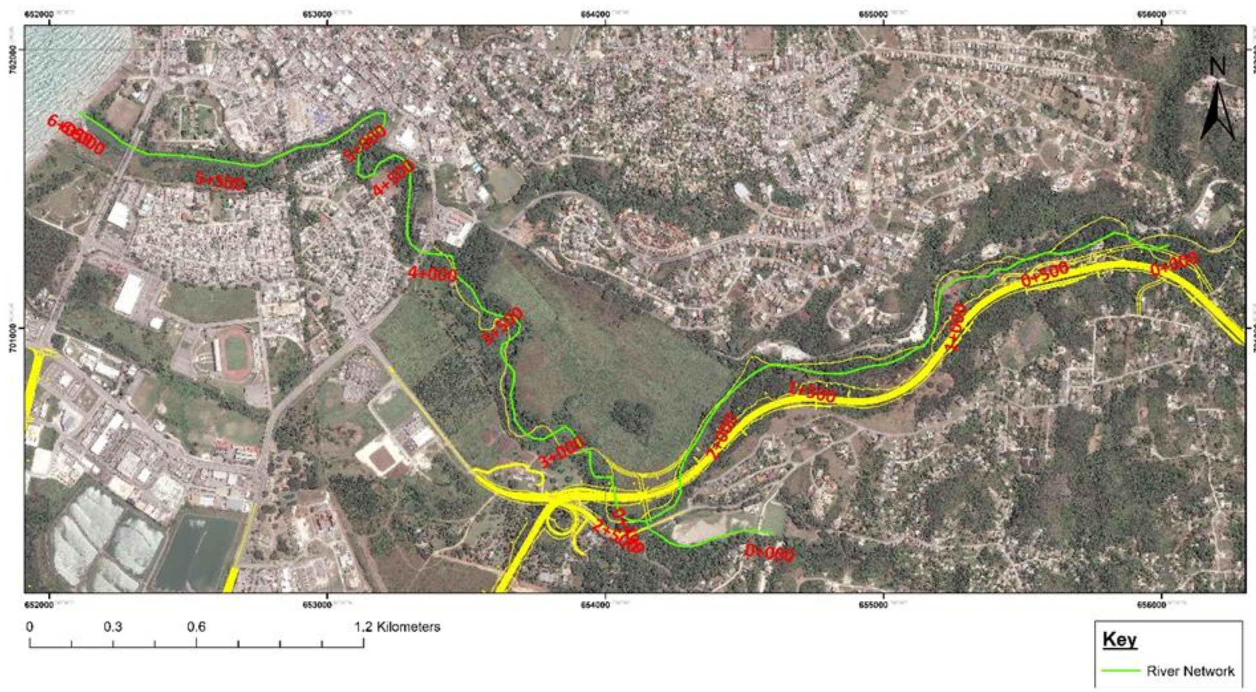


Figure 3-32 Plan view of the section of Montego River assessed

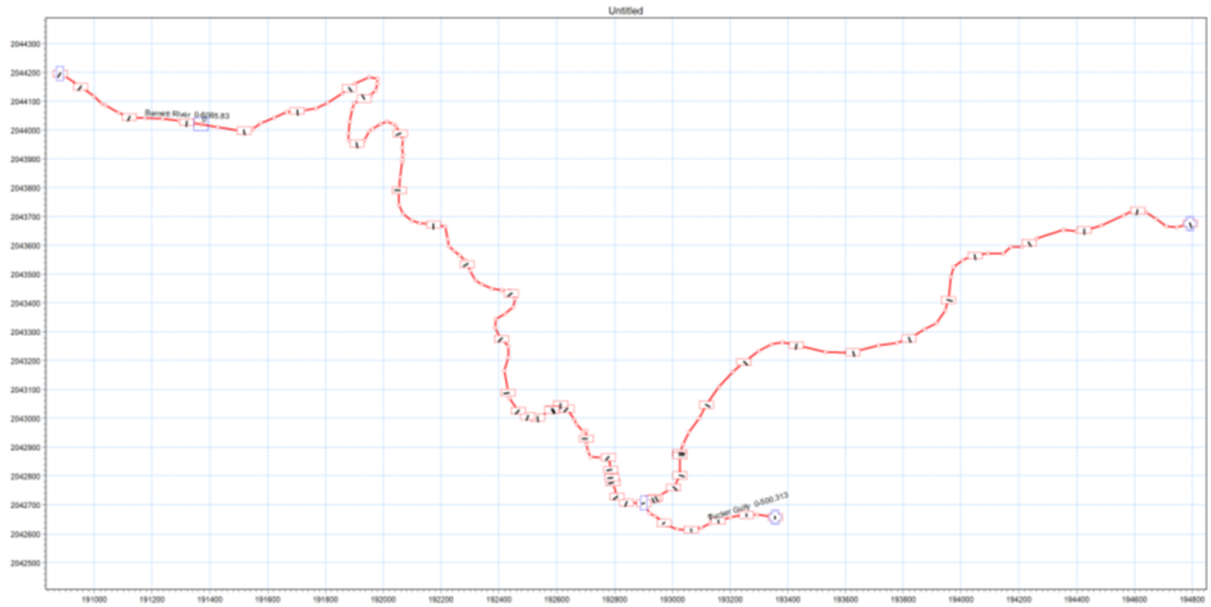


Figure 3-33 River Network Model Plan View

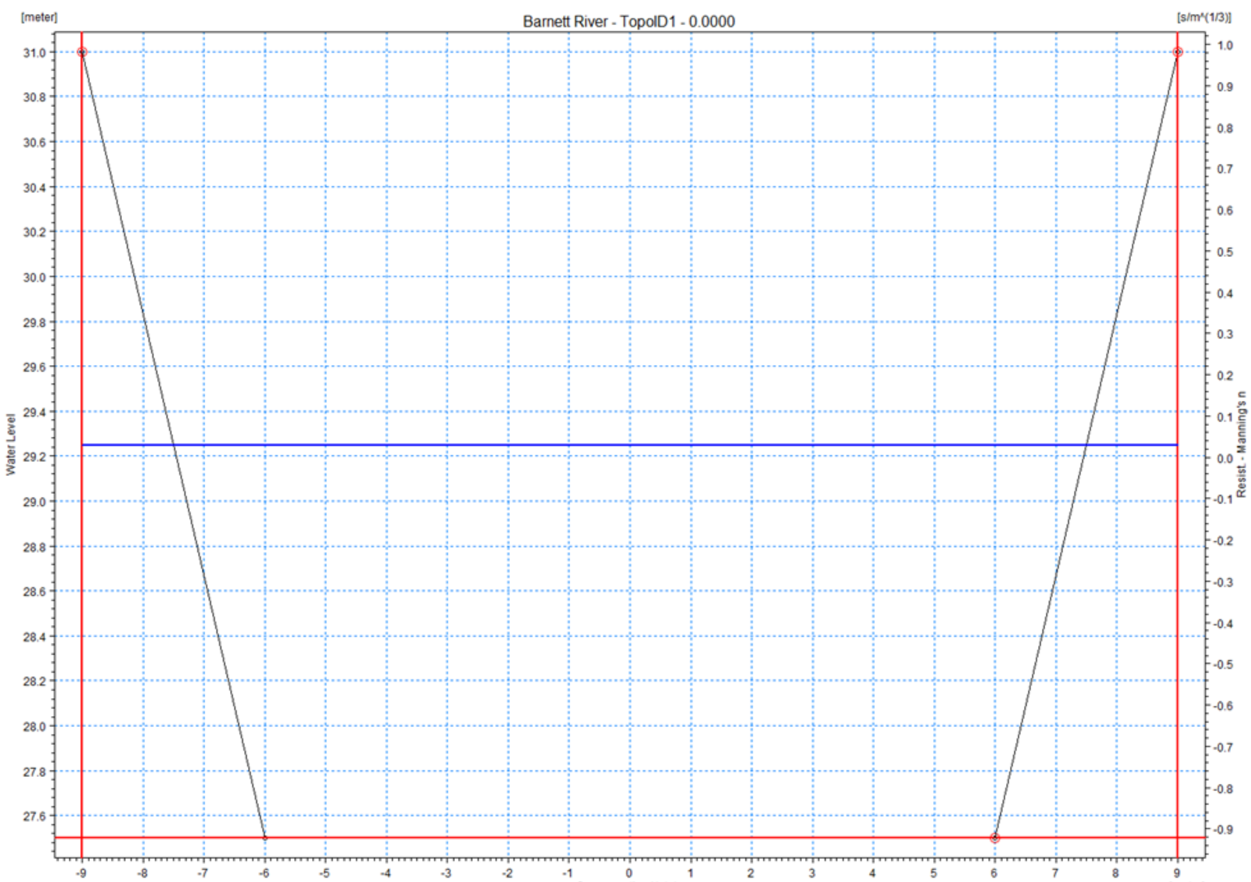


Figure 3-34 Typical Cross section used for analysis (Manning's Coefficient 0.035)

Assessment of the pre-realignment river network revealed an average velocity of 7.0 m/s in the Tucker/Irwin are, just upstream of the realignment area (chainage 1+800 – 2+200). Further along the river network, the simulation showed an average velocity of 5.5 m/s downstream of the proposed realignment area, in the vicinity of Barnett Estates (chainage 2+800 – 3+200). Where the alignment passes the Barnett Street Road Bridge (chainage 4+200 – 4+300), the simulation showed an average velocity of 5.4 m/s. Further along the alignment in proximity of the Westgate Shopping Centre (chainage 4+300 – 4+500), the average velocity was 5.5 m/s. The section of alignment along the West Green Community (chainage 4+500 – 5+000) had an average velocity of 6.1 m/s. Finally, the section of the river network in the vicinity of the Charles Gordon Market and its environs (chainage 5+000 – 5+200) showed an average velocity of the 6.3 m/s. Figure 3-35 shows the velocities along the assessed section of the Montego River network as it exists.

Figure 3-35 Graph showing velocities along the Montego River: pre-realignment

Table 3-13 Table showing average velocities pre-realignment

Chainage	Velocity (m/s)	Description of Location
1+800 - 2+200	7.0	Tucker/Irwin (Upstream)
2+800 - 3+200	5.5	Barnett Estates (Downstream)
4+200 – 4+300	5.4	Barnett Street Road Bridge (Downstream)
4+300 – 4+500	5.5	West Gate Shopping Centre (Downstream)
4+500 – 5+000	6.1	West Green Housing Scheme (Downstream)
5+000 – 5+200	6.3	Charles Gordon Market (Downstream)

3.1.5.5 Sinkholes

Sinkholes are natural depressions or holes in the ground caused by some form of collapse of the ground's surface layer. These may form gradually, or suddenly and are found all over the island. Sinkholes also function as a means through which surface runoff recharges the aquifers associated with various wells.

Throughout the length of the proposed alignment (0+000 – 24+901), the topography includes various depressions in which potential sinkholes may be present. These locations, in proximity to the proposed highway, were investigated. Offset distances of 100m, 200m and 500m were established around the proposed highway alignment, where fifty-two (52) potential sinkholes were identified (Figure 3-36). Fifteen (15) potential sinkholes were identified within the most critical 100m buffer zone, eight (8) of which were located directly along the proposed alignment whereas seven (7) are within the 100m buffer (Table 3-14).

Table 3-14 Sinkhole sites visited along proposed alignment

Feature	Chainage	Description	Status
Sinkhole	1+080 - 1+260	1.5km South-West of Mount Carey	Inaccessible
Sinkhole	2+700	1km West of Mount Carey	Verified
Sinkhole	4+920 - 5+100	0.5km East of Childermas	Inaccessible
Sinkhole	5+470 - 5+560	0.5km West of Anchovy Bottom	Verified
Sinkhole	10+300 - 10+500	0.6km South of Torboy	Verified
Sinkhole	11+400 - 11-500	0.5m North of Bogue	Inaccessible
Sinkhole	No chainage available	0.2m West of Barnet	Inaccessible
Sinkhole	No chainage available	0.9m West of Fairfield	Inaccessible

Of the eight (8) potential sinkholes located along the proposed alignment, three (3) were verified during field reconnaissance. These verified sites were mapped with GPS devices. The other five (5) potential sites could not be accessed as the terrain was unsuitable for pedestrian traverse. The sinkhole at 2+700 was located 1 km west of Mount Carey. The observed vegetation in the vicinity suggests that it is a floodplain prone area and that this sinkhole likely facilitates surface discharge to groundwater. The visible feature was approximately 2 to 3 feet in diameter. Between chainages 5+470 to 5+560, a sinkhole was located 500 m west of Anchovy The feature was approximately 3 to 4 feet in diameter and was covered in vegetation. From the surrounding area it was inferred that this sinkhole was formed from the gradual dissolving of rock and not by the collapse of a roof cavern. Another sinkhole was located 0.6 km south of Torboy, between chainages 11+400 to 11+500. This particular hole was in the vicinity of the Bogue wastewater treatment plant. Based on the visible vegetation and the depression in the land it was reasonable to identify the suggested spot as a sinkhole. An accurate description of the size however could not be estimated due to restricted access.

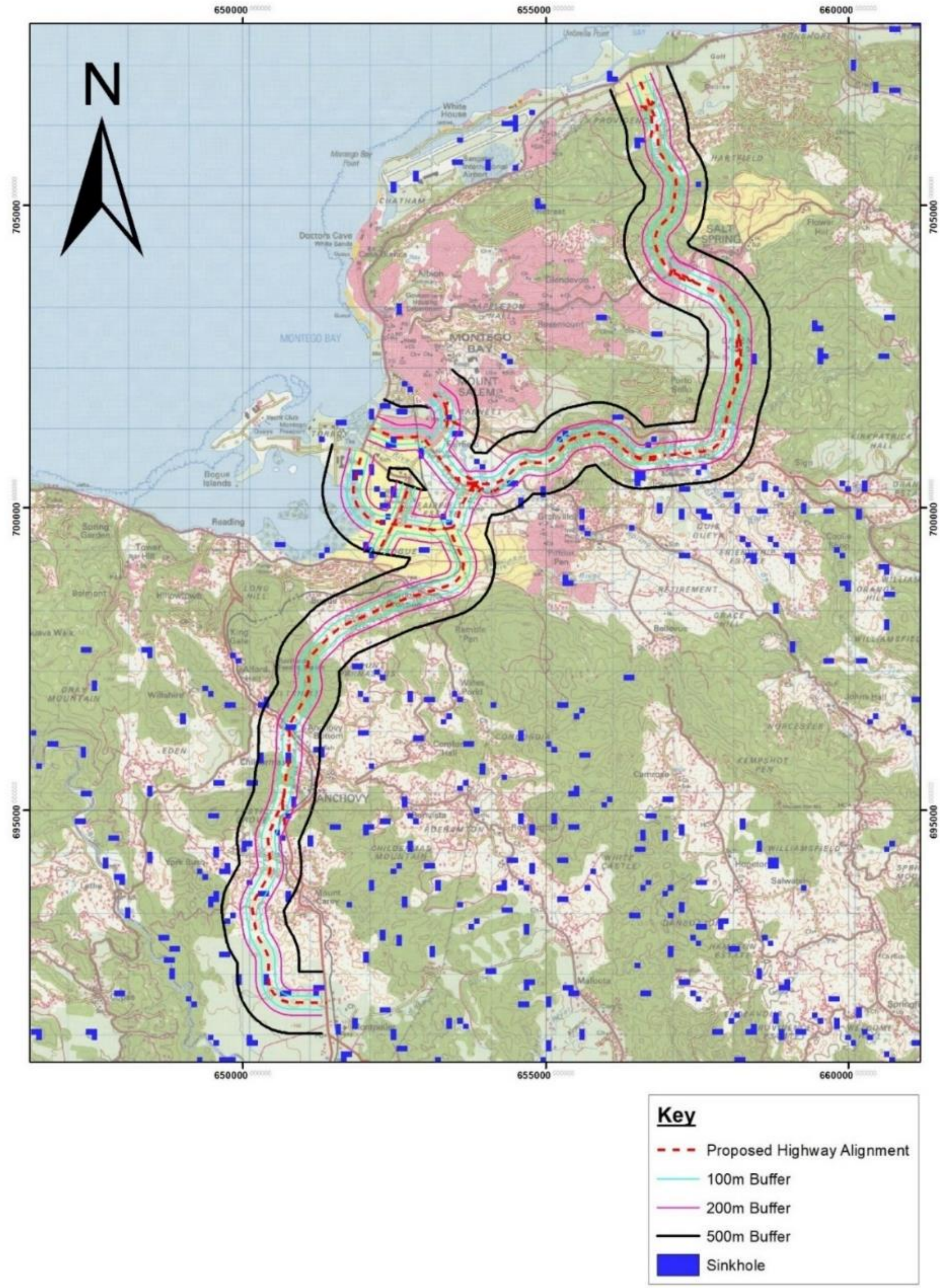


Figure 3-36 Map showing sinkholes within the proposed alignment buffer zones

3.1.6 Water Quality

3.1.6.1 Methodology

Water quality sampling exercises were conducted at eleven (11) stations on January 21st, February 27-28th and March 21st, 2019. On January 21st, only eight (8) of the eleven (11) stations were sampled (Stations 1-8). There was heavy rainfall during the morning time before sampling and intermittent showers into the late morning, with predominantly overcast skies throughout the remainder of this day (January 21st). On the February 27-28th sampling event, weather conditions were fair with sunny with no rainfall. On the March 21st sampling event, there was intermittent drizzle in days prior to sampling and on the sampling day. There was no sample for Station 2 during the February 27-28th and the March 21st sampling events due to the water level in the mangrove being too low.

The sampling locations are listed in Table 3-15 and illustrated in Figure 3-37. Photos of water quality sampling stations are also depicted in Plate 3-14 through to Plate 3-24.

Table 3-15 Water quality sampling locations

STATIONS	LOCATION	NORTHINGS	EASTINGS
1	Bogue Lagoon close to mangrove forest	700011.321	651667.291
2	Inside mangrove forest	700129.971	651868.367
3	Barnett River	700603.994	653685.208
4	Barnett River	700294.797	654131.827
5	Barnett River	701219.334	656912.023
6	Barnett River	701299.705	653346.779
7	Barnett River	701653.365	653209.555
8	Mouth of Salt Spring Gut	707606.596	656666.951
9	Mahoe Bay by Sandals Kokomo Island	707856.942	656975.789
10	Bogue Lagoon west	699645.168	649976.613
11	River*	702933.687	658973.207

** The name of the river has not been ascertained*

Temperature, conductivity, salinity, dissolved oxygen, turbidity, total dissolved solids and pH were collected using a Hydrolab DataSonde-5 water quality multi probe meter (Calibration Test Sheet in Appendix 3). Whole water samples were collected in pre-sterilized bottles, stored on ice and taken to Caribbean Environmental Testing and Monitoring Services Limited (CETMS Ltd.) for analysis of Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), nitrate, phosphate, oil and grease (FOG) and faecal coliform. Samples were also shipped to Test America Laboratories in Florida for analyses for Total Petroleum Hydrocarbons – Gasoline Range Organics (GRO C6-C10), Diesel Range Organics (DRO C10-C28) and Oil Range Organics (ORO C28-C35).

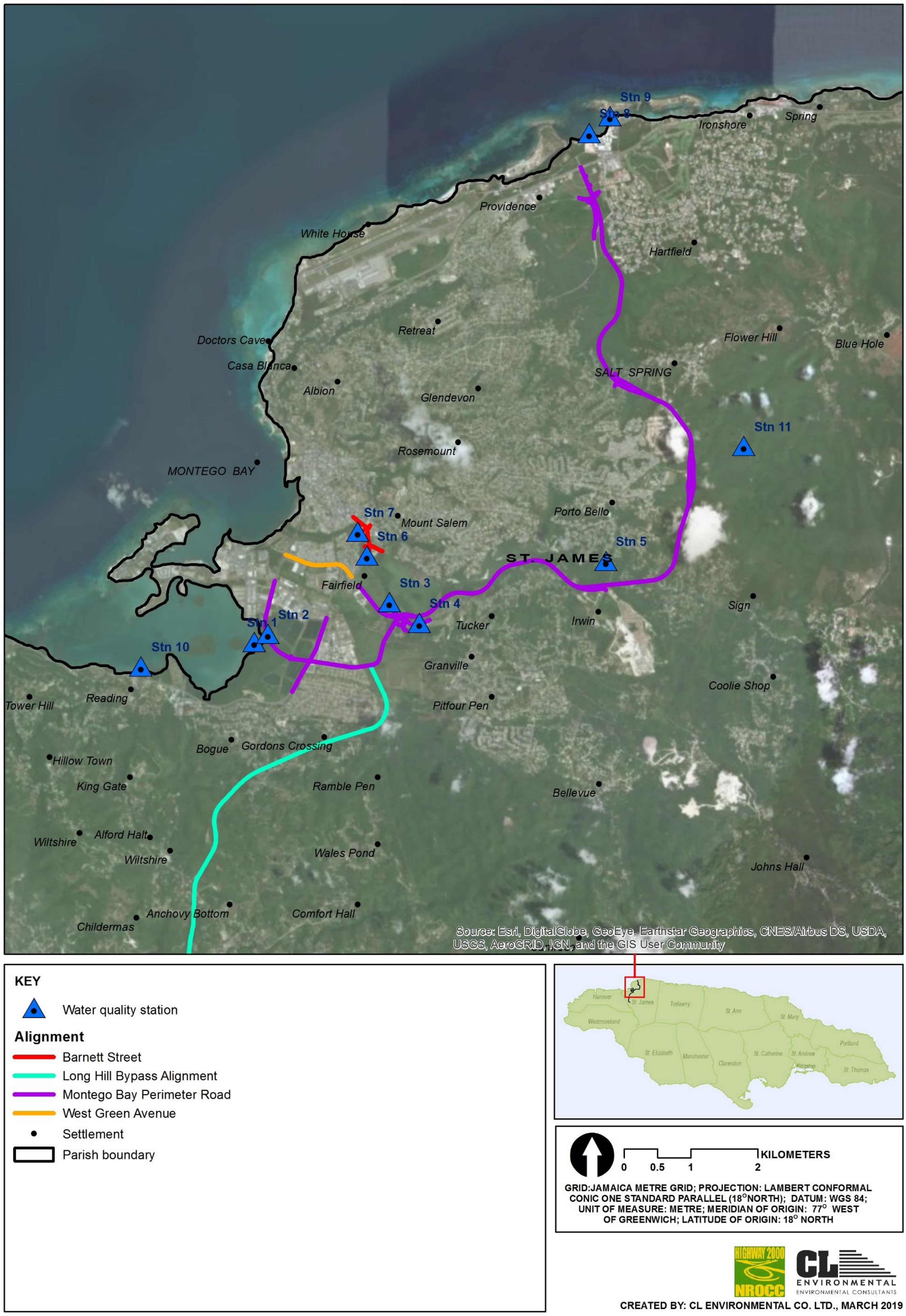


Figure 3-37 Location of water quality sampling stations

Plate 3-14 Water quality station 1

Plate 3-15 Water quality station 2

Plate 3-16 Water quality station 3

Plate 3-17 Water quality station 4

Plate 3-18 Water quality station 5

Plate 3-19 Water quality station 6

Plate 3-20 Barnett River Water Quality Station 7

Plate 3-21 Drain carrying solid waste leading into Barnett River at Water Quality Station 7

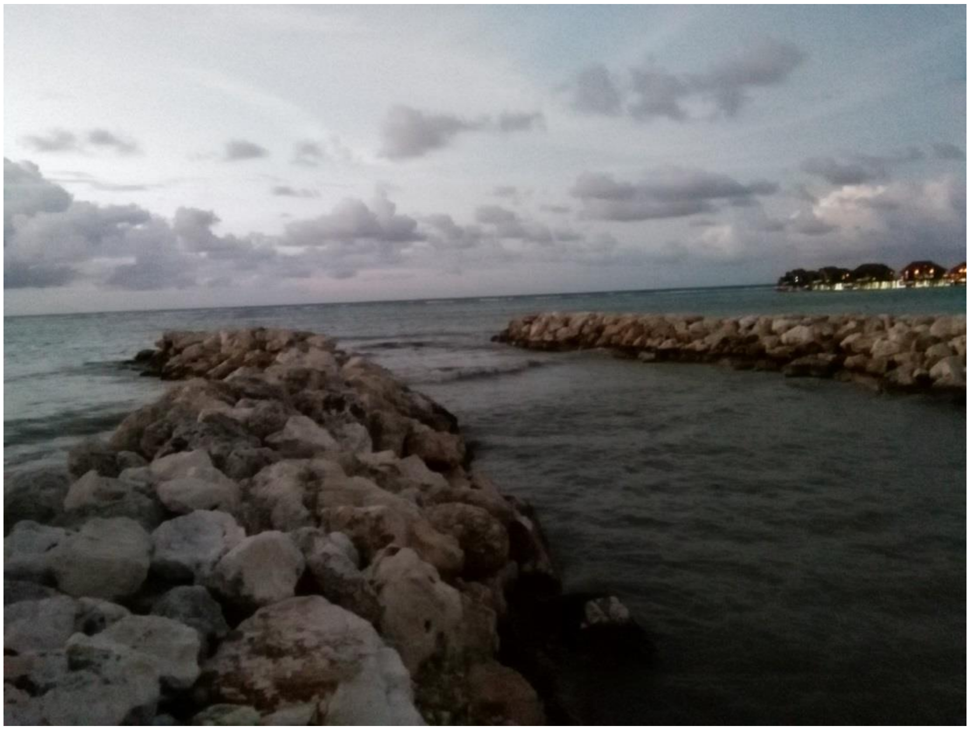


Plate 3-22 Water quality station 8

Plate 3-23 Water quality station 10

Plate 3-24 Water quality station 11

3.1.6.2 Results

Table 3-16 depicts the average physical data results and Table 3-17 shows the average biochemical data results. **Stations 1, 2, 8, 9 and 10** are regarded as **marine water** due to their locations and were compared with NRCA Marine Water Quality Standards. The remainder of the sampling stations (**Stations 3, 4, 5, 6, 7 and 11**) are regarded as **freshwater** and were compared with NRCA Ambient Freshwater Standards.

Temperature values were all considered normal for freshwater and marine water. Marine water temperatures recorded were expected in a tropical marine area influenced by the Trade Winds (≈27 – 30 ^{o}C). Conductivity, salinity and TDS values were all considered normal for both freshwater and marine water. The average conductivity value at Station 4 was non-compliant with the NRCA Freshwater Standard while average TDS values at Stations 3, 4, 5, 6, 7 and 11 were marginally non-compliant with the NRCA Freshwater Standard. Average dissolved oxygen (D.O.) values were all within acceptable levels (>4 mg/l) and above the level that may be considered detrimental to aquatic life (≤ 3 mg/l). The lowest D.O. value was recorded at Station 2, which is located in the mangrove forest which had a very low water level (2 cm), hence the low D.O. value.

Average pH values were considered normal and were marginally non-compliant with the NRCA marine water quality standard for Station 2. pH at Station 3 was also marginally non-compliant with the NRCA freshwater standard. Water turbidity remained low for most stations but were elevated at Stations 2 and 8. Due to the previous rainfall on January 21st and the low water level (2 cm) in the mangrove swamp (Station 2), bottom sediments were in suspension with the water, hence the elevated turbidity. Station 8 is located at the mouth of the Salt Spring Gut, hence land-based run-off and other anthropogenic sources may have contributed to elevated turbidity.

Table 3-16 Average Physical water quality data

STN.	Temp. (°C)	Cond. (mS/cm)	Salinity (ppt)	pH	D.O. (mg/l)	Turbidity (NTU)	TDS (g/l)
MARINE STATIONS							
1	27.72	54.14	35.85	8.01	5.83	12.24	34.61
2	24.84	52.18	34.43	7.29	3.44	56.8	33.39
8	26.98	54.79	36.20	8.16	5.41	19.84	34.92
9	26.57	54.73	36.48	8.13	4.02	4.75	35.17
10	27.69	54.31	35.98	8.27	7.56	4.35	34.73
NRCA Marine Water Standard	-	-	-	*8 - 8.4*	-	-	-
FRESHWATER STATIONS							
3	25.84	0.53	0.26	8.43	10.79	1.43	0.33
4	24.91	0.72	0.37	7.99	6.42	21	0.45
5	24.56	0.50	0.25	8.22	9.12	1.47	0.32
6	25.98	0.52	0.26	8.38	9.95	2.33	0.33
7	26.13	0.49	0.25	8.21	9.8	4.77	0.32
11	24.38	0.59	0.31	8.11	7.75	0.7	0.38
NRCA Ambient Freshwater Standard	-	*0.15 – 0.6*	-	*7 – 8.4*	-	-	*0.12 – 0.3*

Values in red were non-compliant with their respective NRCA Standard.

Average BOD values were non-compliant with the NRCA standards for all station sampled (Table 3-17). Average faecal coliform values were elevated at most stations; Stations 1 and 10 had the lowest average faecal coliform values and were all compliant with the NRCA marine coliform standard. Elevated BOD and faecal coliform values especially in freshwater environments may be as a result of anthropogenic influences in the form of pollution via solid waste dumping, untreated sewage effluent discharge/disposal, animal farming etc.

TSS values mirror the turbidity values especially at Station 2 and 8 as previously discussed. Nitrate and phosphate values were non-compliant with the NRCA marine standard; however, these nutrient values are considered normal for Jamaican coastal waters and seldom vary outside of this range. Nitrate values were compliant for all freshwater stations, while phosphate values were compliant for all freshwater stations except Station 6. Oil and grease (FOG) concentrations in marine and freshwater environments were similar and ranged from a low of 2.64 mg/l at Station 10 to a high of 6.85 mg/l at Station 3.

No Total Petroleum Hydrocarbons were detected at most of the stations sampled; however, there were traces of Gasoline Range Organics (GRO C6-C10) detected at Station 8 on January 21, located at the mouth of the Salt Spring Gut. This could either have been from petrol associated with heavy motorized boating activity in the area (RIU and Sandals Hotel water sports activities, fishing canoes etc.) or as a result of activities upstream (dumping, run-off etc.). Traces of Diesel Range Organics (DRO C10-C28) were detected at Station 2 on January 21, located in the mangrove swamp. This may also have been a result of petrol from boating activity from fishing canoes and other recreational marine vessels in the Bogue Lagoon. Traces of DRO (C10-C28) as well as Oil Range Organics (ORO C28-C35) were detected at Station 7 on January 21, located along the Barnett River. A lot of solid waste was observed at this station and may be a result of said solid waste dumping and disposal. Drains were also observed leading into the Barnett river which may also have a negative impact on the water quality (Plate 3-21).

Table 3-17 Average biochemical water quality data and NRCA standards

STN.	BOD (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	FOG (mg/l)	Faecal Coliform (MPN/100ml)	TPH - GRO C6-C10 (mg/l)	TPH – DRO C10-C28 (mg/l)	TPH – ORO C28-C35 (mg/l)
MARINE STATIONS									
1	4.21	12.33	1.33	0.11	3.41	13.33	ND	ND	ND
2	6.60	52.00	0.17	0.17	6.21	36.00	ND	0.14	ND
8	5.14	21.00	1.23	0.13	3.85	53.33	0.1	ND	ND
9	7.43	4.00	1.40	0.06	4.79	15.50	ND	ND	ND
10	4.98	4.00	1.60	0.08	2.64	10.00	ND	ND	ND
Marine Water Standard	*1.16*	-	*0.007 – 0.014*	*0.001-0.003*	-	*<2 - 13*	-	-	-
FRESHWATER STATIONS									
3	5.70	4.00	1.90	0.10	6.85	130.00	ND	ND	ND
4	7.61	4.00	3.50	0.13	3.85	396.67	ND	ND	ND
5	5.14	7.00	1.30	0.11	3.56	150.67	ND	ND	ND
6	4.73	4.00	1.37	0.99	4.31	150.67	ND	ND	ND
7	6.18	14.67	0.87	0.11	4.14	320.00	ND	0.39	0.18
11	5.35	4.00	1.30	0.44	4.34	53.00	ND	ND	ND
Ambient Freshwater Standard	*0.8 – 1.7*	-	*0.1 – 7.5*	*0.01-0.8*	-	-	-	-	-

Values in red were non-compliant with their respective NRCA Standard.

ND – None Detected

3.1.7 Ambient Noise

3.1.7.1 Montego Bay Perimeter Road

Ambient noise readings were collected at eight (8) locations along the Montego Bay Perimeter Road alignment (Figure 3-38, Table 3-18). These noise monitoring exercises were collected over a three-day period. The dates of the noise monitoring were March 21 – 24, 2019.

Brüel & Kjaer noise analysers and Quest Technologies Type I Sound Level Meters (Calibration Certificates in Appendix 4) were programmed to log every 10 seconds with signal recording set at 50 dBA for night-time and 55 dBA for day-time at the residential areas. This feature allows the sound level meter to record the noise at the time when the thresholds (50 and 55 dBA) are exceeded.

The results indicated that the noise climate at Stations 6, 7 and 8 monitored over the 72-hour period, exceeded the NRCA day and nighttime standards of 55 dBA and 50 dBA respectively. Noise at Stations 2, 3 and 5 were compliant with NRCA day and nighttime standards (Table 3-19). The noise meters at Stations 1 and 4 failed to run due to equipment malfunction.

Table 3-18 Noise and Particulate Station Coordinates for Montego Bay Perimeter Road

STATIONS	NORTHINGS	EASTINGS
1	706760.400	656845.500
2	705738.683	657023.300
3	703528.878	657778.952
4	700845.998	657337.626
5	700966.437	656234.629
6	700312.597	653847.235
7	699642.671	652851.342
8	700634.543	651906.333

Table 3-19 Ambient noise levels for the Montego Bay Perimeter Road

STN	AVG. ($LAeq_{72h}$)	MAX (dBA)	MIN (dBA)	NRCA DAYTIME (dBA)	NRCA NIGHT-TIME (dBA)	L10 (dBA)	L90 (dBA)
1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	48.8	79.4	25.1	49.6	46.7	50.3	36.5
3	40.7	74.1	23.1	41.7	38.3	41.3	30.7
4	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	51.6	80.8	61.1	53.0	48.0	52.6	42.3
6	57.8	83.7	35.6	**58.3**	**52.9**	52.8	41.9
7	62.5	96.3	31.2	**64.2**	**55.6**	63.2	38.7
8	61.5	95.4	36.1	**63.3**	**54.6**	65.3	45.2

NB: Red bold numbers are non-compliant with NRCA noise standards

Noise Meters at Stations 1 and 4 failed to run due to equipment malfunction

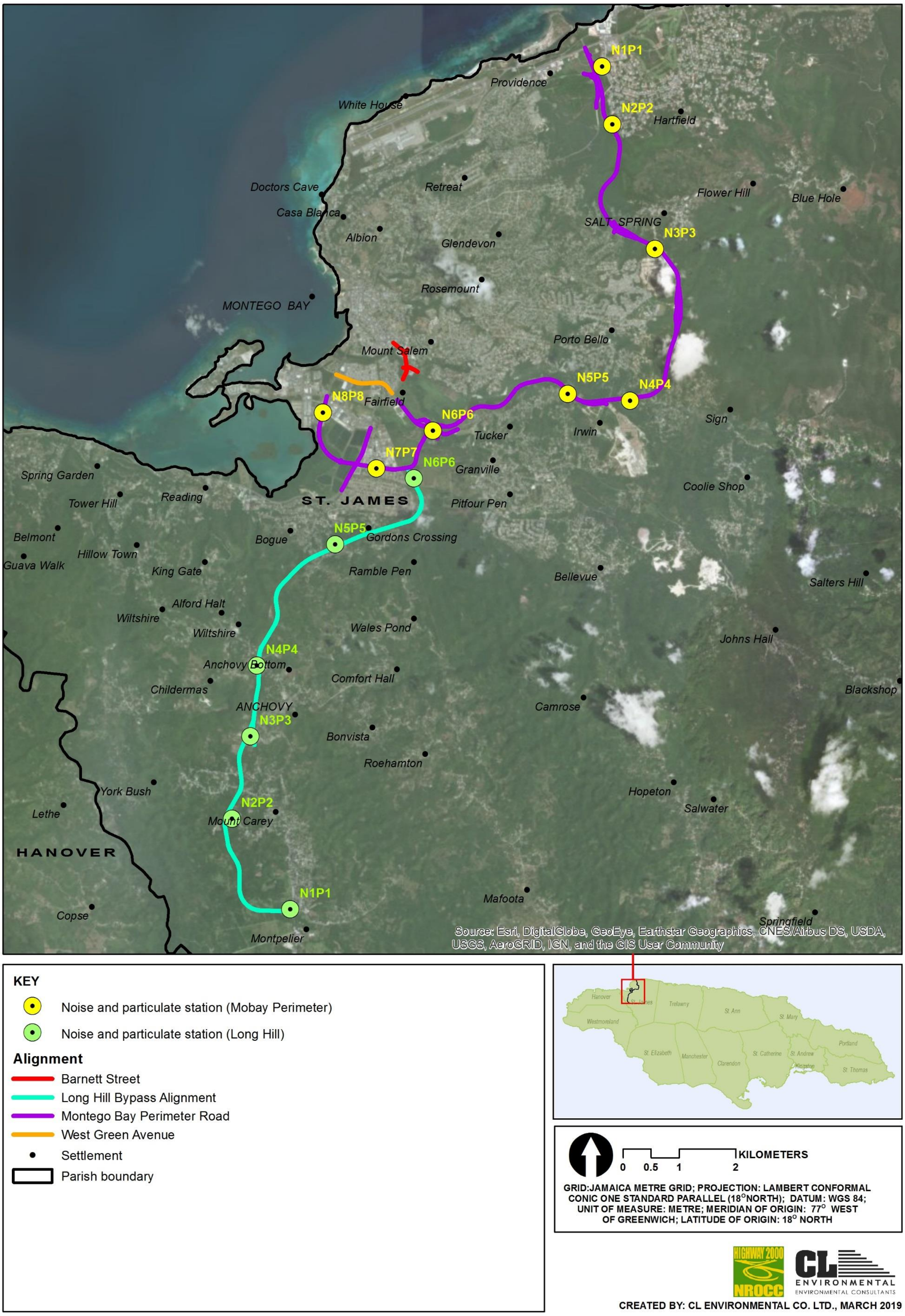


Figure 3-38 Noise and particulates stations for Montego Bay Perimeter Road and Long Hill alignments

3.1.7.1.1 Station 2

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 25.1 dBA to a high (Lmax) of 79.4 dBA. Average noise level for this period was 48.8 L_{Aeq} (72h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 12.5 Hz (octave frequency range is 11 - 14 Hz).

L10 AND L90

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

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

Figure 3-39 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 83% of the time; large fluctuations 6 % of the time; and no significant fluctuations 11% of the time, in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 50.3 dBA and 36.5 dBA respectively.

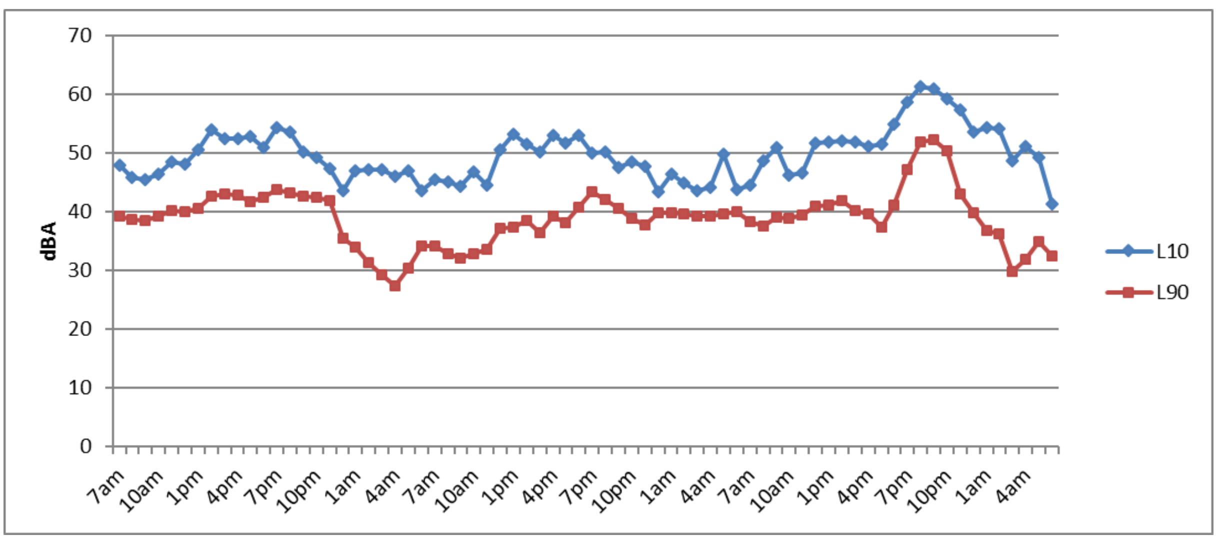


Figure 3-39 L10 and L90 for Station 2 – Montego Bay Perimeter Road

3.1.7.1.2 Station 3

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 23.1 dBA to a high (Lmax) of 74.1 dBA. Average noise level for this period was 40.7 L_{Aeq} (72h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 50 Hz (octave frequency range is 45 - 56 Hz).

L10 AND L90

Figure 3-40depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 56% of the time; large fluctuations 1 % of the time; and no significant fluctuations 43% of the time, in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 41.3 dBA and 30.7 dBA respectively.

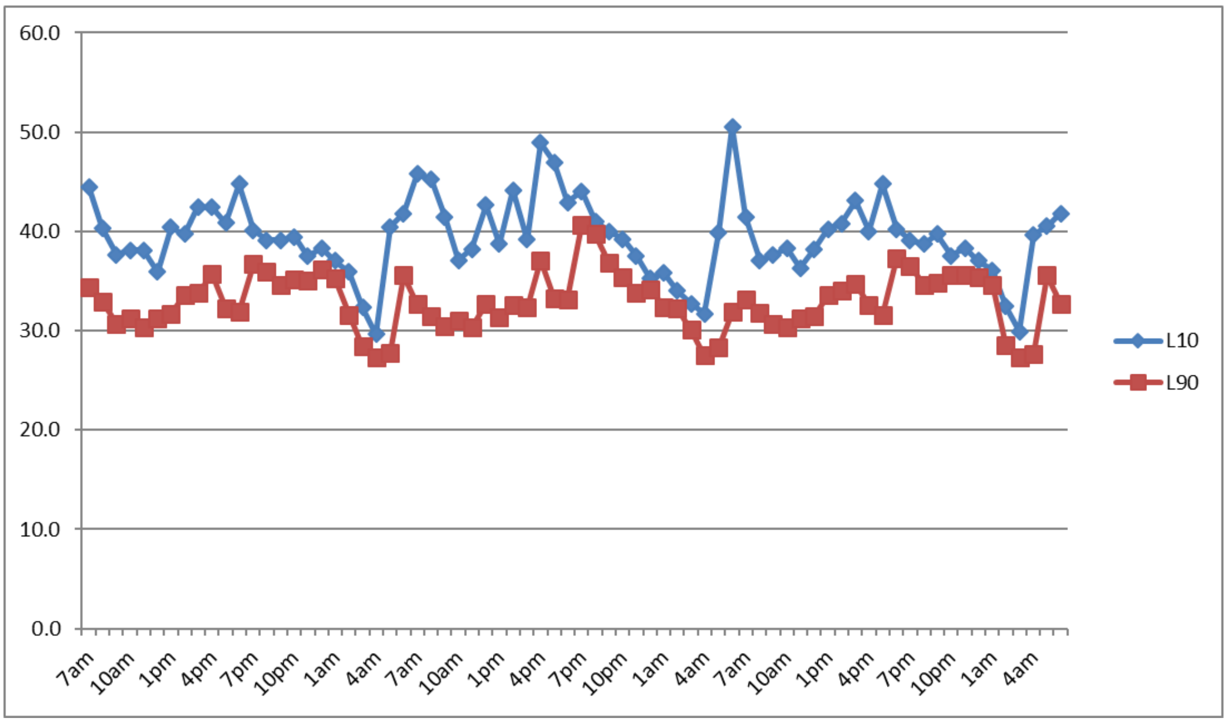


Figure 3-40 L10 and L90 for Station 3 – Montego Bay Perimeter Road

3.1.7.1.3 Station 5

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 61.1 dBA to a high (Lmax) of 80.8 dBA. Average noise level for this period was 51.6 L_{Aeq} (72h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 12.5 Hz (octave frequency range is 11 - 14 Hz).

L10 AND L90

Figure 3-41 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 36% of the time; large fluctuations 1 % of the time; and no significant fluctuations 63% of the time, in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 52.6 dBA and 42.3 dBA respectively.

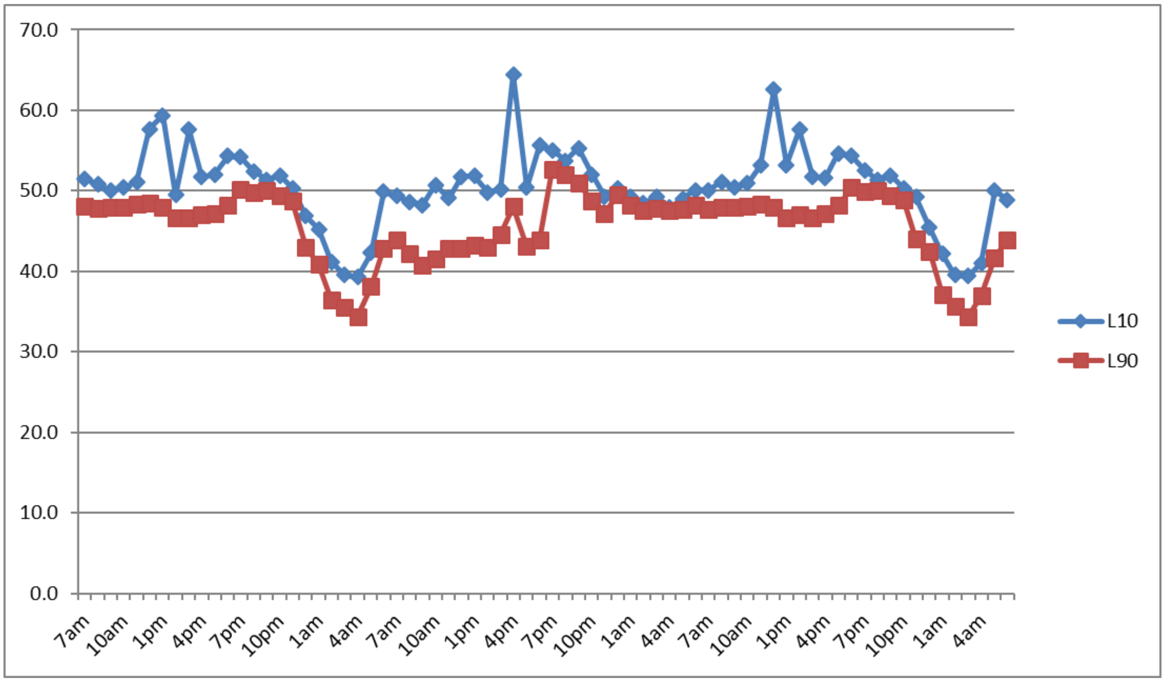


Figure 3-41 L10 and L90 for Station 5 – Montego Bay Perimeter Road

3.1.7.1.4 Station 6

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 35.6 dBA to a high (Lmax) of 83.7 dBA. Average noise level for this period was 57.8 L_{Aeq} (72h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 12.5 Hz (octave frequency range is 11 - 14 Hz).

L10 AND L90

Figure 3-42 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 74% of the time; large fluctuations 4 % of the time; and no significant fluctuations 22% of the time, in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 52.8 dBA and 41.9 dBA respectively.

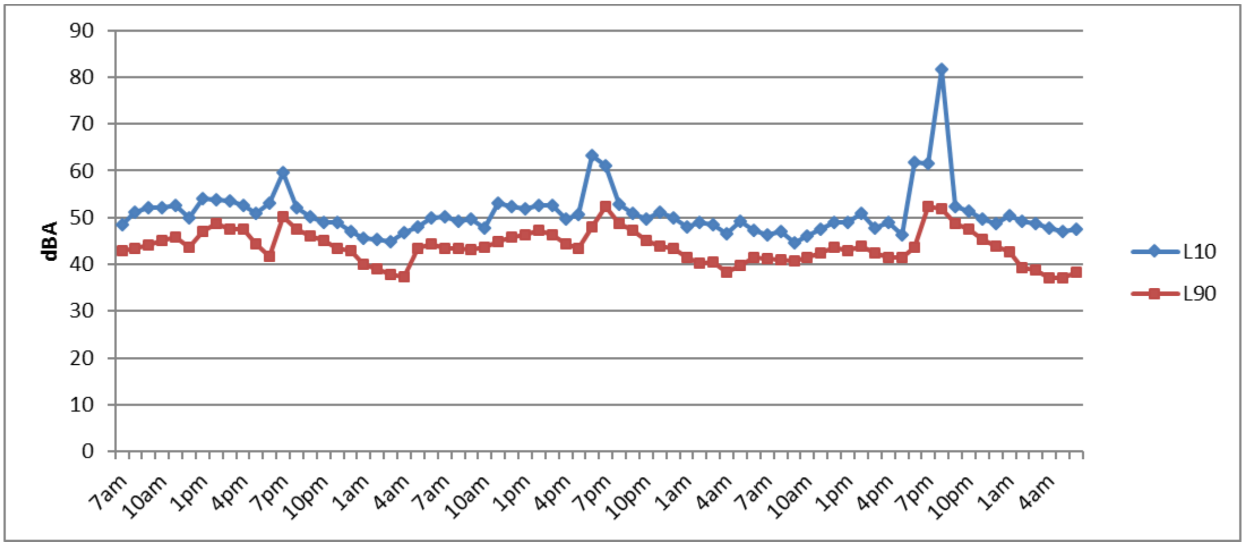


Figure 3-42 L10 and L90 for Station 6 – Montego Bay Perimeter Road

3.1.7.1.5 Station 7

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 31.2 dBA to a high (Lmax) of 96.3 dBA. Average noise level for this period was 62.5 L_{Aeq} (72h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 12.5 Hz (octave frequency range is 11 - 14 Hz).

L10 AND L90

Figure 3-43 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 79% of the time; large fluctuations 21 % of the time; and no significant fluctuations 0% of the time, in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 63.2 dBA and 38.7 dBA respectively.

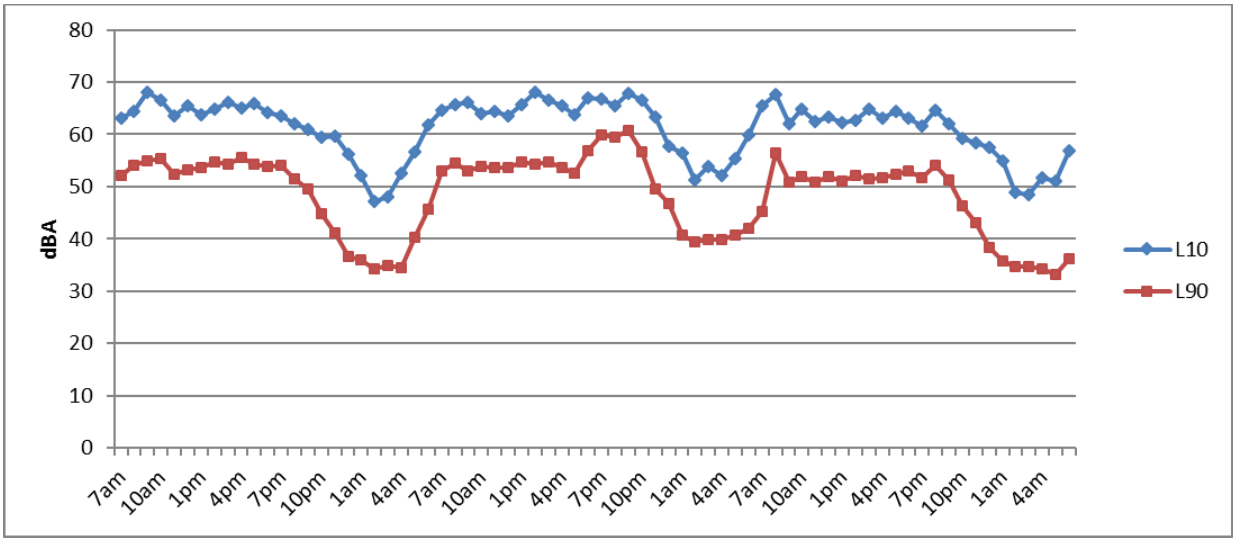


Figure 3-43 L10 and L90 for Station 7 – Montego Bay Perimeter Road

3.1.7.1.6 Station 8

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 36.1 dBA to a high (Lmax) of 95.4 dBA. Average noise level for this period was 61.5 L_{Aeq} (72h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 31.5 Hz (octave frequency range is 28 - 35 Hz).

L10 AND L90

Figure 3-44 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 56% of the time; large fluctuations 7 % of the time; and no significant fluctuations 36% of the time, in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 65.3 dBA and 45.2 dBA respectively.

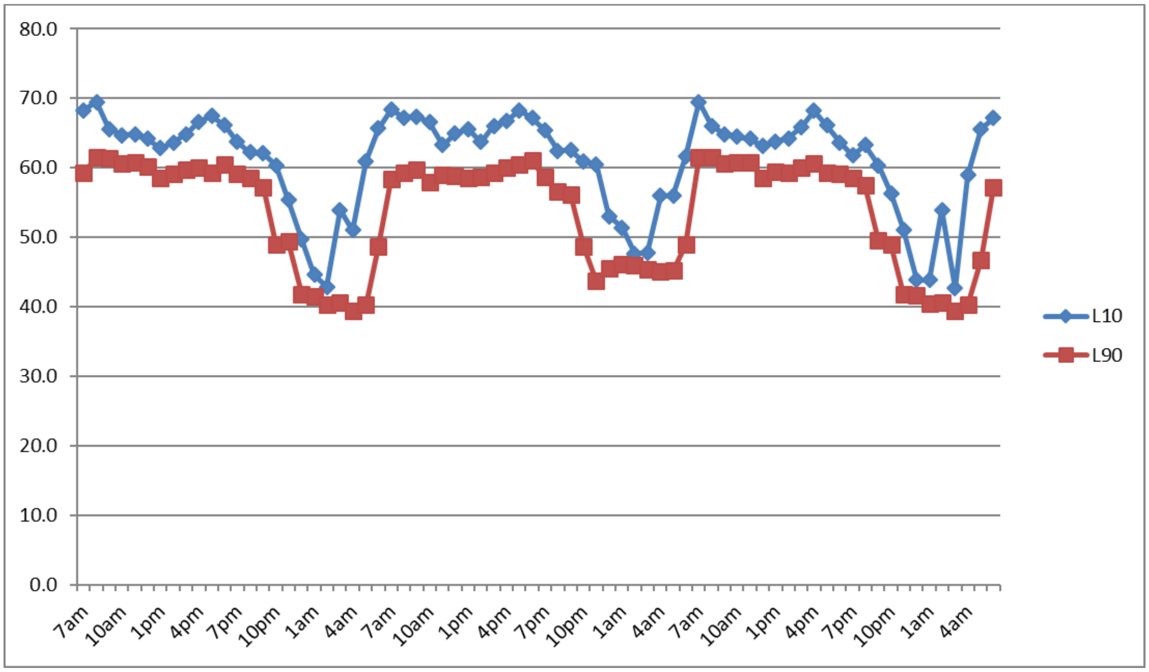


Figure 3-44 L10 and L90 for Station 8 – Montego Bay Perimeter Road

3.1.7.1.7 Federal Highway Administration Standards

Noise standards issued by the Federal Highway Administration (FHA) of the United States Department of Transportation for use by state and Federal highway agencies in the planning and design of highways are depicted in Table 3-20. Based on the land use categories listed above, **Category B** is the most apt to describe the land use within the study area of the noise assessment.

Table 3-20 FHA 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.

Comparisons with the FHA standard (Category B) has indicated that for the entire 72 hours, the L10 noise levels were in full compliance with the FHA standard at all stations assessed except for Station 6, where it had exceeded the 70 dBA design level at approximately 8:00 pm on March 23rd (Figure 3-45 - Figure 3-50).

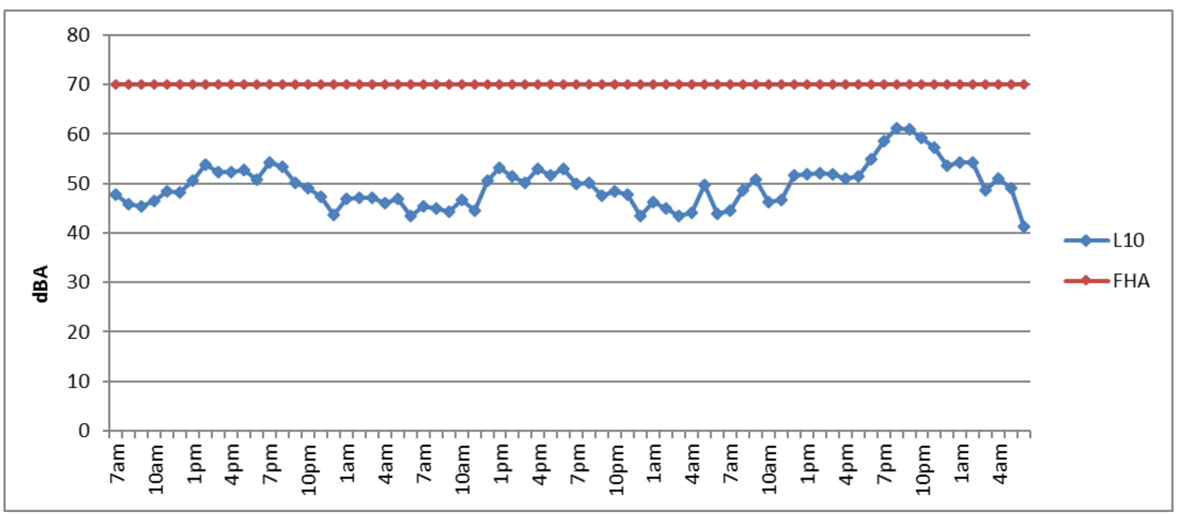


Figure 3-45 Comparison of L10 at Station 2 (Montego Bay Perimeter Road) with FHA standard

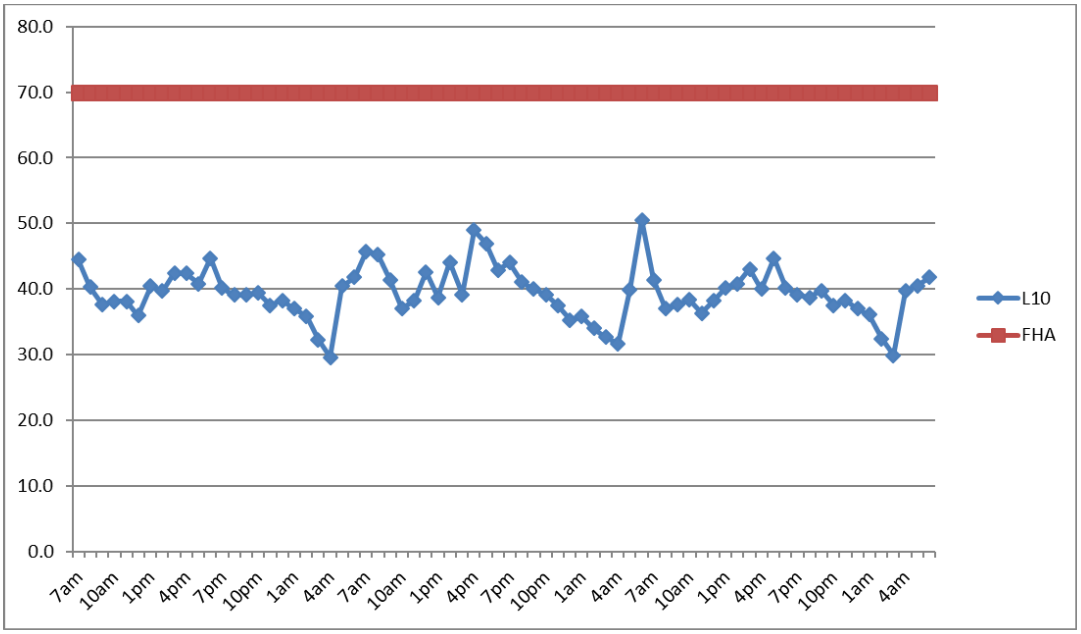


Figure 3-46 Comparison of L10 at Station 3 (Montego Bay Perimeter Road) with FHA standard

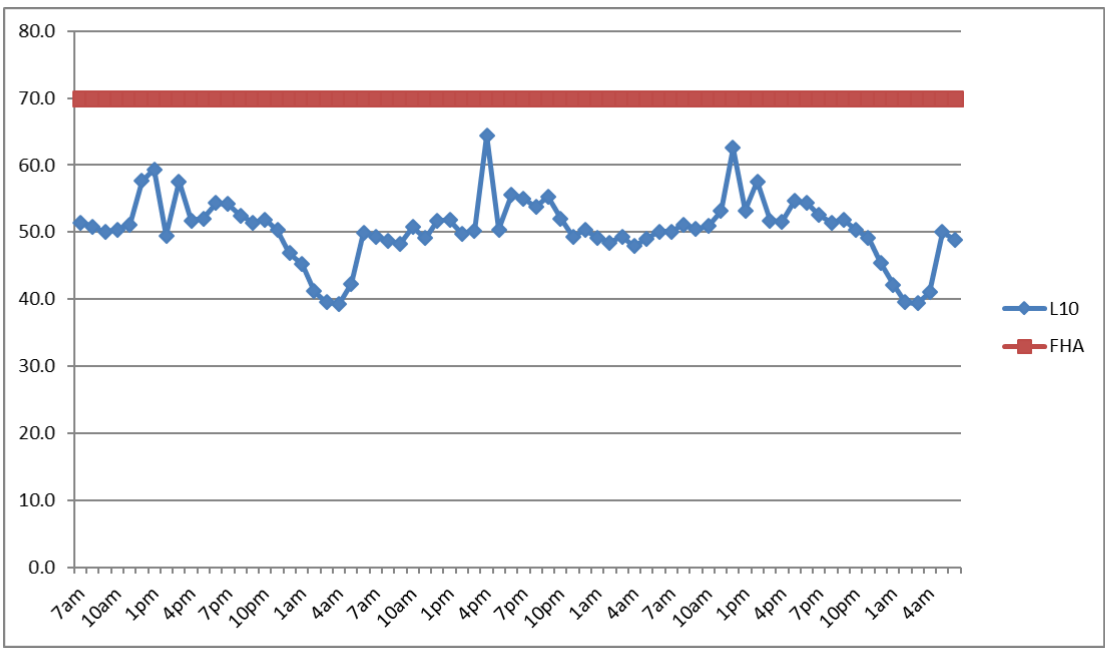


Figure 3-47 Comparison of L10 at Station 5 (Montego Bay Perimeter Road) with FHA standard

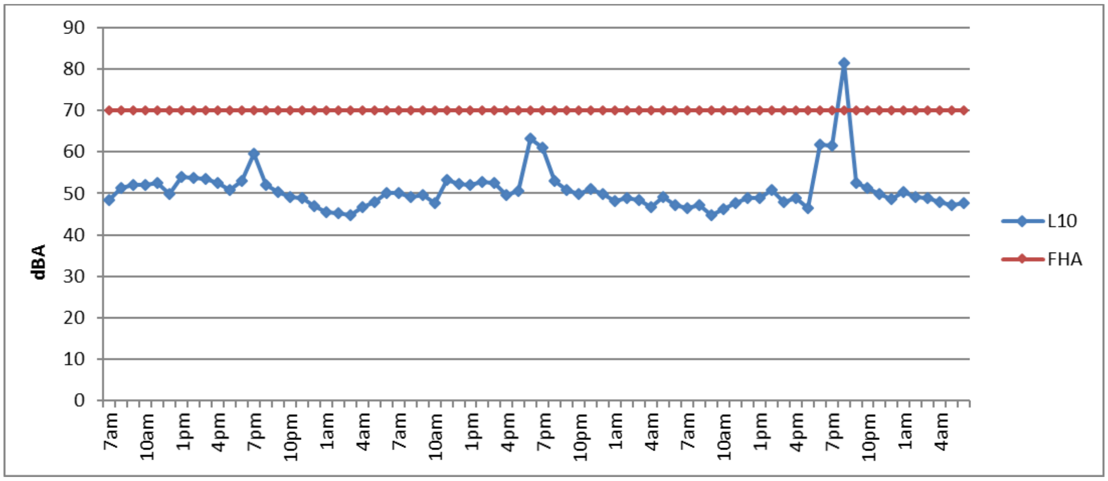


Figure 3-48 Comparison of L10 at Station 6 (Montego Bay Perimeter Road) with FHA standard

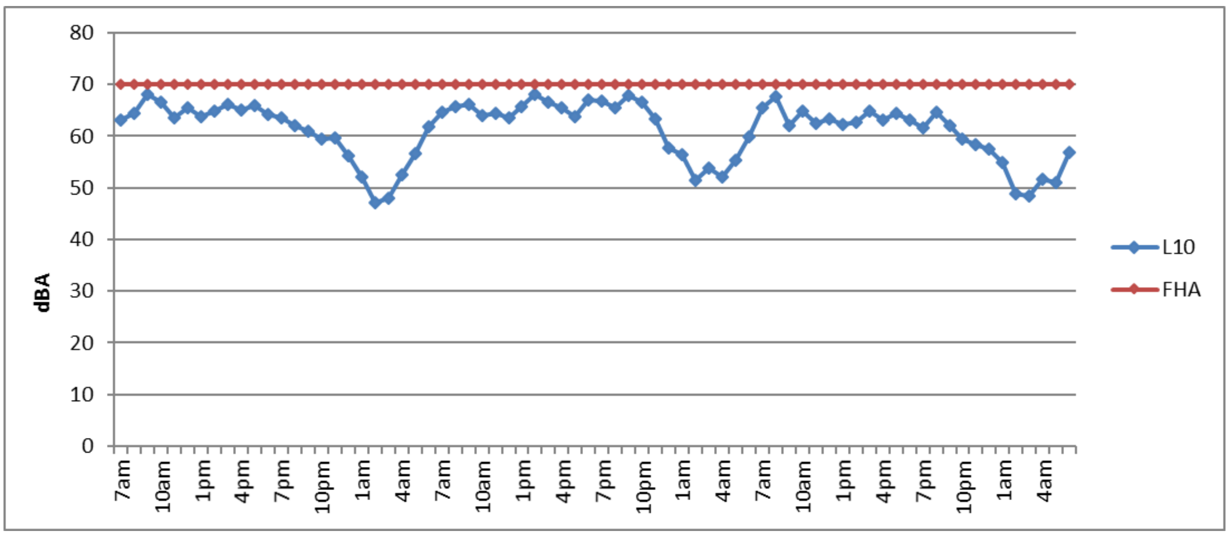


Figure 3-49 Comparison of L10 at Station 7 (Montego Bay Perimeter Road) with FHA standard

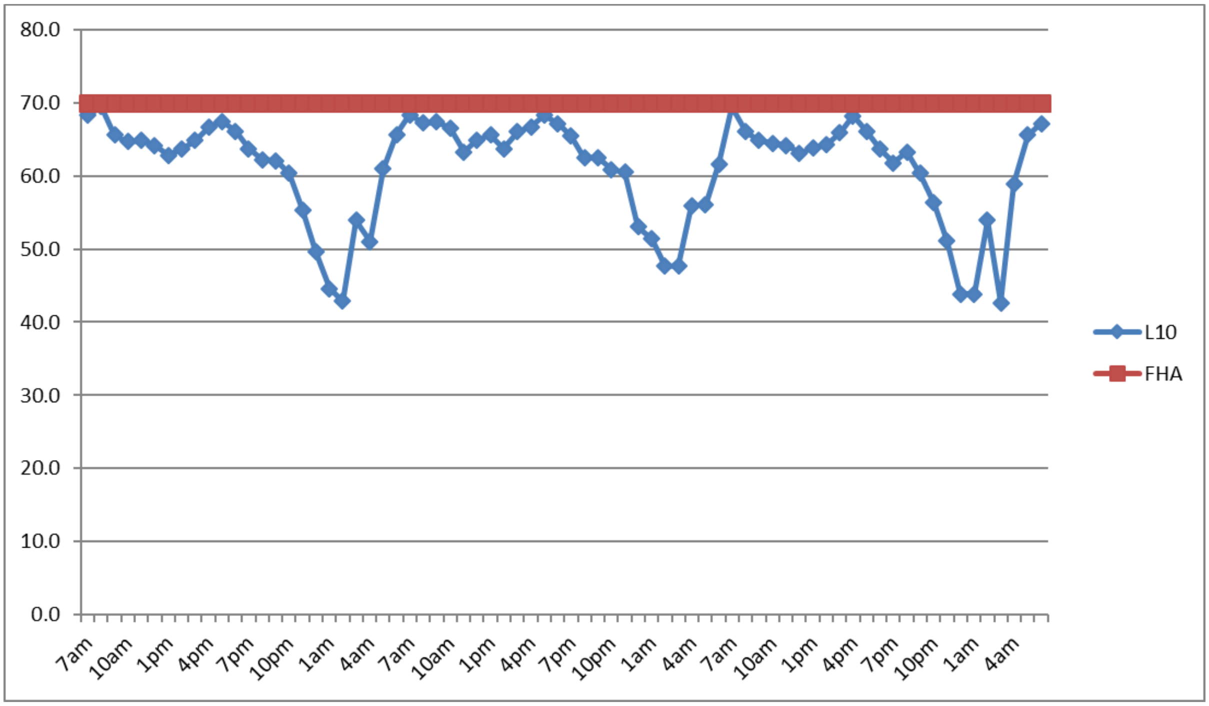


Figure 3-50 Comparison of L10 at Station 8 (Montego Bay Perimeter Road) with FHA standard

3.1.7.2 Long Hill Bypass

Ambient noise readings were collected at six (6) locations along the Long Hill Bypass alignment (Figure 3-38, Table 3-21). These noise monitoring exercises were collected over a three-day period. The dates of the noise monitoring were March 14-17, 2019.

Brüel & Kjaer noise analysers and Quest Technologies Type I Sound Level Meters were programmed to log every 10 seconds with signal recording set at 50 dBA for night-time and 55 dBA for day-time at the residential areas. This feature allows the sound level meter to record the noise at the time when the thresholds (50 and 55 dBA) are exceeded.

The results indicated that the noise climate at Stations 1 and 3 monitored over the 72-hour period, exceeded the NRCA day and night-time standards of 55 dBA and 50 dBA respectively. Daytime noise at Stations 2 and 6 were non-compliant with the daytime standard, however, the night-time noise values were compliant. Noise at Stations 4 and 5 were compliant with NRCA day and night-time standards (Table 3-22).

Table 3-21 Noise and Particulate Station Coordinates for Long Hill Bypass

STATIONS	NORTHINGS	EASTINGS
1	699470.244	653514.253
2	698302.675	652121.021
3	696154.349	650734.376
4	694906.994	650618.436
5	693447.563	650293.827
6	691842.845	651328.420

Table 3-22 Ambient noise levels for the Long Hill Bypass

STN	AVG. ($LAeq_{72h}$)	MAX (dBA)	MIN (dBA)	NRCA DAYTIME (dBA)	NRCA NIGHT-TIME (dBA)	L10 (dBA)	L90 (dBA)
1	67.9	95.7	26.2	**69.1**	**64.8**	70.9	57.8
2	54.7	83.2	28.9	**56.3**	49.0	54.6	36.0
3	64.8	98.3	27.8	**66.2**	**60.5**	67.7	53.0
4	53.4	81.7	25.9	54.8	48.9	55.6	39.0
5	50.8	79.9	25.6	52.6	41.9	52.7	35.7
6	64.6	98.2	29.2	**66.6**	45.2	60.7	35.5

NB: Red bold numbers are non-compliant with NRCA noise standards

3.1.7.2.1 Station 1

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 26.2 dBA to a high (Lmax) of 95.7 dBA. Average noise level for this period was 67.9 L_{Aeq} (72h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 50 Hz (octave frequency range is 45 - 56 Hz).

L10 AND L90

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

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

Figure 3-51 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 75% of the time; large fluctuations 17 % of the time; and no significant fluctuations 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 70.9 dBA and 57.8 dBA respectively.

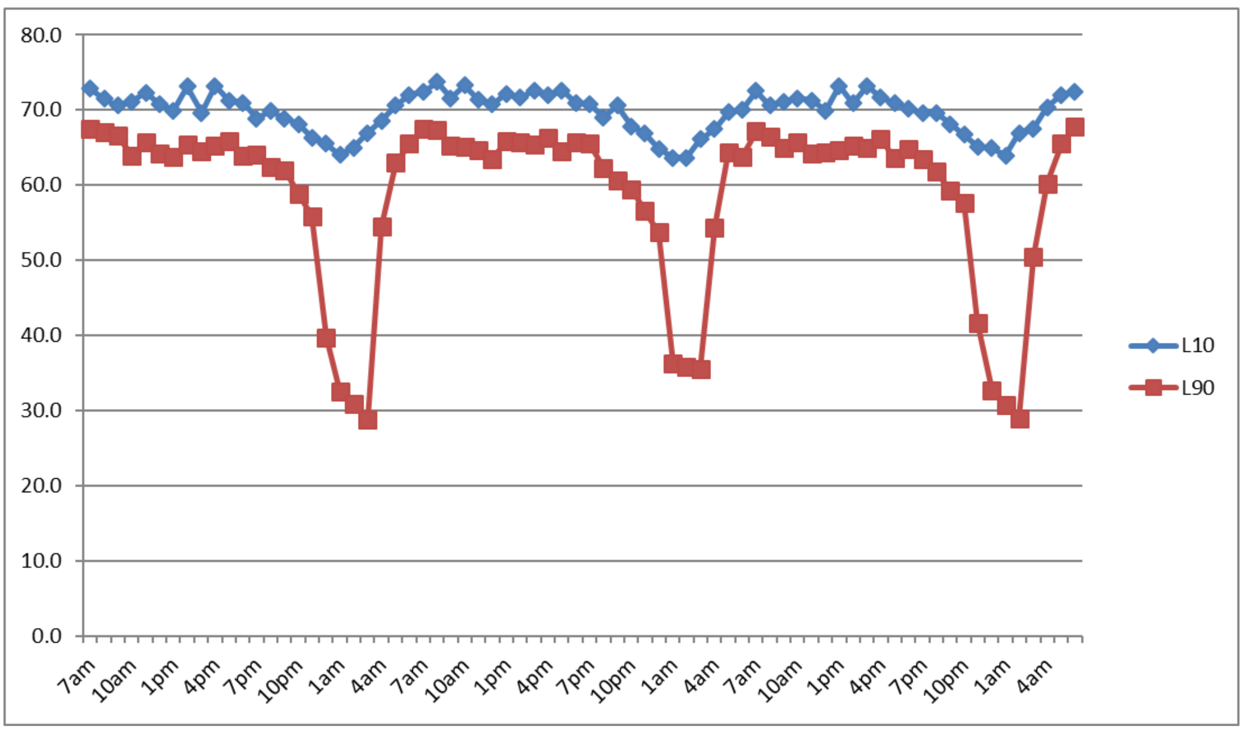


Figure 3-51 L10 and L90 for Station 1 – Long Hill Bypass

3.1.7.2.2 Station 2

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 28.9 dBA to a high (Lmax) of 83.2 dBA. Average noise level for this period was 54.7 L_{Aeq} (72h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 50 Hz (octave frequency range is 45 - 56 Hz).

L10 AND L90

Figure 3-52 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 51% of the time; large fluctuations 25 % of the time; and no significant fluctuations 24% of the time, in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 54.6 dBA and 36.0 dBA respectively.

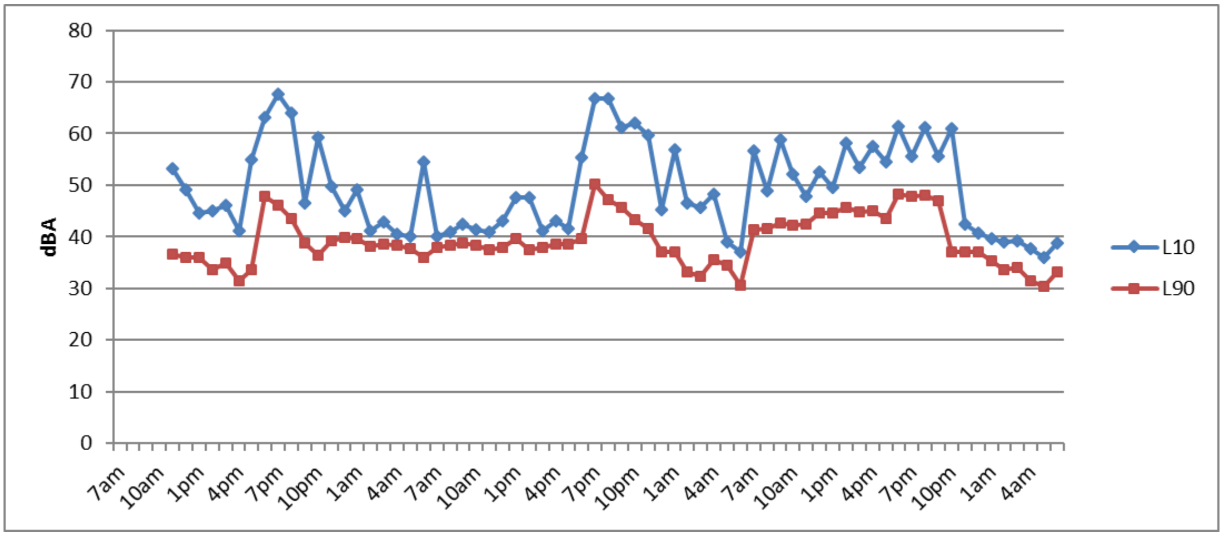


Figure 3-52 L10 and L90 for Station 2 – Long Hill Bypass

3.1.7.2.3 Station 3

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 27.8 dBA to a high (Lmax) of 98.3 dBA. Average noise level for this period was 64.8 L_{Aeq} (72h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 63 Hz (octave frequency range is 56 - 71 Hz).

L10 AND L90

Figure 3-53 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 74% of the time; large fluctuations 18 % of the time; and no significant fluctuations 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 67.7 dBA and 53.0 dBA respectively.

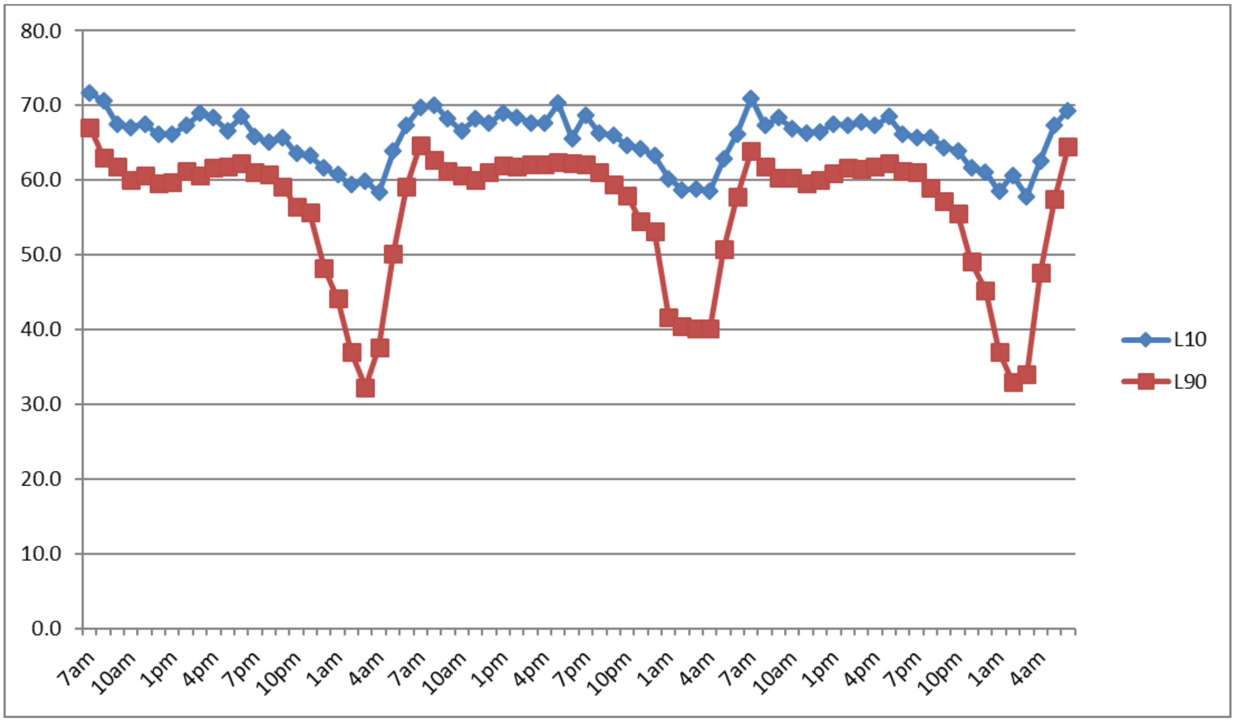


Figure 3-53 L10 and L90 for Station 3 – Long Hill Bypass

3.1.7.2.4 Station 4

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 25.9 dBA to a high (Lmax) of 81.7 dBA. Average noise level for this period was 53.4 L_{Aeq} (72h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 50 Hz (octave frequency range is 45 - 56 Hz).

L10 AND L90

Figure 3-54 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 79% of the time; large fluctuations 18 % of the time; and no significant fluctuations 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 55.6 dBA and 39.0 dBA respectively.

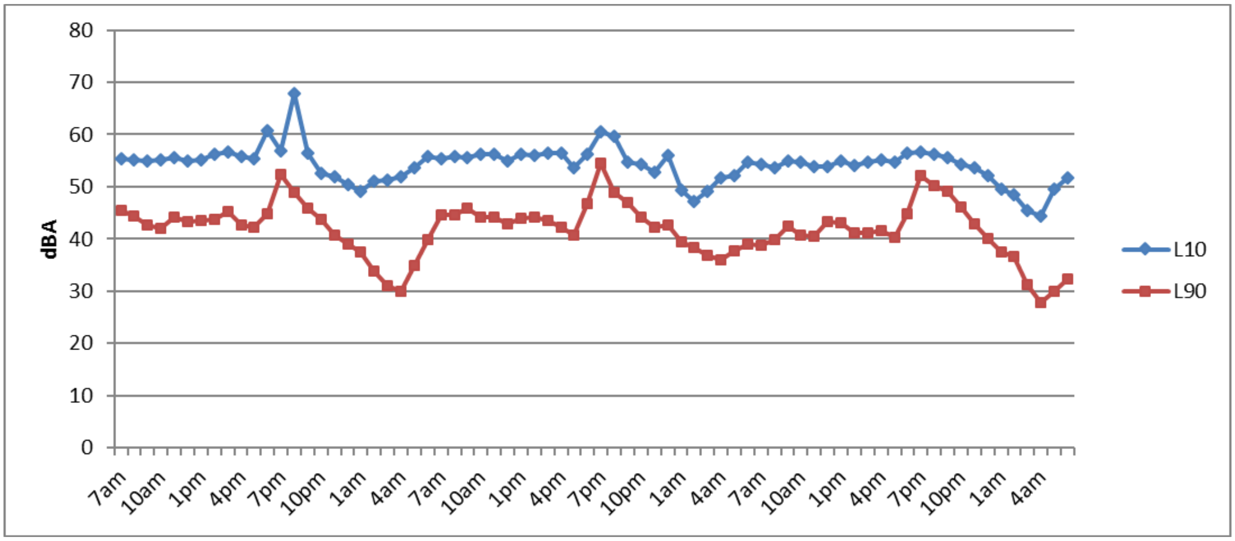


Figure 3-54 L10 and L90 for Station 4 – Long Hill Bypass

3.1.7.2.5 Station 5

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 25.6 dBA to a high (Lmax) of 79.9 dBA. Average noise level for this period was 50.8 L_{Aeq} (72h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 63 Hz (octave frequency range is 56 - 71 Hz).

L10 AND L90

Figure 3-55 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 64% of the time; large fluctuations 17 % of the time; and no significant fluctuations 19% of the time, in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 52.7 dBA and 35.7 dBA respectively.

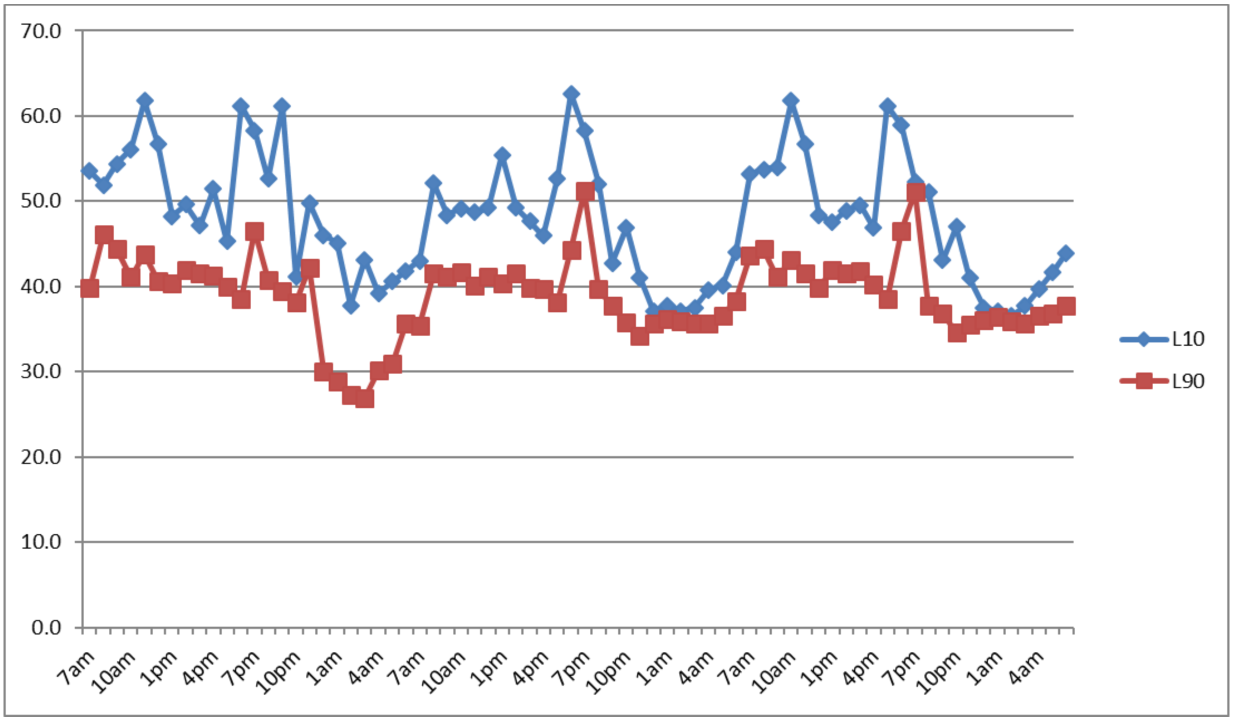


Figure 3-55 L10 and L90 for Station 5 – Long Hill Bypass

3.1.7.2.6 Station 6

During the assessment period, noise levels at this station ranged from a low (Lmin) of 29.2 dBA to a high (Lmax) of 98.2 dBA. Average noise level for this period was 64.4 L_{Aeq}. The noise at this station was in the low frequency band centred around the geometric mean frequency of 50 Hz (octave frequency range is 45 - 56 Hz). The meter at Station 6 only ran for 48 hours from March 14-16.

L10 AND L90

Figure 3-56 depicts the hourly L10 and L90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 44% of the time; large fluctuations 30 % of the time; and no significant fluctuations 26% of the time, in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 60.7 dBA and 35.5 dBA respectively.

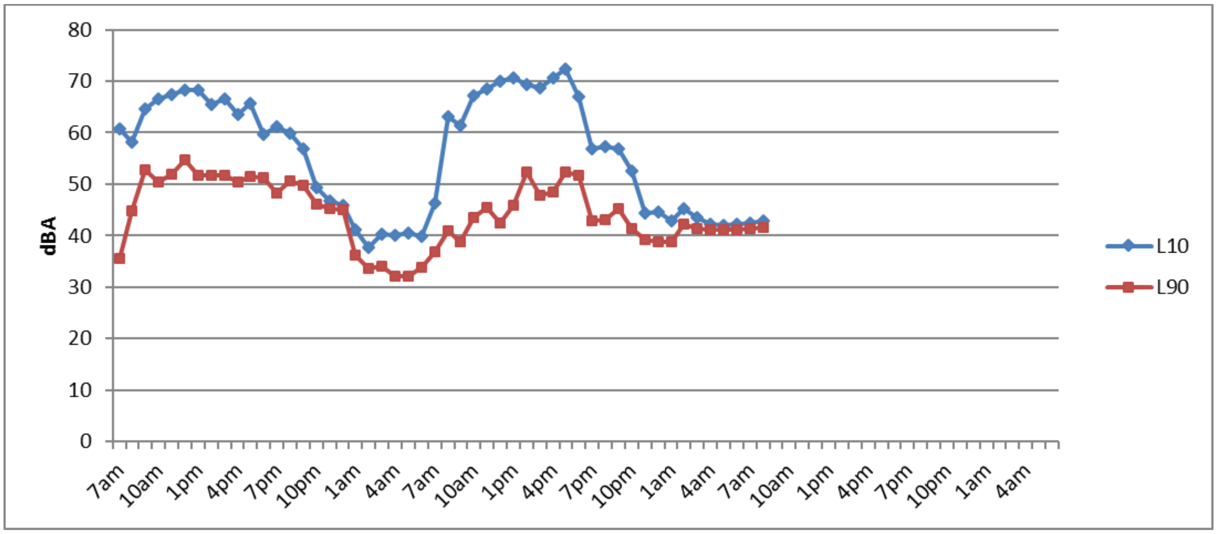


Figure 3-56 L10 and L90 for Station 6 – Long Hill Bypass

3.1.7.2.7 Federal Highway Administration Standards

Noise standards issued by the Federal Highway Administration (FHA) of the United States Department of Transportation for use by state and Federal highway agencies in the planning and design of highways, are depicted in Table 3-23.

Table 3-23 FHA 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 listed above, **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) has indicated that for the entire 72 hours, the L10 noise levels were in full compliance with the FHA standard at Stations 2, 4 and 5 only. Noise levels had exceeded the 70 dBA design level at the other stations for certain periods during the assessment.

Station 1 exceeded the 70 dBA design level at 7am – 6pm on March 14th, 5am – 9pm on March 15th, 6am – 6pm on March 16th and 4am – 7am on March 17th. Station 3 exceeded the 70 dBA design level at 7am – 9am on March 14th, 8am – 9am and 5pm – 6pm on March 15th, on 7am – 8am on March 16th. Station 6 exceeded the 70 dBA design level at 12pm – 1pm and 4pm – 5pm on March 15th (Figure 3-51 - Figure 3-56).

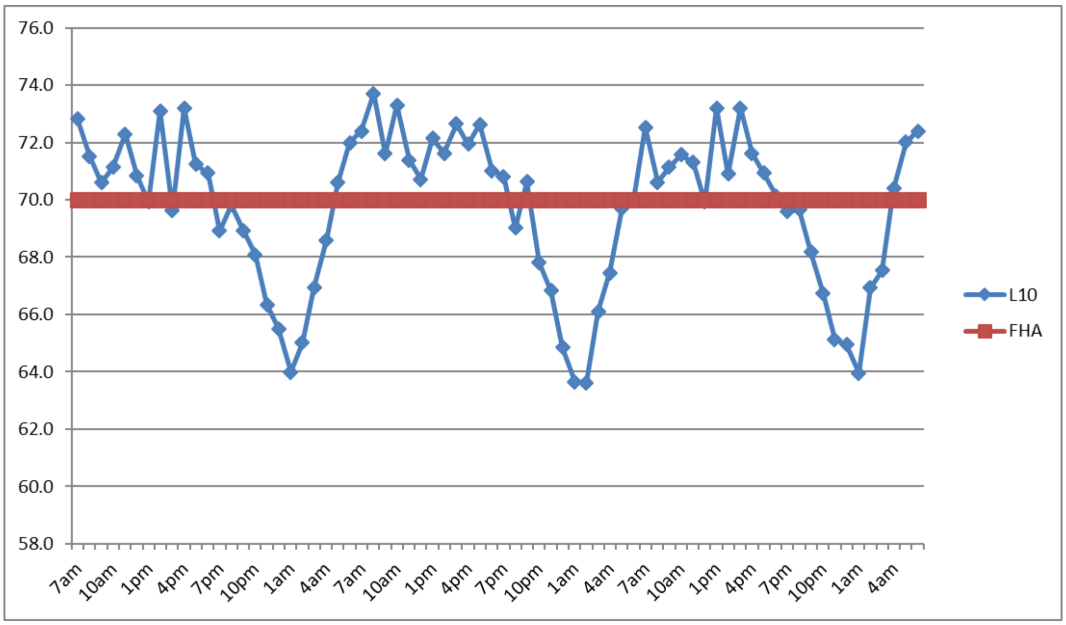


Figure 3-57 Comparison of L10 at Station 1 (Long Hill Bypass) with FHA standard

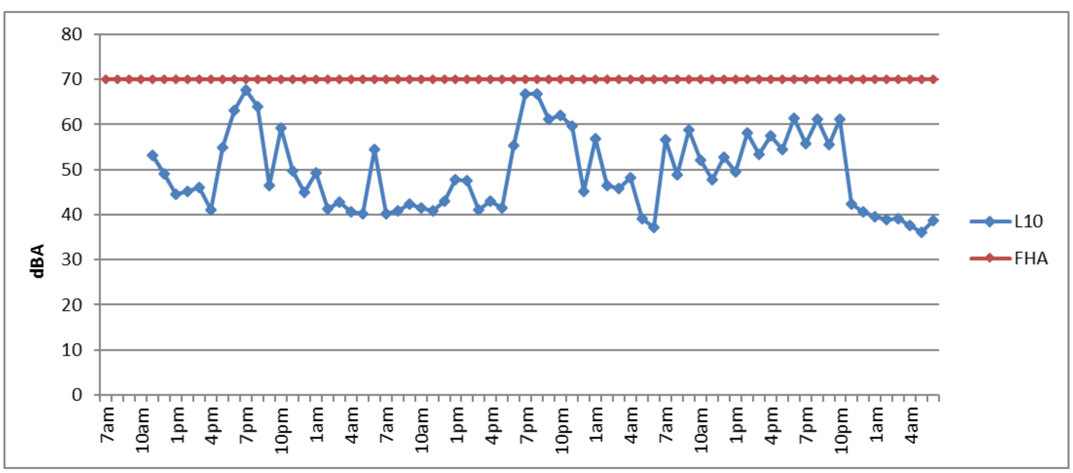


Figure 3-58 Comparison of L10 at Station 2 (Long Hill Bypass) with FHA standard

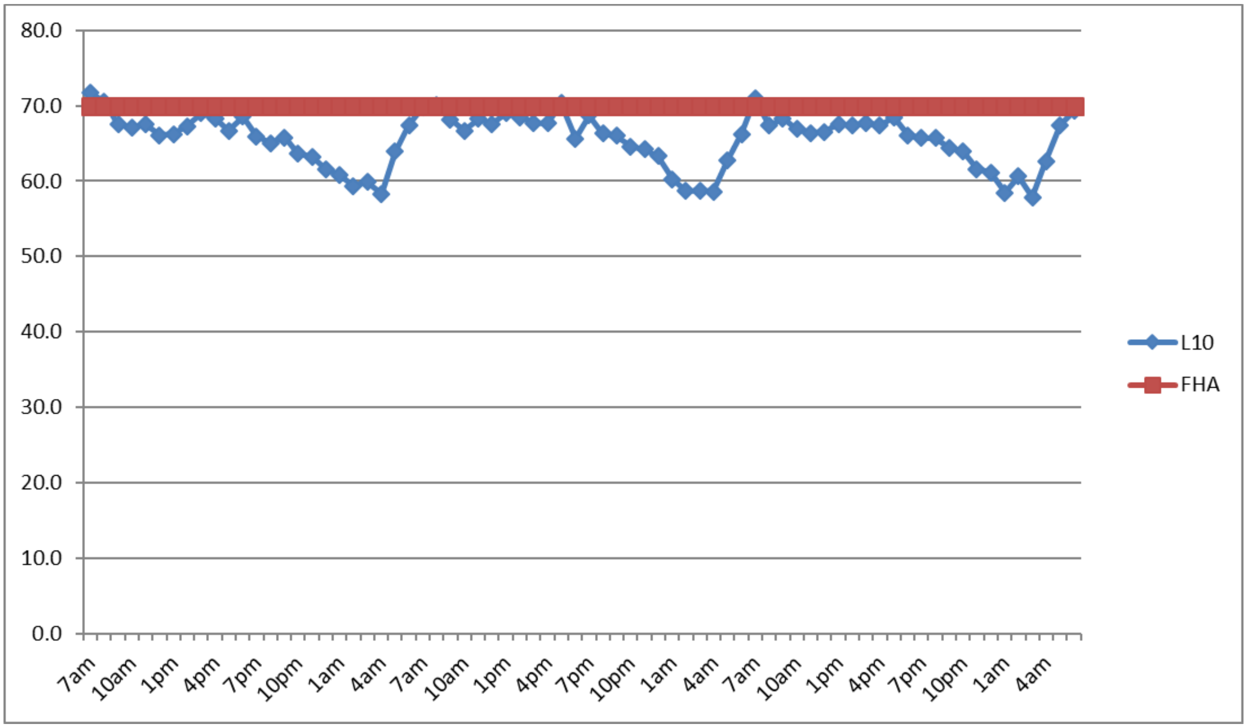


Figure 3-59 Comparison of L10 at Station 3 (Long Hill Bypass) with FHA standard

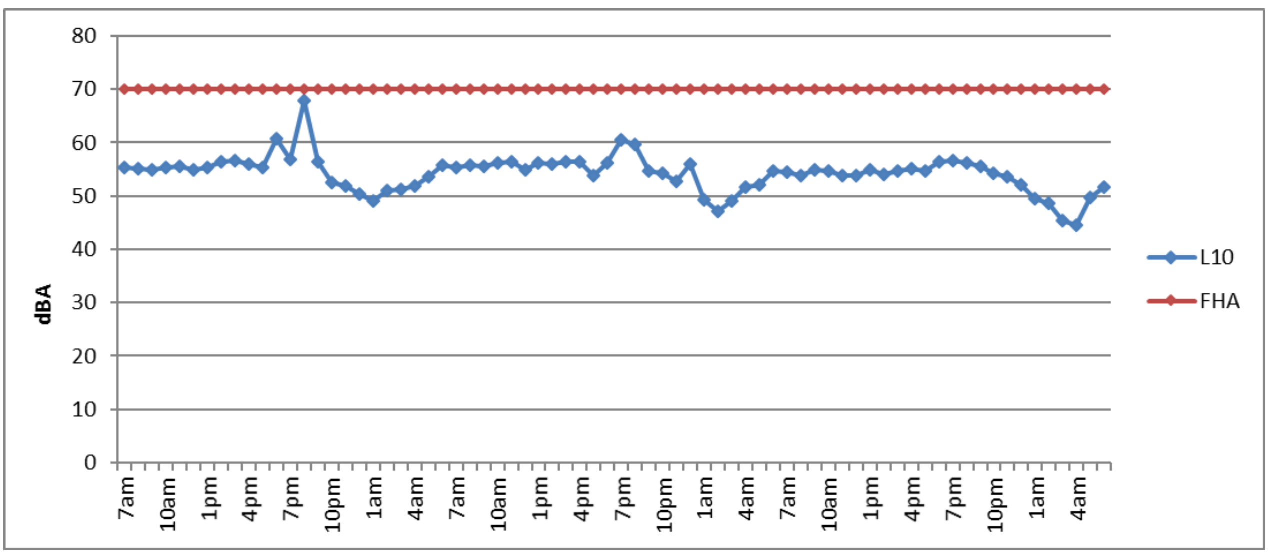


Figure 3-60 Comparison of L10 at Station 4 (Long Hill Bypass) with FHA standard

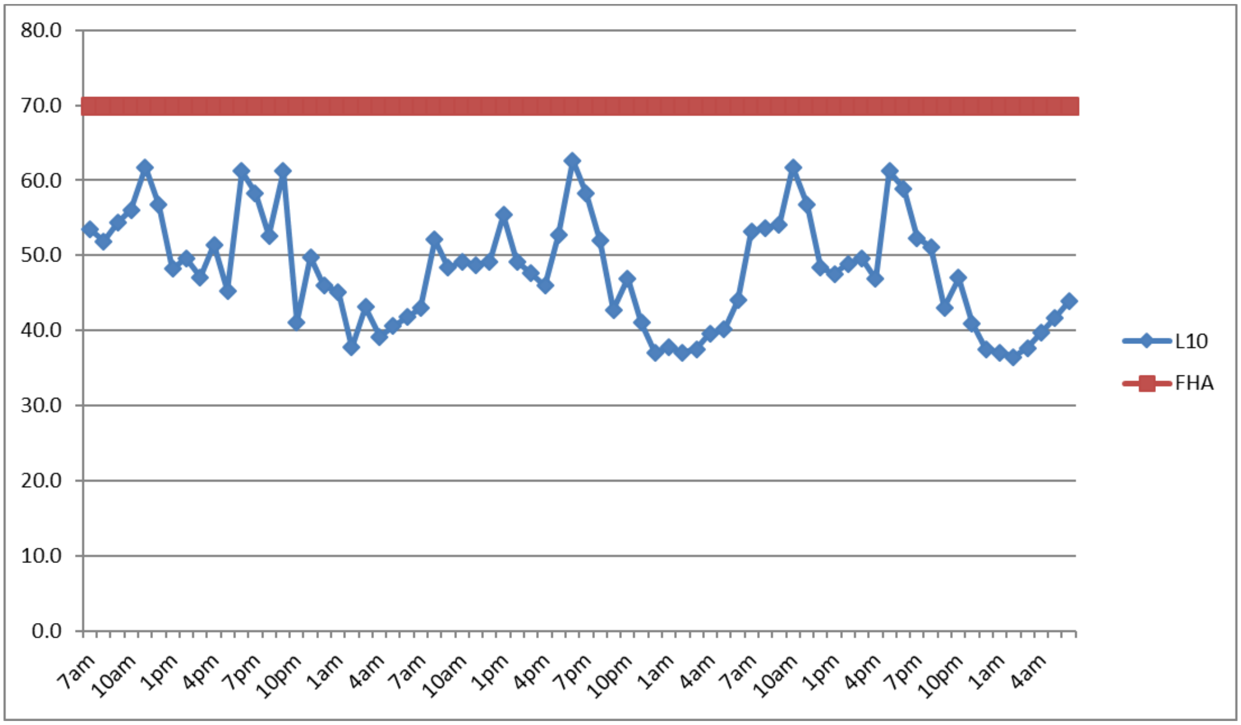


Figure 3-61 Comparison of L10 at Station 5 (Long Hill Bypass) with FHA standard

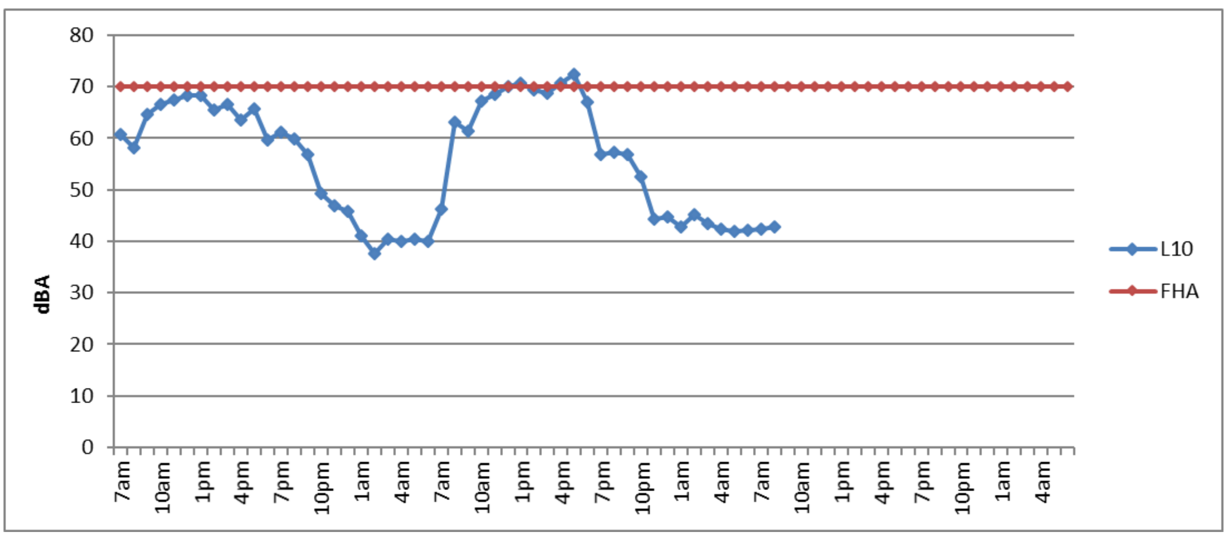


Figure 3-62 Comparison of L10 at Station 6 (Long Hill Bypass) with FHA standard

3.1.7.3 Barnett Street and West Green Avenue to Fairfield Road Dualization

Ambient noise readings were collected at two locations each along Barnett Street and along West Green Avenue to Fairfield Road, where dualization is to occur (Table 3-24, Figure 3-63 and Figure 3-38). These noise monitoring exercises were collected over a four-day period at each location. The dates of the noise monitoring were January 10 – 14, 2019 for Barnett Street and January 17 – 21, 2019 for the West Green Avenue (West Green and Catherine Hall).

Brüel & Kjaer noise analysers were programmed to log every 10 seconds with signal recording set at 50 dBA for night-time and 55 dBA for day-time at the residential areas (West Green) and 60 dBA for night-time and 65 dBA for day-time in commercial areas (Barnett Street) (Plate 3-26 and Plate 3-27). This feature allows the sound level meter to record the noise at the time when the thresholds (50 and 55 dBA and 60 dBA and 65 dBA respectively) are exceeded.

The results indicated that the noise climate at the four locations monitored over a 96-hour period were relatively high, in fact at three of the four locations the noise levels exceeded the NRCA day and night-time standards (Table 3-25).

Table 3-24 Noise and Particulate Station Coordinates for Barnett Street and West Green Avenue

STATIONS	LOCATION	NORTHINGS	EASTINGS
B1	Barnett Street	701771.935	653300.789
B2		701319.067	653340.279
WG1	West Green Avenue	701149.674	653001.443
WG2		701179.690	652521.368

Table 3-25 Ambient noise levels at Barnett Street and West Green Avenue

STN	LOCATION	AVG. ($LAeq_{96h}$)	MAX (dBA)	MIN (dBA)	NRCA DAYTIME (dBA)	NRCA NIGHT-TIME (dBA)	L10 (dBA)	L90 (dBA)
B1	Barnett St.	67.0	104.1	41.3	**68.0**	**65.0**	68.0	53.5
B2		63.0	96.2	42.5	64.0	59.0	63.3	49.3
WG1	West Green Ave.	68.0	100.7	37.4	**69.0**	**66.0**	70.2	49.2
WG2		66.0	97.2	39.5	**67.0**	**63.0**	68.2	47.6

NB: Red bold numbers are non-compliant with NRCA noise standards

Figure 3-63 Noise and particulates stations for Barnett Street and West Green Avenue

3.1.7.3.1 Station B1 – Barnett Street

During the 96-hour period, noise levels at this station ranged from a low (Lmin) of 41.3 dBA to a high (Lmax) of 104.1 dBA. Average noise level for this period was 67.0 L_{Aeq} (96h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 50 Hz (octave frequency range is 45 - 56 Hz).

L10 AND L90

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

Figure 3-64 depicts the hourly L10 and L90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 83% of the time; large fluctuations 17 % of the time; and no significant fluctuations 0% of the time, in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 68.0 dBA and 53.5 dBA respectively.

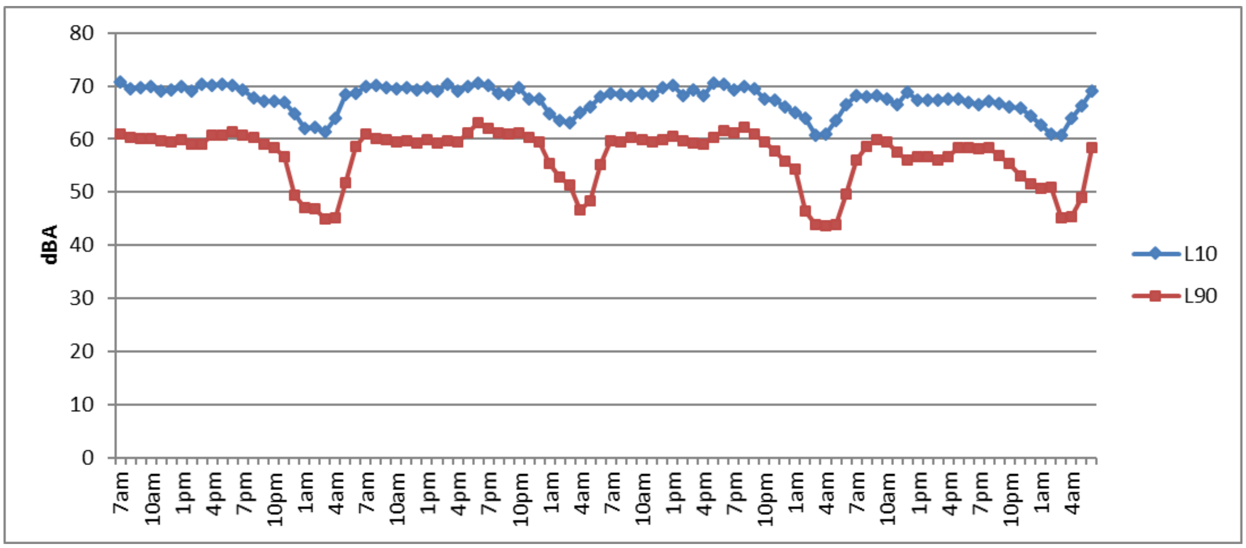


Figure 3-64 L10 and L90 for Station B1 – Barnett Street upgrade

3.1.7.3.2 Station B2 – Barnett Street

During the 96-hour period, noise levels at this station ranged from a low (Lmin) of 42.5 dBA to a high (Lmax) of 96.2 dBA. Average noise level for this period was 63.0 L_{Aeq} (96h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 25 Hz (octave frequency range is 22 - 28 Hz).

L10 AND L90

Figure 3-65 depicts the hourly L10 and L90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 96% of the time; large fluctuations 2% of the time; and no significant fluctuations 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 63.3 dBA and 49.3 dBA respectively.

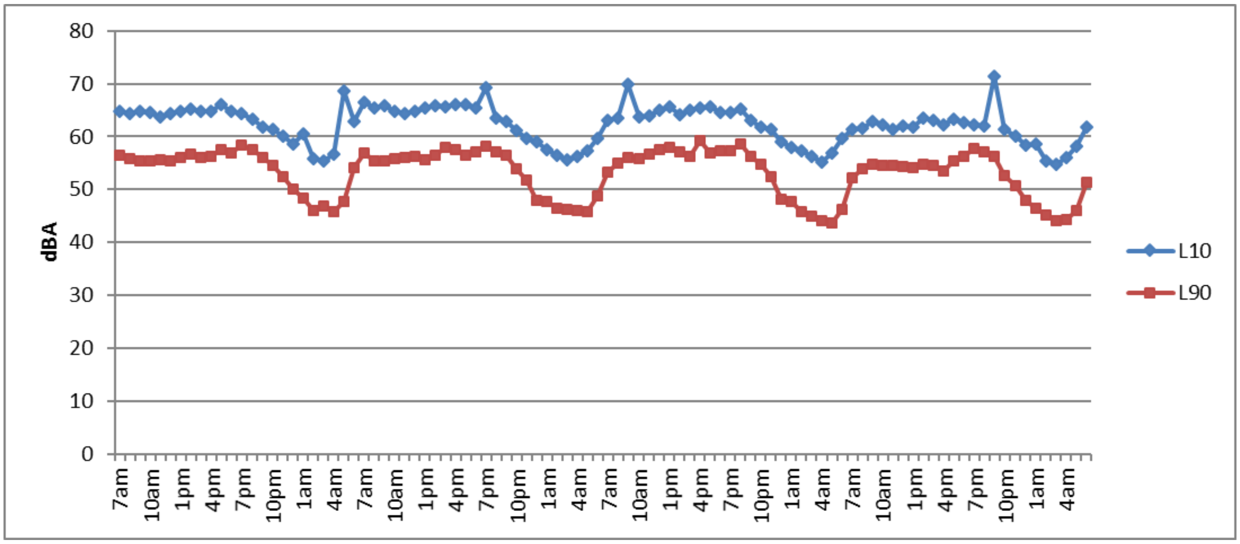


Figure 3-65 L10 and L90 for Station B2 – Barnett Street upgrade

3.1.7.3.3 Station WG1 – West Green Avenue

During the 96-hour period, noise levels at this station ranged from a low (Lmin) of 37.4 dBA to a high (Lmax) of 100.7 dBA. Average noise level for this period was 68.0 L_{Aeq} (96h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 12.5 Hz (octave frequency range is 11-14 Hz).

L10 AND L90

Figure 3-66 depicts the hourly L10 and L90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 53% of the time; large fluctuations 47% of the time; and no significant fluctuations 0% of the time, in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 70.2 dBA and 49.2 dBA respectively.

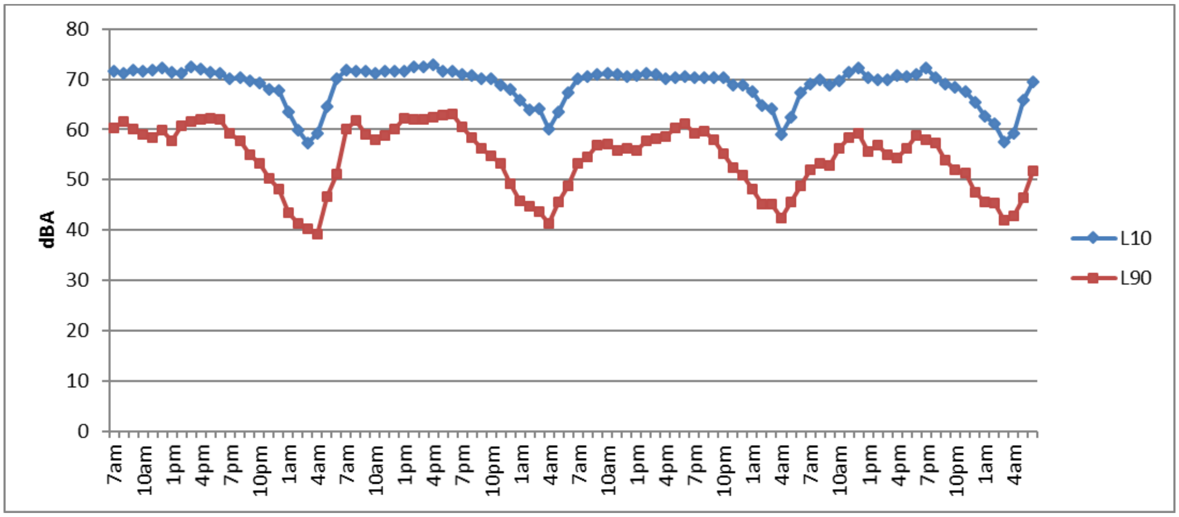


Figure 3-66 L10 and L90 for Station WG1 – West Green Avenue upgrade

3.1.7.3.4 Station WG2 – West Green Avenue

During the 96-hour period, noise levels at this station ranged from a low (Lmin) of 39.5 dBA to a high (Lmax) of 97.2 dBA. Average noise level for this period was 66.0 L_{Aeq} (96h). The noise at this station was in the low frequency band centred around the geometric mean frequency of 63 Hz (octave frequency range is 56-71 Hz).

L10 AND L90

Figure 3-67 depicts the hourly L10 and L90 statistics for this station over the noise assessment period. The data shows moderate fluctuations 62.5% of the time; large fluctuations 37.5 % of the time; and no significant fluctuations 0% of the time, in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 68.2 dBA and 47.6 dBA respectively.

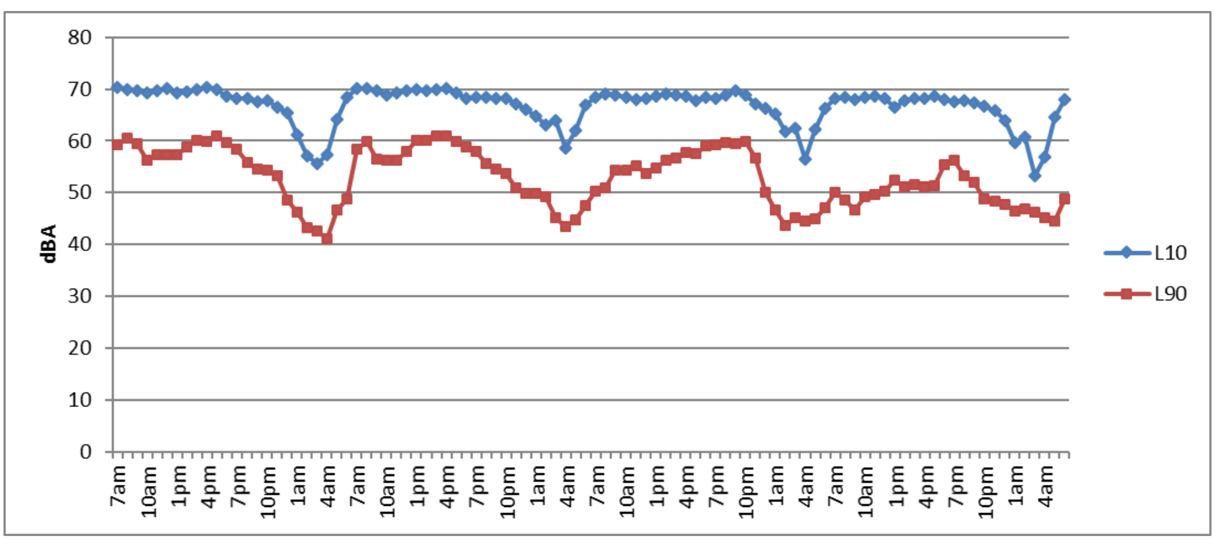


Figure 3-67 L10 and L90 for Station WG2 – West Green Avenue upgrade

3.1.7.3.5 Federal Highway Administration Standards

Noise standards issued by the Federal Highway Administration (FHA) of the United States Department of Transportation for use by state and Federal highway agencies in the planning and design of highways are depicted in Table 3-20. Based on the land use categories listed above, **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) has indicated that for the entire 72 hours, the L10 noise levels were in full compliance with the FHA standard at Stations 2, 4 and 5 only. Noise levels had exceeded the 70 dBA design level at the other stations for certain periods during the assessment.

Station B1 exceeded the 70 dBA design level at 7am – 8am and 3pm - 7pm on January 10th, 8am – 9am, 3pm – 4pm and 6pm – 8pm on January 11th, 1pm – 2pm and 5pm – 7pm on January 12th. Station B2 exceeded the 70 dBA design level at 9pm – 10pm on January 13th. Station WG1 exceeded the 70 dBA design level at 7am – 9pm on January 17th, 6am – 11pm on January 18th, 7am – 11pm on January 19th, 11am – 2pm and 4pm – 9pm on January 20th. Station WG2 marginally exceeded the 70 dBA design level at 7am – 9am on January 17th (Figure 3-68 - Figure 3-71).

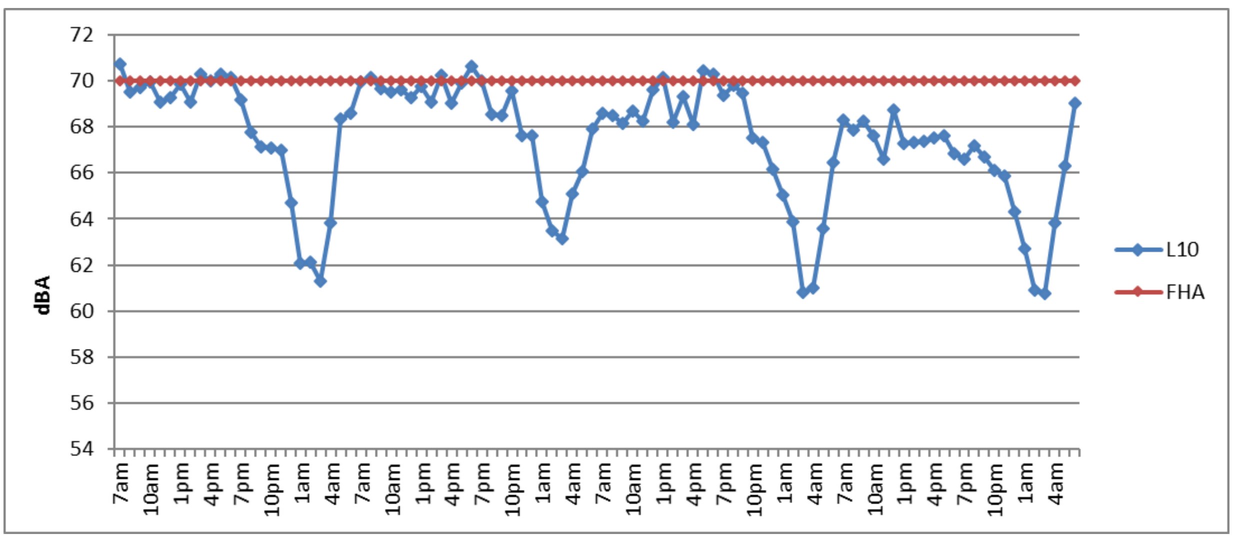


Figure 3-68 Comparison of L10 at Station B1 (Barnett Street) with FHA standard

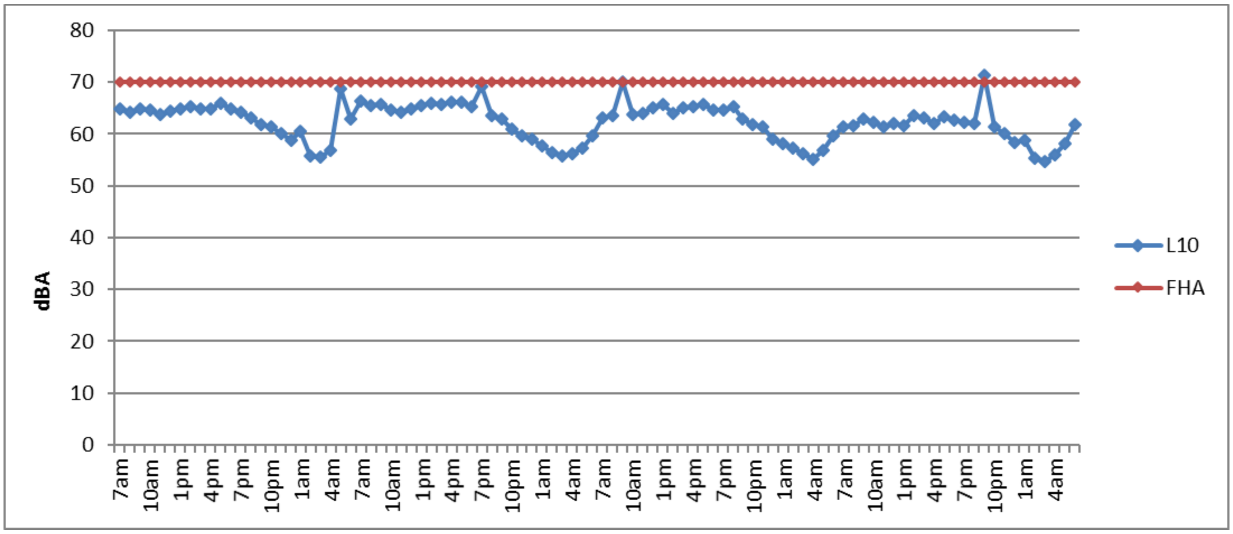


Figure 3-69 Comparison of L10 at Station B2 (Barnett Street) with FHA standard

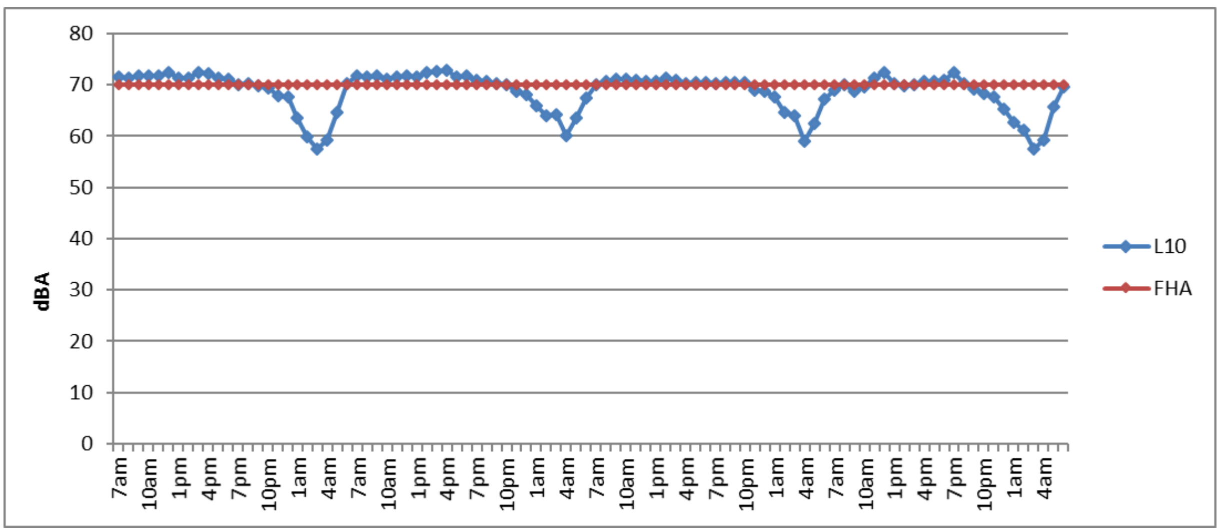


Figure 3-70 Comparison of L10 at Station WG1 (West Green Avenue) with FHA standard

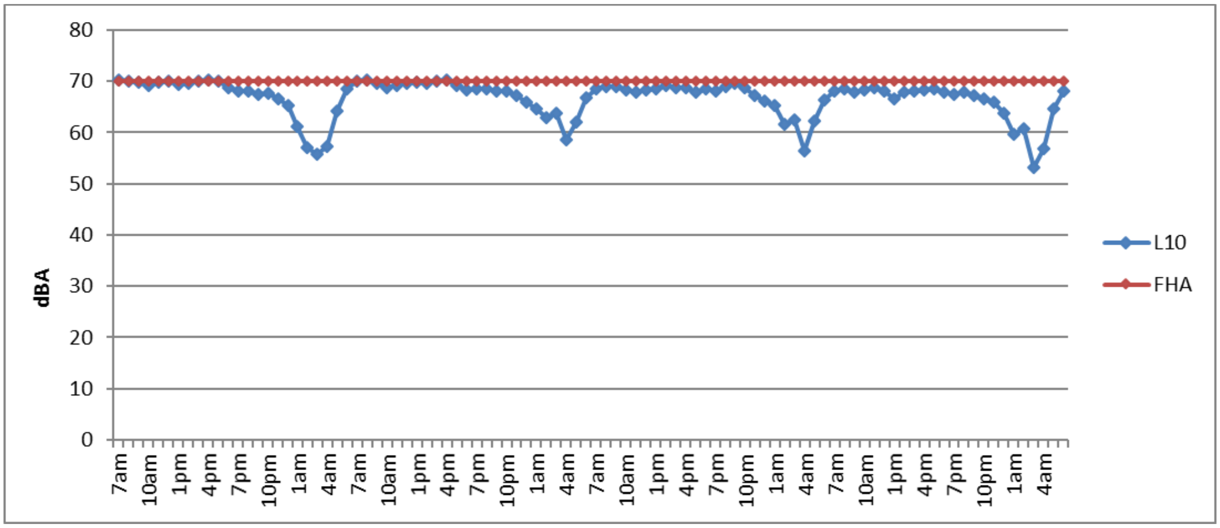


Figure 3-71 Comparison of L10 at Station WG2 (West Green Avenue) with FHA standard

3.1.8 Ambient Air Quality

3.1.8.1 Particulates (PM10 and PM2.5)

Coarse particles are airborne pollutants that fall between 2.5 and 10 micrometres in diameter. Fine particle are airborne pollutants that fall below 2.5 micrometres in diameter. Sources of coarse particles include crushing or grinding operations and dust stirred up by vehicles traveling on roads. Sources of fine particles include all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes.

PM10 and PM2.5 ambient particulate sampling was conducted along the various sections of proposed project areas.

3.1.8.1.1 Montego Bay Perimeter Road

Ambient air quality sampling was conducted at the same eight (8) locations as the noise survey (Figure 3-38, Table 3-18) using Airmetrics Minivol samplers (Calibration Certificate in Appendix 5) for 24 hours. Sampling was conducted on March 21st (PM10) and 23rd (PM2.5), 2019. The particulate measurements indicated that the PM10 levels were compliant with the NRCA ambient air quality standard (Table 3-26). However, the PM2.5 levels were non-compliant with the United States Environmental Protection Agency (USEPA) standard.

Table 3-26 Ambient particulate levels for Montego Bay Perimeter Road

STN.	PM 10 (μg/m³)	PM10 NRCA STD (μg/m³)	PM 2.5 (μg/m³)	PM2.5 USEPA STD (μg/m³)
1	5.69	*150*	155.83	*35*
2	12.36	*150*	45.08	*35*
3	8.19	*150*	165.83	*35*
4	17.78	*150*	154.44	*35*
5	7.08	*150*	160.00	*35*

STN.	PM 10 (µg/m³)	PM10 NRCA STD (µg/m³)	PM 2.5 (µg/m³)	PM2.5 USEPA STD (µg/m³)
6	10.97	***150***	**128.05**	***35***
7	34.44	***150***	**165.56**	***35***
8	18.19	***150***	**72.64**	***35***

NB: Red bold numbers are non-compliant with USEPA particulate standards

3.1.8.1.2 Long Hill Bypass

Ambient air quality sampling was conducted at the same six (6) locations as the noise survey (Figure 3-38,Table 3-21) using Airmetrics Minivol samplers for 24 hours (Plate 3-17). Sampling was conducted on March 14th (PM2.5) and 16th (PM10), 2019. The particulate measurements indicated that the PM10 levels were compliant with the NRCA ambient air quality standard (Table 3-27). However, the PM2.5 levels were non-compliant with the United States Environmental Protection Agency (USEPA) standard.

Table 3-27 Ambient particulate levels for Long Hill Bypass

STN.	PM 10 (µg/m³)	PM10 NRCA STD (µg/m³)	PM 2.5 (µg/m³)	PM2.5 USEPA STD (µg/m³)
1	26.94	***150***	**180.28**	***35***
2	22.08	***150***	**158.19**	***35***
3	24.86	***150***	**271.11**	***35***
4	24.72	***150***	-	***35***
5	18.33	***150***	**304.31**	***35***
6	58.89	***150***	**293.81**	***35***

NB: Red bold numbers are non-compliant with USEPA particulate standards
The Meter at Station 4 did not run during PM2.5 sampling due to equipment malfunction

Plate 3-25 Photograph showing the Bruel & Kjaer noise meter and Airmetrics Minivol sampler at Station along Long Hill Bypass

3.1.8.1.3 Barnett Street and West Green Avenue to Fairfield Road Dualization

Ambient air quality sampling was conducted at the same four (4) locations as the noise survey (2 along Barnett Street and 2 along West Green Avenue) (Table 3-24, Figure 3-63) using Airmetrics Minivol samplers for 24 hours (Plate 3-26 and Plate 3-27). Sampling was conducted on January 10th (PM10) and 12th (PM2.5), 2019 for Barnett Street and January 17, 2019 (Both PM10 & 2.5) on West Green Avenue (West Green and Catherine Hall).

The particulate measurements at the 2 locations along Barnett Street and the 2 locations along West Green Avenue indicated that the PM10 levels were compliant with the NRCA ambient air quality standard (Table 3-28). However, the PM2.5 levels were non-compliant with the United States Environmental Protection Agency (USEPA) standard.

Table 3-28 Ambient particulate levels at Barnett Street and West Green area

STN	LOCATION	PM 10 (µg/m³)	*PM10 NRCA STD (µg/m³)*	PM 2.5 (µg/m³)	*PM2.5 USEPA STD (µg/m³)*
B1	Barnett St.	47.5	***150***	73.47	***35***
B2		39.17	***150***	141.53	***35***
WG1	West Green Ave.	14.03	***150***	75.83	***35***
WG2		40.00	***150***	106.94	***35***

NB: Red bold numbers are non-compliant with USEPA particulate standards

Plate 3-26 Photograph showing the Bruel & Kjaer noise meter and Airmetrics Minivol sampler at UTECH Caribbean School of Nursing Montego Bay, Campus on Barnett Street

Plate 3-27 Photograph showing the Bruel & Kjaer noise meter and Airmetrics Minivol sampler at Cornwall Gardens on Barnett Street

3.1.8.2 Other Air Emissions

Spot measurements were taken using a Eurotron Instruments RASI800-A008 Emissions Analyser for analysis of nitrogen oxide (NO), nitrogen dioxide (NO_2), NOx, sulphur dioxide (SO_2), methane (CH_4), carbon monoxide (CO) and carbon dioxide (CO_2). Measurements were taken for ten (10) minutes at each of the various locations along the different alignments and road upgrade sections. The results for the various sample locations are displayed in Table 3-29, Table 3-30 and Table 3-31.

The only locations in which any NO, NO_2 or NO_X were detected were Anchovy Bottom and West Green Avenue. Methane (CH_4) was detected at most locations sampled and carbon monoxide (CO) was only detected at one (1) location – Bogue near UWI. SO_2 was not detected at any of the locations sampled. The presence of the various gases detected can most likely be attributed to motor vehicle exhaust emissions. CO_2 however, is naturally occurring and was detected at all locations sampled.

Table 3-29 Air Emission concentrations along the Montego Bay Perimeter Road alignment

FAIRVIEW	
CO_2 (%)	0.18
CO (ppm)	0
NO (ppm)	0
NO_2 (ppm)	0
NO_x (ppm)	0
SO_2 (ppm)	0
CH_4 (ppm)	10-30
TEMPLE GALLEY ROAD	
CO_2 (%)	0.12
CO (ppm)	0
NO (ppm)	0

NO_2 (ppm)	0
NO_x (ppm)	0
SO_2 (ppm)	0
CH_4 (ppm)	20
IRWIN	
CO_2 (%)	0.11
CO (ppm)	0
NO (ppm)	0
NO_2 (ppm)	0
NO_x (ppm)	0
SO_2 (ppm)	0
CH_4 (ppm)	40-120
CORNWALL COURTS	
CO_2 (%)	0.16
CO (ppm)	0
NO (ppm)	0
NO_2 (ppm)	0
NO_x (ppm)	0
SO_2 (ppm)	0
CH_4 (ppm)	50-200
IRONSHORE	
CO_2 (%)	0.12
CO (ppm)	0
NO (ppm)	0
NO_2 (ppm)	0
NO_x (ppm)	0
SO_2 (ppm)	0
CH_4 (ppm)	120-210

Table 3-30 Air Emission concentrations along the Long Hill Bypass alignment

MONTPELIER	
CO_2 (%)	0.04
CO (ppm)	0
NO (ppm)	0
NO_2 (ppm)	0
NO_x (ppm)	0
SO_2 (ppm)	0
CH_4 (ppm)	0
ANCHOVY BOTTOM	
CO_2 (%)	0
CO (ppm)	0
NO (ppm)	0
NO_2 (ppm)	0.1
NO_x (ppm)	0.1
SO_2 (ppm)	0
CH_4 (ppm)	20-60
BOGUE – NEAR UWI	
CO_2 (%)	0.15
CO (ppm)	0.1
NO (ppm)	0
NO_2 (ppm)	0

NO_x (ppm)	0
SO_2 (ppm)	0
CH_4 (ppm)	0-40

Table 3-31 Air Emission concentrations along West Green Avenue and Barnett Street

WEST GREEN AVENUE	
CO_2 (%)	0.3
CO (ppm)	0
NO (ppm)	0.1
NO_2 (ppm)	0.1
NO_x (ppm)	0
SO_2 (ppm)	0
CH_4 (ppm)	0
BARNETT STREET – CORNWALL GARDENS	
CO_2 (%)	0.12
CO (ppm)	0
NO (ppm)	0
NO_2 (ppm)	0
NO_x (ppm)	0
SO_2 (ppm)	0
CH_4 (ppm)	10-40
BARNETT STREET – UTECH NURSING SCHOOL	
CO_2 (%)	0.11
CO (ppm)	0
NO (ppm)	0
NO_2 (ppm)	0
NO_x (ppm)	0
SO_2 (ppm)	0
CH_4 (ppm)	10-30

3.1.9 Vibration

3.1.9.1 Effects of Vibration and Modelling

Various governmental agencies have criteria regarding architectural and structural damage, as well as annoyance and acceptability of vibration. In general, most of the criteria specify that for a Peak Particle Velocity (PPV) less than approximately 3.048 mms-1 (0.12 inches per second), the potential for architectural damage due to vibration is unlikely. A PPV of approximately 3.048 mms-1 (0.12 inches per second) to 12.7 mms-1 (0.50 inches per second) there is potential for architectural damage due to vibration, and for a PPV greater than approximately 12.7 mms-1 (0.50 inches per second) the potential for architectural damage due to vibration is very likely.

Human beings are known to be very sensitive to vibration, the threshold of perception being typically in the PPV range of 0.14 mms-1 to 0.3 mms-1 (British Standard BS 5228-2:2009). An indication of the effects of ground vibration on humans is detailed by the standard and detailed in Table 3-32.

Table 3-32 Guidance on the effects of vibration

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

British Standard BS 5228-2:2009

Vibrations from various types of construction equipment under a wide range of construction activities have been measured by the Federal Transit Administration (FTA) in the United States. The data in Table 3-33 provides a reasonable estimate for a wide range of soil conditions and were obtained from measurements on several projects including the Central Artery/Tunnel Project in Boston and from several published sources including the FTA Manual and Dowding's Textbook.

To predict the vibration at a receptor from the operation of the equipment listed in Table 3-33, the following equation is used:

$$PPV_{equipment} = PPV_{ref}\,(100/D_{rec})^n$$

Where:

PPV_{ref} = *reference PPV at 100 ft.*

D_{rec} = *distance from equipment to the receiver in ft.*

n = 1.1 (the value related to the attenuation rate through ground)

Table 3-33 Equipment Vibration Emission Levels

Equipment Description	Vibration Type Steady or transient	Ref PPV at 100 ft.
Auger Drill Rig	Steady	0.011125
Backhoe	Steady	0.011
Bar Bender	Steady	N/A
Boring Jack Power Unit	Steady	N/A
Chain Saw	Steady	N/A
Compactor	Steady	0.03
Compressor	Steady	N/A
Concrete Mixer	Steady	0.01
Concrete Pump	Steady	0.01
Concrete Saw	Steady	N/A
Crane	Steady	0.001
Dozer	Steady	0.011
Dump Truck	Steady	0.01
Excavator	Steady	0.011
Flat Bed Truck	Steady	0.01
Front End Loader	Steady	0.011
Generator	Steady	N/A
Gradall	Steady	0.011
Grader	Steady	0.011
Horizontal Boring Hydraulic Jack	Steady	0.003
Hydra Break Ram	Transient	0.05
Impact Pile Driver	Transient	0.2
Insitu Soil Sampling Rig	Steady	0.011125
Jackhammer	Steady	0.003
Mounted Hammer hoe ram	Transient	0.18975
Paver	Steady	0.01
Pickup Truck	Steady	0.01
Pneumatic Tools	Steady	N/A
Scraper	Steady	0.000375
Slurry Trenching Machine	Steady	0.002125
Soil Mix Drill Rig	Steady	0.011125
Tractor	Steady	0.01
Tunnel Boring Machine (rock)	Steady	0.0058
Tunnel Boring Machine (soil)	Steady	0.003
Vibratory Pile Driver	Steady	0.14
Vibratory Roller (large)	Steady	0.059
Vibratory Roller (small)	Steady	0.022
Welder	Steady	N/A
Concrete Batch Plant	Steady	N/A
Pumps	Steady	N/A
Blasting	Transient	0.75
Clam Shovel	Transient	0.02525
Rock Drill	Steady	0.011125
3-ton truck at 35 mph	Steady	0.0002

3.1.9.2 Vibration Model Calibration

Using the above prediction calculations, vibration levels were predicted at a distance of 10.5 metres from the existing roadway using a loaded truck as the operating equipment/vehicle. Results showed that the PPV vibration value was 0.820 mm/sec.

A vibration measurement was performed on January 9, 2013, using a Nomis Seismometer Type Mini Supergraph. The Mini Supergraph consisted of a 3-axis velocity transducer, an air over-pressure transducer, and a data acquisition and storage device. The transducer measures velocities on three mutually perpendicular axes (Vx, Vy, Vz) corresponding to a radial, vertical, and transverse component at a linear frequency response range from 2 Hz to 400 Hz. The Mini Supergraph was calibrated to meet ISO-9000 requirements on April 23, 2019. The seismometer was set to summarize every 5 minutes at a sampling rate 1024/sec. The measurement was conducted over a ten (10) hour period 8 am to 6 pm on June 3, 2019 at a distance of 10.5 metres from road.

The results of the vibration events recorded (PPV of 0.762 mm/sec) indicated that vibration levels are likely in residential environments to cause complaint (continuous vibrations begin to annoy in buildings), but can be tolerated if prior warning and explanation has been given to residents and have no effect on building structures (Figure 3-72). Based on the predicted vibration value of 0.820 mm/sec and the measured value of 0.762 mm/sec, both at the same distance of 10.5 metres from existing road, the vibration model can be considered properly calibrated. All predicted vibration values for construction and operational impacts (section 5.2.1.7and section 5.3.1.5 respectively) are therefore justified.

3.1.9.3 West Green Avenue

Currently, there are complaints of vibrations from residents living along West Green Avenue, resulting from vehicles traversing West Green Avenue. The distances from closest houses to the existing road range from 9.8 metres to 13 metres. The vibration impact was predicted on the closest receptor (9.8 metres away) using a loaded truck as the operating equipment/vehicle.

Results showed that the PPV vibration value was 0.88 mm/sec. When compared to the standards as outlined in Table 3-21 and Table 3-22, from a building standpoint, the vibration levels predicted will have no effect on building structures. However, from a human standpoint, vibration levels predicted are perceptible and may annoy persons inside their homes if continuous.

Predicted vibration levels using a loaded truck therefore confirm what is currently being experienced by some residents living along West Green Avenue.

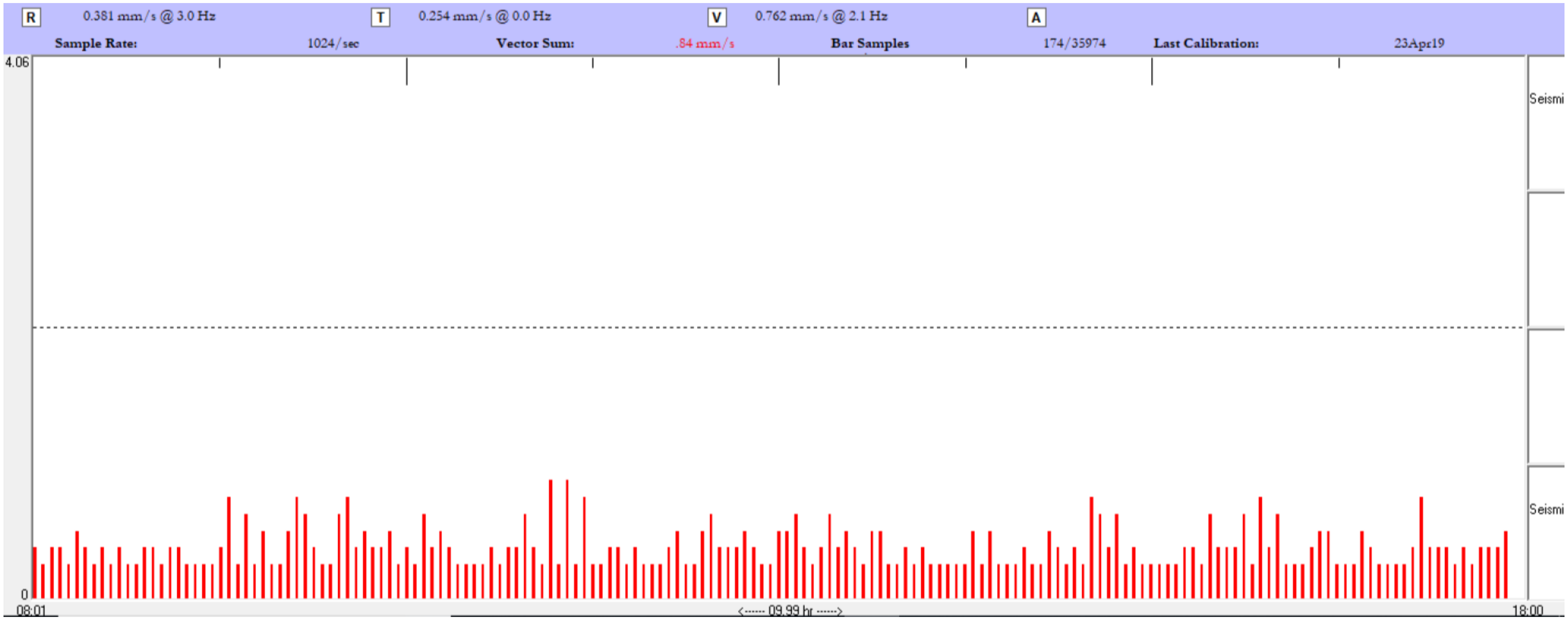


Figure 3-72 Ten-hour seismogram at West Green Avenue, June 3, 2019

3.1.10 Sources of Pollution

Pollution sources include sedimentation from rivers such as the Montego/Barnett River as well as various drains and gullies which traverse the project area and associated anthropogenic pollutants. Other forms include indiscriminate solid waste disposal, air pollution from charcoal burning and field preparation, noise pollution from truck engine brakes and honking of horns and domestic sewage disposal (e.g. pit latrine).

3.1.11 Hazard Vulnerability

3.1.11.1 Earthquakes

Jamaica straddles the boundary between Caribbean tectonic plate and Gonave micro-plate. The Walton and the Enriquillo Fault Zones, extending respectively to the west and the east of Jamaica, form the boundary between these two plates. The movement across these two fault zones are transmitted through the Jamaican Fault system and are the source of significant earthquake activity in the island. The closest active faults near the project site are the Duanevale Fault zone and the Montpelier-New-Market Fault zone which intersects near Montego Bay and has respectively an E-W and NNW- SSE orientation. Figure 3-73 shows the M-NM fz - Montpelier-New-Market Fault zone ((DeMets, C and Wiggins-Grandison, M.D., 2007). During a large earthquake, inactive faults can be reactivated. Faults normally correspond with zones of weaknesses but that is not always the case, in particular with soft limestone such as marls and chalks. Water flowing along fractures in those deposits can cause secondary recrystallization which sometimes forms harder rocks in the fault zone.

Epicentres and magnitudes of earthquake events between of 1977 and 2014 are presented in Figure 3-74. The earthquake activity in the Montego Bay area is demonstrably lower than in Kingston area. The March 1, 1957 earthquake which impacted mainly Montego Bay was a clear reminder however that the earthquake risk exposure in the North-western region of Jamaica is still significant and cannot be ignored.

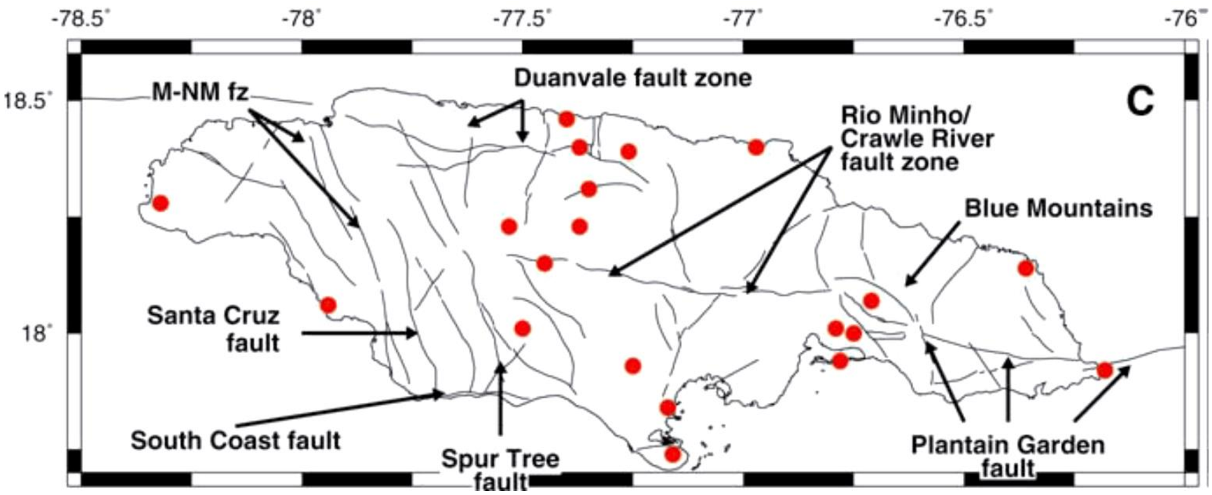


Figure 3-73 Potentially Active Major Faults (M-NM fz is the Montpelier-New-Market Fault zone) (source DeMets C. and Wiggins-Grandison M.D. (2007)).

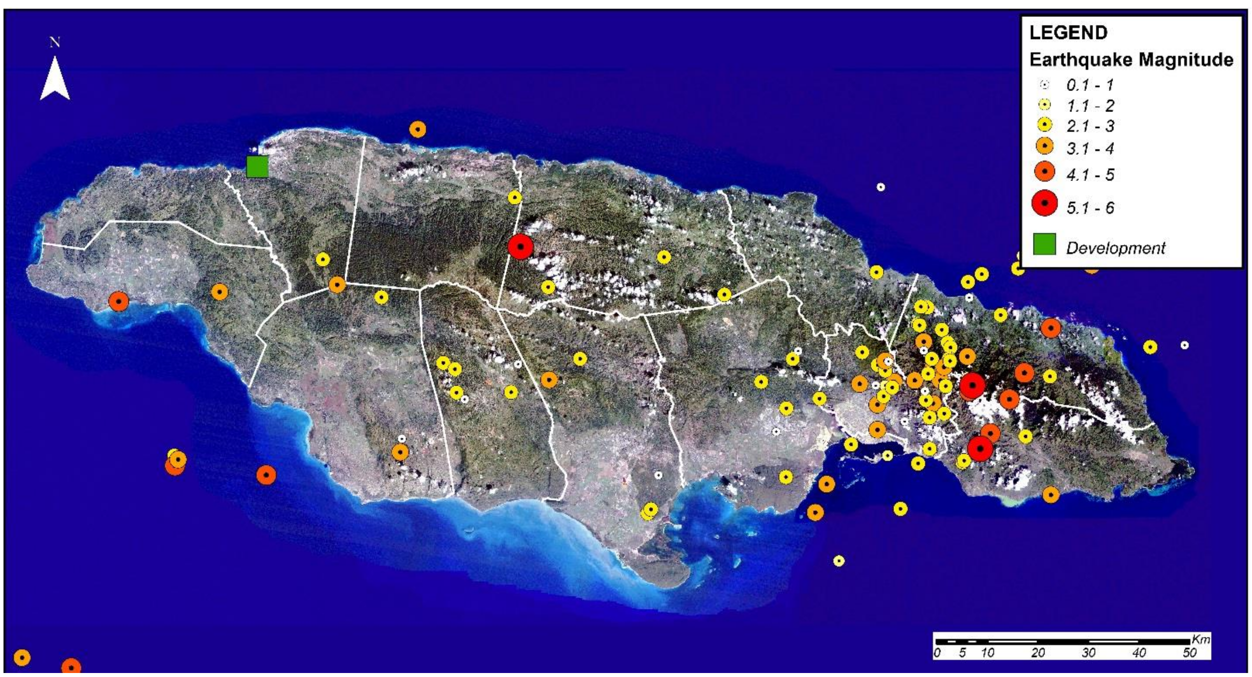


Figure 3-74 Earthquakes in Jamaica 1977-2014 (Source: earthquake.usgs.gov Earthquake Archive)

The Probabilistic Seismic Hazard Assessment of Jamaica by (Salazar, W, Brown, L and Mannette, G, 2013) based on updated earthquake catalogue for Jamaica covering the period 1551-2010 provides design estimates for Peak Ground Acceleration (PGA) for the Return Period of 475 years and Spectral Acceleration (SA) for structural periods of 0.2s and 1s and 5% damping for the 2475-year and 4975-year Return Period. Peak ground acceleration (PGA) is the maximum horizontally acceleration (or rate of change of speed) that the ground is subjected to by an earthquake. Spectral Acceleration is the maximum horizontally acceleration that an object (i.e. a building) will experience by a seismic wave of a specific period. The Spectral Acceleration (SA) is the preferred Seismic Hazard intensity parameter used in most modern building code including the International Building Code 2012 is. The oscillator period is chosen to match the fundamental period of the structure; the short period 0.2 sec corresponds with low buildings that are a few floors tall and the long period of 1.0 sec is used for tall buildings of more than 7 floors. The Peak Ground Acceleration and Spectral Accelerations for the project area extrapolated for the project area from the seismic hazard maps for Jamaica published in (Salazar, W, Brown, L and Mannette, G, 2013) are summarized in Table 3-34.

Table 3-34 Estimated Peak Ground Acceleration & Spectral Accelerations for the Montego Bay Area

Parameter	Return Period in Years		
	475	2,475	4,975
PGA	0.173-0.191g	-	-
S_S (0.2s SA)	-	0.794-0.868g	1.028-1.116g
S_1 (1.0s SA)	-	0.230-0.255 g	0.282-0.314g

It should be noted that these parameters are in reference to rocky site conditions only. They do not take in account the amplification caused by local conditions and may have to be adjusted to address site-specific conditions. For example, saturated sands with an SPT N-value of approximately 12 or less will have a factor of safety of 1 or less for liquefaction when subjected to shaking equivalent to the Peak Ground Acceleration (PGA) of 0.19g or an earthquake with a magnitude of 7.0 or greater. The consequences of liquefaction may include loss of shallow foundation bearing capacity, loss of axial and lateral resistance within the liquefied zone and post-earthquake settlement. The Liquefaction in the project area would be limited to the area with Quaternary Alluvial and Swamp and March Deposits and can be avoided using appropriate road foundation designs.

3.1.11.2 Landslide Susceptibility

Landslide is a term used to describe several forms of mass wasting that includes a wide range of ground movements, such as slope-failure, mudflow, rockfalls, and debris flow. Landslides occur in a variety of environments, characterized by either steep or gentle slope gradients. Gravity is the primary driving force for a landslide to occur, but there are other factors affecting slope stability which produce specific conditions that make a slope prone to failure. The causes of landslides are usually related to instabilities in slopes and it is usually possible to identify one or more landslide causes and one landslide trigger. The difference between these two concepts is subtle but significant. The landslide causes are the reasons that a landslide occurred in that location and at that time. Landslide causes include geological factors, morphological factors, physical factors and factors associated with human activity. A landslide trigger, however, describes an event that finally initiates the landslide.

3.1.11.2.1 Methodology

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

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 (raster dataset containing verified historical landslides throughout the island) 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.

Data was collected regarding observed landslides throughout island of Jamaica. Preliminary examinations revealed that the 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.

3.1.11.2.2 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:

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

P(A|B): "the probability of Event A ***given*** *Event B has occurred"*
Event ***A*** *is a* *landslide; Event* ***B*** *are the* *parameters* *which cause landslides to occur.*
The parameters include site specific data such as soil type, distance to roads, proximity to faults and slope angles.

The probabilities of existing landslides occurring under the above-mentioned parameters were determined and used to weight/rank the varying subtypes of each parameter. 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.

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

The Analysis was conducted using available Shuttle Radar Topography Mission (SRTM) data. The cell size for this analysis was 91m. Given that LIDAR data is not available for the entire island, SRTM was used to represent island-wide topography. Due to the extensive span of the existing landslide inventory, topographical data outside of the project areas were essential.

3.1.11.2.3 Model Predicted 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 results for the project area plotted as shown in the landslide susceptibility map (Figure 3-75). The general vulnerability of landslides is very low to slight throughout the environs of the proposed highway 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 resulting landslide susceptibility map demonstrates that over the 25km length of the proposed highway alignment, the mid-section segment between chainages 12+800 and 18+000 is the most vulnerable length to landslides. In total, there has been twenty-two (22) locations along the proposed highway alignment identified as being susceptible to landslides (Table 3-35). Heading north along this alignment there is relatively low susceptibility but as the mountainous areas are traversed, the probability of landslides occurring increases and accordingly the susceptibility enters the moderate to high risk classes. The slope angles have significantly increased as well as fault lines are being intersected which may pose a hazard. It is recommended that slope stabilization measures be implemented at these particular locations so as to maintain sustainability and operability of the proposed highway.

The vulnerability model's predictions were assessed by field evaluation to determine whether the predicted sites had experienced landslides or seemed to show early signs of land slippage. Of the twenty (20) visited susceptible landslide areas, only a few showed visible signs of past landslides or a likelihood of its occurrence in the future. While the other sites may not show visible signs, other factors such as the geology and presence of a fault area may invisibly influence and affect the susceptibility.

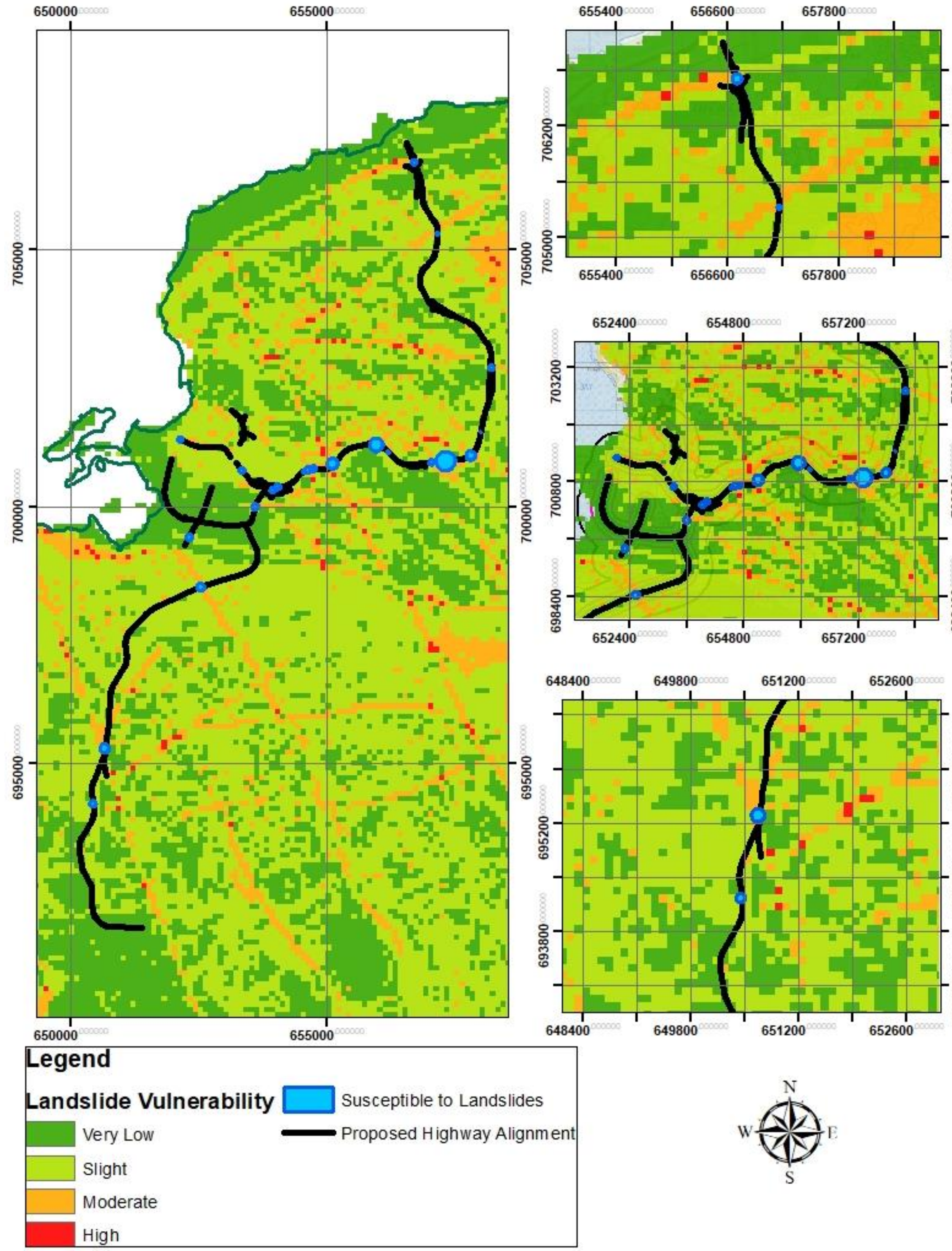


Figure 3-75 Proposed highway alignment superimposed on the Landslide Vulnerability Map

Table 3-35 Susceptible locations identified along proposed highway corridor

No.	Location	Vulnerability	Status
1	K2+320	Moderate	Inaccessible
2	K3+300	Moderate	Verified
3	K3+860	Moderate	Verified
4	K4+100 - K4+440	Moderate	Verified
5	K6+180	Moderate	Verified
6	K7+760	Moderate	Verified
7	K8+420 - K8+540	Moderate	Inaccessible
8	K13+000	Moderate	Verified
9	K13+622	Moderate	Verified
10	K14+200 - K14+500	Moderate	Verified
11	K14+800	High	Verified
12	K14+800 - K14+921	Moderate	Verified
13	K15+750 - K15+950	Moderate	Verified
14	K16+100	Moderate	Verified
15	K17+000 - K17+100	Moderate	Verified
16	K17+200 - K17+500	Moderate	Verified
17	K17+600 - K17+900	Moderate	Verified
18	K18+300	Moderate	Verified
19	K20+600	Moderate	Verified
20	K23+000	Moderate	Verified
21	K24+500	Moderate	Verified
22	Port Bello (Interchange at K17+000)	High	Verified

3.1.11.3 Hurricanes

Hurricanes produce heavy rainfall, high winds, and storm surge, all of which have the potential to cause damage and dislocation. Extreme rainfalls and sea levels are typically associated with hurricanes and tropical storms and depressions. Hurricanes can form almost anywhere in the Tropical Atlantic Basin from the West Coast of Africa near the Cape Verde Islands, to the Gulf of Mexico and the Caribbean Sea which are the main development areas. Jamaica lies in the Atlantic hurricane belt west of one of the Main Development Area, Cape Verde Islands. Over the past twenty years, at least five major hurricanes have impacted the Caribbean region (Figure 3-76).

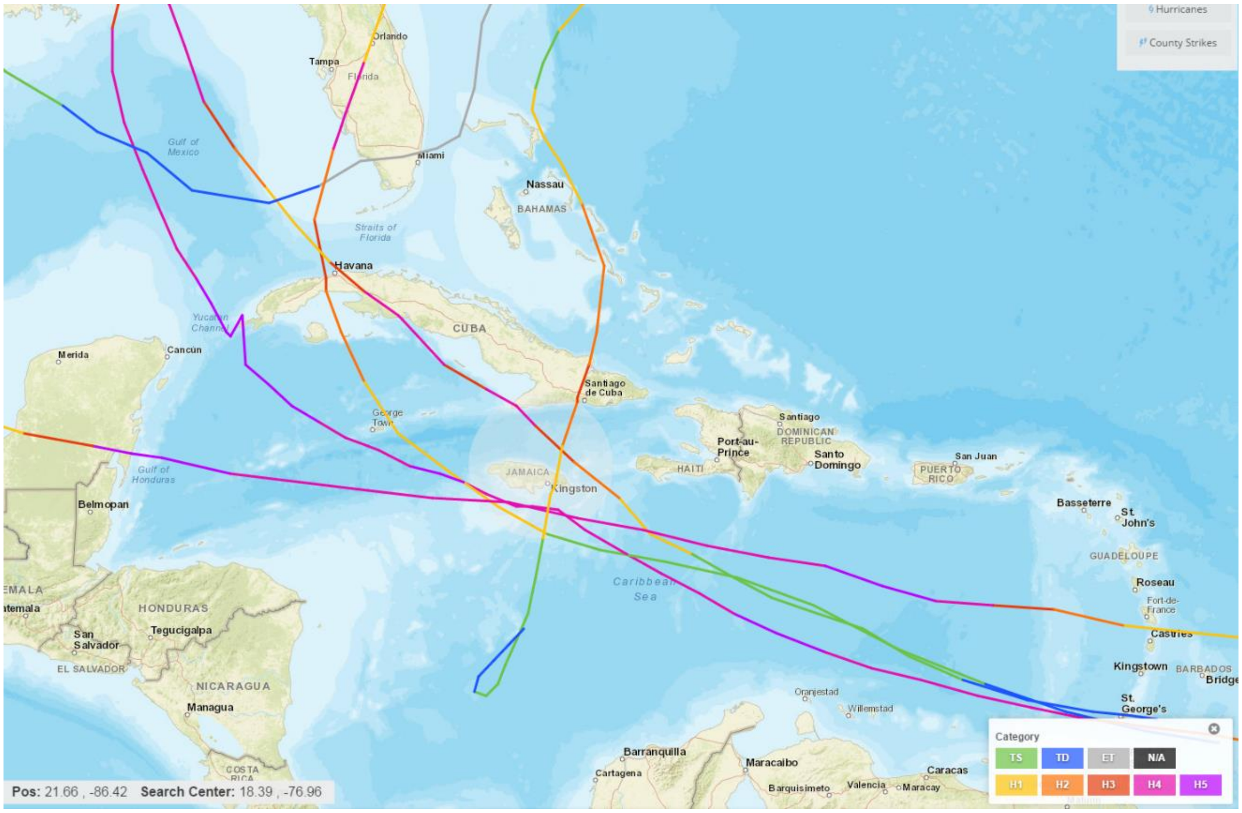


Figure 3-76 Tropical storms/Hurricanes passing through the Caribbean over the past fifteen (15) years.

In recent times, global and regional climate change models have been predicting changes in the climate conditions that may increase the impacts of the coastal hazards. Jamaica's Second National Communication (SNC) on Climate Change (Government of Jamaica, 2011) lists the main climate change hazards as follows:

- Sea level rise
- Increase in extreme events – precipitation and drought
- More intense storms and increased storm surge levels
- Increased temperature

The Intergovernmental panel on Climate Change (IPCC) have made projections based on numerical models which indicate tropical storms are far more intense storms than in previous years. The (2007) IPCC report (Solomon, 2007) stated the following:

> *"There is evidence from modelling studies that future tropical cyclones could become more severe, with greater wind speeds and more intense precipitation. Studies suggest that such changes may already be underway; there are indications that the average number of Category 4 and 5 hurricanes per year has increased over the past 30 years."*

Others have isolated the influence of increasing temperatures on the frequency of hurricanes and have suggested that a 0.5C increase will result in a 40% increase in hurricane activities (Saunders & Lea, 2008). The predictions of the IPCC are consistent with the number of category 4 and 5 storms that have tracked within 400 kilometres Jamaica in the past 130 years (Figure 3-77); the number of category 4 and 5 storms has increased from 10 to 15 storms per twenty year intervals up to 1950 to 30 to 35 storms per twenty years after 1950. This doubling of storm occurrences coupled with increased sea level rise can result in shoreline retreat as beach profiles adjust to a more intense wave climate.

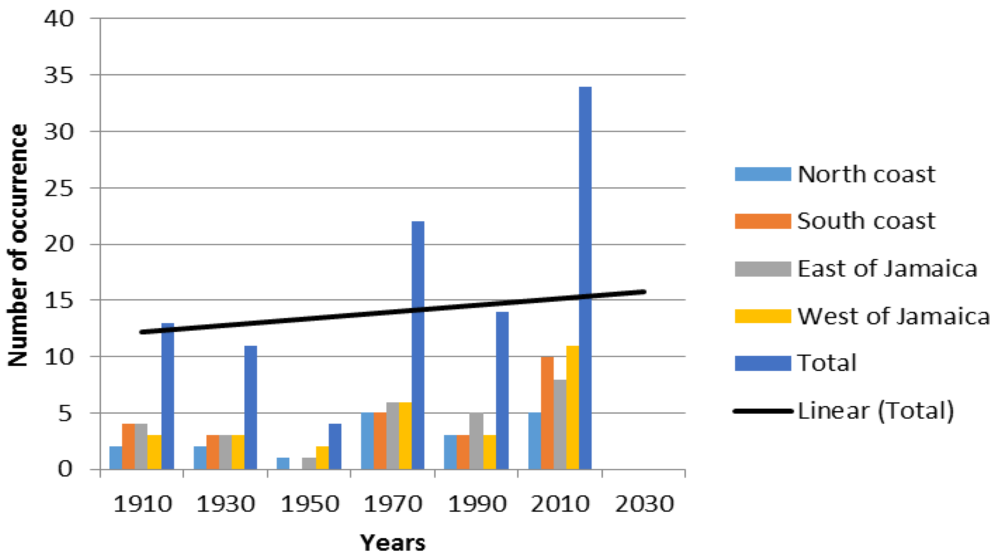


Figure 3-77 Occurrences of Category 4 and 5 hurricanes that have passed within 300 kilometres of Jamaica's shoreline since 1890 to 2014, in twenty years intervals.

3.1.11.4 Flooding

The parish of St. James has experienced several instances of localized flooding in previous years; intense rainfall has caused severe flooding in areas both within and outside of the Montego Bay Town Centre. Three areas were identified as particularly vulnerable to instances of severe flooding: Ironshore, Green Pond and sections of the Montego Bay Town Centre (Figure 3-78). In order to assess the vulnerability of these areas to flooding, residents of the areas identified were interviewed.

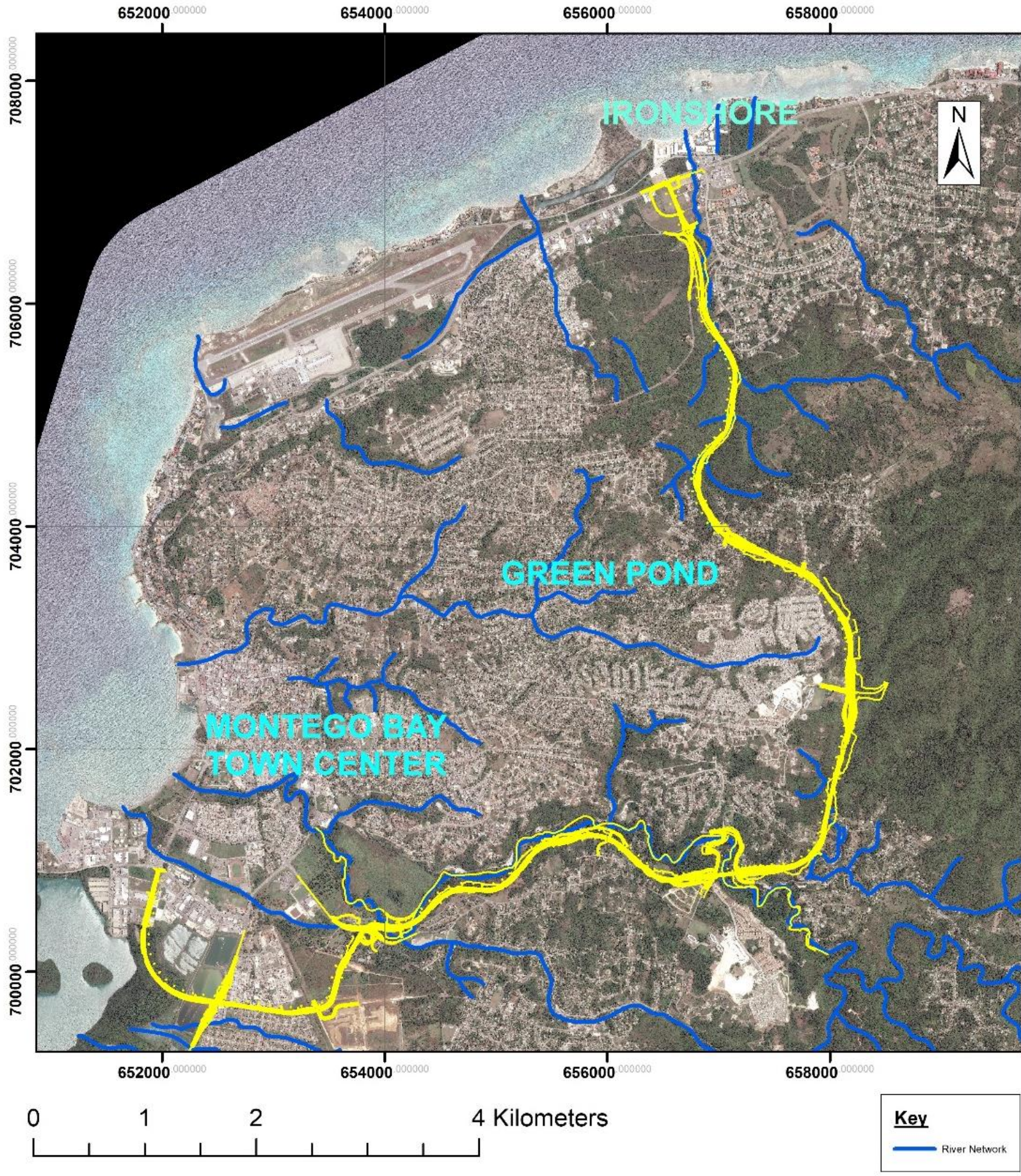


Figure 3-78 Proposed Highway Alignment in relation to the areas vulnerable to flooding.

3.1.11.4.1 Ironshore

Interviewees in Ironshore generally stated that the heavy rainfall of November 2017 was the cause of flooding in the area. They went on to say that flooding in the area was primarily in at the RIU Montego Bay Hotel, which saw flood levels exceed one (1) meter on some sections of the property. The interviewees stated that the cause of the extensive flooding was the Salt Spring Gully which sits adjacent to the hotel (Figure 3-79). During the storm event, the gully was significantly restricted by the presence debris and silt, which caused the gully to overflow its banks causing the intense flooding. Since that event, the gully has been cleaned and flooding in that area has not reoccurred.

Figure 3-79 RIU Montego Bay Hotel in relation to the Salt Spring Gully

Plate 3-28 Photo of Salt Spring Gully, significantly blocked by debris and sediments (Assessment of the St. James November 2017 Flooding, 2018)

3.1.11.4.2 Montego Bay City Centre and Green Pond

Persons interviewed stated that several areas within the Montego Bay City Centre were severely affected by flooding. They continued naming Church Street, Harbour Street and Union street as some of the most severely affected areas.

Respondents recalled flooding in Montego Bay City that extended as far as the Green Pond High School. They went on to state that the area experienced flood depths exceeding one (1) meter above the road level. The gully that runs from the Green Pond area to the city experienced overtopping throughout the entire length of the channel. The interviewees stated that the overtopping of the channel and subsequent flooding as a result of debris and sediment deposits in the channel, reducing its carrying capacity.

Two major gullies which service the Montego Bay area are at the forefront of the flooding issue. Overtopping of the North Gully (Figure 3-80) resulted in severe flooding along Union Street and Church Street with both areas experiencing flood depths exceeding one (1) meter. Similarly, South Street overtopped its banks resulting in severe flooding along Princess Street. Along with blockage due to debris, another possible cause for the overtopping is the rainfall events exceeding the design capacity for both the North and South Gullies. Flood plain encroachment is also a serious issue in the area. Building and infrastructure constructed in close proximity to these gullies and drains are exceedingly vulnerable to the effects of flooding once the channel exceeded its capacity and overtopping has occurred.

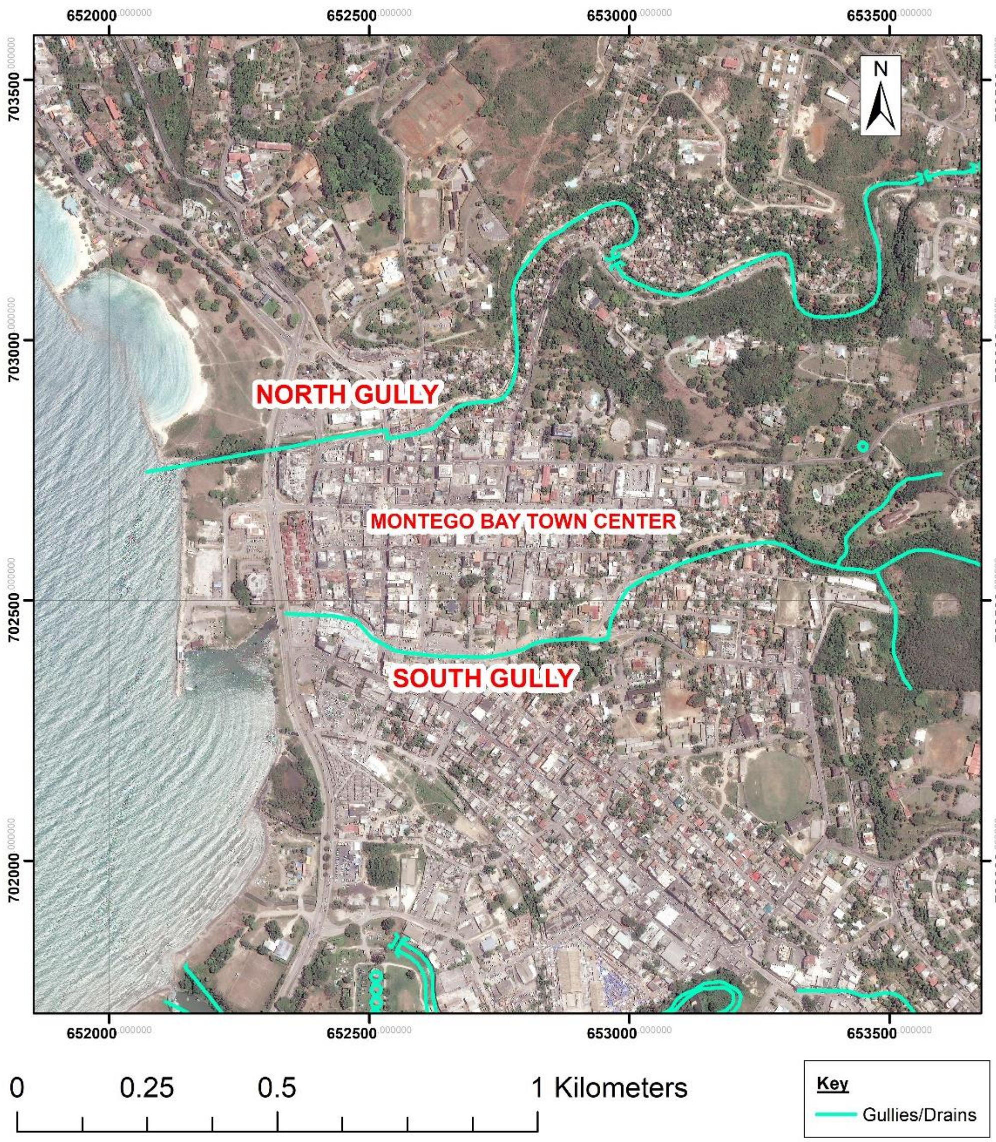


Figure 3-80 Map of Montego Bay City Centre, and alignment of North and South Gullies

Source: Clean-up operations of the North Gully in Montego Bay, St. James. URL: http://rjrnewsonline.com/local/gun-recovered-in-montego-bay-clean-up/

Plate 3-29 North Gully being cleared of debris and sediment after intense rainfall

Source: Debris blocking the South Gully in Montego Bay, St. James. URL: http://www.caribfocus.com/mobay-drain-blockage-caused-by-condoms-report/

Plate 3-30 South Gully blocked by debris

3.1.11.5 Coastal Flooding

There would be only one area that would be subjected coastal inundation. That area is the section of the highway within the Bogue Lagoon. The predicted storm surge heights in numerous reports of between 1.8 – 2.4m, means that the proposed final road elevation of 4 – 6m in that region would be above the expected water levels and therefore would not pose a threat to the proposed road infrastructure.

3.2 BIOLOGICAL ENVIRONMENT

3.2.1 Terrestrial Flora

3.2.1.1 Survey 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.

3.2.1.1.1 Montego Bay Perimeter Road and Long Hill Bypass

The dynamics of the study area were as such that the planned footprint of the highway development encountered both highly developed lands (used for agricultural, semi-industrial and residential purposes) as well as disturbed, woodland vegetation growing on alluvium with some limestone outcroppings. Owing to this heterogeneity in topography and land use, two approaches were used in assessing the vegetation along the planned corridor. For disturbed, urbanised/residential areas a window survey was conducted where the existing road network was utilised to traverse the areas to be affected by the proposed development.

For areas more remote with more contiguous stands of vegetation, a series of walk-throughs were conducted. These processes were aided by a Trimble Geo 7x handheld GPS unit programmed with the coordinates of the highway paths. General notes were made regarding the plant species and the land-use types observed. For contiguous woodland areas, where the vegetation was deemed to be more ecologically important, a more thorough field assessment was required. As such, a combination of plot-less[2] field-sampling methodologies was employed. These were 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 fewer workers (Barbour et al. 1987; Mitchell 2007).

The PCQ method involved the selection of regular points along a transect line: the area around which was divided into four quarters by an imaginary line bisecting the transect at 90°. The nearest tree within each quarter was then identified and its height, diameter at breast height (DBH), and distance from the central point measured. The sample locations and points were determined with the aid of a Trimble Geo 7x 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[3] 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 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: Absolute density (λ) $= \frac{10000}{\bar{r}^2}$ (# of trees/ha). Where $\bar{r}$ = mean distance for all points.

Equation 2: Relative Density (species k) $= \frac{\lambda_k}{\lambda} * 100$ (%). Where λk = absolute density for species k.

Equation 3: Relative Cover (species k) $= \frac{Total\ BA\ of\ species\ k\ in\ sample\ location}{Total\ BA\ of\ all\ species\ in\ sample\ location} * 100$ (%). Where BA = Basal Area.

Equation 4: Relative Frequency (species k) $= \frac{Absolute\ frequency\ of\ species\ k}{Total\ frequency\ of\ all\ species} * 100$ (%).

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).

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[2] 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)

[3] DAFOR occurrence rank: usually a subjective scale of specie occurrence within an area of study. The acronym refers to, Dominant, Abundant, Frequent, Occasional, Rare.

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.

The inland vegetation survey was conducted January 10-11 and 19, 2019 and the survey site locations may be seen in Figure 3-81.

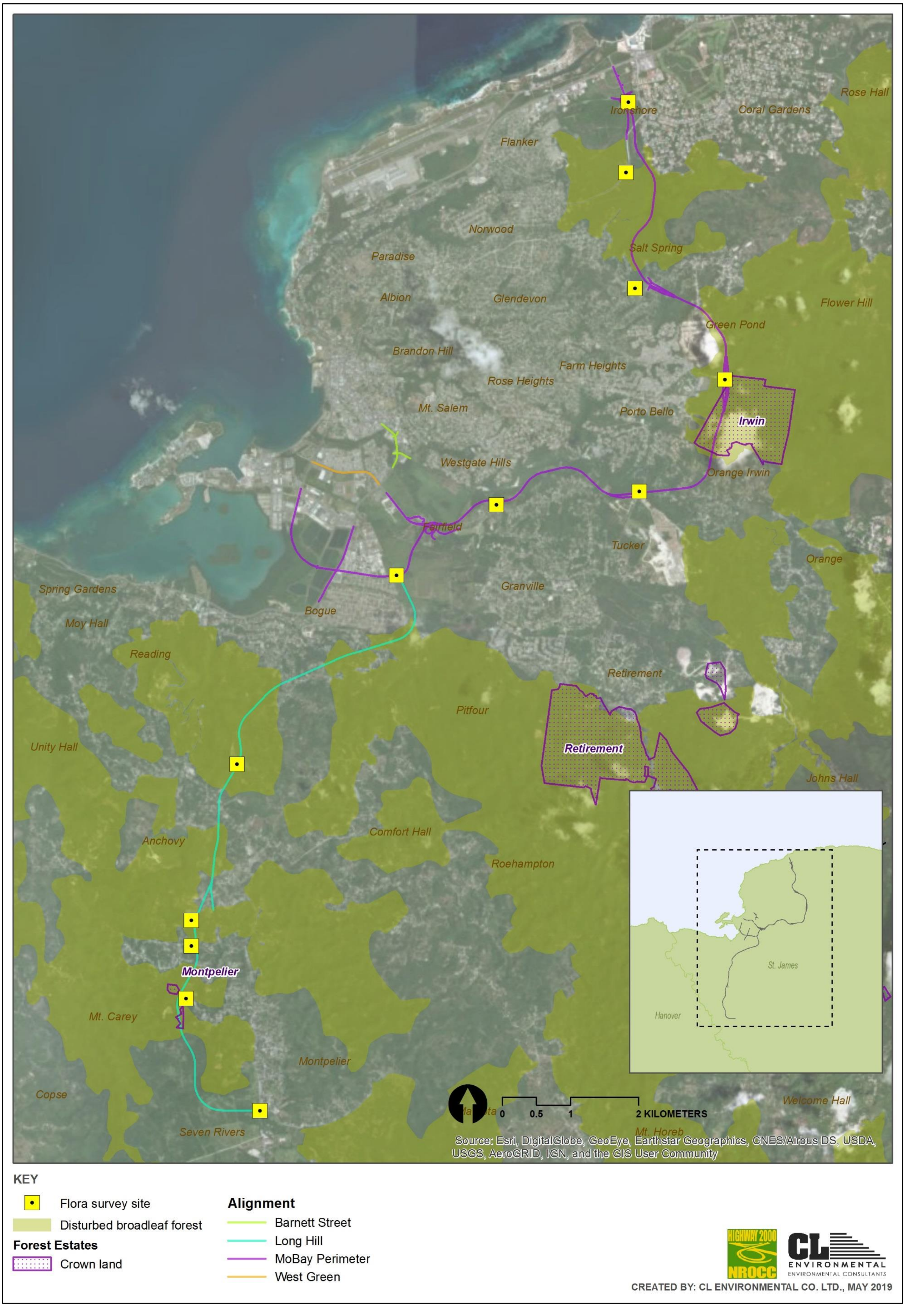


Figure 3-81 Flora survey sites

3.2.1.1.2 West Green Avenue and Barnett Street

The survey was done on May 23, 2019 and involved West Green Avenue (between Howard Cooke Highway and Barnett Street) and Barnett Street (from the intersection of West Green Avenue to the intersection of Cottage Road) roadways. As these areas were highly influenced by human residential and commercial activities, it was believed that a window survey would suffice in gathering the information necessary to describe the flora along these corridors. Species observed were identified in-situ and their occurrence noted according to a DAFOR subjective scale.

3.2.1.2 Montego Bay Perimeter Road

The proposed footprint of the Montego Bay Perimeter Road segment was assessed using seven sampling sites (Figure 3-81) which may be grouped into four zones:

1. South, along the Bogue Village and Fairfield to Irwin roads
2. To the north, near Ironshore, on lands accessible by the Quebec Main Road
3. Centre-east in the Montego Hills
4. To the east, lands adjacent the Green Pond Schools

All sites showed high levels of anthropogenic disturbance given the roadways planned proximity to residential and commercial developments.

3.2.1.2.1 Bogue Village, Fairfield and Irwin (including section of the Irwin Forest Management Area)

The vegetation along this southern leg of the planned highway, mainly encounters lands that had undergone or were currently undergoing residential development. The Bogue Village to Fairfield section, in particular, had undergone extensive housing and road development in just one year (Figure 3-82 and Plate 3-31). As such, contiguous stands of limestone forest or woodland were difficult to locate. Intact communities tended to be located on somewhat steep, rocky slopes – dominated by the ubiquitous *Bursera simaruba* (Red Birch) (Plate 3-32). Otherwise, lands consisted of pastures or fallow fields.

Of the 92 recurring species, *Panicum maximum* (Guinea Grass), *R. altissima* and *Samanea saman* (Guango) were the most common though they did not dominate the flora they occupied (see Appendix 4 for complete listing of flora species). *Bursera simaruba* (Red Birch) dominated limestone relicts, while *Adenanthera pavonina* (Red Bead Tree) was a leading constituent of disturbed woodland margins. Trees on limestone tended to be low in stature (5-7 m tall) and thin-boled (5-15 cm).

Figure 3-82 Development of Bogue Village/Fairfield in one year. Left imagery from 2018, right imagery from 2019

Common shrubs were *Casearia hirsute* (Cloven Berries) and the aromatic, *Chromolaena odorata* (Christmas Bush). *Cordia bullata* and *Zamia* sp. were uncommon, yet endemic constituents of the flora. Grasses dominated pastures (Plate 3-21), especially those species typically used for fodder; namely, *Panicum maximum* (Guinea Grass) and *Pennisetum purpureum* (Elephant Grass). Climbers occurred throughout; however, *Abrus precatorius* (Red Bead Vine) was frequently encountered.

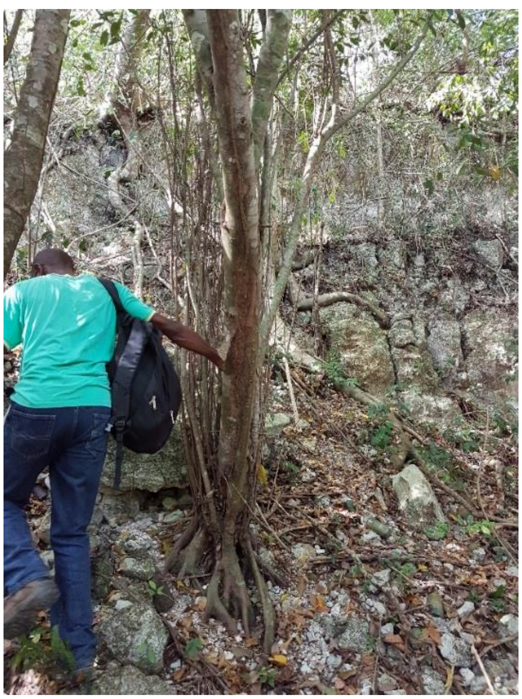


Plate 3-31 Steep, rocky terrain on limestone hill near Irwin, St. James. Note the root types required by the constituent trees and the thin diameter of the trunks.

Plate 3-32 Steep, grass-dominated pastureland along Fairfield main road, St. James

3.2.1.2.2 Lands near the Quebec Main Road

Here, more contiguous woodland stands were encountered; however, these primarily consisted secondary communities growing over limestone rubble and alluvium. Sites located in the lowland areas (near the community of Ironshore) were dominated by *Haematoxylon campechianum* (Logwood) (Plate 3-33), followed by *Malpighia glabra* (Wild Cherry). Phanerophyte heights ranged between three and 12 m; averaging approximately 7.6 m. The mean tree diameter was 12.8 cm and tree density was low, at 280.1 trees/ha.

Plate 3-33 Haematoxylon campechianum (Logwood) trees at the foot of the highland areas near Quebec, St. James

When compared to highland areas (Upper Quebec) the dominance of *H. campechianum* was replaced by *Piscidia piscipula* (Dogwood), while the caustic *Metopium brownii* (Burn Wood) also provided significant canopy cover. Both tree species are common constituents of arid woodlands on limestone. Tree heights were more homogenous in this area, averaging out at approximately 5.7 m. The mean tree diameter was also smaller at 5.3 cm; however, density was notably higher at 4,082.9 trees/ha. These are characteristics of limestone flora where the adaptive strategy is to be conservative due to the lower availability of water and nutrients.

Other common species included *Capparis ferruginea* (Mustard Shrub), *Fagara martinicensis* (Prickly Yellow) and *Lantana camara* (Wild Sage). Herbs and climbers played a lesser role than in the Fairfield communities; in this case turf grasses, such as *Andropogon pertusus* (Seymour Grass) and *Zoysia tenuifolia* (Carpet Grass), occurred frequently.

Endemics were common and included the trees *Eugenia amplifolia* and *Thrinax parvifolora* (Broom Thatch) (Plate 3-34); the shrubs *C. bullata* and *Lisianthius longifolius* (Jamaican Fuchsia) (Plate 3-35); and the climbers *Galactia pendula* and *Paullinia barbadensis* (Supple Jack). Overall there were 61 species encountered in the Quebec area.

Plate 3-34 The endemic Lisianthius longifolius (Jamaican Fuchsia) in bloom

Plate 3-35 The endemic Thrinax parvifolora (Broom Thatch)

3.2.1.2.3 The Montego Hills

The vegetation here showed a very high level of disturbance, with most of the flora consisting of trees and herbs restricted to open lots between dwellings. Only 13 species were recorded here; however, the endemic palm *Sabal jamaicensis* (Bull Thatch) was a conspicuous, possibly relict, constituent. The most abundant trees were cultivated; namely, *Pimenta dioca* (Pimento) and *Blighia sapida* (Ackee). Herbs such as *Andrographis paniculata* (Rice Bitters) and *Bidens pilosa* (Spanish Needle) were common.

3.2.1.2.4 Lands near Green Pond

Some 43 plant species were recorded at this most easterly, highland site located on the outskirts of the Green Pond High School. Of these, five were endemic: *Cordia bullata* (Plate 3-36); *Eugenia amplifolia*; *Hohenbergia* sp.; *Hylocereus triangularis* (God Okra); and *P. barbadensis*. Here, *B. simaruba* dominated the canopy layer, with *H. campechianum* and Nectandra sp. also well represented. Average tree height was 4.9 m and bole diameters ranging between 3.5-18 cm. Despite the forest areas being set back from the residential developments (Plate 3-37), the overall tree-density of the flora investigated was 2,106.6 trees/ha.

Other common species included the trees *F. martinicensis* and *Guazuma ulmifolia* (Bastard Cedar) and the grass *Andropogon pertusus* (Seymour Grass).

Plate 3-36 The endemic Cordia bullata

Plate 3-37 Forested areas set back from residential developments.

3.2.1.3 Long Hill Bypass

The proposed footprint of the Long Hill Bypass was assessed using six sampling sites (Figure 3-81) which may be grouped into three zones (from south to north):

1. Lands near Montpelier
2. Lands along Mount Carey
3. Lands from Anchovy to Bogue Hills

Here the lands were somewhat less disturbed as those encountered on the Montego Bay Perimeter Road, however all sites showed signs of anthropogenic disturbance at varying levels.

3.2.1.3.1 Lands near Montpelier

Much of this area was apparently used as a recreational, off-roading facility and for silviculture. Several tracks could be seen as well as the tree-flora consisted almost entirely of *Spathodea campanulata* (African Tulip Tree) (Plate 3-38). These trees were grown in hedgerows: evenly spaced (roughly 2 m apart) so that an absolute density of 3,363.9 trees/ha was observed. These trees grew to 20 m in some cases and the maximum diameter at breast height recorded was 78 cm. Other tree species found include *Citrus* sp., *Nectandra antillana* (Yellow Sweetwood) and *Peltophorum linnaei* (Braziletto).

Plate 3-38 African Tulip Tree woodlands at Montpelier

The altitude and cool, moist climate was ideal for several epiphytic plants (Plate 3-39 and Plate 3-40); namely, *Guzmania* sp., *Tillandsia juncea* and in more open areas, *Polypodium polypodioides* (Resurrection Fern).

Plate 3-39 Epiphytic fern on African Tulip tree

Plate 3-40 Epiphyte, Guzmania sp

Shrubs were somewhat restricted to the woodlands, where *Cordia bifurcata* and *Miconia impetiolaris* were commonly associated species. In the grasslands surrounding the silviculture plots, *Pennisetum purpureum* (Elephant Grass) was the dominant herb. *Andropogon pertusus* (Seymour Grass) and *Sorghum halepense* (Johnson Grass) were also represented well. Climbers such as *Ipomoea tiliacea* (Wild Potato), Centrosema pubescens and Mikania micrantha (Guaco) occurred frequently, growing on stumps and among the grass blades.

Overall, 65 species were encountered, including the inconspicuous vine *Serjania laevigata* and the endemic tree, *R. altissima*.

3.2.1.3.2 Lands along Mount Carey (Including section of the Montpelier Forest Management Area)

Again, a heavily impacted location influenced by nearby and expanding settlements (Plate 3-41). No contiguous woodlands were accessible. Sixty-one species were recorded here, three of which were endemic. These were *Eupatorium triste* (Old Woman's Bitter Bush), *P. barbadensis* and *R. altissima*.

Plate 3-41 Settlements encroaching into disturbed woodlands

The most common tree was *Cecropia peltata* (Trumpet Tree) which had a very short habit and was sparsely distributed. The arborescent shrub, *Bambusa vulgaris* (Common Bamboo) was common along with *C. odorata* (Christmas Bush) and *Triumfetta triloba* (Bur Weed). However, herbs dominated the flora; mainly the grasses *P. maximum*, *Pennisetum purpureum* (Elephant Grass) and *Themeda arguens* (Piano Grass). The climber, *Psophocarpus palustrus* (Wing Bean) was a frequent constituent as well.

Plate 3-42 Disturbed flora along section of Mount Carey in residential area

3.2.1.3.3 Lands along Anchovy to Bogue Hills

This area was bisected by an overgrown 0.7 km path that allowed pedestrian traffic from Anchovy, northward to Bogue hills. The ground cover of this community was dominated by the fern *Nephrolepis* sp. (Plate 3-43) while common tree species were *Andira inermis* (Cabbage Bark Tree), *Casearia guianensis* (Wild Coffee), the ubiquitous *S. campanulata* and H. campechianum (Logwood). The shrub Miconia impetiolaris was well represented. Interestingly the Resurrection Fern was also an occasional constituent.

Overall, six of the 62 plant species encountered along this northern route were endemic or of national importance. These included the national tree, *Hibiscus elatus* (Blue Mahoe); the epiphytes *Hohenbergia* sp. (Plate 3-44) and *H. triangularis*; the trees *Eugenia amplifolia* and *Piper amalago* var. *nigrinodum* (Black Jointer); as well as the herb *Rytidophyllum tomentosum* (Search-me-Heart).

Plate 3-43 Fern dominated ground cover

Plate 3-44 *Hohenbergia sp* in bloom

3.2.1.3.4 Flora of Highly Residential and Urban Areas

These areas include areas such as West Gate Hills, Barnett Street and Bogue Village. Here the flora is mainly represented within residential lots or in public spaces. As expected, fruit trees, such as *Artocarpus altilis* (Breadfruit) and *B. sapida* were most frequent. Along verges and round abouts *P.*

maximum and *Colubrina asiatica* (Hoop Withe) tend to be common as well as shade trees; namely, *Samanea saman* (Guango) and *Delonix regia* (Poinciana).

The Cuban Royal Palm (*Roystonea regia)* was found in landscaped yards within residential/private premises.

3.2.1.4 West Green Avenue

This roadway delimits the southern boundary of the residential community of Catherine Hall. It separates a large number of dwelling units to the north from commercial retail facilities and a large, open plot of land to the south. As such, the flora along this corridor was heavily influenced by landscaping activities and nearby residential gardens. One could argue that apart from what occurred along unkempt verges, the majority of the species encountered were planted or escaped from garden cultivation.

Herbs dominated the flora, where the grass *Sporobolus* sp. was a major constituent along verges, walkways and landscaped roundabouts. In unkempt areas, the species gave way to patches of *Panicum maximum* (Guinea Grass) (Plate 3-45). Associated with these grasses were the Asterids, *Bidens pilosa* (Spanish Needle) and *Tridax procumbens*. The climber, *Ipomoea tiliacea* (Wild Potato) frequently occurred along fences and on trees in open lots.

Plate 3-45 Section of West Green Ave. adjacent open lot. Large Samanea saman (Guango) tree in background; verge dominated by Panicum maximum (Guinea Grass)

The roadway and some of its roundabouts (Plate 3-46 and Plate 3-47) were lined with ornamental trees. These were apparently selected for their aesthetics and/or the fruit they bore. The most common trees were the conspicuous, *Casuarina equisetifolia* (Willow) (Plate 3-48), *Mangifera indica* (Mango) and *Samanea saman* (Guango); he latter casting large areas of shade where planted. These trees ranged in height, approximately, from 7.5 m, 6 m and 12 m respectively; along with bole-diameters between 20 cm and 50 cm.

Plate 3-46 Large S. saman trees planted at one of the roundabouts on West Green Ave.

Plate 3-47 Large Ficus sp. trees planted at a roundabout on West Green Ave.

Plate 3-48 View of West Green Ave. looking west. Note tree lined verges – in this scene, several Terminalia catappa (W.I. Almond) and Casuarina equisetifolia (Willow) trees line the verges.

3.2.1.5 Barnett Street

This corridor appeared to be under less residential and landscaping influence than West Green Avenue. With this being an active thoroughfare, it could be seen that the verges were regularly cleared; allowing mainly grasses, such as the ubiquitous *Andropogon pertusus* (Seymour Grass), *Eleusine indica* (Yard Grass), *Panicum maximum* (Guinea Grass) and *Sporobolus* sp., to grow along the curbs (Plate 3-49). Other common herbs included *Amaranthus dubius* (Spanish Calalu) and *Boerhavia diffusa* (Hog Weed).

Plate 3-49 Grassy verge along Barnett Street. Note trees set back from roadway. Mangifera indica in foreground; verge dominated by grasses – Panicum maximum and Andropogon pertusus

Overall, tree species were limited and set-back from the roadway (Plate 3-49). The largest stand of trees occurred mainly along the banks of the Barnett River, which the road crosses (Plate 3-50). Trees closest to the roadway consisted mainly of a large representative or two of *Samanea saman* (Guango), *Spathodea campanulata* (African Tulip Tree) and *Cordia sebestena* (Geiger Tree). As the roadway entered a more urban setting, palms became more prevalent (Plate 3-51). *Livistona* sp., *Phoenix roebelenii*, *Roystonea regia* (Cuban Royal Palm) and *Washingtonia* sp. were planted along the borders of commercial complexes. The stature of the trees varied greatly in height, from 2-metre tall trees located in high stress areas (exposed to high light and low water; poor soil conditions near roadside margins), to 11-metre tall trees located in areas under more favourable conditions (shaded areas with better soil quality due to nutrients from leaf-fall). Bole diameters of the trees were just as variable.

Plate 3-50 Vegetation along banks of the Barnett River as it meets the Barnett Street Bridge

Plate 3-51 Prevalence of palms in built up areas along Barnett Street

3.2.1.6 Summary of Findings

In total the following number of species were encountered on the flora surveys:

- 142 along the Montego Bay Perimeter Road
- 135 along the Long Hill Bypass
- 76 along West Green
- 49 plant along Barnett Street

Based on species composition, Montego Bay Perimeter Road and Long Hill Bypass study areas had a moderate Jaccard Similarity Coefficient of 49.6 % (where approximately half the species encountered were common to both segments). Overall, 15 endemic species were noted along Montego Bay Perimeter Road and Long Hill Bypass, most occurring along the Montego Bay Perimeter Road segment. The most commonly occurring was the palm *Roystonea altissima* (Mountain Cabbage), occurring in five of 13 sites. They appeared to be relicts of prior communities and planted in some cases (Plate 3-52). No endemic or ecologically threatened species were found along West Green or Barnett Street alignments.

Please see Appendix 6 for a complete listing of flora species encountered throughout the flora survey.

Plate 3-52 Residential occurrence of the Royal Palm Roystonea sp.

Most of the species recorded were trees; however, in terms of percentage occurrence, shrubby herbs and climbers were most frequently encountered, especially along the Montego Bay segment. Typically, such growth forms are indicative of (but not exclusive to) secondary regeneration after disturbances. This was evidenced by the several adjacent agricultural plots and residential communities in the developments' paths (Plate 3-53 and Plate 3-54). Overall, the frequency of epiphyte-species matched that of tree-species, with notably more epiphytes occurring along the Long Hill Bypass segment, when compared to the Montego Bay segment. Of these species, a few were Bromeliads, which are noted for the importance they play in creating micro-ecosystems with the water and detritus they collect in the axils of their leaves.

Table 3-36 Percentage occurrence of growth forms encountered for sites investigated along the Montego Bay Perimeter Road and Long Hill Bypass

Growth Forms	Species Count	Mean % Frequency (Montego Bay Perimeter Road)	Mean % Frequency (Long Hill Bypass)	Overall Mean % Frequency
Arborescent Shrubs	1	14.3	16.7	15.5
Bryophytes	1		16.7	8.3
Climbers / Twiners	24	21.8	25.0	17.0
True Epiphytes	7	14.3	33.3	18.0
Herbs	50	21.7	23.9	14.7
Shrubs	42	25.4	23.3	15.2
Shrubby Herbs	3	35.7	25.0	20.2
Trees	80	25.7	27.0	18.1

Plate 3-53 Animal Pen located on pastureland near Fairview, Montego Bay

Plate 3-54 Large housing development adjacent the Fairview Theatre, Montego Bay.

3.2.2 Fauna

3.2.2.1 Site Description

The fauna survey for the proposed perimeter road project was conducted in areas classified and zoned according to vegetation type (Plate 3-55through to Plate 3-58); the zones included:

- Woodland
- Secondary Limestone Forest
- Wetlands
    - Artificial sewage ponds
    - Riverine vegetation

Faunal sampling sites are displayed in Figure 3-83.

Plate 3-55 Examples of areas zoned as a Woodland

Plate 3-56 Upper Lower Secondary Limestone forest

Plate 3-57 Lower Secondary limestone forest (moist)

Plate 3-58 Wetland, the riverine habitat

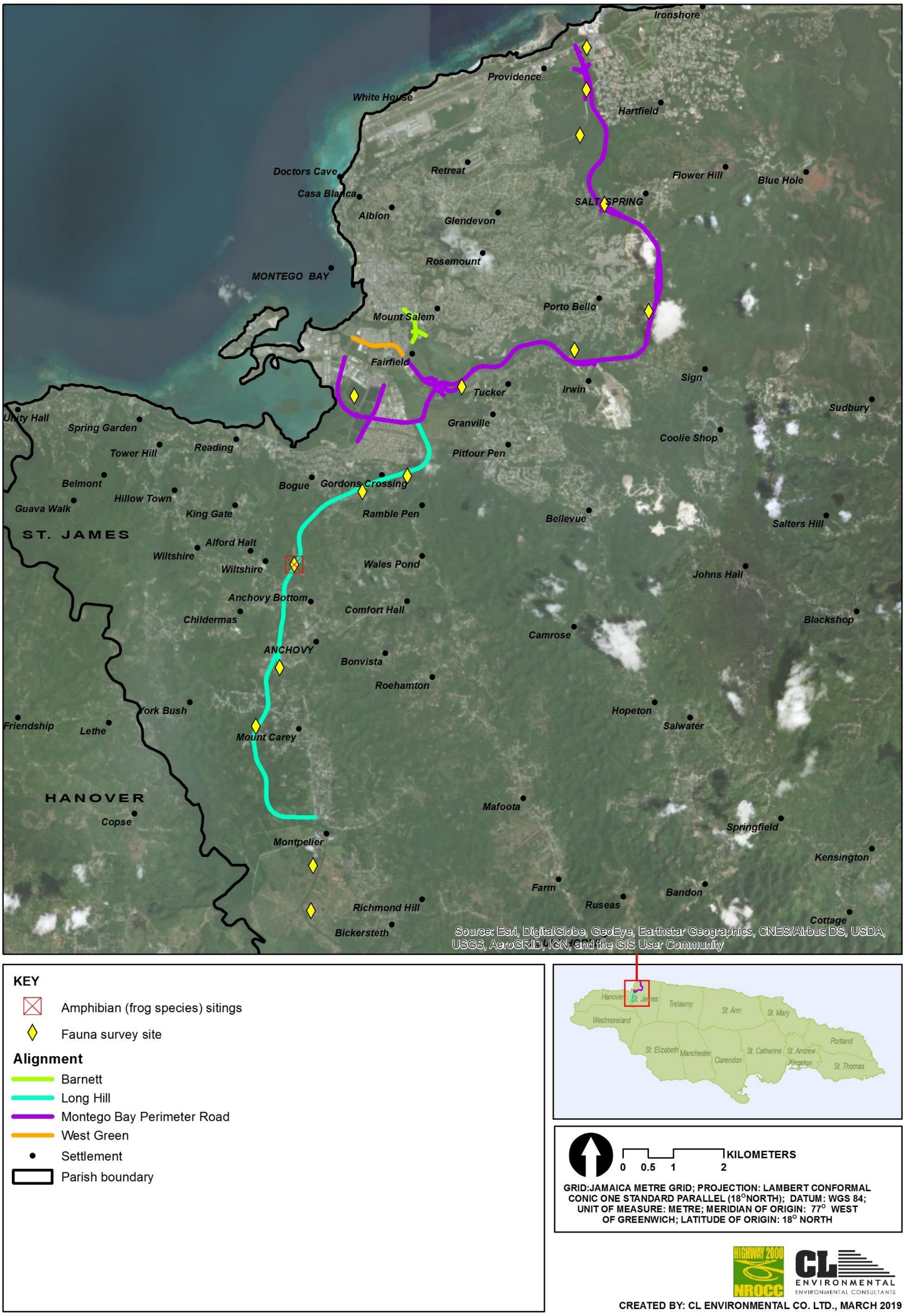


Figure 3-83 Fauna sample sites

3.2.2.2 Methodologies

A total of fifteen (15) sample sites were selected in areas representing the main habitat type at the actual or near to the proposed footprint of the Highway. At each site the following methodologies were used for the faunal assessment.

3.2.2.2.1 Butterfly Assessment

Butterflies were recorded directly. Specimens that could not be identified on the wing were collected using a flight net.

3.2.2.2.2 Land Snails

A method developed by Garraway and Blake, which includes a combination of hand search of soil surface and trees combined with dry sieving of soil was utilized. Shells were hand-picked from substrate systematically working along trails at each sample site covering an approximately 4 m width checking all possible hiding places including rotting or fallen logs, rock crevices, beneath large loose rocks under leaf litter and on the tree trunks and leaves. Soil was collected from random points in the site. Large shells were removed while small shells were collected using standard field sieves followed by examination using the dissecting microscope. Most specimens were identified readily. Others were identified from descriptions from the literature, by comparison with the "Blake & Garraway Collection" and the "Munroe & Garraway Collection" at the University of the West Indies.

3.2.2.2.3 Bromeliad Fauna

Bromeliad fauna were studied in the field as well as in the laboratory. In the field over 10 bromeliads were removed from the trees and were examined in detail. The animals observed were identified and photographed. If the animal could not be identified in the field voucher specimens were taken and later identified at the University of the West Indies Lab.

Plate 3-59 Bromeliad on forest floor

Plate 3-60 Bromeliads in the canopy

3.2.2.2.4 Amphibians and Reptiles

The amphibian and reptile assessment was conducted along the trails at each sample site. The search points include trees, stone piles, small water bodies and other debris. All specimens seen were identified or pictures were taken for further study if necessary. It was necessary to capture some specimens for closer examination; these were placed in glass bottles or catchment containers; but were subsequently returned to the habitat. Herps which could not be identified in the field were collected and identified using Amphibians and Reptiles of Caribbean Islands keys (Caribherp, 2015) and Amphibians and reptiles of the West Indies (Schwartz & Henderson, 1991).

3.2.2.2.5 Avifauna Assessment

Point counts were mainly used for the assessment of the avifaunal community. Bird species were either identified with the aid of binoculars, or by their calls. The point count method is based on the principle of counting birds seen and heard at a defined point or spot. This was carried out for 8 minutes, before moving to another point a specified distance away >150 m.

Table 3-37 DAFOR scale used to rank the bird densities in the study

DAFOR	Total number of birds observed during the survey
Dominant	≥ 20
Abundant	15 – 19
Frequent	10 – 14
Occasional	5- 9
Rare	< 4

3.2.2.3 Results

3.2.2.3.1 Bromeliads

Two genera of bromeliads were observed during the assessment which include *Hohenbergia* and *Tillandsia.* The Tillandsia does not retain as much as water as compared to the larger *Hoenbergia* that has been reported to retain over 1 litre of water and significant amount of detritus.

One species of a Blue earth worm (Annelida) and one land snail (Pulmonata) were observed in the bromeliad. Three frog species were observed in the bromeliad: the endemic frog, *Osteopilus ocellatus* (the Jamaican Laughing Frog) was present. *O. ocellatus* is widespread across Jamaica, although numbers may be sparse in some south coast areas. The IUCN lists the conservation status of this species as 'Least Concern".

Plate-3-61 *Anolis grahami* observed on bromeliad in upper secondary Limestone Forest

Plate 3-62 *Anolis opalinus* observed on tree trunk in upper secondary Limestone Forest

Plate 3-63 Jamaica masked frog *Eleutherodactylus luteolus* removed from bromeliad in upper secondary Limestone Forest

Plate 3-64 Jamaican Bromeliad Crab *Metopaulias depressus* removed from bromeliad in upper secondary Limestone Forest

Plate 3-65 The yellow bromeliad frog or Spaldings tree frog (*Osteopilus marianae*) removed from bromeliad in upper secondary Limestone Forest

Plate 3-66 Green tree frog *Osteopilus wilder* removed from bromeliad in upper secondary Limestone Forest

3.2.2.3.2 Herpetofauna

AMPHIBIANS

Seven species of amphibians were recorded; two are introduced while the remainder is endemic. The status of the introduced species is of 'little concern'. Three of the five endemic species are listed by the IUCN as endangered; these are *Eleutherodactylus luteolus, Osteopilus marianae and Osteopilus ocellatus; these* species are addressed separately below.

ELEUTHERODACTYLUS LUTEOLUS

Eleutherodactylus luteolus is listed as endangered because, despite its local abundance, its extent of occurrence is less than 5,000 km^2, and its distribution is severely fragmented. This species' geographical range is restricted to western Jamaica (Schwartz & Henderson, 1991) and can be found in coastal lowlands to elevations as high as 680 metres uplands. It is found in terrestrial and arboreal bromeliads or on rocks in wet limestone forests and appears to be intolerant of any disturbance to its habitat. It is threatened by habitat degradation and deforestation.

OSTEOPILUS OCELLATUS (THE JAMAICAN LAUGHING FROG)

Osteopilus ocellatus is an endemic species. This species' geographical range is widespread, occurring throughout most of Jamaica, with the exception of the southern section of the island. Its occurrence is estimated by the IUCN Redlist to be 8,600 km^2. It has been observed in coastal lowlands to elevations as high as in 1500 metres uplands. All stages of the lifecycle were found in the bromeliads. The adults of *Osteopilus ocellatus* are nocturnal and hide in moist places (such as bromeliads) during the day. They lay their eggs in Bromeliads and the tadpoles develop in the water in the tank of the plant. The adults feed on insects; the young larvae feed on algae and detritus, while the mature larvae may tend towards a carnivorous diet.

OSTEOPILUS MARINAE

Osteopilus marinae is listed as endangered (Table 3-38) because its extent of occurrence is less than 5,000 km^2, and its distribution is severely fragmented. This species is endemic to central and western Jamaica with an altitude range of 120 – 880 metres. There has been a decline in its abundance and this species is now rarely encountered or heard calling, except in pockets of suitable habitat. This species is found in mesic broadleaf woods and forests on tree trunks and in bromeliads; it requires large dead trees. Males call from hollows in branches and bromeliads, and eggs are laid in bromeliads. It is not found in significantly altered habitats but can be found in regenerating forests. It is threatened by habitat degradation and deforestation.

Table 3-38 The amphibians observed during the survey of the area for the proposed Highway

Species	Common name	Species Status	IUCN Status
Rhinella marina	Cane Toad	Intro.	L. concern
Eleutherodactylus johnstonei	Lesser Antillean Frog	Intro.	L. concern
Eleutherodactylus cundalli	Jamaican Rock Frog	End.	Vulnerable.
Eleutherodactylus luteolus	Masked Frog	End.	Endangered
Osteopilus marianae	Jamaican Yellow Treefrog	End.	Endangered
Osteopilus ocellatus	Jamaican Laughing Treefrog	End.	L. concern
Osteopilus wilder	*Green tree frog*	End.	Endangered

Of note the majority of the amphibians were found on the upper section of the secondary limestone forest. This forest type was received more rainfall than the lower section of the forest. It should be noted that several bromeliads were seen in the trees in the area. This provided a habitat for the majority of the frog species.

3.2.2.3.3 Reptiles

Thirteen (13) species of reptiles were recorded (Table 3-39); one is introduced while the remainder are endemic to Jamaica. One species, *Osteopilus crucialis* (Jamaican Yellow Boa) is listed by the IUCN as endangered and is also protected by Jamaican law. However, no snakes were encountered in the area, but residents reported seeing large snakes on the upper section of the survey area. The status of all endemic reptilian and amphibian species are of concern mainly because the distribution of their populations is limited to Jamaica.

Table 3-39 Reptilian Fauna of the study site

Scientific name	Common name	Species Status	IUCN Status	DAFOR
Celestus crusculus	Jamaican Galliwasp	End.	Near threa.	O
Anolis garmani	**Jamaican Giant Anole**	End.	Near threa.	O
Anolis grahami	**Jamaican Turquoise Anole**	End.	Near threa.	O
Anolis lineatopus	**Jamaican Gray Anole**	End.	Near threa.	D
Anolis opalinus	**Bluefields Anole**	End.	Near threa.	O
Anolis sagrei	Brown Anole	End.	Near threa.	F
Anolis valencienni	**Jamaican Twig Anole**	End.	Near threa.	R
Hemidactylus mabouia	Croaking lizard, Tropical House Gecko, Wood slave	Intro.	L. concern	F
Aristelliger praesignis	Croaking lizard, Cochran's croaking gecko	End.	Near threa.	A

Scientific name	Common name	Species Status	IUCN Status	DAFOR
Sphaerodactylus argus	Ocellated geckos	End.	Near threa.	O
Sphaerodactylus goniorhynchus	**Jamaican Forest Dwarf Gecko**	End.	Near threa.	R
Sphaerodactylus richardsoni	Northern Jamaica Banded Dwarf Gecko	End.	Near threa.	R
Typhlops jamaicensis	**Jamaican Blindsnake**	End.	Near threa.	D

Intro. = Introduced; End. = Endemic; L. concern = Least concern; Near threat. = Near threatened

3.2.2.3.4 Birds

Seventy-seven (77) species of birds were observed during the assessment; 44 of these were terrestrial species and 33 were species wetland species (Table 3-40).

WETLAND BIRD SPECIES

The Bogue wetland is a habitat for local and migrant waterfowls. Most of the wetland birds observed were migrant waterfowl. The Northern Shoveler was the most dominant species at the sewage ponds and it is also a migrant. More than 500 birds were observed at the sewage pond. Of note no wetland bird of special conservation status was observed at the sewage pond. Other ducks such as the Blue Wing Teal, Lesser Scaup and Ruddy ducks were observed in the sewage ponds.

Table 3-40 Wetland birds observed during the survey for the proposed Highway. Of note majority of the wetland species were observed at the Bogue Sewage ponds.

Groupings	Proper Name	*Scientific Name*	Status	DAFOR
Coots	American Coot	*Fulica americana*	Resident	F
Ducks	American Wigeon	*Anas americana*	Migrant	O
Kingfishers	Belted Kingfisher	*Ceryle alcyon*	Migrant	R
Bitterns, herons and egrets	Black-crowned Night Heron	*Nycticorax*	Resident	R
Stilt	Black-necked Stilt	*Himantopus mexicanus*	Resident	O
Ducks	Blue-winged Teal	*Anas discors*	Migrant	F
Pelicans	Brown Pelican	*Pelecanus occidentalis*	Resident	R
Coots	Caribbean Coot	*Fulica caribaea*	Resident	O
Bitterns, herons and egrets	Cattle Egret	*Bubulcus ibis*	Resident	O
Swallows	Cave Swallow	*Petrochelidon fulva*	Resident	O
Moorhen	Common Moorhen	*Gallinula chloropus*	Resident	O
Ibeses	Glossy Ibis	*Plegadis falcinellus*	Resident	O
Bitterns, herons and egrets	Great Blue Heron	*Ardea herodias*	Migrant	O
Bitterns, herons and egrets	Great Egret	*Ardea alba*	Resident	O
Bitterns, herons and egrets	Green Heron	*Butorides virescens*	Resident	O
Plover's	Killdeer	*Charadrius vociferus*	Resident	O
Gulls	Laughing Gull	*Leucophaeus atricilla*	Resident	O
Grebes	Least Grebe	*Tachybaptus dominicus*	Resident	O
Ducks	Lesser Scaup	*Aythya affinis*	Migrant	O
Sandpipers	Lesser yellowlegs	*Tringa solitaria*	Migrant	O
Herons and egrets	Little Blue Heron	*Egretta careulea*	Resident	R
Frigate birds	Magnificent Frigatebird	*Fregata magnificens*	Resident	O
Jacana	Northern Jacana	*Jacana spinosa*	Resident	O
Ducks	Northern Shoveler	*Anas clypeata*	Migrant	D
Raptors	Osprey	*Pandion haliaetus*	Migrant	R
Grebes	Pied Billed Grebe	*Podilymbus podiceps*	Resident	O
Ducks	Ruddy Duck	*Oxyura jamaicensis*	Resident	F
Bitterns, herons and egrets	Snowy Egret	*Egretta thula*	Migrant	R

Groupings	Proper Name	*Scientific Name*	Status	DAFOR
Sandpipers	Solitary Sandpiper	*Tringa solitaria*	Migrant	R
Bitterns, herons and egrets	Tricolored Heron	*Egretta tricolor*	migrant	O
Ibeses	White Ibis	*Eudocimus albus*	Resident	O
Plover's	Wilson's Plover	*Charadrius wilsonia*	Resident	O
Herons and egrets	Yellow-Crowned Night Heron	*Nycticorax violaceus*	Resident	O

TERRESTRIAL BIRD SPECIES

Forty-four species of bird (15 endemic; 20 resident; 8 migrant; 1 introduced) were observed during the study, which was carried out over three days. Bird species that are typical of a dry limestone forest (Downer and Sutton1990) were observed in the majority of the surveyed areas, excluding the wetland areas. These birds include Caribbean Dove, Parakeets, Hummingbirds, Jamaican Woodpeckers, Orioles and Warblers (Table 3-41).

Eight (8) migrant warblers were observed during the assessment, although the survey was carried in March, a time when most of the migrants are returning to North America. It should be note that the migrants are known to depart as early as late February.

Table 3-41 Terrestrial Birds observed during the assessment.

Proper Name	Scientific Name	Status	Woodland	Limestone forest
American Redstart	*Setophaga ruticilla*	*Migrant*	*F*	*O*
Antillean Palm Swift	*Tachornis phoenicobia*	*Resident*	*O*	*F*
Bananaquit	*Coereba flaveola*	*Resident*	*F*	*O*
Black and White Warbler	*Mniotilta varia*	*Migrant*	*O*	*R*
Black-faced Grassquit	Tiaris bicolor	*Resident*	R	O
Black-throated blue warbler	*Setophaga caerulescens*	*Migrant*	*O*	*R*
Black-whiskered Vireo	*Vireo altiloquus*	*Migrant*	*O*	*R*
Caribbean Dove	*Leptotila jamaicensis*	*Resident*	*O*	*F*
Common Ground Dove	*Columbina passerina*	*Resident*	*O*	*R*
Greater Antillean Bullfinch	*Loxigilla violacea*	*Resident*		*R*
Greater Antillean Grackle	*Quiscalus niger*	*Resident*	*O*	*R*
Green-rumper parrotlet	*Forpus passerinus*	*Introduced*		*O*
Jamaican Euphonia	***Euphonia Jamaica***	***Endemic***		***O***
Jamaican lizard cuckoo	***Coccyzus vetula***	***Endemic***		***R***
Jamaican Mango	***Anthracothorax mango***	***Endemic***	***R***	***O***
Jamaican Oriole	***Icterus leucopteryx***	***Endemic***	***R***	***O***
Jamaican Pewee	***Contopus pallidus***	***Endemic***	***R***	***R***
Jamaican Tody	***Todus***	***Endemic***		***O***
Jamaican Vireo	***Vireo modestus***	***Endemic***	***R***	***O***
Jamaican Woodpecker	***Melanerpes radiolatus***	***Endemic***	***O***	***O***
Loggerhead Kingbird	*Tyrannus caudifasciatus*	*Resident*	*O*	*O*
Louisiana Waterthrush	Parkesia motacilla	*Migrant*		*R*
Mangrove cuckoo	*Coccyzus minor*	*Resident*		*R*
Nothern Mockingbird	*Mimus polyglottos*	*Resident*	*O*	*R*
Nothern Parula	*Setophaga americana*	*Migrant*	*R*	
Olive-throated parakeet	*Eupsittula nana*	***Endemic***	*R*	*F*
Orange Quit	***Euneornis campestris***	***Endemic***		***R***
Praire Warbler	*Dendroica discolor*	*Migrant*	*O*	
Red-billed Streamertail	***Trochilus polytmus***	***Endemic***	***O***	***O***

Proper Name	Scientific Name	Status	Woodland	Limestone forest
Ruddy quail-dove	*Geotrygon montana*	*Resident*		*R*
Rufous-throated Solitaire	*Myadestes genibarbis*	*Resident*		*R*
Sad Flycatcher	***Myiarchus barbirostris***	***Endemic***		***R***
Smooth-billed Ani	Crotophaga ani	*Resident*	*F*	*O*
Stolid flycatcher	**Myiarchus stolidus**	***Endemic***		**O**
Turkey Vulture	*Carthartes aura*	*Resident*	*R*	*R*
Vervain Hummingbird	*Mellisuga minima*	*Resident*	*R*	*R*
White Crowned Pigeon	*Columba leucocephala*	*Resident*	R	O
White-chinned Thrush	***Turdus aurantius***	***Endemic***	***R***	**O**
White-Winged Dove	*Zenaida asiatica*	*Resident*	*R*	*O*
Yellow Warbler	*Dendroica petechia*	Resident	*O*	*R*
Yellow-faced Grassquit	*Tiaris olivacea*	*Resident*	*O*	*O*
Yellow-shouldered Grassquit	***Loxipasser anoxanthus***	***Endemic***	***R***	**O**
Yellow-throated Warbler	*Dendroica dominica*	*Migrant*	*O*	*R*
Zenaida Dove	*Zenaida aurita*	*Resident*	*R*	*O*

Thirty-two (32) bird species were observed in the woodland habitat. The most dominant species were the American redstart and the Bananaquit. Forty-four (44) species were observed in the limestone forest. The most dominant species was the Palm Swift and the Caribbean dove. It should also be noted that more endemic birds including forest specialists such as the Jamaican Lizard Cuckoo, Jamaican Euphonia and the Jamaica Tody were observed.

3.2.2.3.5 Land Snails

LAND SNAILS OF THE WOODLAND

Fourteen (14) species of land snails from eight families were recorded. Twelve (12) species were endemic and one (1) introduced. One species was only identified to the level of genus, *Urocoptis,* and its status is thus unknown (Table 3-42).

Table 3-42 Land snails from the Wood Land

FAMILY	SPECIES	DISTRIBUTION/ COMMENTS
Annulariidae	*Annularia mitis*	Endemic
	Parachondria sp.	Endemic
Camaenidae	*Pleurodonte (Dentellaria) invalida*	Endemic
	Pleurodonte lucerna	Endemic
	Thelidomus aspera	Endemic
	Zachrysia provisoria	Introduced
Helicinidae	*Helicinia neritella neritella*	Endemic
Neocyclotidae	*Cyclchittya chittyi*	Endemic
Orthalicidae	*Orthalicus undatus*	Endemic
Sagdidae	*Aerotrochus mcnabianus*	Endemic
	Sagda spei	Endemic
	Hyalosagda arboreiodes	Endemic
Subulinidae	*Allopeas gracile*	Endemic
Urocoptidae	*Urocoptis sp.*	unknown

LAND SNAILS OF THE SECONDARY LIMESTONE FOREST

Sixteen (16) species of land snails from eight families were recorded. All species except *Zachrysia provisoria* are endemic to Jamaica (Table 3-43). All species are widely distributed across Jamaica and generally associated with areas which have suffered significant disturbance. No special conservation measure is required.

Table 3-43 Land snails from the Secondary Limestone forest

FAMILY	SPECIES	STATUS/ COMMENTS
Annulariidae	*Annularia fimbriatula*	Endemic
	Annularia mitis	Endemic
Bulimulidae	*Drymaeus immaculatus*	Endemic
Camaenidae	*Thelidomus aspera*	Endemic
	Pleurodonte invalida	Endemic
	Zachrysia provisoria	Introduced
Helicinidae	*Helicinia neritella neritella*	Endemic
	Lucidella (Perenna) foxi	Endemic
	Eutrochatella pulchella	Endemic
Neocyclotidae	*Cyclochittya chittyi*	Endemic
	Cyclojamaicia bondi	Endemic
Sagdidae	*Hyalosagda arboreoides*	Endemic
	Sagda spei	Endemic
Subulinidae	*Allopeas gracile*	Endemic
Urocoptidae	*Spirostemma simile*	Endemic
	Urocoptis aspera.	Endemic

3.2.2.3.6 Butterflies

Twelve (12) species of butterflies, from five families were recorded from the Wood land areas. There were no endemic species, and all have widespread distribution in Jamaica (Table 3-44). Nineteen (19) species of butterflies from five families, were recorded form the Secondary Limestone Forests. Two of these were endemic. All species have widespread distribution in Jamaica (Table 3-45). The number of species recorded here is relatively low. However, this survey was done during a time of intense drought. Consequently, larval food plants in the form of shrubs or young leaves were absent. The butterfly fauna is expected to much greater during the wet season.

Table 3-44 Butterflies from the Wood Land

FAMILY	SPECIES	STATUS/COMMENT
Nymphalidae	*Dione vanellae*	Widespread
	Anartia jatrophae	Widespread
	Euptoieta hegesia	Widespread
	Heliconius charitonius	Widespread
	Dryas iulia	Widespread
Lycaenidae	*Leptotes cassius*	Widespread
Pieridae	*Ascia monuste*	Widespread
	Eurema nise	Widespread
	Phoebis sennae	Widespread
Papilionidae	*Papilio andremon*	Widespread
Hesperidae	*Pyrgus oileus*	Widespread

FAMILY	SPECIES	STATUS/COMMENT
	Chioides catillus	Widespread

Table 3-45 Butterflies from the Secondary Limestone forest

FAMILY	SPECIES	STATUS/COMMENT
Satyridae	*Calisto zangis*	Endemic, wide spread
Nymphalidae	*Mestra Dorcas*	Endemic, wide spread
	Junonia evarete	Widespread
	Anartia jatrophae	Widespread
	Euptoieta hegesia	Widespread
	Heliconius charitonius	Widespread
	Dryas iulia	Widespread
	Dione vanellae	Widespread
Lycaenidae	*Leptotes cassius*	Widespread
	Hemiargus hanno	Widespread
Pieridae	*Ascia monuste*	Widespread
	Appias drusilla	Widespread
	Eurema nise	Widespread
	Phoebis sennae	Widespread
Papilionidae	*Papilio andremon*	Widespread
	Papilio thersites	Widespread
Hesperidae	*Pyrgus oileus*	Widespread
	Chioides catillus	Widespread
	Astraptes jaira	Widespread

3.2.2.3.7 Other Fauna Associated with the Wetlands

Three (3) species of dragonflies were recorded; these were *Erythemis* sp., *Orthemis* sp. and Erythrodiplax *umbrata*. None of these species are protected in Jamaica. Other aquatic insects documented were Coleopterans from the familiy Gyrinidae, and Hemipterans from the families Vellidae, and Geridae.

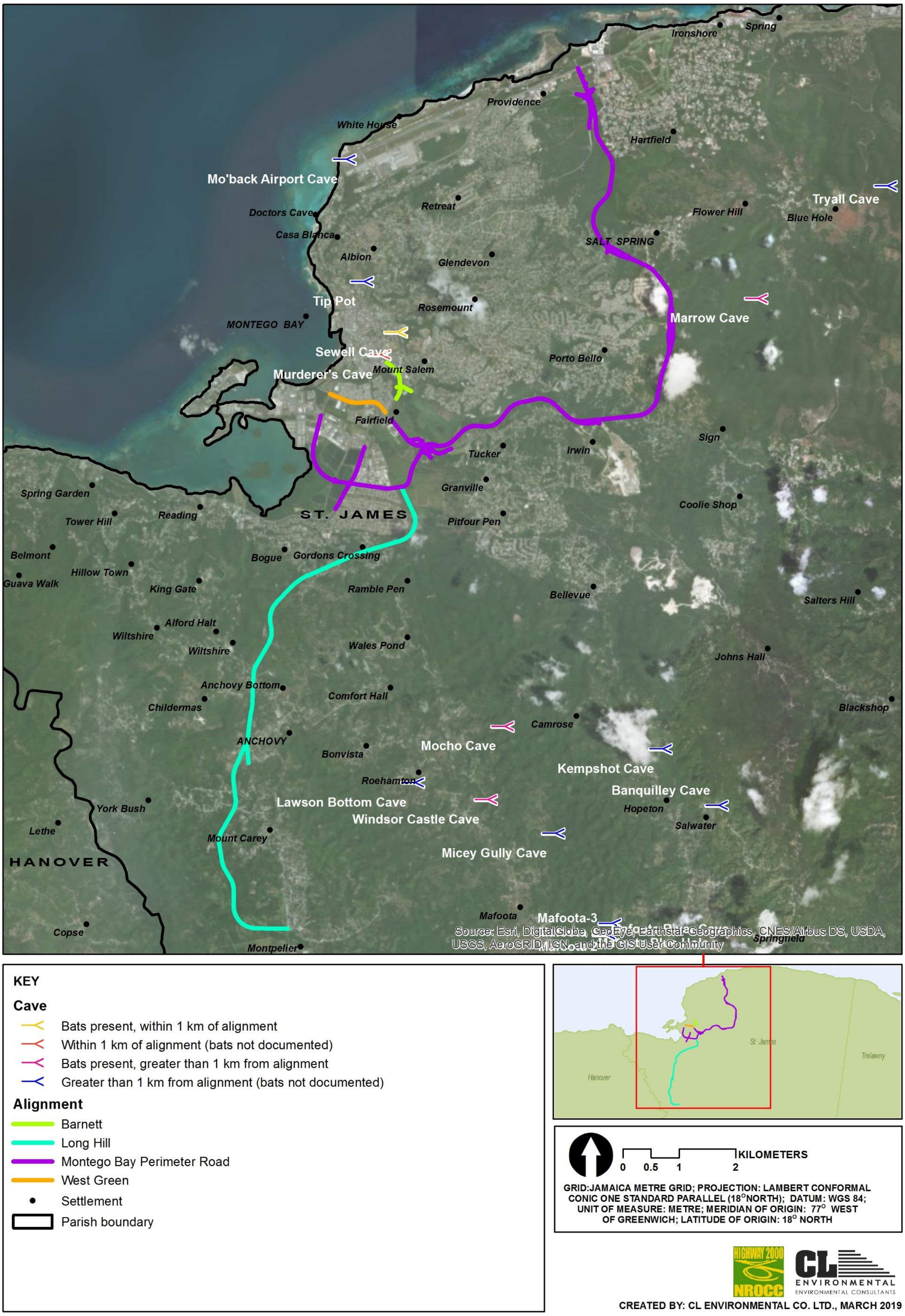
3.2.2.3.8 Bats

The cave surveyed (located at Latitude 18.436743, Longitude -77.915812), situated within 1 kilometre of the alignment, did not show any signs of bat presence.

The closest cave recorded to have bats is located 553.4 metres away from the proposed Barnett Street upgrade component (Sewell Cave, Figure 3-84).

3.2.3 Broadleaf Forest

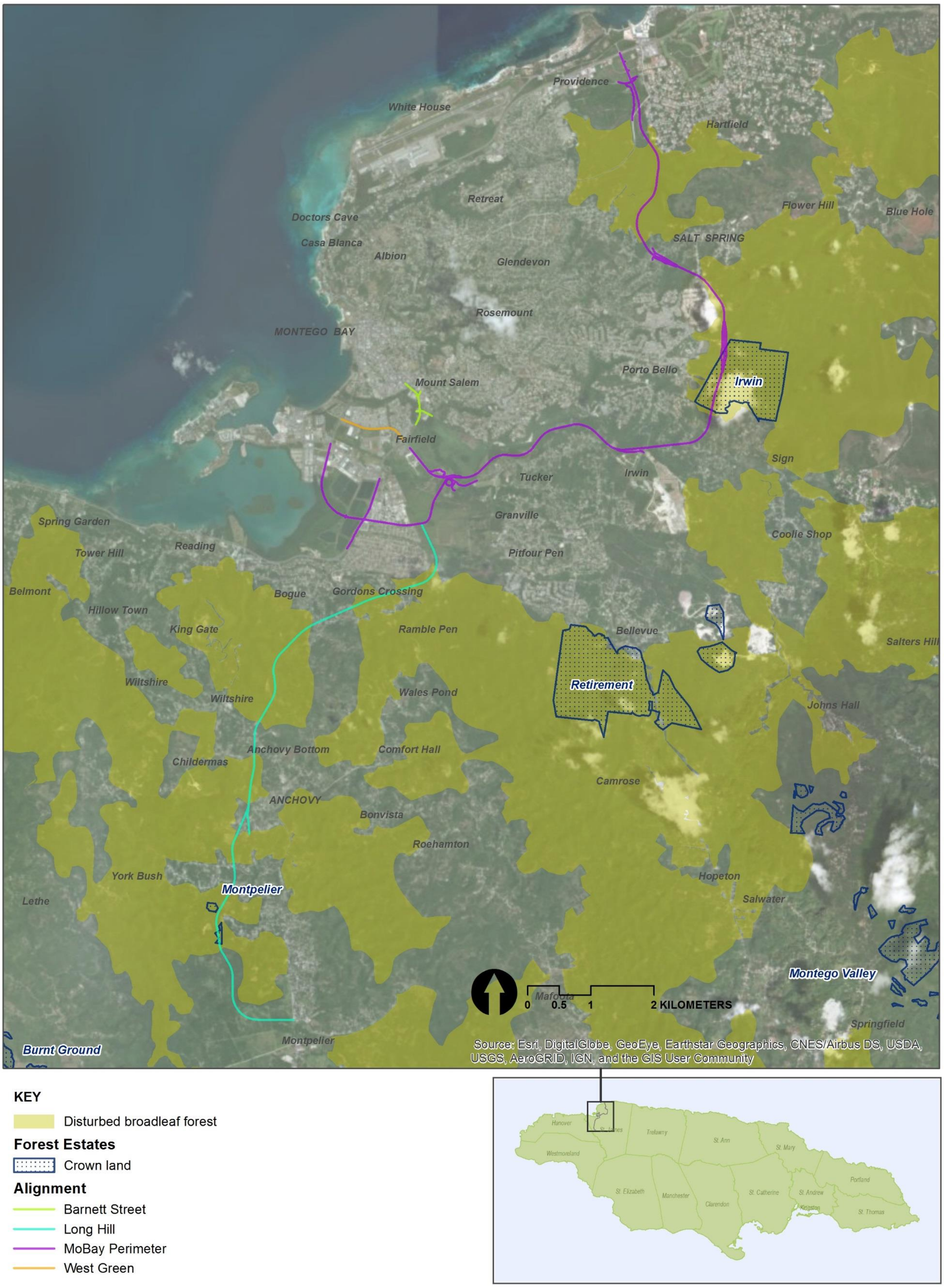
The proposed Montego Bay and Long Hill alignments traverse expanses of disturbed broadleaf forest, some of which are designated as forest estates and specifically crown lands, that is lands transferred to the Forestry Department for management by the Commission of Lands (Figure 3-85). The Montpelier estate is traversed by the Long Hill alignment and Irwin estate by the Montego Bay Perimeter Road. Detailed floral structure descriptions are given in Sections 3.2.1.2 and 3.2.1.3.



Please note that bat presence denotes being documented by the Jamaican Cave Organisation (JCO) and/ or confirmed by NEPA.

Source: Caves geolocated using (Fincham, 1998) (four caves located in St. James were not mapped: Schaw Castle Cave, Thompsons Cave, Rocky Road Cave and Marrow Cave 2); information regarding bat presence sourced from the Town and Country Planning (St James Parish) Provisional Development Order 2018.

Figure 3-84 Presence of bats in caves



HIGHWAY 2000 NROCC

CL ENVIRONMENTAL ENVIRONMENTAL CONSULTANTS

CREATED BY: CL ENVIRONMENTAL CO. LTD., MAY 2019

Figure 3-85 Disturbed broadleaf forested areas and forest estates

3.2.4 Mangrove Community

3.2.4.1 Methodology

Roving surveys of the proposed development areas were conducted on November 13, December 15, and December 28, 2018. Discrete belt transects were also sampled within specific areas of the forest. The centre point of the proposed road alignment was located using a Trimble Geo-7x GPS and belt transects were thereafter laid 40m east and 40m west of the centre points, each belt being 10m wide (Figure 3-86). This derived a survey area of 400m² for each sampled location. Within belt transects, the following data was collected:

- Standing water salinity
- Visible fauna noted
- Tree species and numbers within sample area
- Tree heights(m) for up to 10 of each species present
- Diameter at breast height (DBH)in cm, for up to 10 of each species present
- Density of mangrove seedlings within 1 m². This was conducted in a randomly selected patch within the sample area.

Figure 3-86 Belt transect locations (numbers) relative to the projected road alignment impact zone (100m buffer)

Additional data was collected by deploying data loggers for a minimum of 25 days. Hobo U-20 water level loggers were placed at two locations within the forest floor (south and north). The water level loggers were secured in place on the substrate surface, and recorded water temperature and pressure of water above the device (in PSI), which may be converted into cm of depth. This provides evidence on the influence of water on the forest over a specified time.

3.2.4.2 Results

3.2.4.2.1 Vegetation

Over 30,000m^2 of the mangrove forest were surveyed (Table 3-46). Based on the density of trees recorded in each zone, a tree density was recorded for each sector. The mean tree density derived from all areas was 0.180625 mangrove trees per m^2. The surveys of the forested areas revealed pure stands of healthy mangrove forest; the survey transects, and roaming surveys showed the following traits:

- Standing water presence throughout entire survey area (fresh and saline water)
- Evidence of tidal water movements and influence on vegetation
- Mature *Rhizophora mangle* (Red), *Avicennia germinans* (Black), *Laguncularia racemosa* (White) mangroves, with lower amounts of *Acrostichum speciosum* (mangrove/golden fern)
- Ample seedlings and saplings for forest regeneration
- Expected zonation of a Caribbean mangrove forest (red mangroves on fringes, black and white trees at higher inter-tidal zone)
- Numerous faunal species associated with mangrove forest (snails, crabs, birds)

Table 3-46 shows that the forest structure had red mangroves dominated the northern areas (transects 7 and 8), a transition zone in transect 6 area and dominance by black mangroves moving south. White mangroves were also well accounted for in the mid-southern sections, but *Avicennia* was superior.

Table 3-46 Adult mangrove Density for transect plots across the survey site

Transects	*Avicennia germinans* (Black)	*Laguncularia racemosa* (White)	*Rhizophora mangle* (Red)	Total trees	Area surveyed	Density (per m2)
Transect 1 (10m x 40m) E	23	6	0	29	400	0.0725
Transect 2 (10m x 40m) W	36	6	0	42	400	0.105
Transect 3 (10m x 40m) E	**89**	25	1	115	400	0.2875
Transect 4 (10m x 40m) W	**84**	15	4	103	400	0.2575
Transect 5 (10m x 40m) E	**84**	0	1	85	400	0.2125
Transect 6(10m x 40m) W	43	4	16	63	400	0.1575
Transect 7 (10m x 40m) E	21	0	**34**	55	400	0.1375
Transect 8(10m x 40m) W	22	0	**64**	86	400	0.215
Mean						**0.180625**

Tree heights are taller in the south of the forest, where black mangroves dominate (up to 14m) (Table 3-47). Red mangrove trees are shorter, with smaller associated DBH. The mid to southern areas of the forest also had higher seedling densities of the black mangrove, consistent with a tidally influenced mangrove forest (smaller seedlings are pushed further inland where they take root; Rabinowitz, 1978) and may also indicate a healthy crab population (prefers Red mangrove seedlings). Adjacent (north) to the transect 7 and 8 areas exist a mangrove rehabilitation site, which is currently being monitored by a team from the University of the West Indies-(Plate 3-67).

Table 3-47 Average Tree height, Diameter at Breast Height, Seedling Density and Salinity of the Dense Survey Area

Transects	Avg. Tree height (m)	Avg. Diameter at breast height (cm)	Seedling density (per m^2)	Salinity (parts per thousand)
Transect 1	14	24.2	105	2 ppt
Transect 2	12	11.8	80	2 ppt
Transect 3	9.5	10.8	97	35 ppt
Transect 4	12	12	103	35 ppt
Transect 5	9	7	64	35 ppt
Transect 6	8	6.3	23	35 ppt
Transect 7	6.5	6.4	_	35 ppt
Transect 8	6.5	6.3	2	35 ppt

Plate 3-67 Rehabilitation plot adjacent to impact zone-north of transect 7 and 8

Plate 3-68 Mangrove forest near transect 4 - Dense assemblages of Black mangroves

Plate 3-69 Transect 6 - Showing dense network of roots of Rhizophora mangle (red mangrove)

COMPARISON WITH NEARBY CONTROL SITE

A mangrove study site within the Bogue lagoon mangrove area (outside of the highway alignment footprint) was used to conduct a comparison with mangrove trees located within the highway alignment footprint. This study site can be seen in Figure 3-87.

A study conducted by Amanda Chin (*A Comparative Study of Mangrove Forests on the North Coast of Jamaica with reference to the Port Royal Mangroves*) (Chin, 2014) showed that mangrove tree heights and DBH were similar between the two areas. Average tree heights recorded for transect 6 (8 metres) and transect 7 (6.5 metres) (both giving an average of 7.25 metres) for the EIA study were similar to tree heights found at the Chin 2014 study site (7.046 metres). The same goes for DBH, whereby average DBH for transect 6 (6.3 cm) and transect 7 (6.4 cm) (both giving an average of 6.35 cm) were similar to the DBH of trees found at the Chin 2014 site (6.175 cm).

Figure 3-87 Map showing Amanda Chin (2014) mangrove study site (used as a control site) in relation to the EIA proposed highway alignment

3.2.4.2.2 Tidal Influence within the Forest

Observations and results from hobo water level loggers, solidify the beliefs that this current mangrove forest is well connected to the neighbouring Bogue Lagoon and Caribbean Sea. Water level data for the logger deployed south, showed a lower level of water level fluctuation as compared to the Northern deployment (Figure 3-88, Figure 3-89 and Table 3-48).

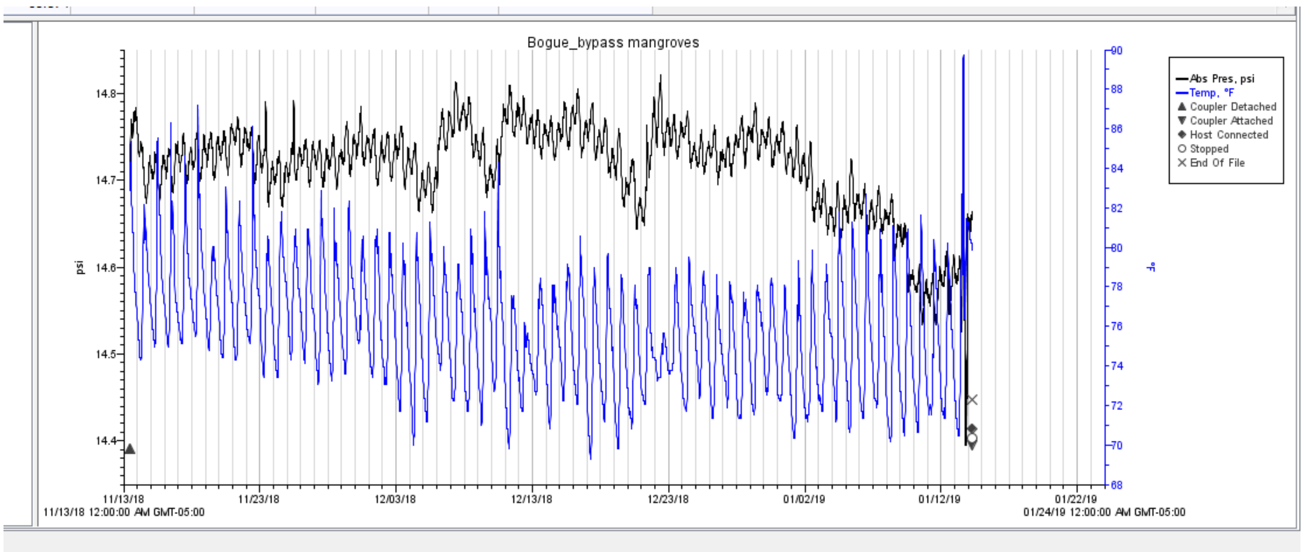


Figure 3-88 Water level logger results for bypass road -South

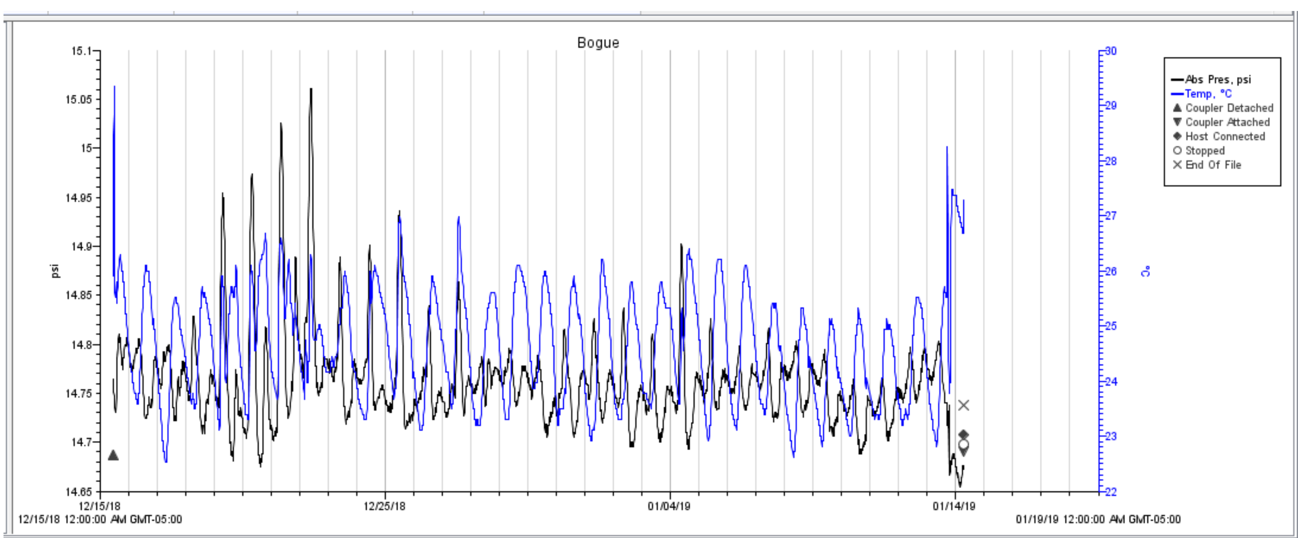


Figure 3-89 Water level logger results for bypass road-North

Table 3-48 Water level highlights and calculations for North and South sites

Site of logger	Mean Reading (PSI)	Maximum reading (PSI)	Difference (psi)	Max water level (cm)

Bypass Road North	14.762	15.0609	0.2988	**21.723**
Bypass Road South	14.71	14.82	0.11	7.734

Table 3-48 shows the calculated water heights (cm) recorded on the mangrove forest floor, within the roadway footprint. These figures were derived from subtracting the mean water height from the max water height recorded, then converted to cm, using an online pressure conversion tool. The northern site showed a +21.7 cm increase in water height, above the mean water level over a month. This presents strong evidence of tidal influence. The southern site showed only a 7.7cm rise in water level. This shows a weak/minimal tidal influence, despite this area was approximately 320m from its closest coastline (north to Bogue Lagoons).

3.2.4.2.3 Salinity and Freshwater Inputs

The majority of the forest floor exhibited salinities of normal sea water (35ppt), with a lesser fresh water influence being south-close to the projected roadway NW impact point (close to sewage treatment ponds), showing a fresh water salinity of 2 ppt (Figure 3-90). The standing fresh water in transect 1 area showed no evidence of sewage contamination. No direct fresh water flows were observed. However, a culvert was observed less than 200 m south of this area, which is the likely source of this freshwater influence. This area showed no evidence of human disturbance (no solid waste or cutting of trees).

Figure 3-90 Salinity map of road alignment areas within the mangrove forest, showing water level loggers locations (red circles) tidal flow (yellow arrows) and land based fresh water (blue arrow) flows

Fresh water inputs are also provided from a storm drain at the end of dead-end road from Howard Cooke Boulevard, which is the proposed Eastern entry point of the bypass Road. This water shows strong evidence of sewage contamination and has an extremely high solid waste load (plastic beverage bottles very evident). There was a fair amount of solid waste, mainly plastic bottles, found in the transect 3 and 4 area, a possible indication of a previous storm event that pushed floating materials far in-land. This theory may be verified that there was less visible solid waste at transects 5 and 6, which are closer to the coastline. A strong sewage outflow was also observed first-hand, arising from a man-hole cover at the end of the road (close to NWC lift station*).

Other freshwater inputs are evident from another storm drain, emerging from the Freezone Area. Figure 3-90 shows that the salinity was lowered (22 ppt) by freshwater inputs (2 x storm drains), combined with tidal waters at the western tip of the mangrove clearing (rehabilitation site).

Plate 3-70 Standing water near transect Northern roadway impact zone-showing water with evidence of sewage

3.2.4.3 Other Mangrove Rehabilitation Sites

Apart from the University of the West Indies mangrove rehabilitation site located north of Transects 7 and 8, there also exists a Montego bay Marine Park (MBMP) mangrove rehabilitation site as well as a Sandals Royal Caribbean rehabilitation site just west of the proposed highway alignment (Figure 3-91).

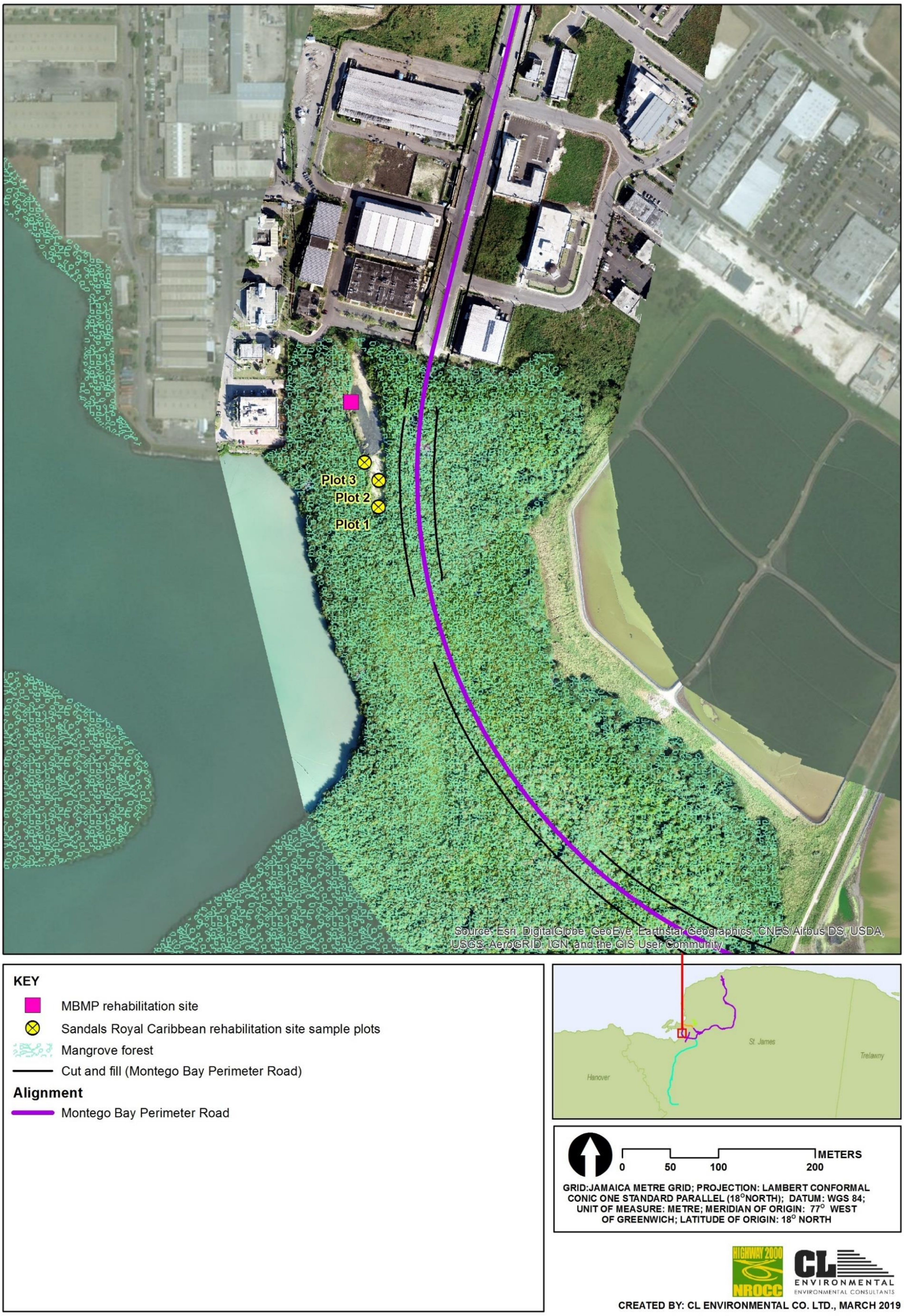


Figure 3-91 Other existing mangrove rehabilitation sites adjacent to proposed highway alignment

3.2.4.4 Mangrove Forest Fauna Observations

Thirteen (13) species of birds were observed during the surveys, along with two (2) crabs, *Anolis sp.* lizards, coffee snails and wasps (Table 3-49).

Table 3-49 Fauna observed throughout mangrove forest survey area

Fauna observed	Ecology/Description
American redstart *Setophagia ruticilla*	A migratory warbler which breeds in North America and winters in the tropics. The adult male is mostly black with bright orange patches on the sides, wings and tail. While females and immature males have a yellow or yellowish orange patches.
Baldplate/ White-crowned Pigeon *Patagioenas leucocephala*	This bird is a strong and fast flier. The adult is dark grey with green and white bars on the nape, a prominent white crown on the head and a pale-tipped red bill. These pigeons forage almost entirely in the trees feeding on fruits and berries and rarely comes to the ground to feed.
Bananaquit *Coereba flaveola*	Most have dark grey underparts, black crown and sides of the head, a prominent white eye stripe and yellow chest and belly. They inhabit a variety of habitats such as scrublands and tropical lowland forest.
Black-necked Stilt *Himantopus mexicanus*	Widely distributed long legged birds that feed on insects and crustaceans on the surface of the water. These wading birds have long stilt like legs usually reddish in colour, slim wings and a needle-like bill.
Blue-winged teal *Spatula discors*	This is a small dabbling duck with a rounded head and a large bill. Breeding males are brown bodied with dark speckling on the breast, slaty blue head with a white crescent behind the bill. Females are a darker patterned brown. They are often around the edges of ponds and they thrive is grassy habitats intermixed with wetlands.
Common moorhen/swamp chicken *Gallinula chloropus*	The common moorhen lives around well-vegetated marshes, ponds, canals and other wetlands.
Glossy Ibis *Plegadis falcinellus*	Long legged wading birds that inhabit wetlands, forest and plains. The naked facial skin is grey and surrounds a brown eye and the bill is brown. They nest among other species of wading birds and their nests are usually at ground or water level in reeds or low shrubs.
Green Heron *Butorides virescens*	The green heron is a small, stocky heron with short legs and a short, thick neck that is usually drawn into their bodies. Adults have a deep green back and crown, while juveniles are browner overall. They feed on fish and amphibians and live around wooded ponds, marshes or rivers.
Least Grebe Tachybaptus Dominicus	These are the smallest grebes in the Americas and they feed on aquatic invertebrates by surface diving. They have yellow eyes, thin dark bill and a dark greyish coloured head and body.
Least Sandpiper *Calidris minutilla*	These are small sandpipers with relatively round bodies and short pointed wings. They have short yellow legs and their bills are thin tipped. They have brown upperparts and white underparts and a whitish rump bisected with a black line. They prefer muddier shores and so they feed on invertebrates in the mud and sand along the edges of water.
Olive throated Parakeet	Commonly occurs in the forest and scrub in its range. Two subspecies are recognized, with the nominate subspecies found on Jamaica and the other distributed along the east slope of Central America. They have a pale bill, green head, back, and tail, an olive throat and bold, whitish eye ring. The species is often located by the strident shrieks of flocks moving through the forest.
Saffron finch *Sicalis flaveola*	Resident bird in Jamaica, common in open and semi-open areas in lowlands. The male is a very bright yellow bird with an orange crown while the female, is a paler yellow.
Yellow crowned night heron *Nyctanassa violacea*	The Yellow-crowned Night Heron is a medium-sized but rather chunky grey heron. The adult is dark grey with black and yellowish-white head markings. The immature resembles the young black-crowned Night heron but is light grey with finer specks.

Fauna observed	Ecology/Description
	Solitary and nocturnal, it feeds on hard-shelled invertebrates for the most part. Feeds and breeds in a variety of habitats, though preferring saltwater areas.
Fiddler crab *Uca sp.*	Fiddler crabs are small crabs found along beaches and brackish intertidal mud-flats, lagoons and mangrove forests. They can occur in large numbers and each individual has its own borrow for protection during high tide, refuge from predators and for mating and incubation. Males have one large claw and females have two feeding claws.
Mangrove Root Crab *(Goniopsis cruentata)*	The Mangrove Root Crab is about 6.3cm in length at maturity, with a square dark brown carapace that varies in colour, short red-stalked eyes on the anterior corners, and equal-sized chelipeds (claws) with no hairs and shallow teeth. The legs are red and hairy with yellow and white spots laterally arranged and have larger white spots along the edges of the carapace.
Coffee snails *Melampus coffea*	These coffee bean shaped snails, range in size from 1 to 2 cm and are found on both coasts of Florida and throughout the Caribbean. They are detritivores and herbivores that forage on fresh and decaying mangrove leaf litter. Their habitat is the mangrove forest and they would be found around the roots and branches of Red, White and Black mangrove trees.
Anolis sp.	Small tree-dwelling lizards related to iguanas that occur throughout the warmer regions of the Americas and are abundant in the West Indies. Majority of the 250 species have enlarged finger and toe pads that are covered with hooks that help with climbing. Most species can also change their colour in an effort to camouflage.
Wasps	Feeding – at certain times of the year feed on insects including caterpillars / harmful flies, as colonies increase they are attracted to food consumed by humans. Nesting - in trees / shrubs, or internally in attics, hollow walls/ flooring, sheds, under porches/eaves of buildings

3.2.4.5 Mangrove Prop Roots

The lower inter-tidal region of the forest is dominated by *Rhizophora mangle*, with numerous prop roots extending into the shallow waters (Plate 3-71 and Plate 3-72). Observations of these roots revealed aggregations of *Isognomon alatus* (Plate 3-73) dominated the prop root community. These oysters can adapt to intermittent freshwater introductions as these bivalves close their shells for extended periods of time to prevent freshwater impact. Crabs, sponges, hydroids and other encrusting species also form part of the prop root community. Some of the roots were overgrown with macroalgae, preventing recruitment and colonization.

Plate 3-71 Colonized prop root

Plate 3-72 Prop root dominated by macroalgae and some encrusting bivalves

Plate 3-73 *Isognomon alatus* bivalves dominating a red mangrove prop root, with *Goniopsis cruentata* (mangrove root crab)

3.2.5 Benthic Community

As part of the benthic assessment, seven (7) grab samples were taken along the nearshore (Figure 3-92). This area was chosen based on existing drainage/run-off areas with the possibility of sensitive species such as seagrass. The seven grab samples taken covered this span of potentially sensitive area. The nearshore is dominated by silty or clay-like mud with an anoxic smell (Plate 3-74 and Plate 3-75). This is likely to result in a limited benthic community, consisting of meiofauna such as crabs, worms and bivalves.

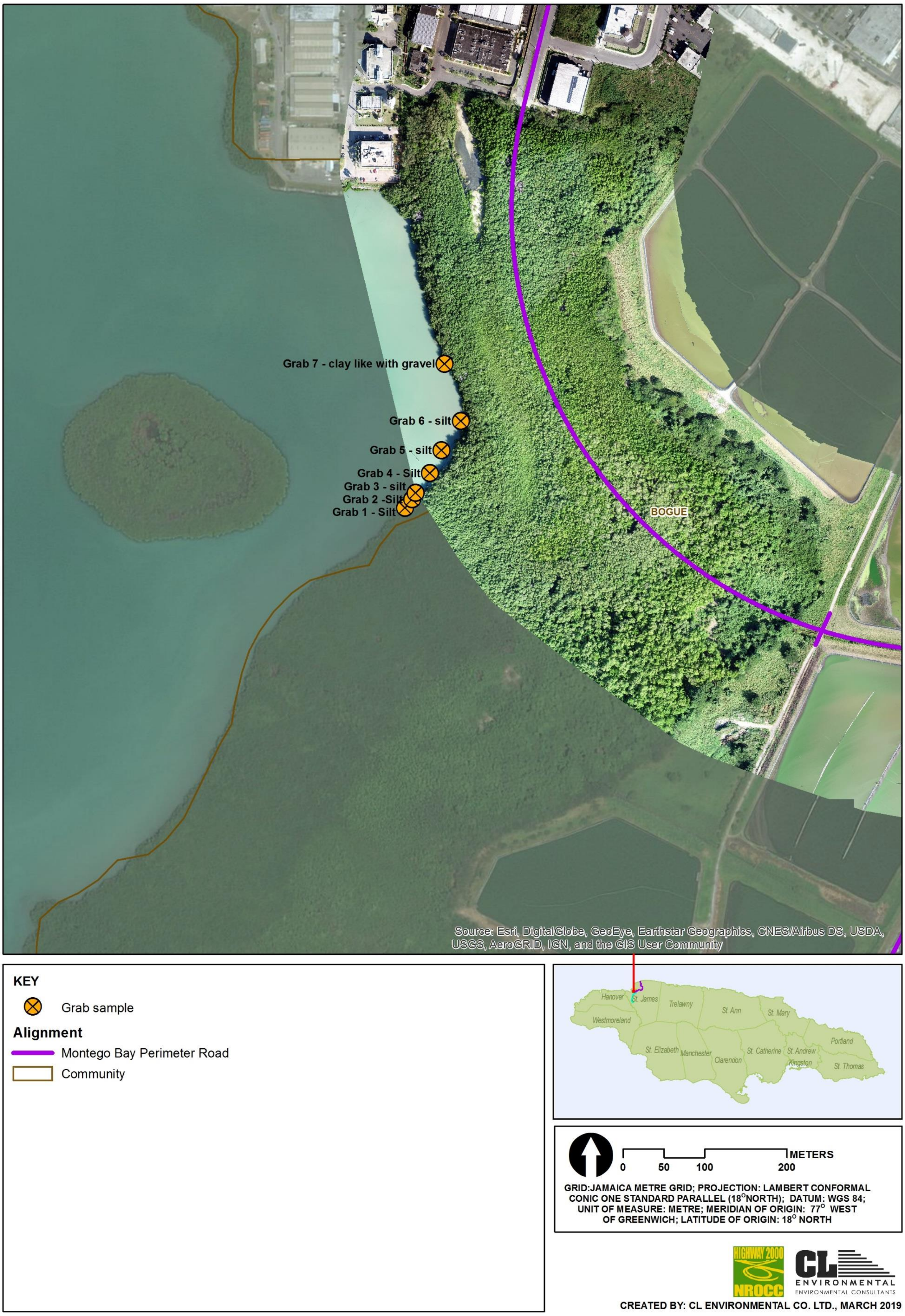


Figure 3-92 Grab sample locations

Plate 3-74 Grab sample; dense, clay-like mud with an anoxic smell

Plate 3-75 Grab sample; silty, soft mud with an anoxic smell

3.3 SOCIO-ECONOMIC ENVIRONMENT

3.3.1 Approach

3.3.1.1 Social Impact Area

In order to assess the various social elements of the proposed project, a Social Impact Area (SIA) is established. An SIA may be described as the estimated spatial extent of the proposed project's effect on the surrounding communities. Demographic analyses are carried out utilising this SIA demarcation, and social services, infrastructure and industrial facilities are described in relation to this area as well. For the purposes of this project, the SIA encompasses a five (5) kilometre buffer around all four proposed roadway alignments (Figure 3-93). The SIA is located within 53 communities in the parishes of St. James and Hanover; of these, the proposed alignment centrelines traverse 16 (Table 3-50). The total land portion of the SIA is 231.8 sq. km in area, with the remaining north-western section of the SIA extending over the Caribbean Sea.

Table 3-50 Communities located within the SIA, indicating those through which each alignment traverses (shaded)

Source: Communities (Social Development Commission)

	Community	Parish	Alignment
1	Albion	St. James	
2	Anchovy	St. James	Long Hill
3	Belmont/Tower Hill	St. James	
4	Bickersteth	St. James	
5	Bogue	St. James	Long Hill, Montego Bay Perimeter Road
6	Brandon Hill	St. James	
7	Cacoon Castle	Hanover	
8	Cambridge	St. James	
9	Canterbury	St. James	
10	Catherine Hall	St. James	West Green
11	Catherine Mount	St. James	
12	Chester Castle	Hanover	
13	Comfort Hall	St. James	
14	Copse	Hanover	
15	Coral Gardens	St. James	
16	Cornwall	St. James	
17	Fairfield	St. James	Barnett, Long Hill, Montego Bay Perimeter Road, West Green
18	Farm Heights	St. James	
19	Flanker	St. James	
20	Flower Hill	St. James	
21	Glendevon	St. James	
22	Granville	St. James	
23	Green Pond	St. James	Montego Bay Perimeter Road
24	Hopeton	St. James	
25	Ironshore	St. James	Montego Bay Perimeter Road

	Community	Parish	Alignment
26	Johns Hall	St. James	
27	Mafoota	St. James	
28	Montego Bay Business District	St. James	Barnett
29	Montpelier	St. James	Long Hill
30	Moy Hall	St. James	
31	Mt. Carey	St. James	Long Hill
32	Mt. Horeb	St. James	
33	Mt. Salem	St. James	
34	Norwood	St. James	
35	Orange	St. James	
36	Orange Irwin	St. James	Montego Bay Perimeter Road
37	Paradise	St. James	
38	Pitfour	St. James	Long Hill
39	Porto Bello	St. James	Montego Bay Perimeter Road
40	Ramble	Hanover	
41	Reading	St. James	
42	Retirement	St. James	
43	Rose Hall	St. James	
44	Rose Heights	St. James	
45	Rosemount	St. James	
46	Rosemount Gardens	St. James	
47	Salt Spring	St. James	Montego Bay Perimeter Road
48	Seven Rivers	St. James	Long Hill
49	Spring Gardens	St. James	
50	Tucker	St. James	Montego Bay Perimeter Road
51	Unity Hall	St. James	
52	West Green	St. James	West Green
53	Westgate Hills	St. James	

Montego Bay Business District is one of forty-four communities located in the Greater Montego Bay Development. The community comprises sections of Montego Bay. The city of Montego Bay may be roughly divided into two sections: the tourist area, which occupies the northern section of the bay along the shoreline, and the commercial and industrial sections. Montego Bay Business District also comprises five inner-city districts, namely: Jackson Town, North Gully, Business District, Jarrett Park and Railway Gardens.

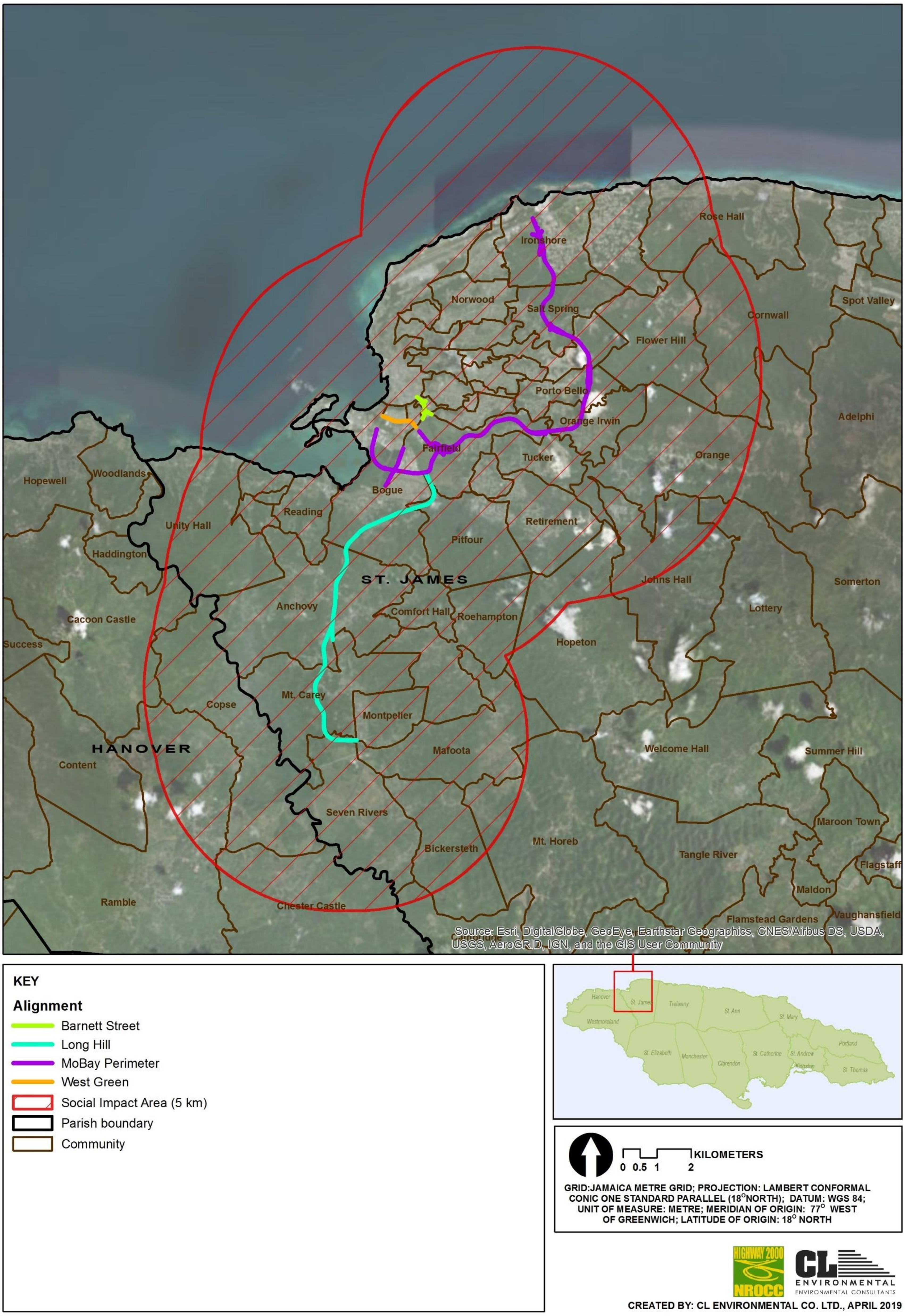


Figure 3-93 Social Impact Area (SIA) for all proposed alignments

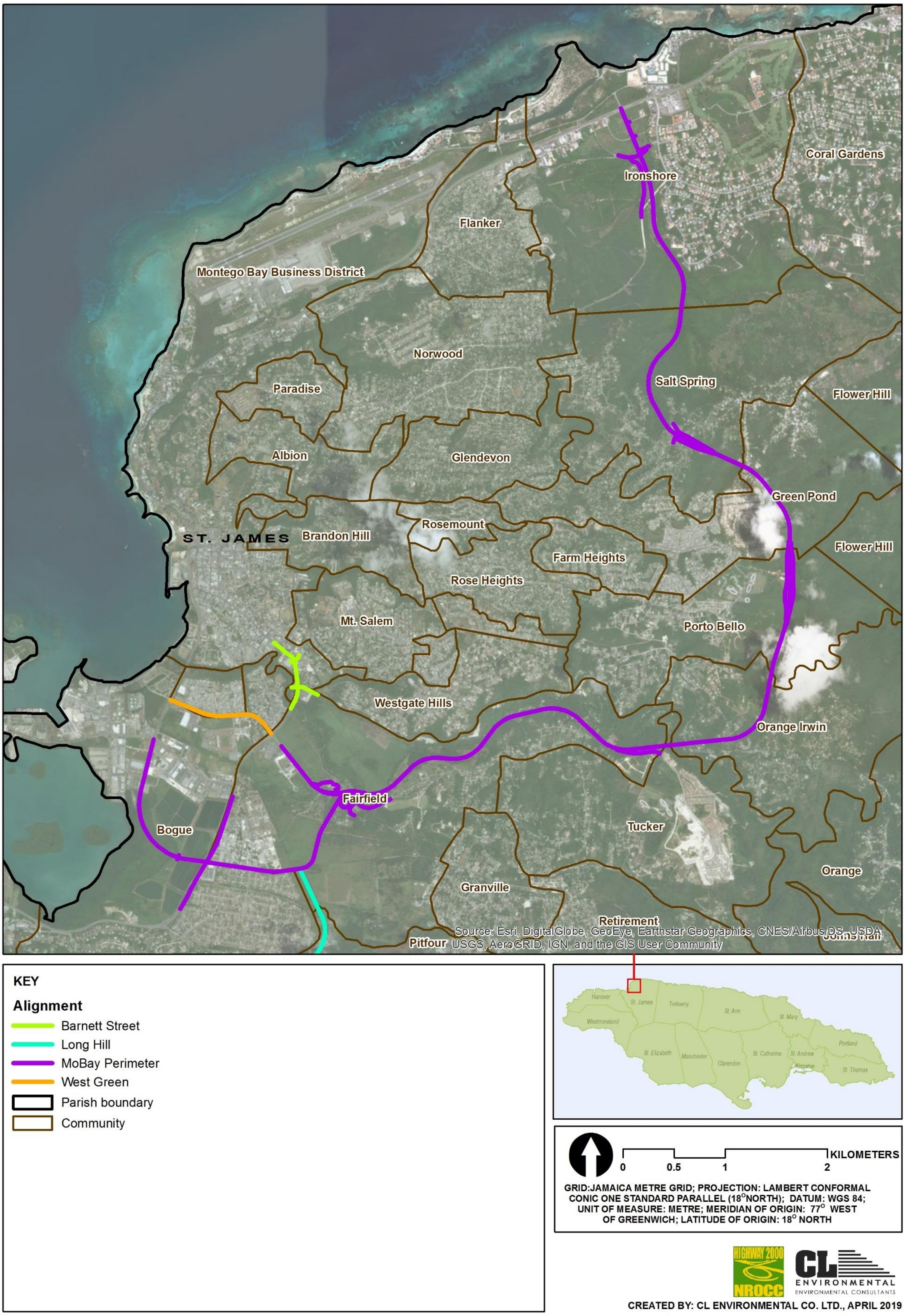


Figure 3-94 Communities through which each alignment centreline traverses - Montego Bay Perimeter, Barnett and West Green

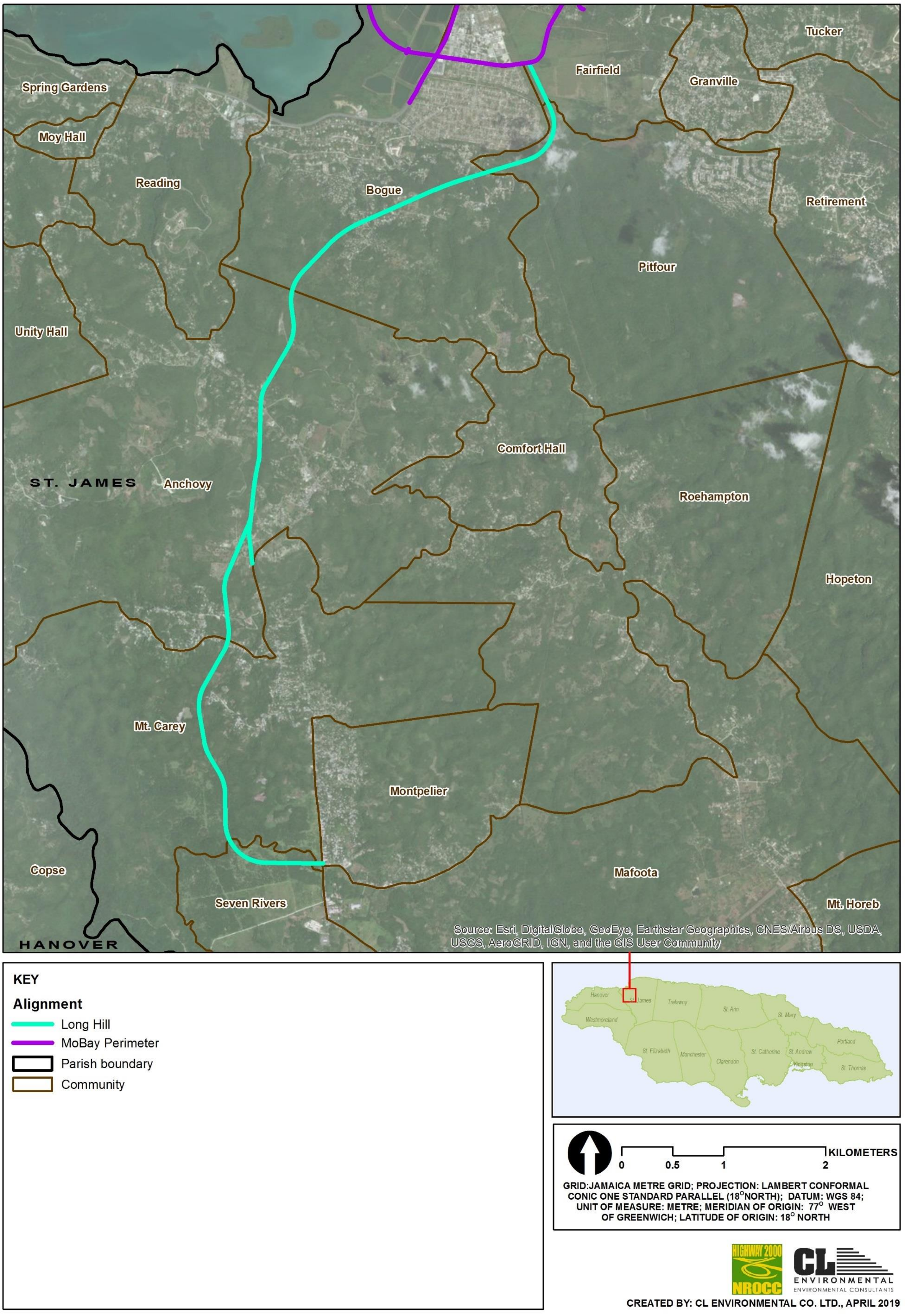


Figure 3-95 Communities through which each alignment centreline traverses – Long Hill

3.3.1.2 Demographic Analyses and Census Database

Population data from the Statistical Institute of Jamaica (STATIN) 2011 Population Census database by enumeration district (ED) was the main input to demographic analyses. It should be noted that all Census data relates to the resident population and does not take into consideration persons working in or visiting the ED.

The Census spatial datasets (for population, housing, dwellings and education) were clipped to the SIA using Geographic Information Systems (GIS) tools. For those EDs that were only partially within the SIA, the percentage of the clipped area was calculated based on area and applied to the data to provide proportionate estimates of population and housing statistics. For example, if 25% of the EDs area was included in the SIA, the total population or number of households within that ED would be multiplied by 0.25 in order to estimate the population/ households found within that portion of the ED enclosed by the SIA. Indeed this assumes an even distribution of persons/households within the ED, which may not be the case; however it was deemed necessary to approximate the proportional numbers for these partially included EDs instead of removing or including the entire ED population.

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

- ***Population growth*** - was calculated using the formula [$P_n = P_o (1 + r)^t$]; where P_o is the population at the beginning of a period, t is the period of time in years, r is the annual rate of increase, and P_n is the population at the end of the period (United Nations, 1952).
- ***Population density*** – was derived by dividing the population by the land area. This is useful for determining the locations of greater concentrations of population.
- ***Dependency ratio*** – was calculated using the formula [child population + aged population /working population X 100], where the child population is between ages 0-14, the aged population is 65 & over and the working population is between ages 15-64 years. This ratio is useful for understanding the economic burden being borne by the working population.
- ***Male sex ratio*** – was calculated by using the formula [male population / female population X 100]. This in effect denotes the number of males there are to every 100 females and is useful for determining the predominant gender in a particular area.
- ***Domestic water consumption*** - was calculated based on the assumption that water usage is 227.12 litres/capita/day and sewage generation at 80% of water consumption. Water consumption for workers in Jamaica is calculated at 19 litres/capita/day and sewage generation at 100% water consumption.
- ***Domestic garbage generation*** - was calculated at 4.11 kg/household/day (National Solid Waste Management Authority).

3.3.1.3 Other GIS Data and Information Sources

Geospatial data for various services and infrastructure, including schools, health centres, hospitals, police stations, fire stations and post offices were obtained from the Mona GeoInformatics Institute (MGI). Information gleaned from community profiles created by the Social Development Commission

(SDC) are included throughout this section; those available for communities traversed by the proposed alignment are as follows:

- Anchovy
- Bogue
- Catherine Hall
- Green Pond
- Montego Bay Business District
- Montpelier
- Mount Carey
- Orange Irwin
- Pitfour
- Porto Bello
- Salt Spring
- Seven Rivers
- Tucker
- West Green

Other data sources are stated throughout and include organizations such as the Forestry Department, Planning Institute of Jamaica (PIOJ), Water Resources Authority (WRA) and the National Environmental Planning Agency (NEPA). Additional data were also gleaned from the 1984 national topographic maps (metric series) and satellite imagery available for the project.

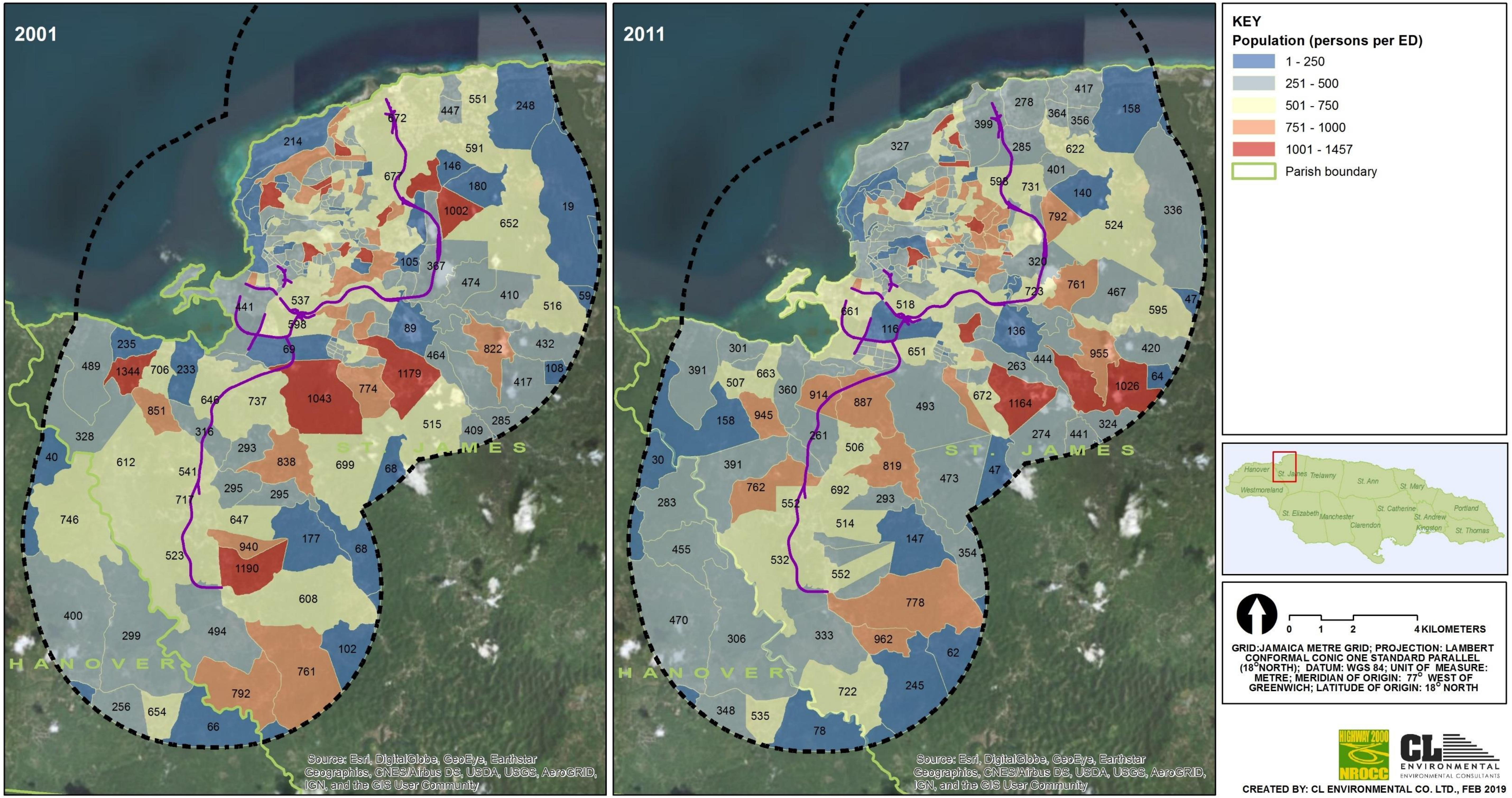
3.3.2 Demography

3.3.2.1 Population Growth

The total population within the SIA in 2011 was approximately 139,429 persons (STATIN 2011 Population Census). Examination of the 2001 population data showed that there were approximately 123,234 persons within the SIA in 2001. From this population, and that calculated for the year 2011 (139,429 persons), it was estimated that the actual growth rate within the SIA between 2001 and 2011 was approximately 1.24% per annum. Based on this growth rate, at the time of this study (2019), the population was approximately 153,904 persons and is expected to reach 209,557 persons over the next twenty-five years if the current population growth rate remains the same.

The annual growth rate for the SIA (0.10%) differs from than that for the parishes of Hanover (0.38%) and St. James (0.51%), as well as the island (0.36%) between 2001 and 2011 (STATIN, 2011). Using the regional rates for Hanover and St. James, the population in 2019 is estimated to range between 143,724 and 145,220 persons, and in 2044, between 158,019 and 164,914 persons.

Figure 3-96 depicts the population within each enumeration district (ED) for the years 2001 and 2011.



Data source: STATIN Population Census 2011 and 2001

Figure 3-96 SIA 2001 (left) and 2011 (right) population data represented in enumeration districts

3.3.2.2 Population Density

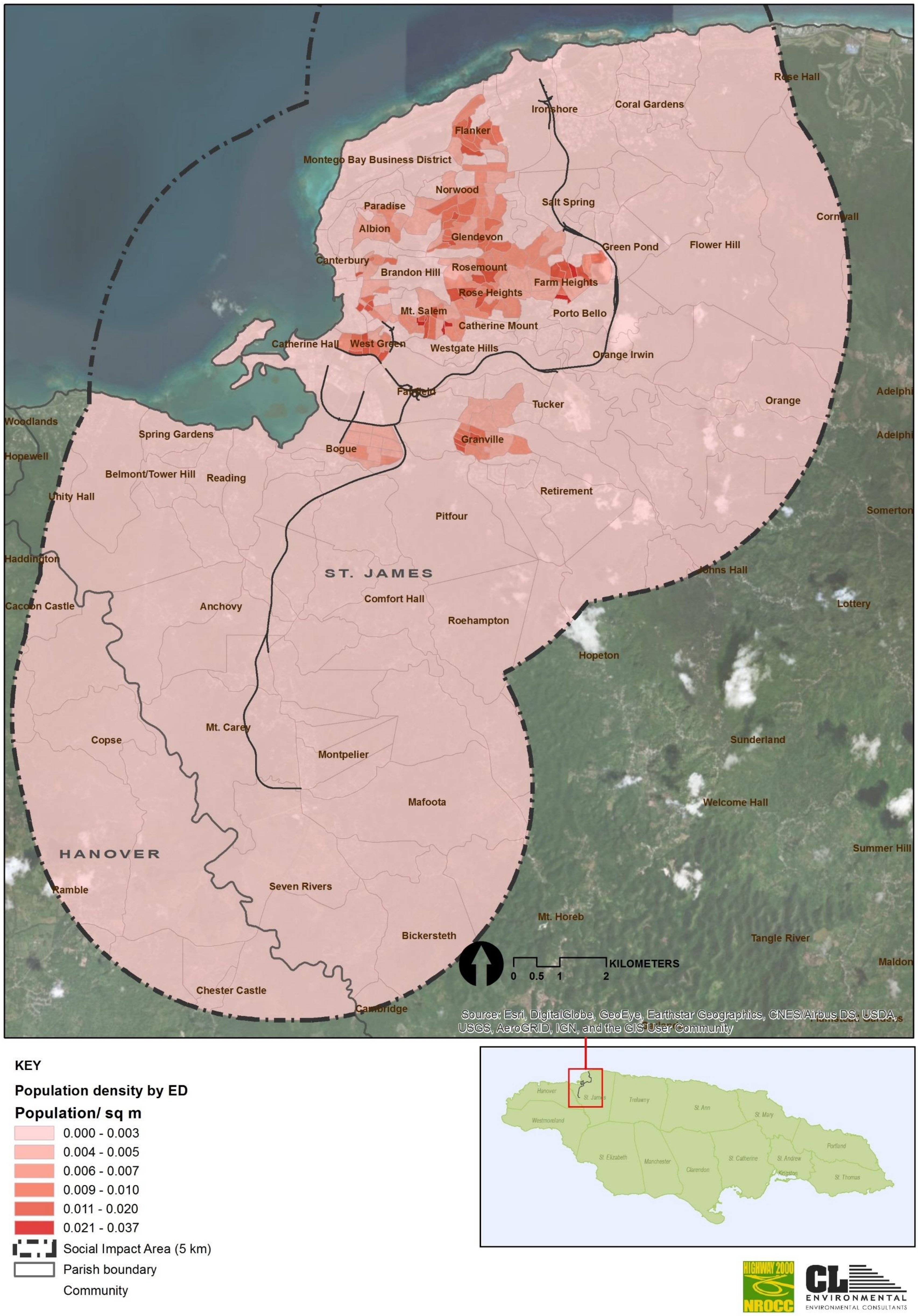
The land area within the SIA was calculated to be approximately 231.8 km^2. With a population of 139,429 persons, the overall population density was calculated to be 602 persons/km^2. This population density is dramatically higher than the national level (245 persons/km^2), as well as the St. James and Hanover regional densities of 310 and 154 persons/km^2 respectively (Table 3-51).

Table 3-51 Comparison of population densities for the year 2011

Source: STATIN Population Census 2011

Category	Jamaica	St. James	Hanover	SIA
Land Area (km^2)	10,991.0	592.1	450.8	231.8
Population	2,697,983	183,811	69,533	139,429
Population Density	245	310	154	602

Population density varies spatially throughout the SIA (Figure 3-97). Communities located west of the Montego Bay Perimeter Road such as Flankers, Norwood, Albion, Glendevon, West Green, Rose Heights and Mt. Salem, as well as Granville and Bogue towards the northern section of proposed Long Hill Bypass have noticeably higher densities than surrounding areas within the SIA….



Source data: STATIN Population Census 2011

Figure 3-97 Population density by ED within the SIA

3.3.2.3 Age & Sex Ratio

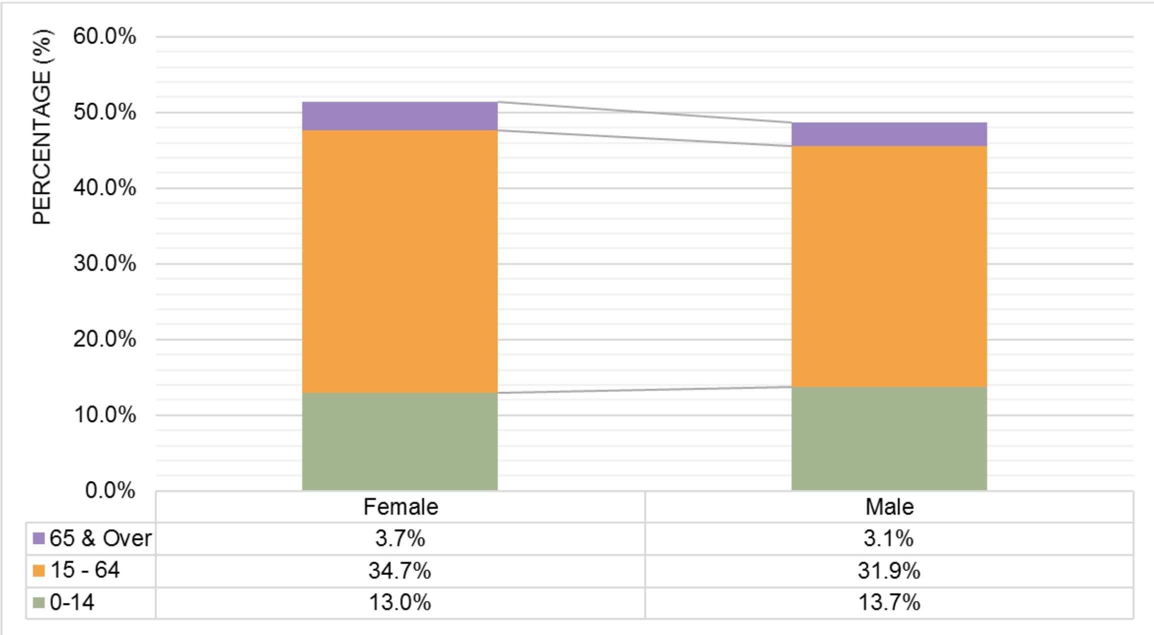
The segment of a population that is considered more vulnerable are the young (children less than five years old) and the elderly (65 years and over). In the SIA population, 8.4% comprised the vulnerable young category, and 6.8% comprised the elderly. Table 3-41 shows the percentage composition of each age category of the population. This is compared on a national, regional and local (SIA) level. Percentage age distribution in the SIA for the 0-14 years' age cohort (26.7%) is comparable with than the island figure (26.1%), as well as the regional figure for St. James (27.0%). As mentioned preciously, elderly persons aged 65 years and greater make up 6.8% of the SIA population; and this value is lower than other extents investigated. Within the SIA, the 15-64 years' age category accounted for 66.5% and can therefore be considered a working age population, similar to that for the nation (65.9%) (Table 3-52).

Table 3-52 Age categories as percentage of the population for the year 2011

Source: STATIN Population Census 2011

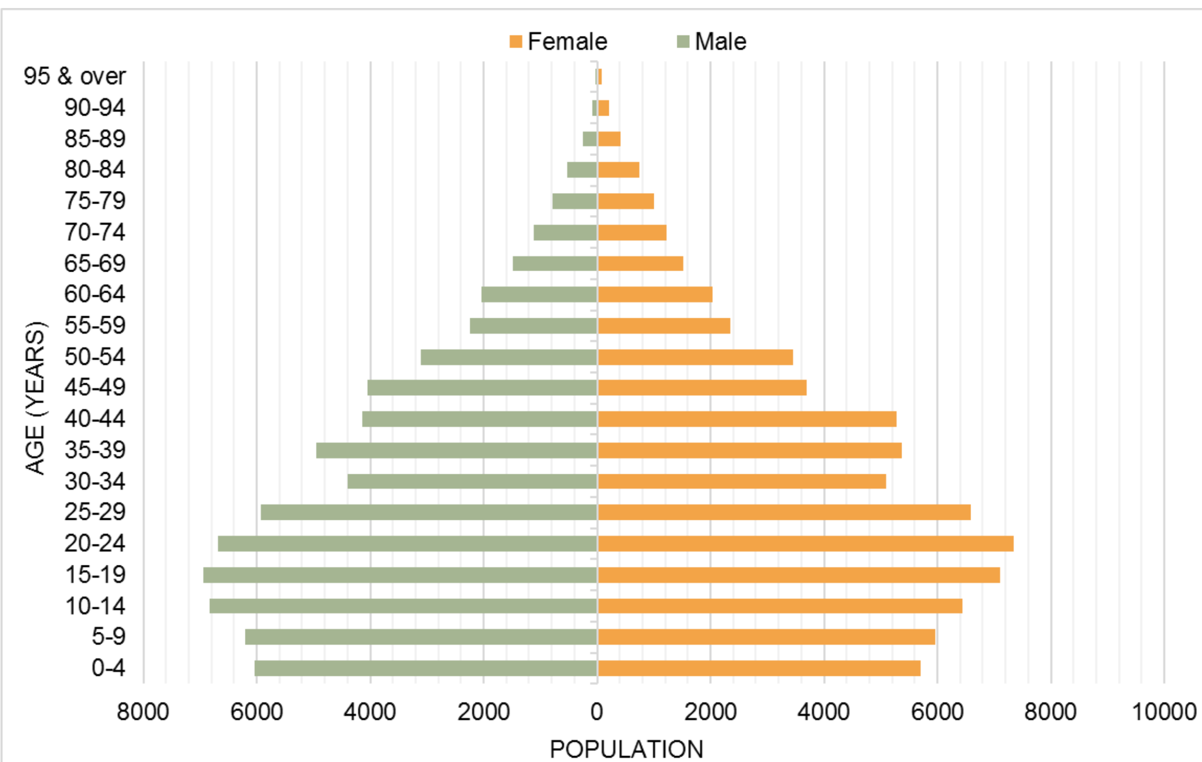
Age Categories	Jamaica	St. James	Hanover	SIA
0-14	26.1%	27.0%	28.4%	26.7%
15 - 64	65.9%	66.0%	64.2%	66.5%
65 & Over	8.1%	7.0%	7.3%	6.8%

As seen in Figure 3-98, Census 2011 data indicated that there were more females within each age cohort when compared to males, with the exception of 0-14 years. A higher portion of females is also seen when these age groupings are further divided using a population pyramid (Figure 3-99). Sex ratio for all age cohorts within the SIA was calculated to be 94.7 males per one hundred females; this ratio however varies spatially across the SIA (Figure 3-100).



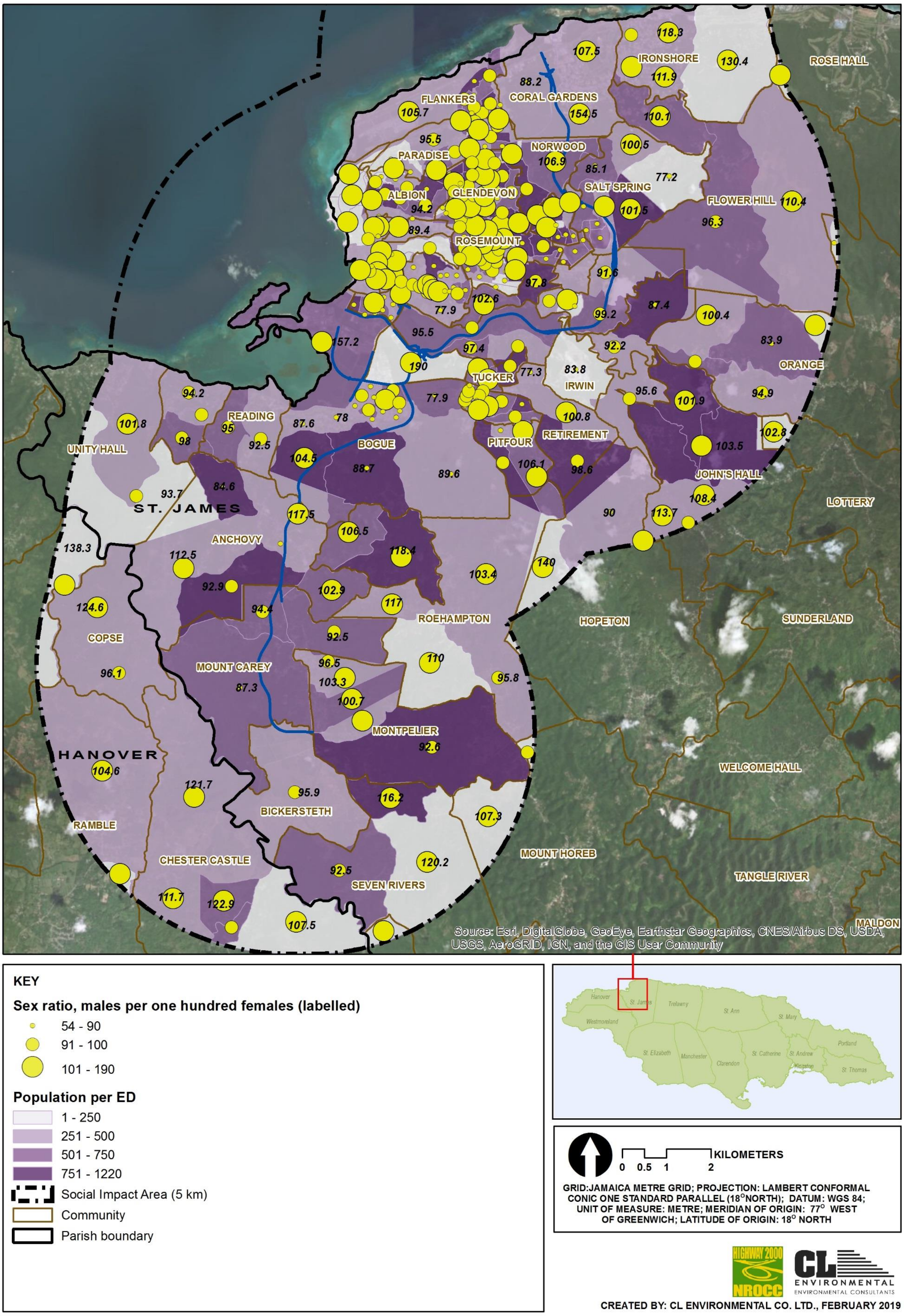
Source data: STATIN Population Census 2011

Figure 3-98 Male and female percentage population by age category in 2011 for the SIA



Source data: STATIN Population Census 2011

Figure 3-99 Population pyramid in 2011 for the SIA

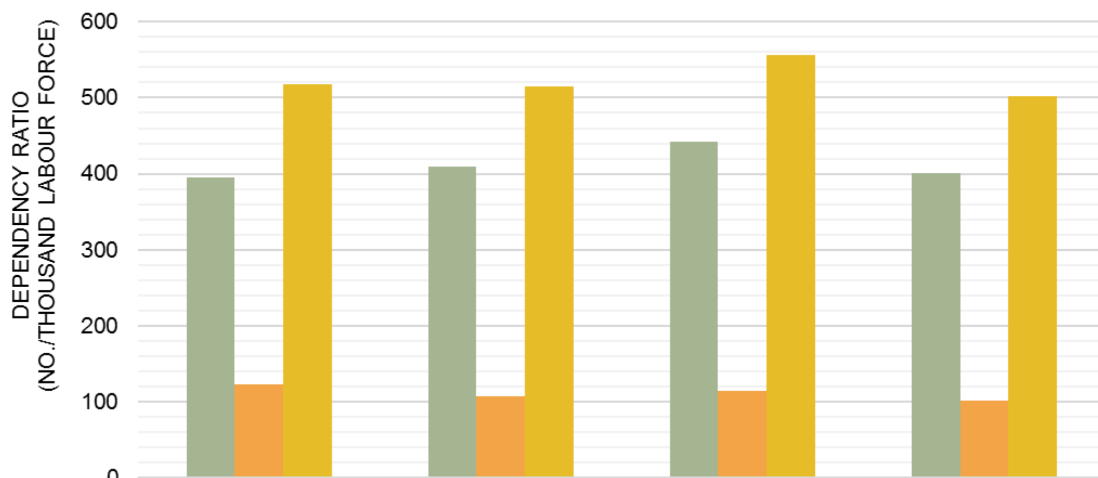


Source data: STATIN Population Census 2011

Figure 3-100 Sex ratio by ED within the SIA

3.3.2.4 Dependency Ratios

The child dependency ratio for the SIA in 2011 was 400.8 per 1000 persons of labour force age; old age dependency ratio stood at 101.9 per 1000 persons of labour force age; and societal dependency ratio of 502.7 per 1000 persons of labour force. This indicates that the youth (child dependency) are far more dependent on the labour force for support when compared with the elderly in the SIA. The SIA child dependency is lower than the figures for the parishes of Hanover and St. James (Figure 3-101), whilst societal age dependency is lowest in the SIA when compared to all extents. Comparing old age dependency to other extents, it is seen that SIA old age dependency is lower than all extents.



	Jamaica	St. James	Hanover	SIA
Child Dependency	395.4	408.9	442.4	400.8
Old Age Dependency	122.4	106.7	114.1	101.9
Societal Dependency	517.8	515.6	556.5	502.7

Source: STATIN Population Census 2011

Figure 3-101 Comparison of dependency ratios for the year 2011

3.3.3 Housing

3.3.3.1 Housing Units, Dwellings and Households

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

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

households reside. Examples are single houses, flats, apartments and part of commercial buildings and boarding houses catering for less than six boarders.

There were 34,886 housing units, 42,217 dwellings and 43,356 households within the SIA in 2011. The average number of dwellings in each housing unit was 1.2 and the average household to each dwelling was 1.0 (Table 3-53). The average household size in the SIA was 3.2 persons/ household; however, this varied spatially by ED with a minimum size of 1.3 person/ household to a maximum of 8.9 persons/ household, both extremes located in Kingston (Figure 3-103).

Comparisons of the SIA with national and regional ratios indicate that the SIA had comparable household/dwelling, average household size and dwelling/ housing unit ratios.

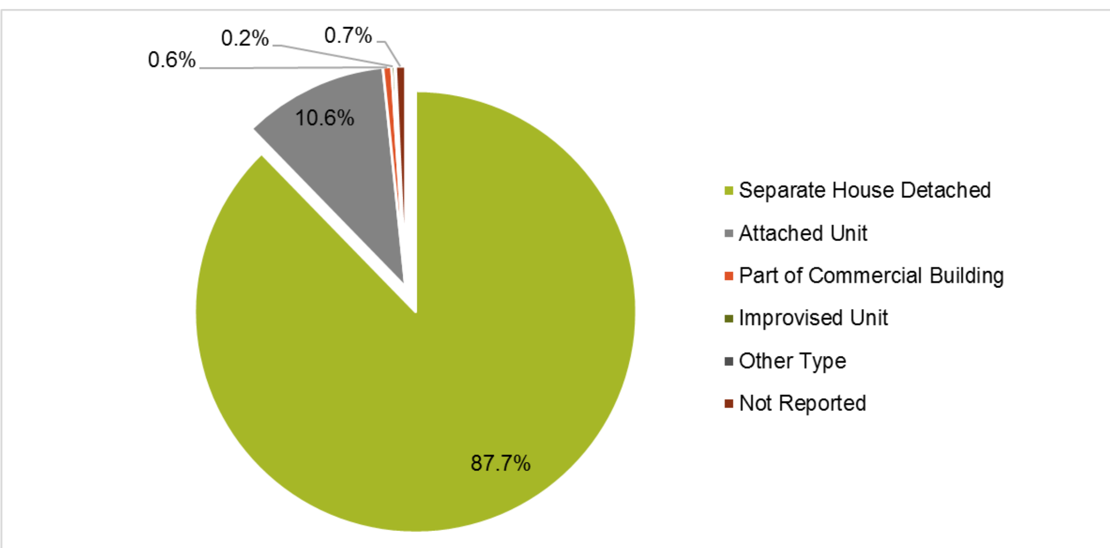
Table 3-53 Comparison of national, regional and SIA housing ratios for 2011

Source: STATIN Population Census 2001

	Jamaica	Hanover	St. James	SIA
Dwelling/Housing Unit	1.2	1.1	1.2	1.2
Household/Dwelling	1.0	1.0	1.0	1.0
Average Household Size	3.1	2.9	3.0	3.2

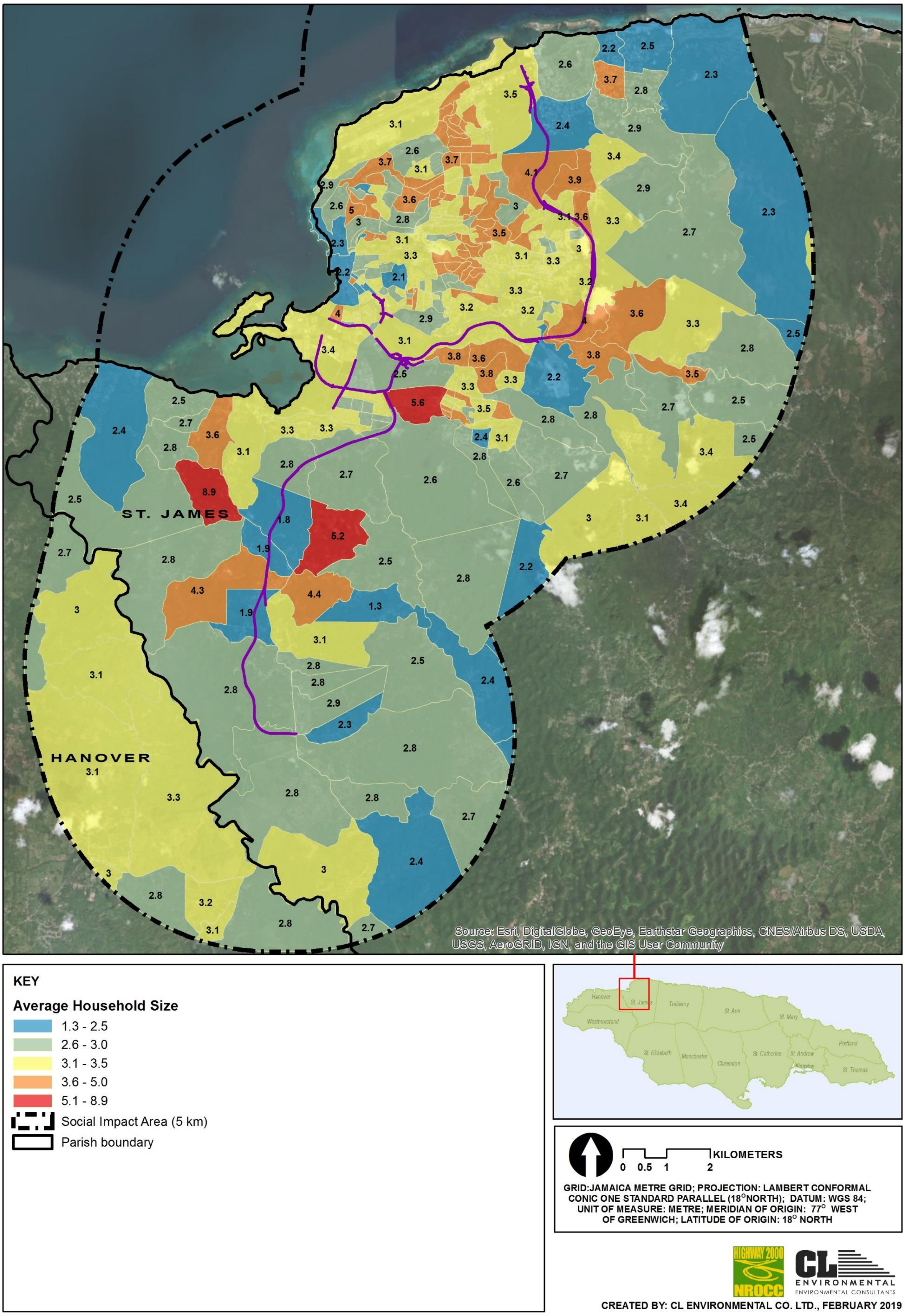
3.3.3.2 Housing Unit Type

Approximately 87.7% of the housing units in the SIA were of the separate detached type, 10.6% were attached, 0.7% not reported, 0.6% part of a commercial building, 0.2% improvised unit and other (0.1%) (Figure 3-102).



Source: STATIN Population Census 2011

Figure 3-102 Percentage of housing units by type within the SIA



Source: Education (STATIN Population Census 2011), Schools (MGI)

Figure 3-103 Household size by ED for 2011 within the SIA

3.3.4 Education and Employment

3.3.4.1 Educational Attainment and Facilities

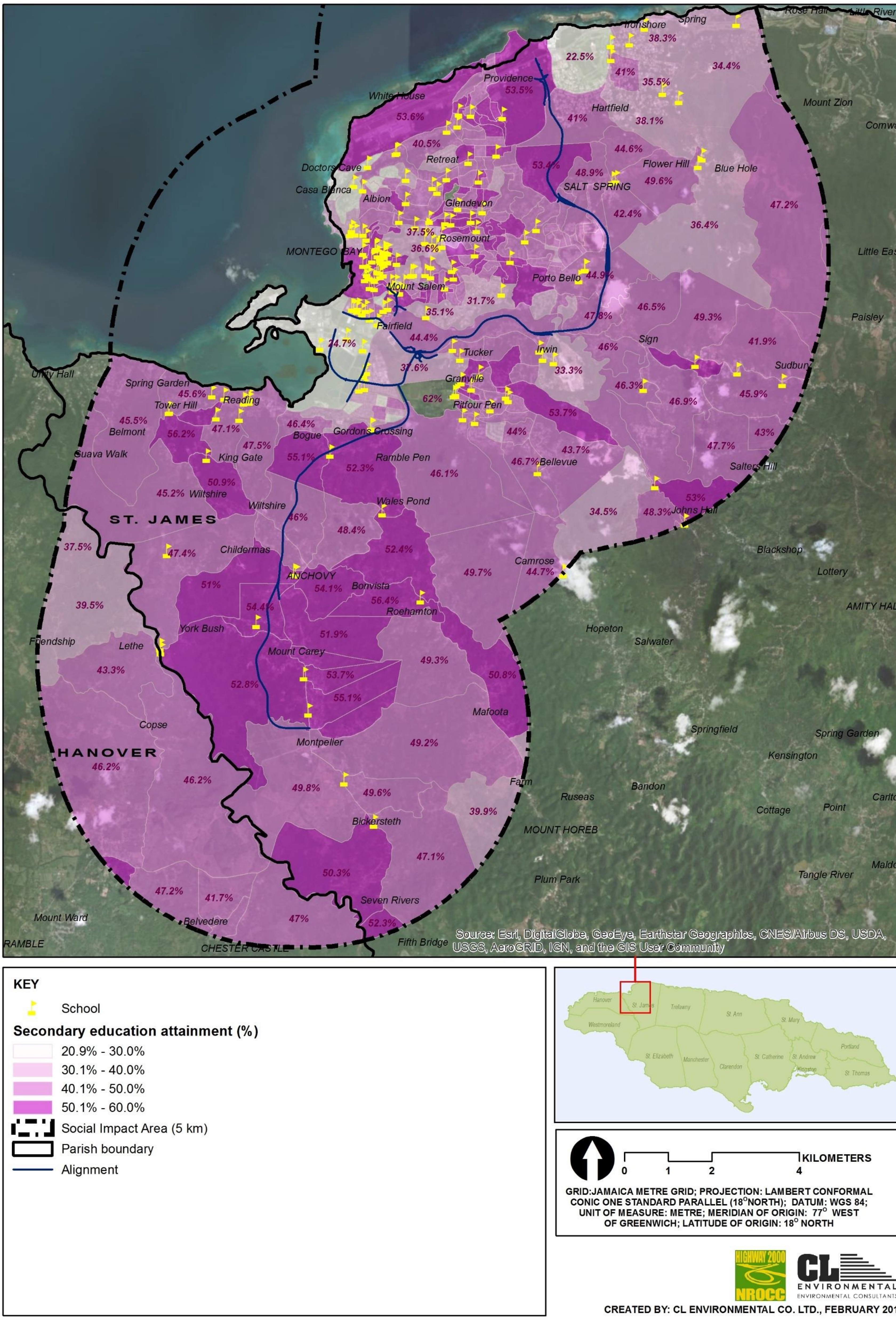
For 2011, the highest level of educational attainment for the national, regional and SIA extents are represented in Table 3-54. When the highest level of educational attainment within the SIA is calculated as a percentage, it becomes evident that there is a propensity towards the attainment of primary and secondary education. Forty-seven percent (47.2%) of the SIA population attained a secondary school education as the highest level, followed by 31.8% attaining primary education. Tertiary education attainment (university and other) as the highest level of education is higher in the SIA (11.0%) when compared to Hanover and St. James parishes (5.7% and 9.9% respectively). The relatively high proportion of the population in proximity to the project location attaining a secondary education, as well as tertiary education suggests that the labour pool is relatively educated.

Table 3-54 Population 3 years old and over by highest level of educational attainment as a percentage for the year 2011

Source: STATIN Population Census 2001

	Jamaica	St. James	Hanover	SIA
No Schooling	0.7%	0.8%	0.7%	0.7%
Pre Primary	4.8%	4.8%	5.4%	4.8%
Primary	34.4%	33.2%	38.6%	31.8%
Secondary	45.7%	47.0%	46.6%	47.2%
University	4.7%	4.0%	2.0%	4.5%
Other Tertiary	5.2%	5.9%	3.6%	6.5%
Other	0.5%	0.5%	0.2%	0.5%
Not Stated	0.0%	3.8%	2.8%	4.0%

Figure 3-104 depicts secondary education attainment within the SIA and the location of schools in proximity to the proposed development. A total of 167 schools are located within the demarcated SIA; these include all levels and types of educational facilities such as Basic, All Age, Primary, Infant, Kindergarten, Preparatory, Junior High, High, University and Vocational.



Source: Education (STATIN Population Census 2011), Schools (MGI and SDC)

Figure 3-104 Percentage population attaining a secondary education within the SIA

3.3.4.2 Employment and Skillsets

More than half the labour force in communities along the alignment are employed, with an average of 1.4 persons per household. Mount Carey had the lowest level of employment of 46% (Social Development Commission, 2008), whilst Catherine Hall had the highest, 87.4% (Social Development Commission, 2010). Employment categories and skillsets for communities traversed by the alignment are as follows:

- **Anchovy** - The majority (73.7%) of workers were employed in the categories of elementary occupations (28.1%), service workers, shop and market sales workers (27.5%), and craft and related trades workers (18.1%). The community skill set revealed that 19.3% of residents had agriculture and farming skills; close to fourteen percent (13.6%) of residents had secretarial/office clerk skills whilst a similar 13.6% of residents had construction and cabinet making skills (Social Development Commission, 2018).
- **Bogue** - The majority (83.6%) of workers were employed in the categories of service workers, shop and market sales workers (48%), professionals, senior officials and technicians (21.3%) and craft and related trades occupations (14.3%). The community skill set revealed that 28.1% of residents had professional and technical skills and 18% had secretarial/office clerk skills. Close to sixteen percent (15.7%) of residents had hospitality skills (Social Development Commission, 2018).
- **Catherine Hall** - Approximately 31% of household members are employed as professionals, senior officials and technicians, twenty-one percent (20.7%) of household members as service workers, shop and market sales workers while 20% are employed as clerks. The community skill set reveals that 33.7% of residents are trained in professional and technical skills; 24.5% are trained in secretarial and office clerk skills and 21.4% of residents are trained in machine and appliance skills. Women are more likely to have secretarial and office clerk skills and hospitality skills while males are more likely to have machine and appliance skills and professional and technical skills (Social Development Commission, 2010).
- **Green Pond** - The majority (69.2%) of the workers in Green Pond are employed in the categories of service, shop and market sales (33.4%), clerks (20.2%) and craft and related trades (15.6%) occupations. Only 13.9% of household members are employed as professionals, senior officials and technicians. The community skills set reveals the majority of residents with a skill possess professional and technical skills (22.2%); secretarial and office clerk skills (20.9%) and hospitality skills (19.2%) (Social Development Commission, 2013).
- **Montego Bay Business District** - The majority (84.6%) of workers in Montego Bay Business District were employed in the categories of elementary occupations (45.7%), service workers, shop and market sales workers (23.9%) and craft and related trades occupations (15%). The community skill set revealed that 20.7% of residents had hospitality skills and 13.9% had construction and cabinet making skills. Approximately eleven percent (11.2%) of residents had had secretarial/office clerk skills whilst 8.7% had beauty care and services skills. (Social Development Commission, 2018).
- **Montpelier** - The majority of persons in the community are employed as service and shop/market sales workers (35%). 35%). Women significantly dominate in this area (45% vs.

30%). However, men dominate in the craft and related trade occupations by approximately (26% vs. 3%); this is the third highest area of employment, followed by clerks (10%), skilled agricultural and fisheries workers (6%) professionals/senior officials/technicians (5%), and plant & machine operators (2%). The skill base of Montpelier is centred on Machine and Appliance workers (14%) and hospitality (14%). Further analysis shows that approximately 12% have marketable skills in technical areas (Construction and Cabinet Making, and Professional and Technical). Approximately two percent of residents possess beauty care and services skills and 9% possess agricultural and farming skills (Social Development Commission, 2008).

- Orange Irwin - The majority (54.7%) of the workers are employed in the categories of service, shop and market sales; elementary occupations and craft and related trade workers. Approximately 19% of household members are employed as professionals, senior officials & technicians. The community skill set shows the majority of men having skills in art and craft (17.3%) and machine and appliance (16%). Women were more likely to have secretarial and office clerk skills (20%), apparel and sewn products (10.7%) and professional and technical skills (9.3%) (Social Development Commission, 2009).
- Pitfour - The majority (84%) of the workers are employed in the categories of service, shop and market sales (41.9%); craft and related trade workers (24.1%) and clerks (17.9%). Only 6.2% of household members are employed as professionals, senior officials & technicians; 5.4% of whom are females. The community skill set reveals that 20.9% of residents have secretarial/office clerk skills; 15.7% have machine and appliance skills; 15.1% have hospitality skills and 13.4% have professional and technical skills (Social Development Commission, 2010).
- Porto Bello - Forty percent (40%) of the workers are employed as craft and related trade workers. Approximately thirty-one percent (30.9%) of household members are employed as professionals, senior officials & technicians and 20% are employed as service, shop and market sales. The community skill set reveals that 28.4% of residents have professional and technical skills; 20% of whom are females. Approximately fifteen percent (14.7%) of residents have hospitality skills and 12.6% are skilled in construction and cabinet making skills (Social Development Commission, 2010).
- Salt Spring - The majority (72.3%) of workers in Salt Spring were employed in the categories of: service workers, shop and market sales workers (31.6%), elementary occupations (22.5%) and professionals, senior officials and technicians (18.2%) occupations The community skill set revealed that 18.4% of residents had hospitality skills. Close to seventeen percent (16.5%) of residents had construction and cabinet making skills and 15% had machine and appliance skills. Approximately twelve percent (12.4%) of residents had secretarial/office clerk skills and 11.3% had apparel and sewn products skills. Close to eleven percent (10.9%) of household members had professional and technical skills (Social Development Commission, 2016).
- Seven Rivers - Sixty percent (60%) of household members are employed as service workers, shop and market sales workers. Twenty percent (20%) of household members are employed as skilled agricultural and fisheries workers and 13.3% are employed as professionals. The community skill set reveals that 50% of residents have commercial and sales skills or agricultural and farming skills (Social Development Commission, 2010).

- **Tucker** - The majority (53.9%) of the workers in Tucker are employed in the categories of service, shop and market sales (28.6%), elementary occupations (25.3%) and craft and related trades workers (23.1%). The community skills set reveals that the majority of residents with a skill possess hospitality skills (24.1%), construction and cabinet making skills (21.3%) and machine and appliance skills (13.9%) (Social Development Commission, 2014).
- **West Green** - The majority (87.7%) of workers were employed in the categories of clerks (41.5%), service workers, shop and market sales workers (32.3%) and professionals, senior officials and technicians (13.9%). The community skill set revealed that 41.9% of residents had secretarial/office clerk skills and 16.1% had professional and technical skills. Fourteen percent (14%) of residents had hospitality skills and 7.5% had apparel and sewn products skills (Social Development Commission, 2018).

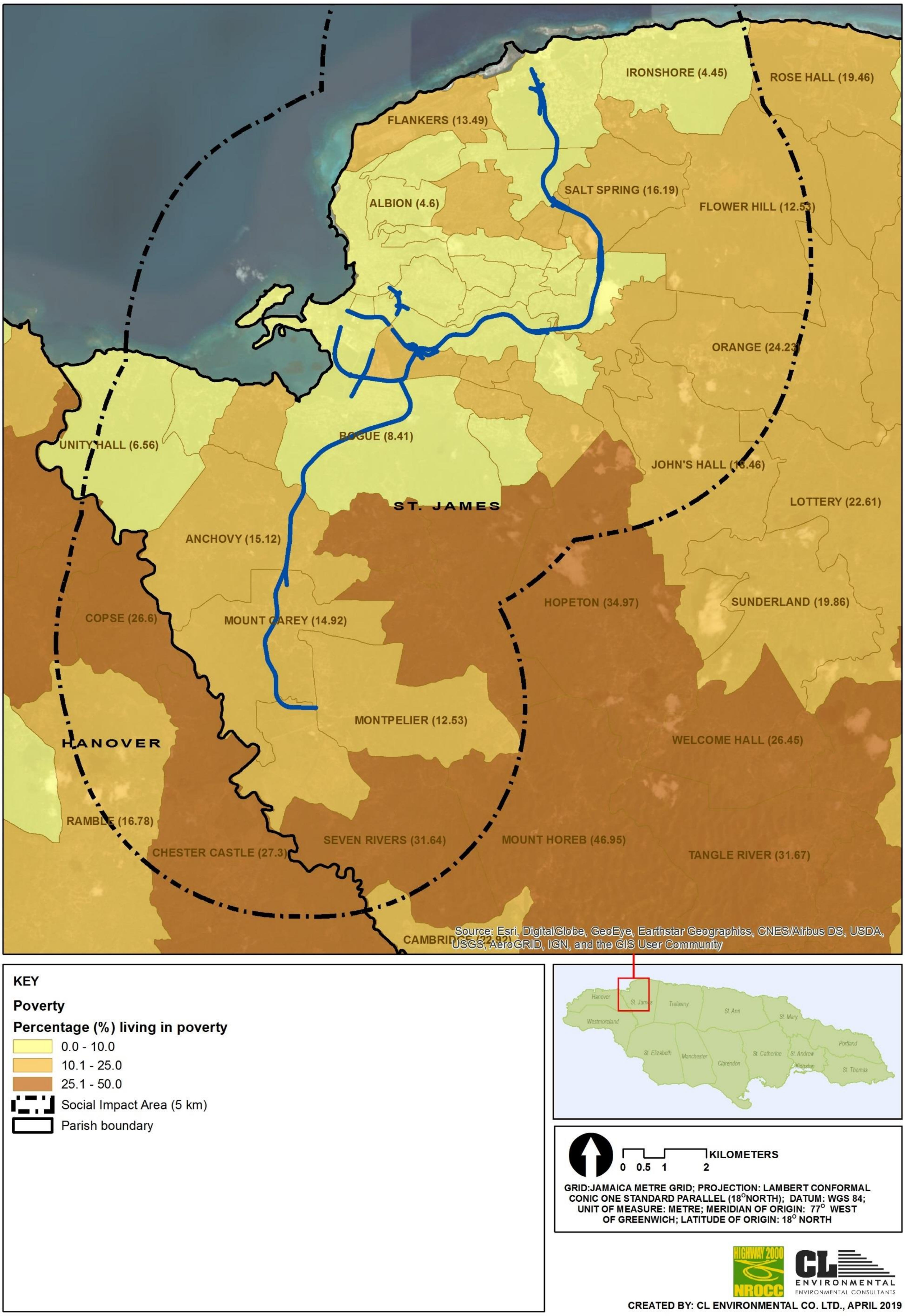
3.3.5 Income and Poverty

The poverty GIS dataset developed by the Planning Institute of Jamaica (PIOJ) (with contributions from STATIN, Social Development Commission (SDC) and the University of Technology), primarily identifies areas of poverty by community. Indicators utilized were those that best predicted per capita consumption levels in households based on data from the Jamaica Survey of Living Conditions (JSLC) 2002. Relevant variables that were common to this survey and the Population Census 2001 were selected and tested for similarity. Members of households that had consumption levels below the poverty line for the region in which their household was located were deemed to be in poverty. The proportion of persons in poverty in each community was used to rank the 829 communities. As seen in Figure 3-105, the community poverty level along the alignment varies; the SIA population has poverty levels ranging between 0.03% and 46.95% of persons living in poverty.

More detailed income distribution provided in SDC community profiles are as follows:

- **Bogue** - Less than a third (31.3%) of household heads had an income in excess of $86,800. Further analysis of the data reveals that 19.4% of household heads' earns between $22,400 and $44,799 per month and 17.9% earned an income between $44,800 and $64,799 per month (Social Development Commission, 2018).
- **Catherine Hall** - Just under four percent (3.8%) of household heads earn an income between $20,000 -$29,999 per month and 2.5% earns between $30,000-$39,999 per month. Only 6.3% of respondents have an income in excess of $40,000.00 per month (Social Development Commission, 2010).
- **Green Pond** - Close to eleven percent (10.6%) of household heads' earns less than $16,280 per month. Further analysis of the data reveals that 20.8% of employed household heads earns between $16,280 and $32,499 per month and 18.9% earn an income between $43,500 and $86,499 per month. Only 13.5% of household heads have an income in excess of $86,500 (Social Development Commission, 2013).
- **Montpelier** - Twenty-two percent of households earn a monthly income ranging from $6000 – $24,999. More than 38% of households earn less than the minimum wage rate of $3,700 weekly (Social Development Commission, 2008).

- **Mount Carey** - Approximately twenty-three percent (23.4%) of employed household heads earn an income below $6,000 per month. Over forty-three percent (43.3%) of employed household heads earn an income between $6,000 -$24,999 per month; 26.7% earns between $25,000 -$39,999 per month and 6.7% have an income in excess of $40,000.00 (Social Development Commission, 2008).
- **Orange Irwin** - Approximately thirteen percent (13.1%) of households earns less than $10,000.00 per month. Eleven percent (11%) of households earn between $40,000 -$79,999 per month; 6.5% earns between $30,000- $39,999 per month and 6.5% earns between $80,000- $129,999 (Social Development Commission, 2009).
- **Pitfour** - Approximately 4.5% of household heads earn between $20,000-$29,999 per month and 4.5% earns between $40,000 - $79,000 per month. Approximately 2.3% of households earns less than $20,000.00 per month and 2.3% earns between $130,000 and $249,000 per month (Social Development Commission, 2010).
- **Porto Bello** - Approximately seven percent of household heads earn an income that is less than twenty thousand dollars ($20,000) per month whilst 11.45% of household heads earn between $20,000 -$29,999 per month. Just under seven percent (6.8%) of household heads earns between $40,000- $79,999 per month and 11.4% earns an income above $80,000 per month (Social Development Commission, 2010).
- **Salt Spring** - Close to thirty percent (29.3%) of household heads' earns less than $32,499 per month. Further analysis of the data reveals that 22.4% of household heads' earns between $32,500 and $43,499 5 per month and a similar 22.4% earn an income between $43,500 and $86,499 per month. Only 10.3% of household heads had an income in excess of $86,500. Over twenty percent (20.5%) of households had no additional source of income (Social Development Commission, 2016).
- **Seven Rivers** - Approximately thirty-three percent (33.3%) of employed household heads earn an income between $6,000 -$24,999 per month; another 33.3% earns between $25,000 - $39,999 per month and 33.3% have an income in excess of $40,000.00 (Social Development Commission, 2010).
- **Tucker** - Eighteen percent (18%) of household heads' earns less than $16,280 per month. The national minimum wage is twenty-two thousand four hundred dollars ($22,400) per month. Further analysis of the data reveals that 28% of employed household heads earns between $16,280 and $32,499 per month and 16% earn an income between $32,500 and $86,499 per month. Only 2% of household heads have an income in excess of $86,500 (Social Development Commission, 2014).
- **West Green** - Approximately nineteen percent (18.5%) of household heads earn between 44,800 and $64,799 per month. Further analysis of the data reveals that 14.8% of household heads earn an income between $64,800 and $86,799 per month. Only 11.1% of household heads had a monthly income in excess of $86,800. Close to fifty-eight percent (57.7%) of households had no additional source of income (Social Development Commission, 2018).



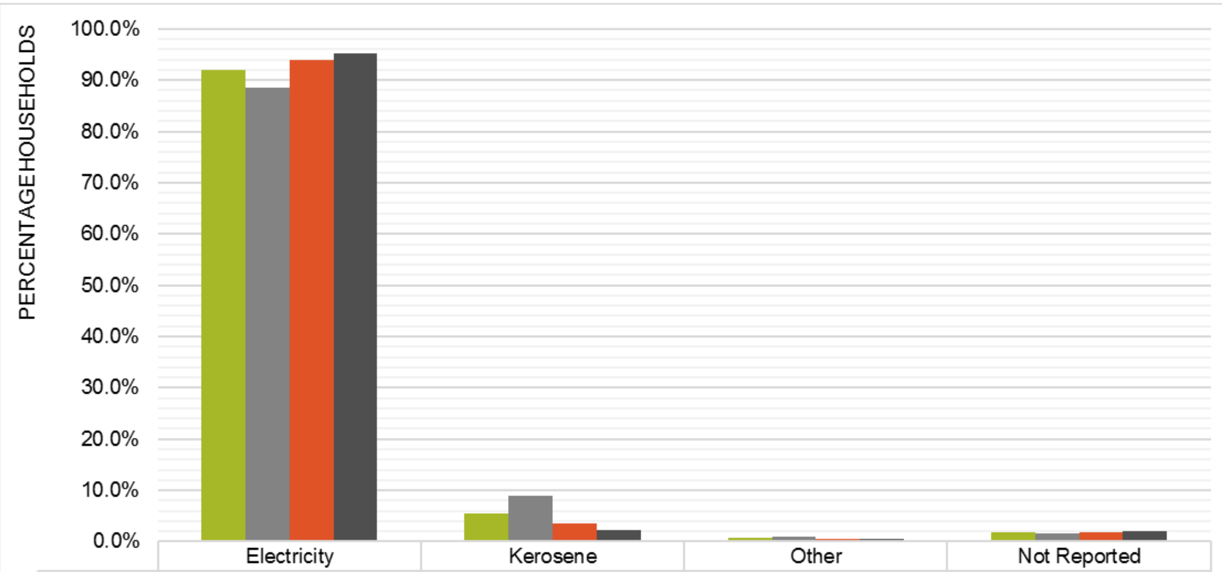
Data source: PIOJ (with contributions from STATIN, SDC and the University of Technology

Figure 3-105 Proportion of persons in poverty in each community within the SIA

3.3.6 Infrastructure and Services

3.3.6.1 Lighting

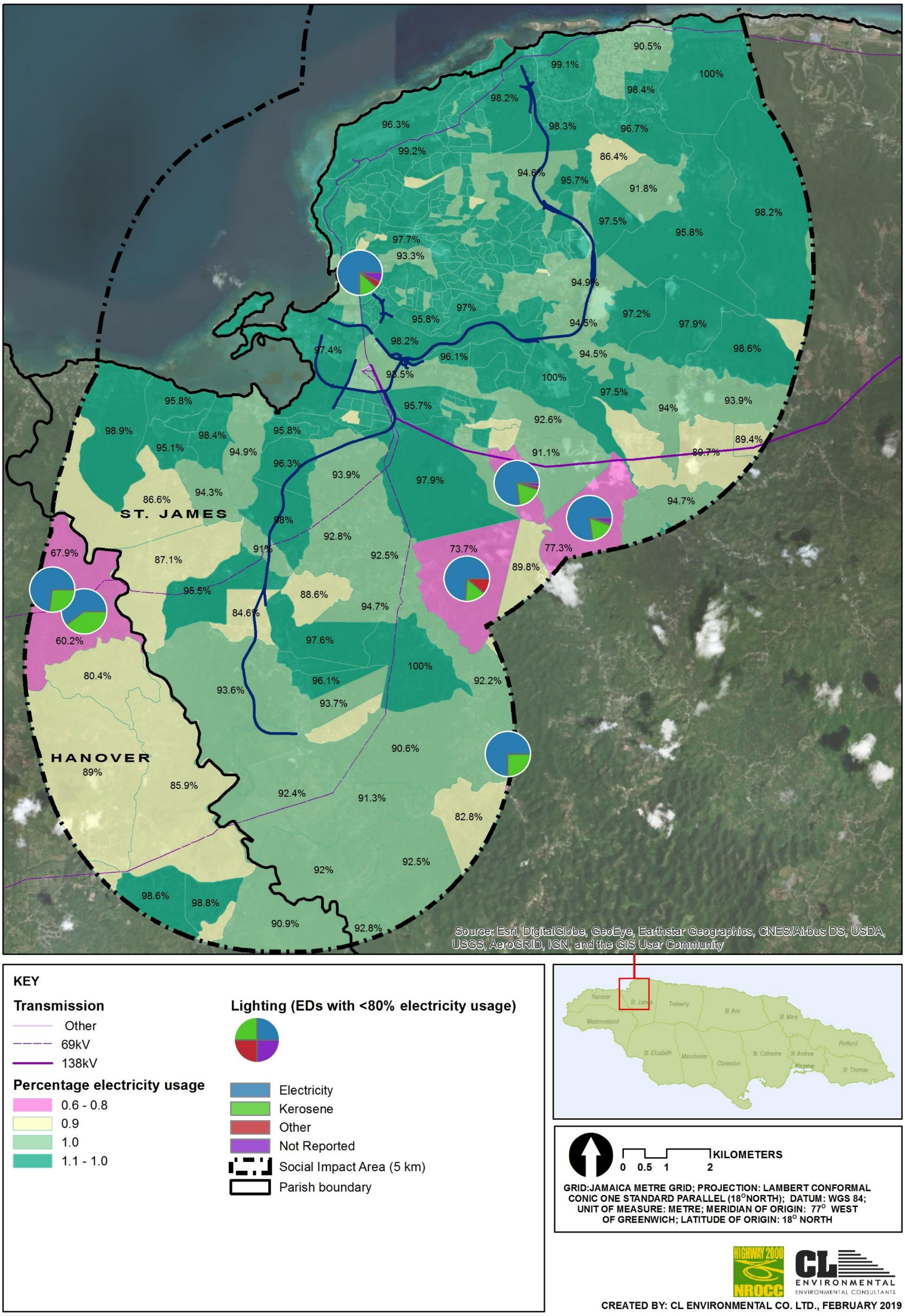
Figure 3-106 details the percentage of households using a category of lighting. Data for all extents (SIA, parish and national) reveal that most of the population utilises electricity as their main source of lighting. Approximately ninety-five percent (95.3%) of households within the SIA use electricity and this is highest amongst all extents examined. The use of electricity is not consistent throughout the SIA (Figure 3-107); in EDs where electricity usage is less than 80%, kerosene is the secondary source of lighting within the ED. Overall however, the percentage of households using kerosene as their main means of lighting in the SIA (2.2%) was lowest amongst all extents (Figure 3-106).



	Electricity	Kerosene	Other	Not Reported
Jamaica	91.9%	5.5%	0.8%	1.8%
Hanover	88.4%	9.0%	1.0%	1.5%
St. James	93.9%	3.6%	0.6%	1.8%
SIA	95.3%	2.2%	0.5%	1.9%

Source: STATIN Population Census 2011

Figure 3-106 Percentage households by source of lighting



Source: STATIN Population Census 2011

Figure 3-107 Percentage electricity usage for the year 2011 and location of transmission lines within the SIA

3.3.6.2 Domestic Water Supply

The National Water Commission (NWC) is the public agency responsible for providing Jamaica's domestic water supply. The majority of the households within the SIA (84.4%) received their domestic water supply from a public source; this is similar to other extents investigated that had the majority of the population's water supply from a public source (Table 3-55).

Table 3-55 Percentage of households by water supply for the year 2011

Source: STATIN Population Census 2011

	Category	Jamaica	Hanover	St. James	SIA
Public Source	Piped in Dwelling	49.7%	43.5%	60.9%	67.5%
	Piped in Yard	16.5%	17.5%	12.9%	12.7%
	Stand Pipe	7.1%	14.2%	5.4%	3.7%
	Catchment	2.2%	1.3%	0.7%	0.5%
Private Source	Into Dwelling	6.4%	3.5%	5.0%	4.4%
	Catchment	9.8%	7.7%	4.3%	6.2%
	Spring/ River	3.0%	4.3%	6.0%	1.3%
	Trucked Water/Water Truck	2.1%	2.8%	1.8%	1.0%
	Other	1.8%	3.5%	1.7%	1.4%
	Not Reported	1.3%	1.6%	1.2%	1.2%

Water demand for the SIA in 2019 is estimated to be 34,954,572 litres/day (~9,234,023 gals/day) and is expected to increase to 47,594,508 litres/day (~12,573,141 gals/day) over the next twenty-five years based on population growth rates calculated previously.

NWC facilities, including storage tanks, relift and pump stations, production wells and reservoirs, as well as the pipeline network that support the provision of water from NWC and that are located within the SIA are shown in Figure 3-108 and listed in Table 3-56; there are a total of 67 potable facilities within the SIA. Also shown in Figure 3-108 are other sources of domestic water, such as naturally occurring springs and rivers, as well as wells owned by various entities including NWC. There are 52 wells (Table 3-57) and six springs found within the SIA. Major river systems include Great River and Montego River and their associated water management units (WMUs) (Figure 3-108).

Table 3-56 NWC potable water facilities within the SIA

Name	Type
Torada Heights #1	Storage Tank
Torada Heights #2	Storage Tank
Torada Heights #3	Storage Tank
Rose Heights #1	Storage Tank
Rose Heights #3	Storage Tank
Providence	Storage Tank
Bogue Hill #3	Storage Tank
Albion Court	Storage Tank
Tucker	Production Well
Tower Hiil	Relift Station
Belmont	Relift Station
Bogue Hill	Production Well
Paradise	Relift Station

Name	Type
Ironshore	Relift Station
Hatfield #1	Storage Tank
Hatfield #2	Storage Tank
Hatfield	Relift Station
Hatfield	Storage Tank
Torada Heights	Relift Station
Torada Heights	Reservoir
Torada Heights	Storage Tank
Coral Gardens	Relift Station
Coral Gardens	Reservoir
Sangster International Airport	Storage Tank
Reading Heights #1	Relift Station
Reading Heights #2	Relift Station

Name	Type
Reading Heights	Storage Tank
Upper Deck	Reservoir
Terminal	Pump Station
Terminal	Reservoir
Paradise	Storage Tank
Bogue Hill #1	Relift Station
Bogue Hill	Storage Tank
Bogue Hill #2	Relift Station
Reading	Pump Station
Reading	Entombment
Moy Hall	Relift Station
Moy Hall	Storage Tank
Moy Hall	Storage Tank
Tower Hill	Storage Tank
Spring Garden	Relift Station
Unity Hall	Storage Tank
Appleton Hall	Relift Station
Appleton Hall	Reservoir
Norwood	Reservoir
Norwood	Pump Station
Norwood	Reservoir
Salt Spring	Relift Station
Salt Spring	Storage Tank
Salt Spring	Reservoir
Salt Spring #2	Relift Station
Salt Spring #2	Reservoir
Farm Heights	Relift Station
Rose Heights #2	Storage Tank
Rosemount	Reservoir
Farm Heights	Storage Tank
Porto Bello	Storage Tank
Irwindale	Production Well
Porto Bello Deep Well	Production Well
Catherine Mount #2	Production Well
Catherine Mount #1	Production Well
Westgate Hills #2	Relift Station
Westgate #1	Storage Tank
Wesgate #2	Storage Tank
Fairfield Deep Well	Production Well
Fairfield	Booster Station
Fairfield	Storage Tank

Table 3-57 Wells located within the project SIA

Location	Parish	Owner	Depth (m)
Rose Hall 2	St. James	Rose Hall Development Limited	45.72
Rose Hall 3	St. James	Rose Hall Development Limited	50.29
Rose Hall 5 (Deep well 2)	St. James	Rose Hall Development Limited	115.82
Leogan Exp. IV	St. James	Dr. Seymour Thomas	151.79
Catherine Mount obs. 1	St. James	National Water Commission	
Catherine Mount obs. 2	St. James	National Water Commission	
Granville Expl. II	St. James	National Water Commission	61.26
Kirkpatrick Hall	St. James	Mr. Suarez	
Riverhead West	St. James	Rose Hall Development Limited	109.73
Riverhead East	St. James	Rose Hall Development Limited	109.73
Anchovy	St. James	Mr. Beckford	16.76
Roehampton	St. James	National Water Commission	
Cornwall Dairy - Montpelier (Test bore)	St. James	Jamaica Industry Development Corporation	60.96
Bogue Heights	St. James	National Water Commission	39.62
Barnett (Pies River)	St. James	Barnett Estates	45.72
Tucker	St. James	National Water Commission	60.96
Casa Montego Hotel	St. James	Casa Montego Hotel	25.91
Bogue CH	St. James	Barnettt Estates	88.39
Irwin Exp. III (Porto Bello)	St. James	National Water Commission	152.4
Irwin obs.	St. James	National Water Commission	152.4
Pitfour Pen	St. James		48.77
Pitfour Pen Exp. I	St. James	National Water Commission	67.97
Latium Dug	St. James	James Spence	
Friendship CH	St. James	Mr. Walker	30.48
Bogue Plant CH #1	St. James	Jamaica Public Service Company Limited	30.48
Montpelier	St. James	Jamaica Milk Products	60.96
Bogue JPS Plant	St. James	Jamaica Public Service Company Limited	64.01
Bogue (Reading) #2	St. James	Desnoes & Geddes Limited	22.86
Catherine Mount #2	St. James	National Water Commission	45.72
Catherine Mount #1	St. James	National Water Commission	45.72
Belfield	St. James	Barnett Estate	24.38
Cornwall Dairy - Montpelier #2	St. James	Jamaica Industry Development Corporation	91.44
Salt Spring CH	St. James	Water Resources Authority	91.44
Ironshore Estate	St. James	Ironshore Estates	28.96
Bogue JPS	St. James	Jamaica Public Service Company	
Green Pond CH	St. James	Mr. David Baugh	33.53
Bogue	St. James	Barnett Estates	76.2
Ironshore Estates No. 1	St. James	Ironshore estates	35.05
Ironshore Estate	St. James	Ironshore Estates	48.46
Bogue (Reading) #1	St. James	Desnoes & Geddes Limited	39.62
Glendevon CH	St. James		39.62
Rose Hall 1	St. James	Rose Hall Development Limited	38.1
Kirkpatrick Hall CH	St. James	Mr. Suarez	45.72
Spring Garden - Reading	St. James	Montego Spa Dev. Co. Ltd.	104.24
Rose Hall 4	St. James	Rose Hall Development Limited	51.82
Retirement Exp. V	St. James	G.W.R. & S.	91.23
Mount Salem CH	St. James	Barnett Estates Property	70.1
Bellvue CH (near roadside)	St. James	Water Resources Authority	79.25
Sign Great House	St. James	Jack Gold	100.58
Orange	St. James	Carl Rhoden	152.4
Leogan obs.	St. James	Dr. Seymour Thomas	92.91
Fairfield	St. James	National Water Commission	77.72

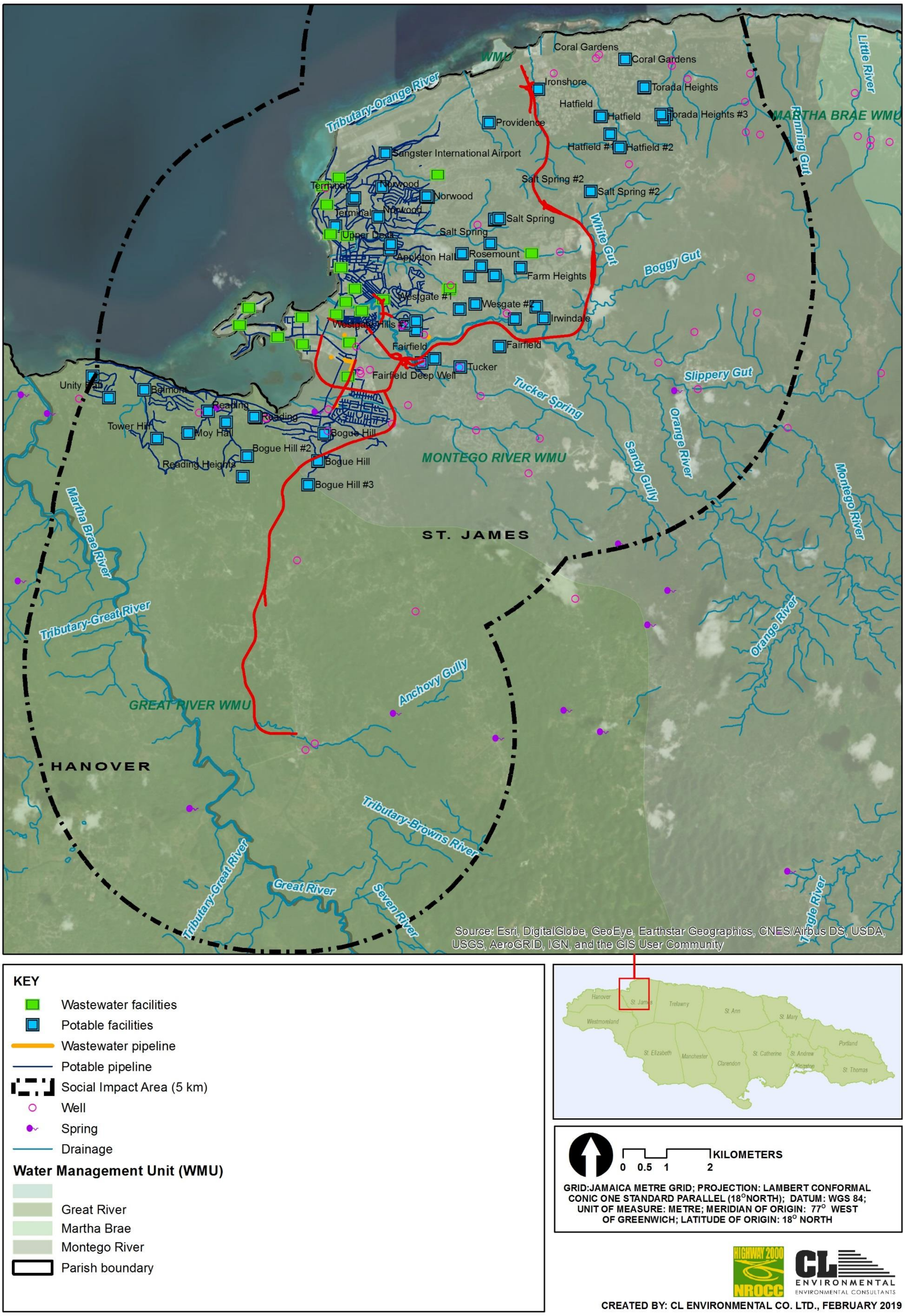


Figure 3-108 Water management units, natural water features, as well as NWC infrastructure located in the SIA

3.3.6.3 Wastewater Generation and Disposal

It is estimated that approximately 27,963,657 litres/day (~7,387,218 gals/day) of wastewater is generated within the study area (for 2019) and is expected to increase to 38,075,607 litres/day (~10,058,513 gals/day) over the next twenty-five years based on calculated growth rates.

Census 2011 data for wastewater disposal methods was not available. However, SDC community profile data revealed varying wastewater disposal methods within communities along the proposed alignments. Water closets not linked to a sewer system were the main method of disposal in the communities of Seven Rivers, Montpelier, Mount Carey, Tucker, Pitfour, Anchovy and Porto Bello (greater than 50%), whilst water closets linked to a sewer system were the predominant method in Bogue, Green Pond, West Green and Catherine Hall. Soak away was the main method in Orange Irwin (63.1%) (Social Development Commission, 2009), whilst shared toilet facilities were relatively common in Montego Bay Business District (43.7%) (Social Development Commission, 2018) and Seven Rivers (31.3%) (Social Development Commission, 2010). In Montego Bay Business District, water closets not linked to a sewer system (42.9%), linked to a system (29.5%), pit latrines (13.3%) and no facility (15.6%) were the other wastewater disposal methods also recorded for this community (Social Development Commission, 2018).

Wastewater (WW) infrastructure shown in Figure 3-108 include pipelines and various WW treatment plants and Relift stations in the Montego Bay area (Table 3-58).

Table 3-58 NWC wastewater (WW) infrastructure within the SIA

Name	Type	Type of treatment	Location
Harbour Street	WW Relift Station		Harbour Street
Mount Salem	WW Relift Station		Mount Salem
Westgreen	WW Relift Station		Westgreen Meadows
Catherine Hall #2	WW Relift Station		Catherine Hall
Catherine Hall #1	WW Relift Station		Catherine Hall
River Bay	WW Relift Station		River Bay
Barnett	WW Relift Station		
Rosemount Gardens	WW Treatment Plant	Oxidation Ditch	Rosemount Gardens
Cornwall Court	WW Treatment Plant	Extended Aeration	Cornwall Court
Norwood	WW Treatment Plant	Oxidation Ditch	Norwood Meadows
Queens Drive	WW Relift Station		Queens Drive
Summit	WW Relift Station		Sunset Boulevard
Cornwall Beach	WW Relift Station		Jamaica Tourist Board Office
Fort Street	WW Relift Station		Fort Street
Orange Street	WW Relift Station		Orange Street (perpendicular to Cornwall College)
Montego Bay Freeport #1	WW Relift Station		Freeport Road
Montego Bay Freeport #2	WW Relift Station		Freeport Road
Montego Bay Freeport #3	WW Relift Station		Freeport Road
Freeport #5	WW Relift Station		Perpendicular to Cazoumar Freezone
Freeport #4	WW Relift Station		Freeport Road
Bogue Sewage Ponds	WW Treatment Plant	Ponds	Bogue Main Road
Beving Avenue	WW Treatment Plant		Beving Avenue

3.3.6.4 Solid Waste

It is estimated that at the time of this study (2019), approximately 196,692 kg (~197 tonnes) of solid waste was being generated.

The National Solid Waste Management Authority (NSWMA) is responsible for domestic solid waste collection within the study area and specifically, WPM Waste Management Ltd. covers the parishes of St. James and Hanover. In residential areas, garbage is collected once per week. This service is provided free (partial covered by property taxes) for the households within the area.

3.3.6.5 Telecommunication

The study area is served with landlines provided by Flow Jamaica Limited (formerly LIME Jamaica Limited). Wireless (mobile) communication is provided by Digicel Jamaica Limited and Flow and a network to support internet connectivity is also provided by Flow. The following Flow infrastructure is located within the SIA (Figure 3-109):

- 25 service switches
- 108 service cabinets
- 14177 poles (not shown on map)
- 33 mobile sites
- 734 manholes
- 5750 distribution panels (not shown on map)

According to SDC community profiles, the majority of household located in communities along the alignments (greater than 93%) utilise telephone services (cellular and landline). Internet usage is more varied; as much as 85% of households in Bogue use Internet (Social Development Commission, 2018), whilst in communities such as Mount Carey and Montpelier internet usage is negligible (2.8% and 0% respectively) (Social Development Commission, 2008) (Social Development Commission, 2008).

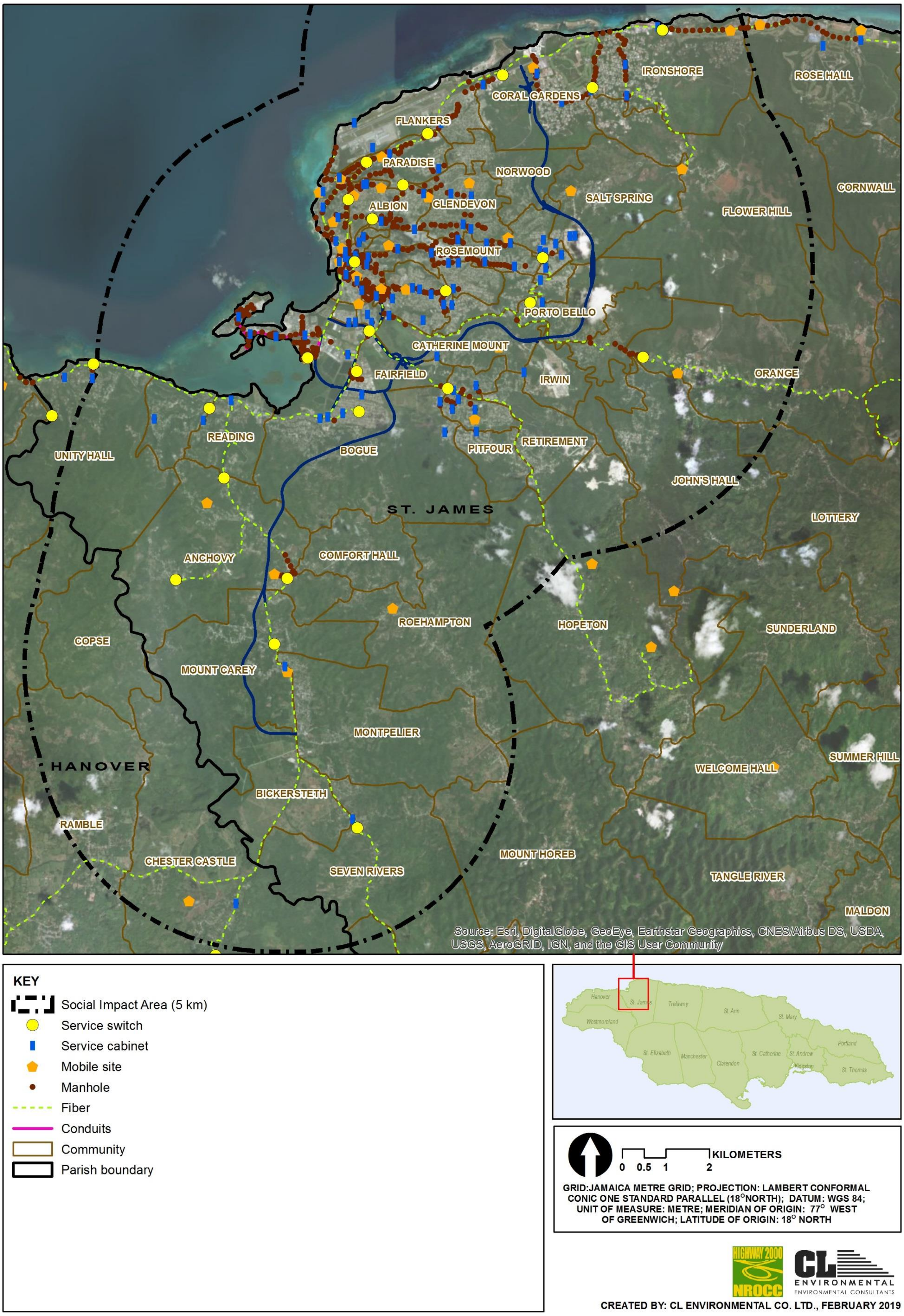


Figure 3-109 Flow infrastructure within the SIA (poles and distribution panels not shown)

3.3.6.6 Health and Emergency

3.3.6.6.1 Health Services and Usage

According to SDC community profiles for the study area, public hospital use by households varies between 26% and 85% in communities along the proposed alignment; this is somewhat similar to health centre usage that ranges between 3% and 88%. Hypertension, diabetes, asthma and arthritis are the top named health problems affecting residents in communities along the proposed alignments.

HEALTH CENTRES

Eleven health centres/ clinics exist within the SIA (Figure 3-110); all of which fall under the responsibility of the Western Regional Health Authority (WRHA):

- Tower Hill Health Centre
- Mount Carey Health Centre
- Granville Health Centre
- Catherine Hall Health Centre
- Salt Spring Health Centre
- Roehampton Health Centre
- Mount Salem Health Centre
- Green Pond Health Centre
- Glendevon Health Centre
- Flanker Health Centre
- Urgent Care
- Hope (Teaching) Health Care, Medical and Dental Clinic

HOSPITALS

There are two hospitals within the SIA, both of which belong to the WRHA:

- Cornwall Regional (Public)
- Faith Maternity (Private)

Cornwall Regional Hospital (CRH) is located in Mount Salem and is a Type A hospital, providing comprehensive secondary and tertiary health care services. It is a 10 storey, 400-bed capacity multidisciplinary institution, currently operating as a 367-bed hospital. The CRH is the only hospital outside of Kingston providing most of the specialist services (Western Regional Health Authority, 2009).

3.3.6.6.2 Fire Stations

Fire stations within the SIA exist at the following three locations (Figure 3-110): Barnett Street, Freeport and Ironshore. The Montego Bay Division of the Jamaica Fire Brigade, which operates from Freeport in Montego Bay, has 3 functional fire units and an ambulance manned by 191 fire fighters. (Social Development Commission, 2018). Fire stations island-wide are served by a fleet of 91 operational firefighting and rescue vehicles and 58 utility vehicles. There are also 3 fire boats, one each assigned to the harbours in Kingston, Montego Bay and Ocho Rios. The Fire Prevention and Public Relations Division and the Emergency Medical Service (EMS) provide fire prevention services and emergency medical rescue/ paramedic services (Jamaica Fire Brigade , 2012).

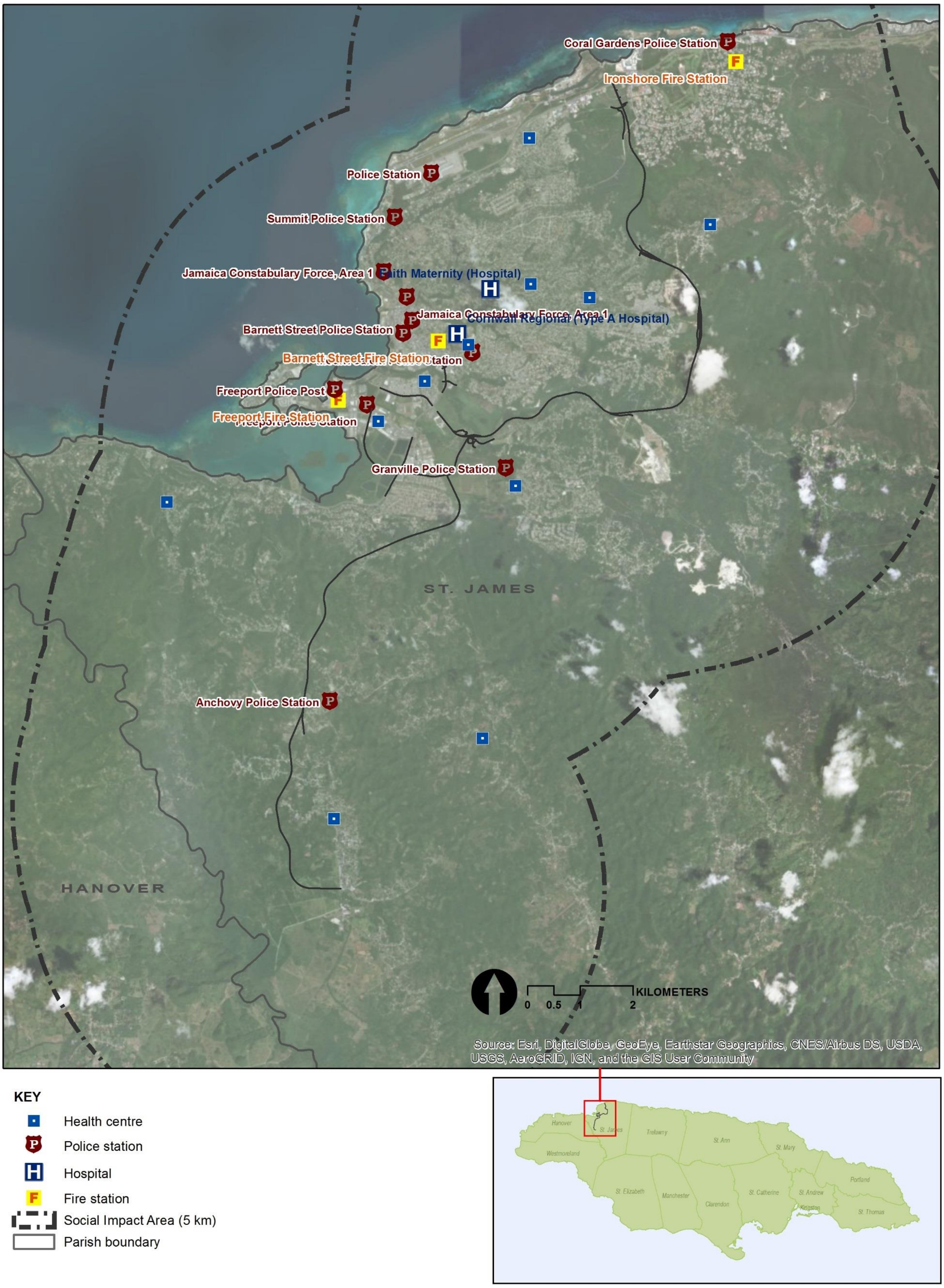
3.3.6.6.3 Police Stations

Thirteen police stations and posts exist within the SIA:

- Granville Police Station
- Mount Salem Police Station
- Barnett Street Police Station
- Jamaica Constabulary Force, Area 1
- Major Organised Crime and Anti-Corruption Agency
- Jamaica Constabulary Force, Area 1
- Summit Police Station
- Jamaica Constabulary Force, Area 1 Control
- Police Station
- Coral Gardens Police Station
- Freeport Police Station
- Freeport Police Post
- Anchovy Police Station

3.3.6.6.4 Crime and Safety

In January 2018 the Government of Jamaica imposed states of emergency in the North Western parish of St James, in response to the spike of violent crimes. The SOE lasted for one year, as which point it was reinstated in April 2019. In the project area there were a few hotspots, Salt Spring, Norwood, Irwin, Catherine Hall, Bogue Hill, Anchovy, York Bush and Fustic Grove. Western Jamaica, St. James is also known as the scamming capital of the country.



CREATED BY: CL ENVIRONMENTAL CO. LTD., APRIL 2019

Data source: Health centres, police stations (Social Development Commission, 2019); hospitals, fire stations (Mona GeoInformatics Institute)

Figure 3-110 Health and emergency services located in and around the SIA

3.3.6.7 Social Facilities

3.3.6.7.1 Post Offices

There are a total of 16 postal service locations within the demarcated SIA (Table 3-59, Figure 3-111 and Figure 3-112).

Table 3-59 Postal service locations within the SIA

Source: (Mona GeoInformatics Institute and Social Development Commission, 2019)

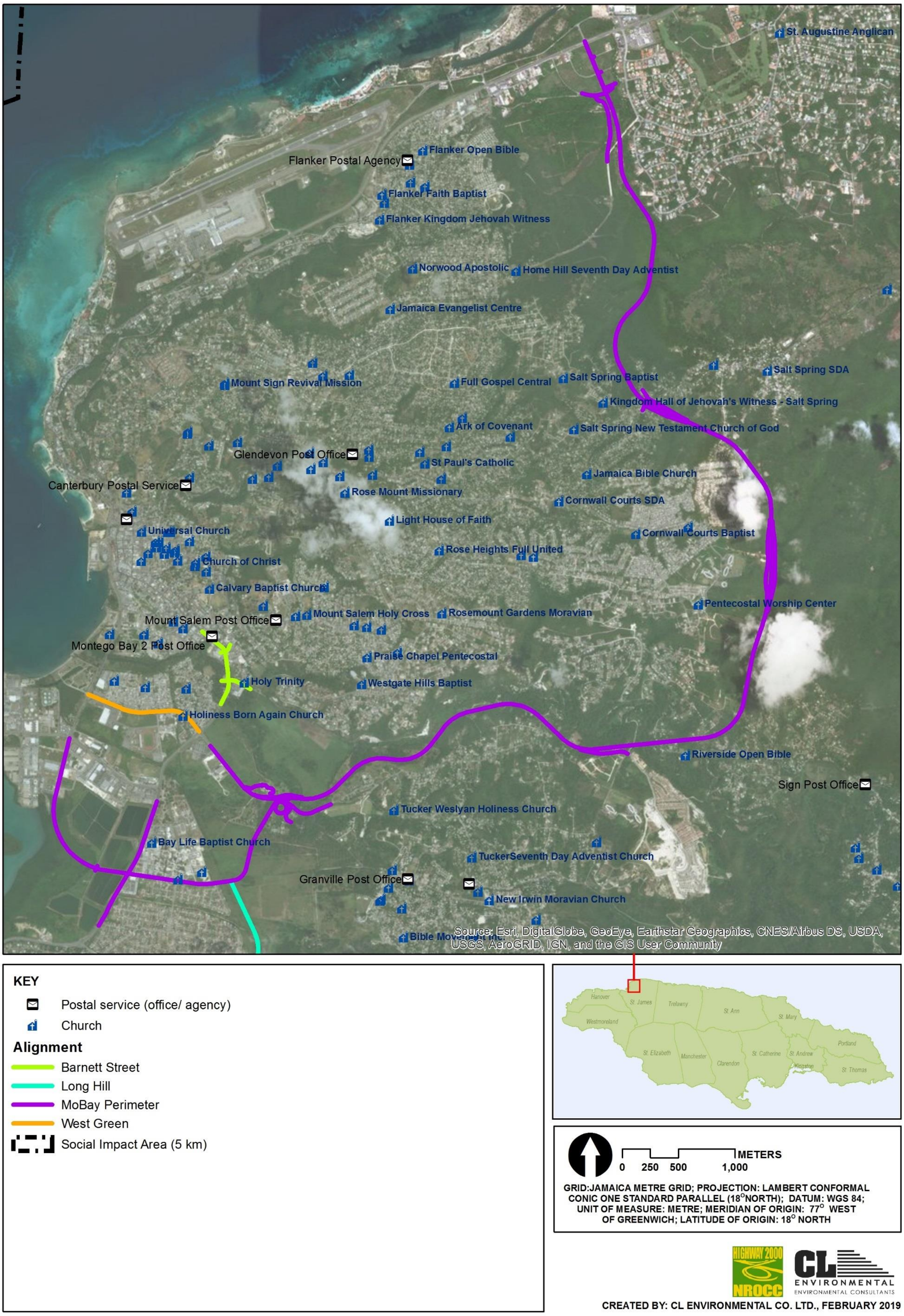
Postal Agency	Post Office	Postal Service
Tower Hill Postal Agency	Montpelier Post Office	Canterbury Postal Service
Tower Hill Postal Agency (New)	Granville Post Office	
Flanker Postal Agency	Reading Post Office	
	Sign Post Office	
	Mount Salem Post Office	
	Montego Bay 2 Post Office	
	Johns Hall Post Office	
	Glendevon Post Office	
	Flanker Postal Agency	
	Anchovy Post Office	
	Montego Bay 1 Post Office	
	Half Moon Post Office	
	White Sands Beach Post Office	
3	13	1

3.3.6.7.2 Churches

A total of 203 churches are located within the demarcated 5-km SIA Figure 3-111 and Figure 3-112).

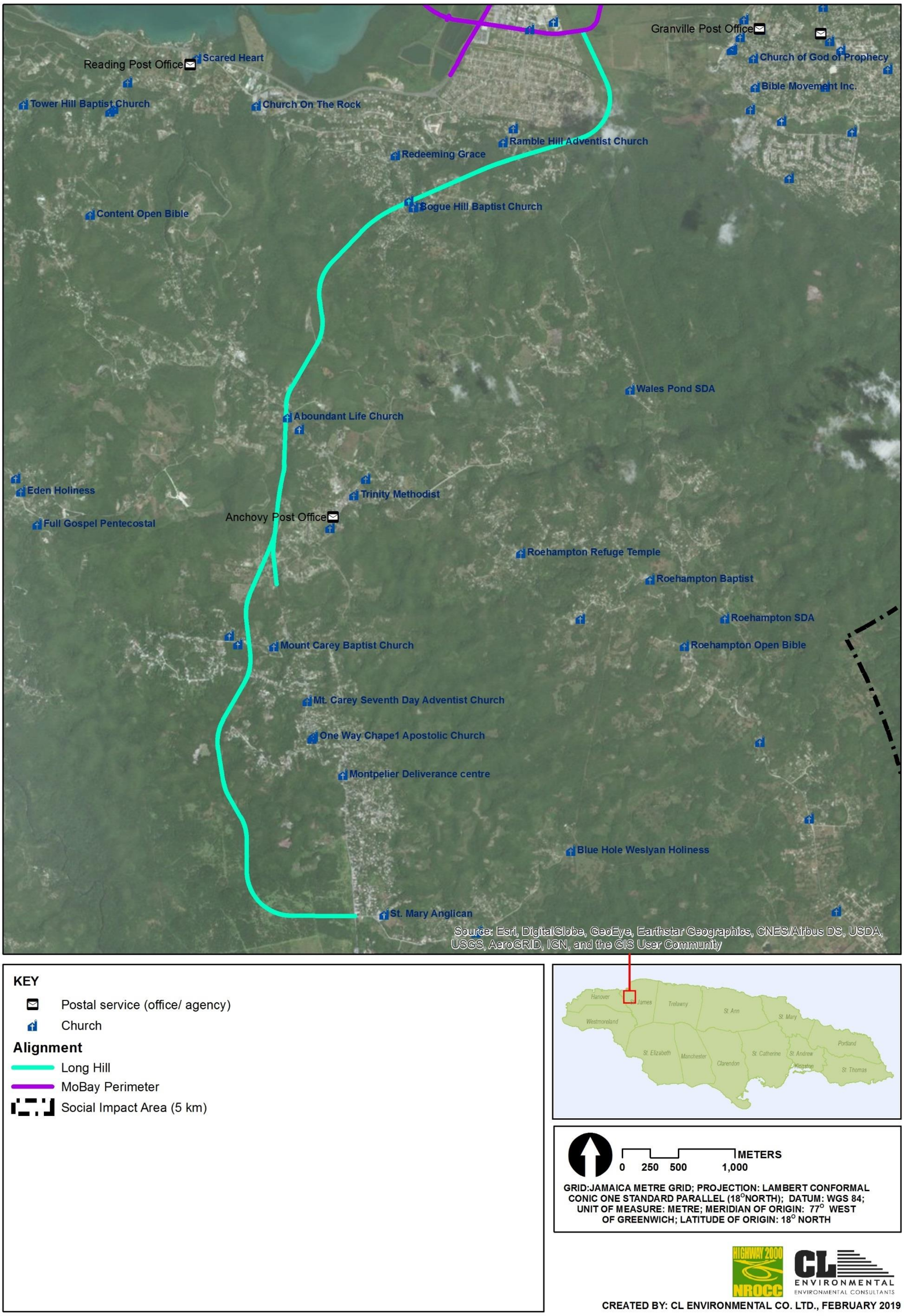
3.3.6.7.3 Recreation

A total of 117 recreational facilities are located within the SIA, including community centres, playfields, cinemas, recreational beaches, yacht clubs, nature parks and attractions (Figure 3-113 amd Figure 3-114). Of mention is the Catherine Hall Entertainment Centre at which the world- renowned “Reggae Sumfest” is staged, amongst other events. Reggae Sumfest draws thousands of overseas visitors to the country each year (Social Development Commission, 2010).



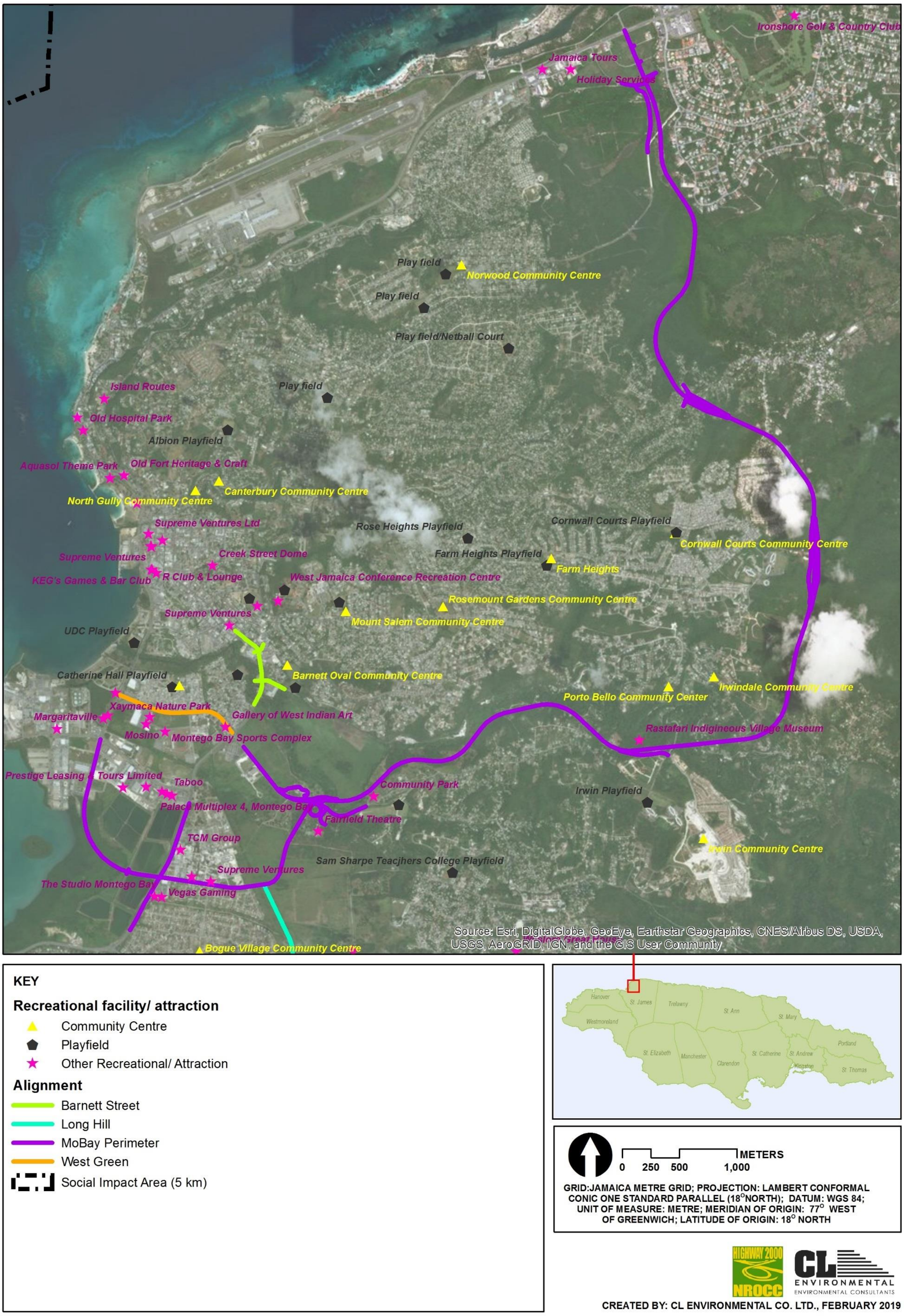
Data source: Churches (Social Development Commission, 2019), postal services (Mona GeoInformatics Institute and Social Development Commission, 2019)

Figure 3-111 Churches and postal services with the SIA - Montego Bay Perimeter, Barnett and West Green



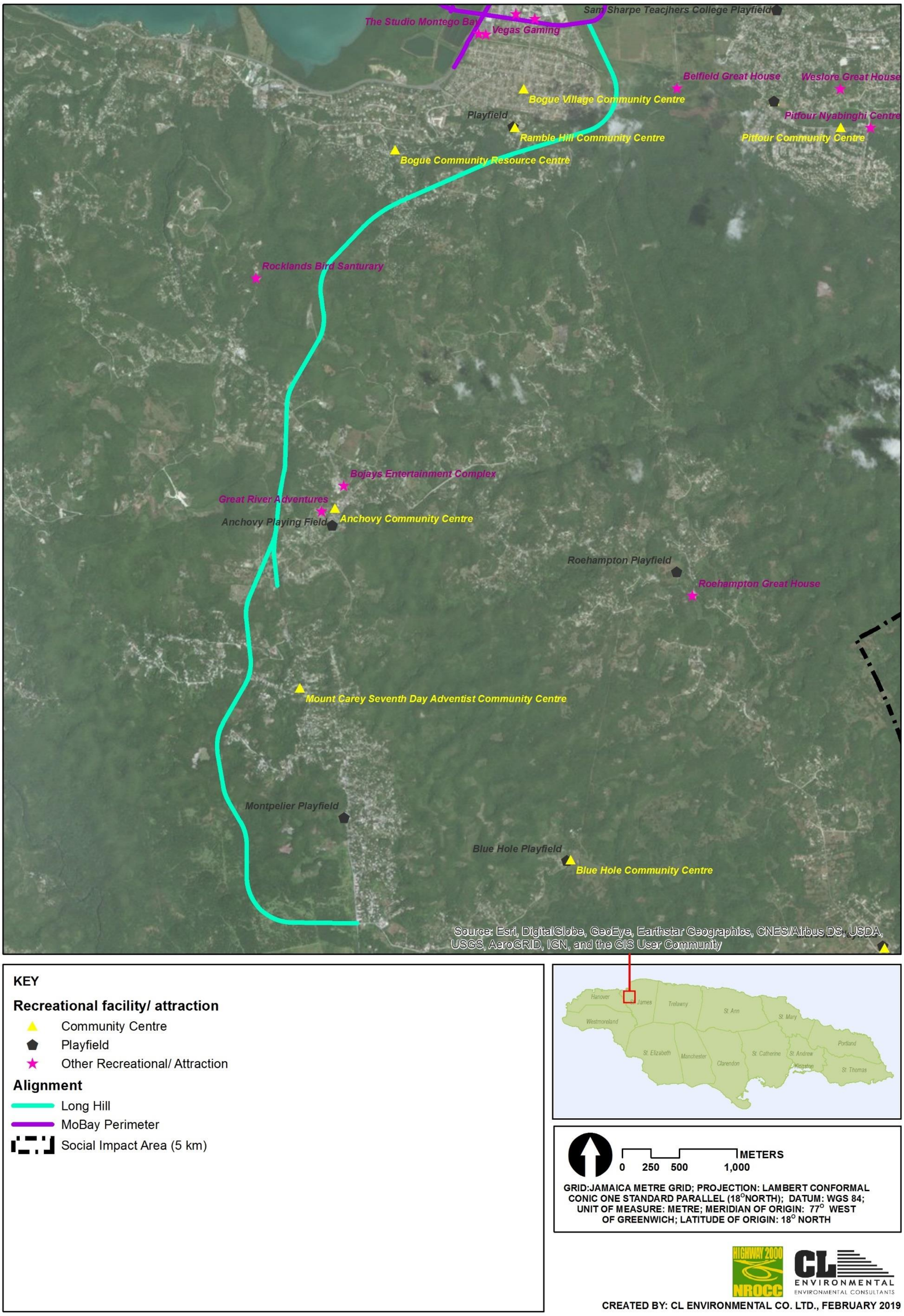
Data source: Churches (Social Development Commission, 2019), postal services (Mona GeoInformatics Institute and Social Development Commission, 2019)

Figure 3-112 Churches and postal services with the SIA – Long Hill



Data source: Assets (Social Development Commission, 2019)

Figure 3-113 Recreational facilities with the SIA - Montego Bay Perimeter, Barnett and West Green



Data source: Assets (Social Development Commission, 2019)

Figure 3-114 Recreational facilities with the SIA – Long Hill

3.3.6.8 Transportation

3.3.6.8.1 Ground Transportation

An overview of the existing road network within the SIA may be found in Figure 3-115. Several modes of ground transportation to and from communities in the SIA exist and include taxi (licensed & unlicensed), bus, private motor car, motorcycle, and bicycle.

Existing traffic conditions in the Greater Montego Bay Metropolitan Area was observed by a combination of origin-destination surveys, field reconnaissance and travel time surveys. The corridors of focus were representative of the main thoroughfares traversing into and out of Montego Bay. The corridors are Alice Eldemire Road to Bogue Road, Bogue Road to Fairfield Road, Fairfield Road to Porto Bello Road, Porto Bello Road to Cornwall Courts, Cornwall Courts to Salt Spring and Salt Spring to Ironshore. Subsequent sections focus on the road network in Greater Montego Bay and information is taken from the *Greater Montego Bay Metropolitan Transportation System Traffic Report* (Stanley Consultants Inc. (SCI), 2017).

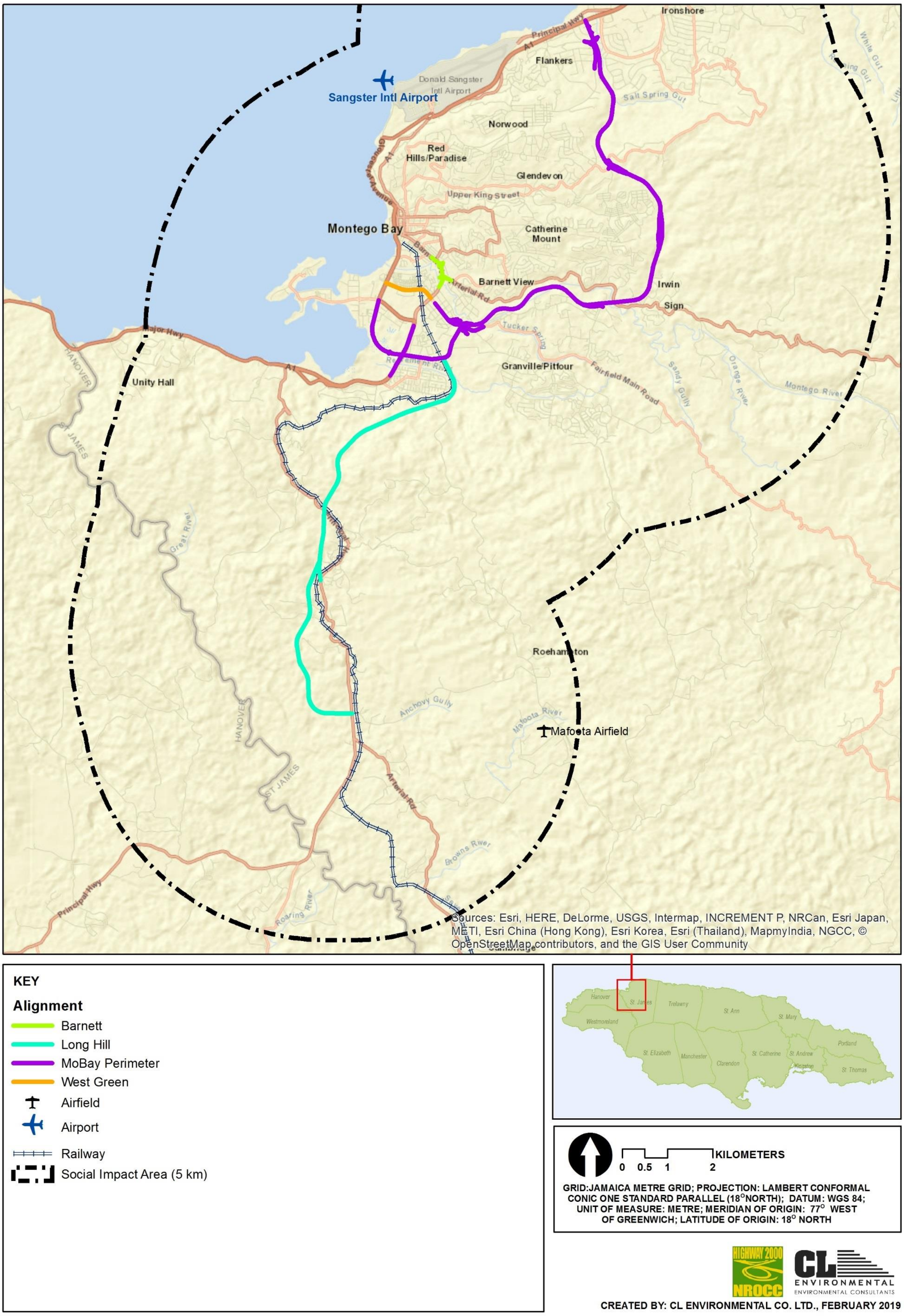


Figure 3-115 Existing transportation within the SIA

Figure 3-116 Road network in central Montego Bay

EXISTING ROAD CONDITONS

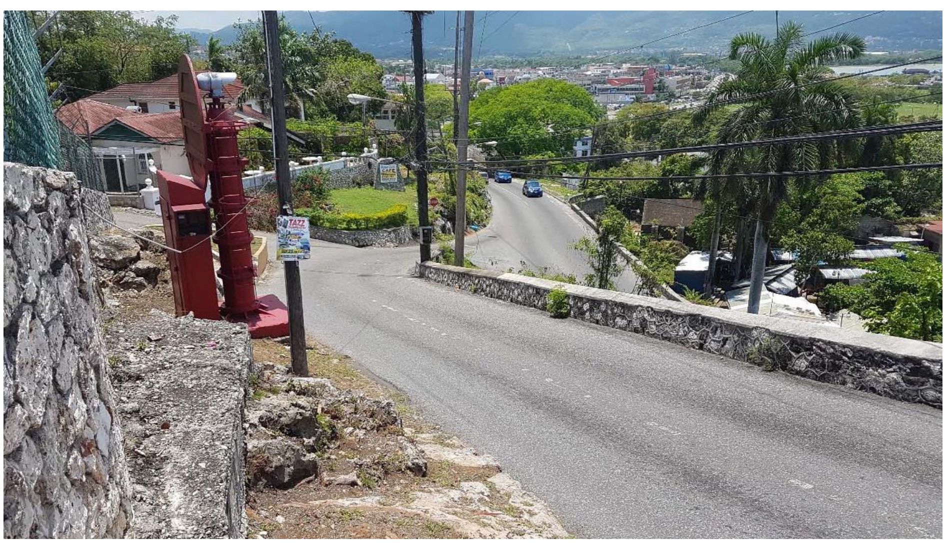
Elegant Corridor

The Elegant Corridor is 14km of four-lane divided major arterial road from the Airport Roundabout in the west to Barrett Town in the east. The road is signed for 80 km/h but drops to 50 km/h approximately 2 km east of the Airport roundabout. The 14-km arterial has fifteen (15) signalized intersections, six (6) of which are signalized driveways for hotels, shopping centres and the conference centre. Elegant Corridor carries over 30,000 vehicles per day; 85% of the vehicles surveyed were cars, 14% of the vehicles recorded were two-axle trucks, and other vehicle classes only accounted for 1% of the total vehicles.

Queens Drive

Queens Drive is 2.5 km of two-lane undivided collector road (Plate 3-76, Figure 3-116). It is also called Top Road since it is parallel to Gloucester Avenue but above it in elevation. Queens Drive runs from the Airport Roundabout to Howard Cooke Boulevard. Queens Drive is at the edge of a hill, therefore much of the alignment has steep embankments on both sides. Apart from the many driveways with direct access to Queens Drive, the intersections of Leader Avenue and Sewell are the main points of congestion. Additionally, there are two schools with direct access to Queens Drive and there is some evidence of attempts at traffic management at the Alvernia school's entrance with signs limiting right turns at certain hours.

Based on a travel time survey conducted in March 2017, travel times from the Roundabout to Howard Cooke, via Queens Drive varied between 4 and 17 minutes. The 1 km section from the roundabout to Leader Avenue recorded the slowest average speeds between 5 to 30 km/h. The remaining 1.5 km from Leader Avenue to Howard Cooke Boulevard recorded average speeds of 18 to 60 km/h. Westbound travel speeds between the Roundabout and Leader Avenue were no higher than 20 km/h. Based on turning movement counts collected at four intersections along Queens Drive, Queens Drive carries over 1,800 2-way volumes in the peak hour.



Source: (Stanley Consultants Inc. (SCI), 2017)

Plate 3-76 Queens Drive (Top Road) and Sewell Avenue

Gloucester Avenue

Gloucester Avenue is 1.9 km of two-lane undivided local road (Figure 3-116). It connects to the Airport Roundabout through 1 km of Sunset Boulevard, a two-lane local road. It is characterized by high pedestrian activity, especially during the peak tourist season. A pedestrian count was done in May 2017 at Margaritaville to determine how often the road is interrupted by pedestrian movements. Counts were collected between 7AM and 10AM, 12 noon and 2PM and 3PM and 6PM. Over 400 pedestrians were recorded during these times with the highest hour being between 3PM and 4PM.

Howard Cooke Boulevard

Howard Cooke Boulevard is 2.1 km four-lane divided major arterial road from Gloucester Avenue/Queens Drive in the north to Alice Eldemire in the south. Howard Cooke Boulevard has 6 signalized intersections, therefore there is a signal approximately every 0.5 km. Based on turning movement counts collected, Howard Cooke Boulevard carries over 4,000 two-way volumes in the peak hour.

Source: (Stanley Consultants Inc. (SCI), 2017)

Plate 3-77 Howard Cooke Boulevard and Barnett Street

Alice Eldemire

Alice Eldemire is a 900-metre four-lane divided major arterial road from Howard Cooke Boulevard in the west to Bogue Road in the east. It has three signalized intersections. Alice Eldemire carries approximately 2,000 2-way volumes in the peak hour.

Bogue Road/AGS Coombs Road

Bogue Road is a 3.8 km four-lane divided major arterial road from Long Hill in the west to Alice Eldemire in the east. It has five signalized intersections. Bogue Road carries approximately 3,000 2-way volumes in the peak hour.

Barnett Street

Barnett Street is a 2-lane 2.7 km collector road from Alice Eldemire to Howard Cooke Boulevard (Figure 3-116). It is constrained between Alice Eldemire Drive and the Porto Bello main road by a two-lane bridge. North of the Porto Bello main road, Barnett Street goes through the congested town centre and becomes one-way between Cottage Road and Harbour Drive. The two-way segment between Fairfield Road and Cottage Drive carries approximately 2,000 vehicles in the peak hour, and the one-way segment carries up to 1,800 vehicles in the peak hour. Barnett Street is characterized by high commercial and pedestrian activity (Plate 3-78).

Source: (Stanley Consultants Inc. (SCI), 2017)

Plate 3-78 Commercial and pedestrian activity along Barnett Street

Harbour Street

Harbour Street is a northbound/eastbound one-way road in the central business district beginning at Barnett Street and ending at the intersection of Howard Cooke Boulevard, Queens Drive and Gloucester Avenue (Plate 3-79). It is two-lanes wide but has a significant number of short distance (approximately 70 m) weaving between Barnett Street and South Street/Creek Street made by vehicles entering from Barnett Street via Howard Cooke who are trying to access the town centre. Particularly in the vicinity of the Craft Market, a lot of on-street parking was observed. The intersection of Harbour Street and Market Street experienced serious congestion due to the closure of Market Street at Strand Street. Vehicles therefore overflow from Market Street and Strand Street to Harbour Street and Market Street. The next capacity constraint on Harbour Street is between Union Street and Embassy Place. In this area, to the west of Harbour Street is the Bay West Shopping Plaza that has limited parking and vehicles queue on to the road waiting for a parking place while blocking a lane on Harbour Street.

Source: (Stanley Consultants Inc. (SCI), 2017)

Plate 3-79 Gloucester Avenue, Queens Drive, Harbour Street/St. James and Howard Cooke Boulevard

St. James Street

St. James Street is a one-way street through the central business district from the intersection of Howard Cooke Boulevard, Queens Drive and Gloucester Avenue to Barnett Street. It is mostly two lanes wide with a wider three lane section closer to Gloucester Avenue. Like with all streets in the central business district, St. James Street has parking along the road which reduces the capacity and narrows the road in some sections to a single lane. At Market Street, St. James Street bends around a fountain which further reduces the capacity of the road.

Union Street

Union Street is a one-way 2-lane road through the central business district from Brandon Hill to Harbour Street. Due to the prevalence of parking on both sides of the road, the capacity of Union Street is mostly single-lane. The Bay West Plaza on Harbour Street causes significant delays on Union Street at Harbour Street since vehicles attempt to enter the plaza from Union Street.

Porto Bello Main Road

Porto Bello Main road is a 2-lane minor arterial and collector that extends from Barnett Street in the west to the settlement of Porto Bello in the east. It is 4.2 km from Barnett Street to Porto Bello Drive. Classified traffic counts were done on the Porto Bello Main Road for two weeks. Based on this data collected, 95.5% of vehicles were cars and 3.5% were two-axle trucks. Less than 1% of the vehicles recorded were larger than a two-axle truck.

Salt Spring Main Road

The Salt Spring Main Road is a 2-lane minor arterial and collector that extends from Upper Kings Street in the west to Flower Hill in the east. Between Upper Kings Street and Flower Hill, Salt Spring Road is approximately 5 km. Classified traffic counts were done on Salt Spring Main Road eastbound for two weeks. Based on this data collected, 98% of vehicles were cars and 1.5% were two-axle trucks. Less than 1% of the vehicles recorded were larger than a two-axle truck.

TRAFFIC VOLUME

The morning peaks occur between 7 and 9 o'clock and the evening peaks occur between 16 and 19 o'clock, and traffic during the day is higher than that at night.

NETWORK ANALYSIS AND PERFORMANCE

Each intersection along Elegant Corridor, Queens Drive, Howard Cooke Boulevard, and Alice Eldemire between Ironshore and Bogue was analysed, and performance measures noted. Eight (8) of the thirteen intersections analysed in the AM peak performed at Level of service (LOS) F (Table 3-60)

Table 3-60 Existing Intersection LOS in the AM Peak

Source: (Stanley Consultants Inc. (SCI), 2017)

	Intersection	LOS	Control Delay (s)
1	Howard Cooke/Alice Eldemire	F	124.9
2	Howard Cooke/West Green	F	166.1
3	Alice Eldemire/Bogue	F	205.7
4	Barnett Street/Fairfield	C	26.1
5	Howard Cooke/Lower Bevin	F	135.6
6	Bogue Road/Temple Gallery	F	152.8
7	Howard Cooke/Barnett Street	B	14.0
8	Howard Cooke/Market Street	E	77.2
9	Howard Cooke/Gloucester/Queens	F	108.5
10	Barnett Street/Porto Bello	F	444.7
11	Queens Drive/Leaders Avenue	F	80.7
12	Elegant Corridor/Providence	D	39.3
13	Elegant Corridor/Morgan Road	C	26.4

Using the control delay and arterial speeds from the HCM analysis, the travel time between Bogue and Ironshore was compiled. This computed travel time was consistent with travel time studies conducted. Based on the model, the eastbound travel time between Bogue and Ironshore was 35 minutes in the AM peak and the westbound travel time was 45 minutes in the AM peak.

The existing network generally performed poor due to inadequate signal timings and low saturation flow rates. Additionally, at the most congested intersections a high number of turning volumes were present which exceeded the allowable capacity. Similar to the patterns observed in the field, the right-turn movements on to Lower Bevin Avenue, Market Street and West Green from Howard Cooke Boulevard, and Howard Cooke Boulevard from Alice Eldemire were over capacity.

SUMMARY OF ISSUES

Many of the roads in the CBD are reduced to single-lane traffic to facilitate parking, stopping, waiting and delivery of goods. All roads within the central business district (CDB) have three main issues that limit capacity:

- Pedestrian activity
- Parking
- Delivery vehicles

According to the investigation, the main problems of the coastal road A1 are as follows:

1 - The coastal road A1 is a 2-lane two-way road without hard shoulder. The width of the road is very narrow, about 6 to 7.2 meters. Both the number of lanes and lane width does not meet future traffic growth requirements.
2 - The road conditions of the coastal road A1 are relatively poor, except the beginning 1km section which is in relatively good condition. Road deterioration consists of the prevalence of rutting, cracks, pits, loose, poor driving comfort, etc. There are some security risks for the existing road.
3 - There are many intersections along the coastal road A1. There are 34 intersections within the 8km long A1 Road segment area in the city; there is a lack of traffic lights at most intersections, largely reducing the traffic efficiency of the area.
4 - There are many hotels, shops, restaurants, and residential buildings along the coastal road A1. The areas along this road are densely populated. The through traffic and urban traffic are mixed along the road, reducing the traffic efficiency, posing safety risks, and causing many traffic accidents.
5 - Subgrade elevation of the existing road is relatively low, plus inadequate drainage facilities along the route, it is vulnerable to heavy rains causing traffic disruption.

3.3.6.8.2 Airfields, Aerodromes and Airports

Two transport facilities exist within the SIA, specially the Sangster International Airport and Mafoota Airfield (Figure 3-115). The Sangster International Airport is the leading tourism gateway to the island of Jamaica and is the larger of two international airports in Jamaica. Approximately 95% of total passengers at this airport are passengers travelling internationally and of the approximately 1.7 million annual visitors to Jamaica, 72% use this airport as their primary airport. Peak arriving and departing capacity is 4,200 passengers per hour (MBJ Airports Limited, 2016).

3.3.6.8.3 Ports, Docks and Marinas

The Port of Montego Bay is the second largest international port in the island and is located in Freeport. It has been owned by the Port Authority of Jamaica since 1986 and Port Handlers Limited manages its operations, which include both cargo and cruise ship activities. A 2694 m² cruise ship terminal, approximately 427 metres of berth, 1.2 hectares of yard space for container storage and 1858 m² warehouse are provided at the Port.

The Montego Bay Yacht Club is located in Montego Bay Freeport on the peninsula. A pier provides berthing facilities in the protected basin where water depths are generally less than 6 metres. Additionally, Pier One Marina is located on Howard Cooke Boulevard; various boat operators charter from this dock (for deep Sea Fishing, sailing, sunset Cruises or just sightseeing), where the management body for the MBMP, the Montego Bay Marine Park Trust is located. It has docking for marine vessels up to 45.7 m (150 ft) in length and 4.6 m (50 ft) draft (Pier 1 on the Waterfront, 2014).

The marine section of project area therefore has a significant amount of maritime traffic, including cargo ships cruise ships, catamaran tours, sail boats and other personal/pleasure vessels, coast guard and marine police

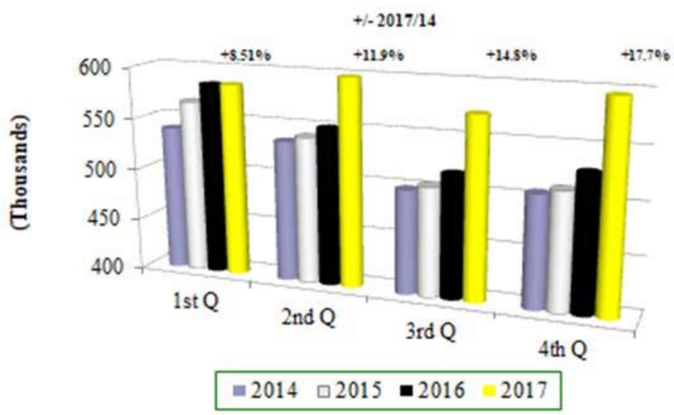
3.3.7 Industrial and Economic Activity

3.3.7.1 Tourism

Information provided in this section is taken from the *Annual Travel Statistics 2017* (Jamaica Tourist Board, 2018).

3.3.7.1.1 Stopover Arrivals

Total stopover arrivals for the year 2017 reached another record of 2,352,915, which was 7.8% above the 2,181,684 arrivals recorded in 2016. This figure represents 171,231 more stopovers than in 2016.



Source: (Jamaica Tourist Board, 2018)

Figure 3-117 Stopover arrivals (quarterly) to Jamaica 2014-2017

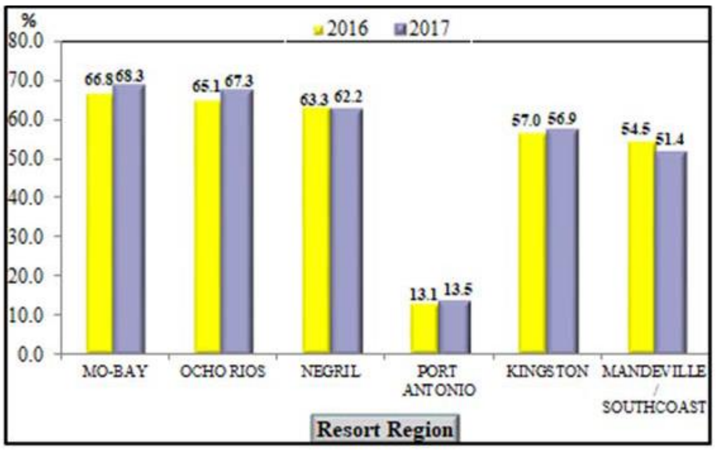
3.3.7.1.2 Cruise Passengers

Jamaica recorded a significant growth in cruise passengers during 2017 from 606 ship calls. This total of 1,923,274 cruise passengers, who visited our shores, was a 16.2% increase over the 1,655,562 recorded for the corresponding period in 2016. The port of Montego Bay accounted for 527,119 passengers or 27.4%.

3.3.7.1.3 Hotel Accommodations

The average available room capacity rose by 9.8% in 2017, moving from 20,543 rooms in 2016 to 22,553 rooms in 2017. Total room nights sold of 5,344,335 in 2017 was up 10.9% above the 4,818,611 room nights sold in 2016. Hotel room occupancy increased by 1.3 percentage point to

64.9%, compared to the 64.1% level in 2016. In the resort region of Montego Bay, the annual hotel room occupancy rate was 68.3%, which was up by 2.3% from the 66.8% recorded in 2016. The total number of room nights sold increased by 20.6% moving from 1,851,574 in 2016 to 2,233,331 in 2017.



Source: (Jamaica Tourist Board, 2018)

Figure 3-118 Hotel room occupancy (percentage) by resort area for 2011 and 2012

3.3.7.1.4 Visitor Expenditure

Gross visitor expenditure in 2017 was estimated at approximately US$3.005 billion. This represents an increase of 15.2% against the estimated US$2.609 billion earned in 2016. Total expenditure of Foreign Nationals amounted to US$2.744 billion. Cruise passenger expenditure totalled US$0.177 billion while US$0.084 billion was estimated as the contribution of Non-Resident Jamaicans. Foreign Nationals spent on the average US$148.61 per person per night while cruise passengers spent an average of US$93.46 per person per night.

3.3.7.1.5 Direct Employment in the Accommodation Sector

The number of persons employed directly in the accommodation sub-sector moved from 46,972 in 2016 to 48,439 in 2017, an increase of 3.1%. The main resorts of Montego Bay, Ocho Rios and Negril accounted for 43,240 persons or 89.3% of the total number of persons employed directly in the accommodation subsector (Montego Bay with 21,126 direct jobs represented 43.6% of those employed).

3.3.7.2 Montego Bay Free Zone (MBFZ)

In 1985 the Montego Bay Free Zone (MBFZ) was established in the Montego Freeport area by the Port Authority of Jamaica (PAJ). Investment from various sectors and in particular information and communications technology (ICT) sector, apparel and other light manufacturing was encouraged. As of 2000, the ICT sector strengthened and its development in the MBFZ was amplified by the relative competitiveness of Jamaica's near shore position, its skilled workforce and secured Free Zone environment (Montego Bay Freezone Ltd., 2012). Today, a number of industrial, commercial and manufacturing facilities are located at the MBFZ.

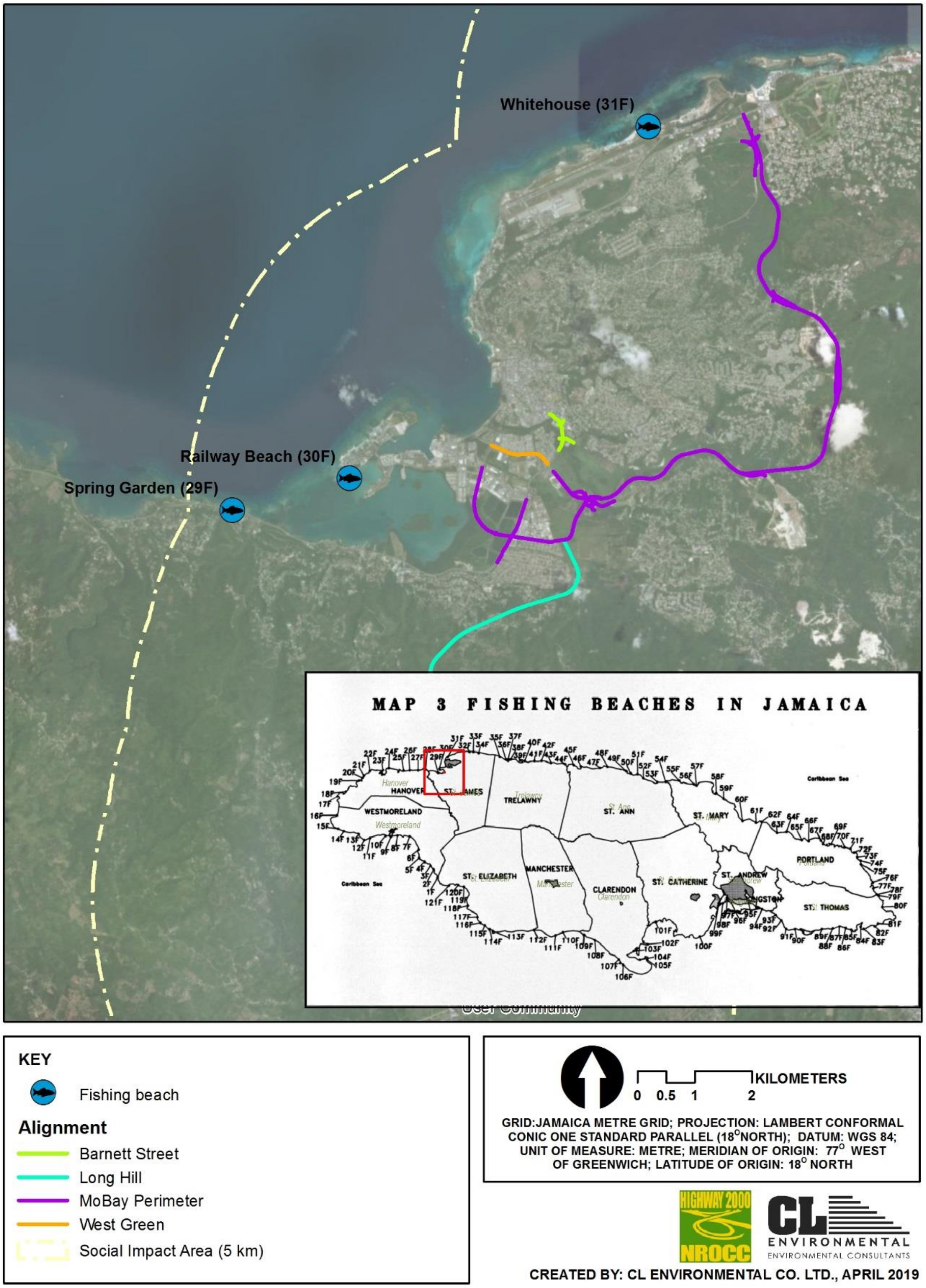
3.3.7.3 Agriculture

3.3.7.3.1 Farming

Residents of the communities along the alignment engage in farming; however this varies by community. In Seven Rivers and Pitfour, over half the households surveyed engaged in farming (Social Development Commission, 2010) (Social Development Commission, 2010), whilst in Catherine Hall and Montego Bay Business District, farming is far less common (1.2% and 5.1%) (Social Development Commission, 2010) (Social Development Commission, 2018). Banana and ground provisions are the predominant crops farmed.

3.3.7.3.2 Fisheries

Three fishing beaches are located within the SIA, namely Spring Garden, Railway Beach and Whitehouse (Figure 3-119) (Natural Resources Conservation Authority, 2000); all are located over 1 km away from the proposed alignments.



Source: Fishing beaches (Natural Resources Conservation Authority, 2000)

Figure 3-119 Fishing beaches located within the SIA

3.3.8 Land Use and Zoning

3.3.8.1 Historical Land Use

3.3.8.1.1 Anchovy

The Anchovy property was a sugar cane plantation that stretched from King Gate in the North to Cotton Tree in the South, encompassing all the lands to the Hanover Parish border at Lethe in the west and the Barnet Estates and Comfort Hall in the Northwest and Roehampton in the east. Up until the late 1800s, the property was owned by the Parkinson family and in the early 1900s, the property was subdivided and sold to the Addisons, the Beckfords and the Coombs. Agricultural activities during this period were centred on the cultivation of yams and corn (Social Development Commission, 2018).

The railway service was introduced in the late eighteen nineties and these structures were uniquely designed two-storey buildings which demonstrate Jamaica/Georgian architecture with Victorian elements. Particular features of these buildings are the decorative fanlights and the Queen Ann entablature and pediment above the windows (Social Development Commission, 2018). Anchovy is the location of the first railway station on the line outside Montego Bay (Plate 3-80). The railway station had much to do with the growth and development of the settlement, which suffered after the railway closure in 1992 (Jamaica National Heritage Trust, 2019).

Source: (Jamaica National Heritage Trust, 2019)

Plate 3-80 The railway station at Anchovy, St. James

The current main road through the town of Anchovy was built in the 1920s. In the 1900s, the primary school, post office and library were built and public water supply and electricity were introduced. Since then, several other major developments have taken place in Anchovy, primary among these is the expansion in housing (Anchovy Meadows, Cotton Tree Heights, Childermas Anchovy Court, etc).

3.3.8.1.2 Bogue

The community of Bogue was formerly part of Barnett's Estate owned by the Kerr-Jarrett's family. During the 18th and 19th century, the area was utilized for sugar cultivation. Most of the persons who worked in the cane fields settled in the hills above the fields – this area is presently known as Bogue Heights. During the period 2002-2006, the housing stock of the community was significant improved with the development of Bogue Village Housing Scheme. This five-phased housing development by Gore Developments Limited comprising 1,600 housing units sits on 250 acres of lands formerly owned by the Kerr-Jarrett family (Social Development Commission, 2018). Table 3-61 provides further detail on the development of Bogue.

Table 3-61 Bogue community timeline

Source: (Social Development Commission, 2018)

TIME PERIOD	MAJOR DEVELOPMENTS	CHALLENGES
1950's – 1970s	• Development of Bogue Heights' sub-division. • Ramble Hill Community Centre was built • Northern Industrial Garage was opened • JPS Power Plant was built • Community affected by flood rains (June 12, 1979); houses damaged and four lives lost	
1980's - 2000	• New Ramble Community Centre began construction	
2001 - Present	• Bogue Village Housing Scheme was built • Bogue Hill Basic School was built • Bogue City Centre was built • New Ramble Community Centre was renovated (USAID COMET II project) • Construction of Bogue Ponds Water Treatment Plant (National Water Commission)	

3.3.8.1.3 Catherine Hall

Catherine Hall was formerly part of Catherine Mount and owned by Kerr-Jarrett's family. The area was primarily used for sugar cane cultivation; however following the decline in the sugar industry, the area was converted to pasture lands and a dump site for Western Parks and Market (WPM). The Dump site was located on what is now the Catherine Hall Entertainment Centre and was removed in the 1970s (Social Development Commission, 2010). In the late 1960s – 1970s, the Urban Development Corporation (UDC) bought 320 acres of land from the Kerr-Jarrett's for housing and business development. From this portion Catherine Mount, West Gate Hills and West Green were sold, leaving the portion that is now called Catherine Hall. During 1970s and 80s eight hundred and twenty-eight (828) starter homes were constructed along with the road network leading from Bogue to Montego Bay. The Catherine Hall Primary and Infant School was started in 1976. In 1982, a special Education Department was developed with the help of the Dutch Government.

Table 3-62 Catherine Hall community timeline

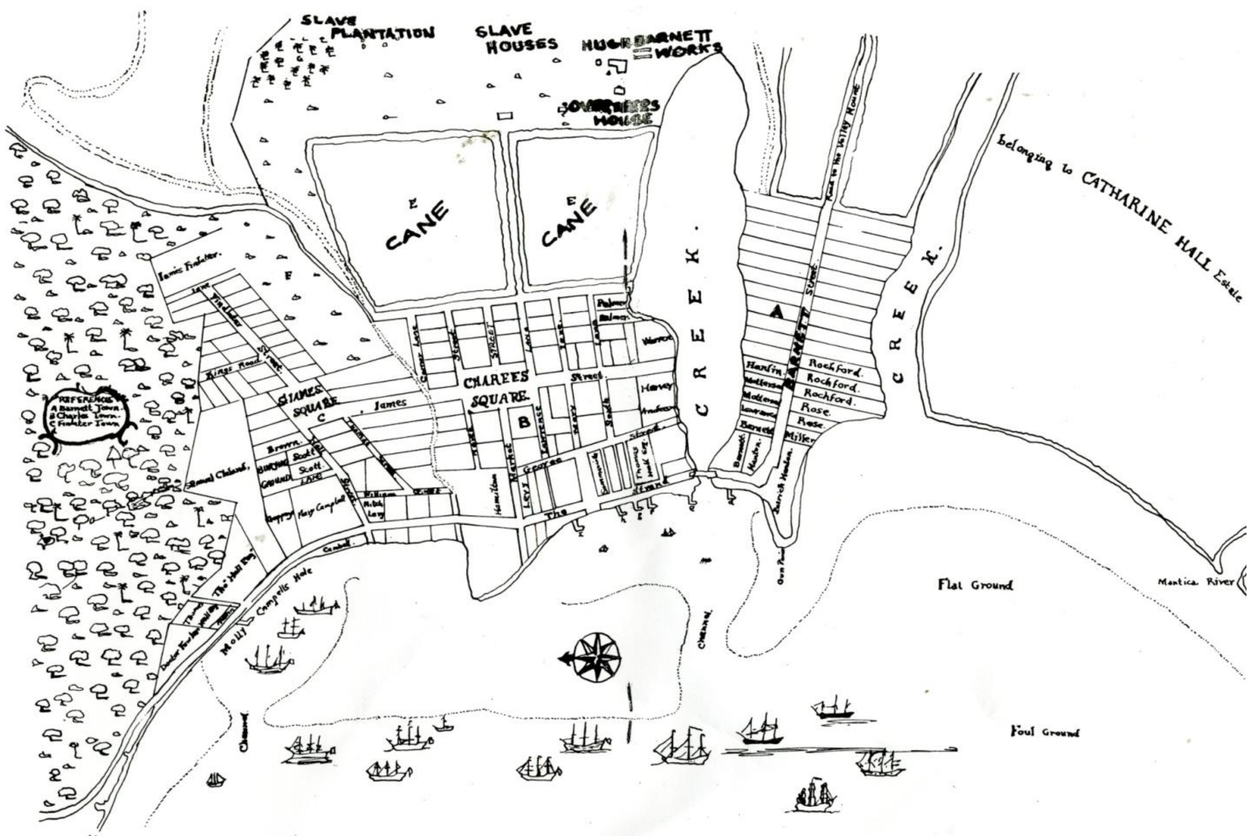
Source: (Social Development Commission, 2010)

TIME PERIOD	MAJOR DEVELOPMENTS	CHALLENGES
1970's	320 acres of Catherine Hall property was brought by UDC Construction of Howard Cooke Boulevard was done Howard Cooke Primary and Infant School was built Catherine Hall Self-help Housing Scheme was built	
1980's	D R B Grant Basic School was built A Special Education Department established at Catherine Hall Primary and infant School The Community Centre was built by UDC and the Ministry of Housing. The main road and interior roads in Catherine Hall Housing Scheme were constructed by UDC.	
1990's	The Seventh Day Adventist Church was built	
2000's	Howard Cooke Boulevard was dualized Catherine Hall Road was upgraded Mega Mart Complex built (2008)	

3.3.8.1.4 Montego Bay

On his visit on 9 May 1494 Christopher Columbus (1451-1506) called the bay Golfo de Buen Tiempo (Fair Weather Gulf) because of the conditions he encountered there. Later the bay became known as Bahia de Manteca because of the lard (manteca) obtained there from the slaughter of the now extinct Pedro Seals (Monachus tropicalis), and wild hogs. For many years after the English settlement of Jamaica, the W of Jamaica could not be settled because of the exposure to coastal attacks from buccaneers and the landward activity of the Maroons. In 1673 only 146 persons resided in the whole parish of St. James. Manteca Bay soon became “Montego Bay”. After the treaty with the Maroons in 1739, St. James was quickly developed by sugar planters and grew to great wealth (Espeut forthcoming). (Jamaica National Heritage Trust, 2019).

Captain Jonathan Barnett (1677-1744) founded the town in the early 1700s. In 1738 barracks were built and Montego Bay was made a free port. On 22 Nov 1758 Montego Bay was declared a legal Port of Entry into Jamaica for customs clearance purposes, along with Kingston, Savanna-la-Mar and Port Antonio. By the 1780s, Montego Bay was regarded as the most flourishing town in Jamaica next to Kingston and was the centre of slave trading; during the slave trade there are records of 125 shiploads of enslaved Africans disembarking here.



Source JNHT

Figure 3-120 Map of Montego Bay, 1765

Fires in 1795 and 1811 destroyed many parts of Montego Bay. After being rebuilt, it was again destroyed in 1831 by one of the largest slave uprisings in Jamaica's history – the Christmas Rebellion of 1831-32, led by Sam Sharpe, one of Jamaica's seven National Heroes. After emancipation in 1834, the fortunes of the town and parish declined. "Montego Bay's first "city status" was taken away in 1865 because of the upheaval of the Morant Bay rebellion. In spite of this setback, the town grew into an important trading centre, and by the early 20th century, Montego Bay enjoyed significant commercial activity. Sugar, rum and coffee were the main exports, but tourism has also dominated the economy of the parish since the late 40s and early 50s" (Jamaica Information Service, 2012). A Freeport was constructed in the 1960s, and later, a cruise ship terminal and the Sangster International Airport were built. In May 1981, Montego Bay regained city status through an act of the Jamaican Parliament which was passed 1980 (Social Development Commission, 2018).

Table 3-63 Montego Bay community timeline

Source: (Social Development Commission, 2018)

TIME PERIOD	MAJOR DEVELOPMENTS	CHALLENGES
1700's – 1950s	• Fire destroyed parts of Montego Bay in 1795, 1811 and 1831 • Montego Bay lost its 'City Status' • Sugar, rum and coffee were the main exports • Tourism dominated the economy of the parish since the late 1940s and early 1950s	
1980's - 2000	• Montego Bay regained city status	
2001 - Present	• Tourism continues to dominate economy • Montego Bay Civic Centre rehabilitated and renamed Montego Bay Cultural Centre • Montego Bay celebrated 35 years city status	

3.3.8.1.5 Montpelier

Montpelier belonged to five generations of a single family from 1752 to 1912 (Table 3-64), the family members living to the greater part of 160 years in England.

Table 3-64 Timeline of Montpelier owners

Source: (Jamaica National Heritage Trust, 2019).

Period	Owners	Land Use	Acreage, value
1739-1750	Francis Sadler (Sadler-Hals) he negotiated the agreement between Cudjoe and Col. John Guthrie		
1750-1757	Janet Guthrie- Hynes-Sadler	Sugar	
1752- 1782	John Ellis	Sugar	
1782-1845	Charles Rose Ellis (1st Lord Seaford)	Sugar	Montpelier Wharf, 10 acres
1845- 1868	Charles Augustus Ellis (6th Lord Howard de Walden, 2nd Lord Seaford)	Ruinate and Pasture	
1868- 1872	Frederick George Ellis (7th Lord Howard de Walden, 3rd Lord Seaford)		
1872-1891	Lucy Cavendish-Bentinck Ellis	Grazing Pen	
1882	William Kerr	Common pasture and pimento, ground provisions, wood and ruinate	
1891-1912	Evelyn Henry Ellis He brought in Indian Mysore and Zebu cattle from Portugal which he crossed with local stock to produce a hardy breed of draft animal	Grazing Pen and tobacco cultivation He had his own cigar factory; this operation merged into the Jamaica Tobacco Company in 1905.	
1912-1920	John Wesley Edwards and Hylton C. Shekell	Grazing Pen, bananas	7,018!/2 £12,000

Period	Owners	Land Use	Acreage, value
1920-1935	John Wesley Edwards	Grazing Pen, tobacco, wood and ruinate, railway	7,0381/2 £24,000
1935-1953	Lindo Bros. & Co.	He went into the production of 1st class beef; in 1938 his herd of Mysore cattle was declared by the visiting Royal Commission as the finest in the world.	
1953-1973	Clifford Delisser and Roy Delisser		
1973-	Government of Jamaica		
1992-	Various (subdivision)		
2011	Citrus company, NLA	Citrus, Attractions- Chukka Cove	

The Montpelier's slaves were vital participants in the 1831-1832 rebellion and this estate was the site of the major pitched battle of that rebellion (Figure 3-121). The works and great house were burnt to the ground in the Rebellion of Sam Sharpe. A great house was built in 1832, and both sugar works were rebuilt. St. Mary's Anglican Church is situated on the Montpelier Estate, which dates back to the days of slavery (cornerstone of the church is dated 1847). The St. Mary's Anglican Church was once the infirmary for the slaves. The site on which the St. Mary's Anglican Church now stands was the scene of a noted slave uprising.

Source: JNHT

Duperly used Hakewill's image and produced a view depicting a scene during the 1831 Christmas Rebellion.

Figure 3-121 Battle at Old Montpelier Works, December 29, 1831

Source: (Jamaica National Heritage Trust, 2019)

Plate 3-81 St. Mary's Anglican Church, Montpelier, St. James.

Montpelier became known for its fine cattle after the collapse of sugar. In the 1890's the owner, a member of the famous British Ellis family, brought in the Indian zebu cattle that he crossed with native stock to produce a hardy breed of draft animal. At the end of the 20th century the main crop at Montpelier was orange. In 1992 three thousand acres, was taken up by the national Commercial Bank which established a subsidiary, the Jamaica Orange Company, to plant 50,000 orange trees. By the end of 1994 the Jamaica Orange Company had planted two thousand acres in citrus; presently an estimated fourteen hundred acres is used. It had acquired the former Cornwall Diaries factory building for processing, and commercial harvesting which commenced in March 1996. Freshly squeezed orange juice is supplied to hotels in Montego Bay and Negril and Chukka Cove operates adventure tours on the property.

Blue Hole is a district of Montpelier, which got its name because there is a water hole containing very blue water. Blue Hole was a tourist attraction, established by Derrick Kellier in the early 1990's. However, the park has not been in full operation since 2006. The water from the spring associated with Blue Hole is bottled and distributed island wide by Cool Runnings Industry (established in 1997).

In the 1980's the majority of persons living on the Blue Hole road were direct descendants of slaves. These individuals have surnames such as Ellis and Beckford.

New Montpelier was studied archaeologically by the University of the West Indies (UWI) Department of History, the Jamaica National Trust Commission and The Institute of Jamaica from 1973-80. This represented the first plantation archaeology site excavated in Jamaica where the object was to look at the slave society thereon.

3.3.8.1.6 Mount Carey

Mount Carey was one of seven free villages established in the parish of St. James in the immediate post slavery period. The community was named in honour of William Carey, a Baptist preacher from England. The Mount Carey Baptist Church was established in 1830 by Thomas Burchell, founder of the Burchell Baptist Church in Montego Bay (Social Development Commission, 2008).

3.3.8.1.7 Orange Irwin

Orange Irwin was originally called Irwin Bush; in 1968 it was renamed to Irwin Village and later to Orange Irwin. At that time, the area was heavily forested and the few houses present were made of Spanish Walls. Electricity was introduced into the community in 1974 and during the late 1980s, water was piped into dwellings by the National Water Commission. The main road through the community was paved during the late nineteen sixties and was redone in 2002. The housing stock was significantly increased during the late sixties with the development of the Irwindale Housing Scheme and later, the Crawford Apartments.

The Riverside Baptist Church was established in the 1950s and a Basic school started about the same time. A Zoo was established in the early eighties; the Zoo and botanical garden provided attraction for locals and visitors and was destroyed by Hurricane Gilbert in 1988. (Social Development Commission, 2009).

3.3.8.1.8 Salt Spring

In the early beginnings, the population of Salt spring was primarily concentrated in the district of Hatfield; these individuals lived and worked on the estates surrounding the district resulting in free housing. This lifestyle was however soon disturbed when the owners of the estates, Mr. Yan Kerr Jarrett and Mr. Duple Irwin, a Canadian native gave notice to the residents whose animals had become a nuisance by grazing on the property which was used for sugar cane cultivation among other crops. Having received notice, the residents started to settle in other areas of the community away from the estate lands (Social Development Commission, 2016).

The livelihood of the residents in Salt Spring was predominantly agriculture as most persons worked on the surrounding plantations and also engaged in subsistence farming. The Salt Spring Baptist Church was the first church to be built in 1897 and this was multifunctional as it served as a school during the week and a church on Sundays. The school was called the Salt Spring Baptist Elementary School. In 1952, the school was relocated to Meggie Top where it still stands today. The school however went through several changes; in addition to more classrooms, the school was renamed Salt Spring All Age and later Salt spring Primary. Today, the community has five schools and eight churches, and one post office.

The community of Salt Spring has a far-reaching history of crime and violence that started back in the late nineteen sixties to early nineteen seventies. Today, an internal community boundary still exists (between Top Salt Spring and Bottom Salt Spring) and is more lethal than ever (Social Development Commission, 2016).

3.3.8.1.9 Seven Rivers

Seven Rivers was originally a sugar cane plantation and was part of the Montpelier Property. It was owned by the British until the late 1800s when it was sold to the DeLisser family who switched from sugar cane cultivation to banana, citrus and cattle rearing. The property was approximately 100 acres.

In the late 1960s the workers on the plantation staged a strike as they had not been granted a salary increase in several years. Mr. Michael Manley through the National Workers Union intervened and an agreement was reached. In 1974, the government of Jamaica purchased the property and sub-divided into lots and leased same to the workers under 49 years lease agreement. In the 1980s, the lease agreement was changed to free-hold tenure.

“In 1990, Roger Portell of the Florida Museum of National History discovered a series of fossil manatee bones near Seven Rivers in St. James. Over the past 12 years a team from UWI (Steve Donovan (formerly of UWI), Simon Mitchell and Thomas Stemann), Howard University (Daryl Doming) and Florida Museum of Natural History (Roger Portell) has been excavating the site supported by the National Geographic Society. The site contains a wealth of fossil vertebrate remains including lizards, turtles, crocodiles, sea cows (manatees) and a rhinoceros. The sea cow has been named *pezosiren portelli* and is the most complete, primitive sea cow yet discovered. It is unique to Jamaica” (Jamaica Gleaner, 2006).

In July 2007 the Seven Rivers irrigation system was built and this was the second of three 'flagship projects' to be put into use by the National Irrigation Commission. The project was made possible through a partnership between the Caribbean Development Bank and the Jamaican Government.

3.3.8.1.10 West Green

West Green was formerly part of the Catherine Mount area owned by the Kerr-Jarrett family. Historically, the area was classified as pristine agriculture lands extensively cultivated with sugar cane. In response to the shortage in the housing stock within the urban cluster of Montego Bay, and the steady development of the city as the major business hub, the Urban Development Corporation (UDC) acquired lands from the Kerr Jarrett’s to undertake the construction of low-density semi-detached houses (Table 3-65). The name West Green was thus ascribed to the area in the early 1970s merely based on that subdivision of lands (Social Development Commission, 2018).

Table 3-65 West Green community timeline

Source: (Social Development Commission, 2018)

TIME PERIOD	MAJOR DEVELOPMENTS	CHALLENGES
1950's – 1970s	• Area under sugar cane cultivation • Urban Development Corporation constructed Phase one • Catherine Hall Primary School became operational (1976) • Catherine Hall Health Centre constructed • Salvation Army Church opened	Lack of river training caused flooding of area in June 1979; water levels reached over 4ft.
1980's - 2000	• Phase Two constructed by National Housing Development Corporation (NHDC) • Special Educational Unit of Catherine Hall Primary constructed through Dutch Government • Phase Three – Development of West Green Meadows • Houses received cable television • Commercialization of area	Sale of houses restricted to only nurses, police and teachers.
2001 - Present	• Increased housing expansions • Establishing the John Joyce ECI • Building the Bright Horizon Kindergarten & Preparatory School • Establishing the Ultimate Care Centre	

3.3.8.1.11 Fairfield

John Tharp Lawrence owned 40,000 acres in 24 different estates, including Fairfield (which included Bellfield), Ironshore, Tower Isle, Charliemont and Amity Hall. The estate produced sugar, rum and molasses utilizing a waterwheel. Owned in 1810 by Richard James Lawrence with 218 slaves and 44 heads of stock; in 1817 with 216 slaves and 172 heads of stock; in 1831 with 196 slaves and 149 heads of stock. During the 1831-1832 Sam Sharpe Rebellion, a military base was established here on 3 January, 1832 by General Sir Willoughby Cotton KCH GCB (Espeut forthcoming). The property remained in the Lawrence family for 234 years and was sold by absentee owner W.F. Lawrence in 1910. Fairfield was owned by the Hon. Sir Francis Moncrieffe Kerr-Jarrett JP (1885-1968), Custos of St. James (1933-1966). The Hon. Sir Francis Moncrieffe Kerr-Jarrett JP (1885-1968), Custos of St. James (1933-1966), converted the Fairfield Great House into a hotel and country club, where golf (9-holes), tennis, swimming and other activities were offered. The golf course opened in 1931.

Source: (Jamaica National Heritage Trust, 2019)

Plate 3-82 The Fairfield, Monetgo Bay

The old slave hospital was converted into St. Mary's Church, which was consecrated on 19 February 1864 (Plate 3-83). In 1885 the owner [Lady Lucy Cavendish-Bentinck (1813-1899), Lady Howard de Walden and Seaford] conveyed to the Anglican Church, the Old Works on about 12 acres of land on which St. Mary's Church was located; the Great House was converted into the rectory and one of the buildings into a school, and another building into a teachers cottage.

Plate 3-83 St. Mary's Anglican Church, Montpelier, St. James.

3.3.8.2 Existing Land Cover and Use

Montego Bay is the second largest city in Jamaica, the capital of the parish of St. James and is also considered the island's tourism capital. For this reason, existing land cover in Montego Bay is primarily buildings and infrastructure (Figure 3-122), with a multitude of uses, including, commercial, industrial, residential, educational and recreational. The Montego Bay Free Zone (MBFZ) is home to a number of industrial, commercial and manufacturing facilities. Companies such as Gas Pro Ltd. (formally Shell Gas) and Caribbean Producers Jamaica Limited are located in Montego Bay Freeport and this is mixed with the city's tourist appeal, with a number of hotels, restaurants/ bars, the Montego Bay Cruise Ship Terminal and the Yacht Club located on the peninsula (CL Environmental Co. Ltd, 2016). The Freeport area "reflects the mix of resort hospitality in an efficient business environment that is characteristic of Jamaica's tourism capital" (Montego Bay Freezone Ltd., 2012).

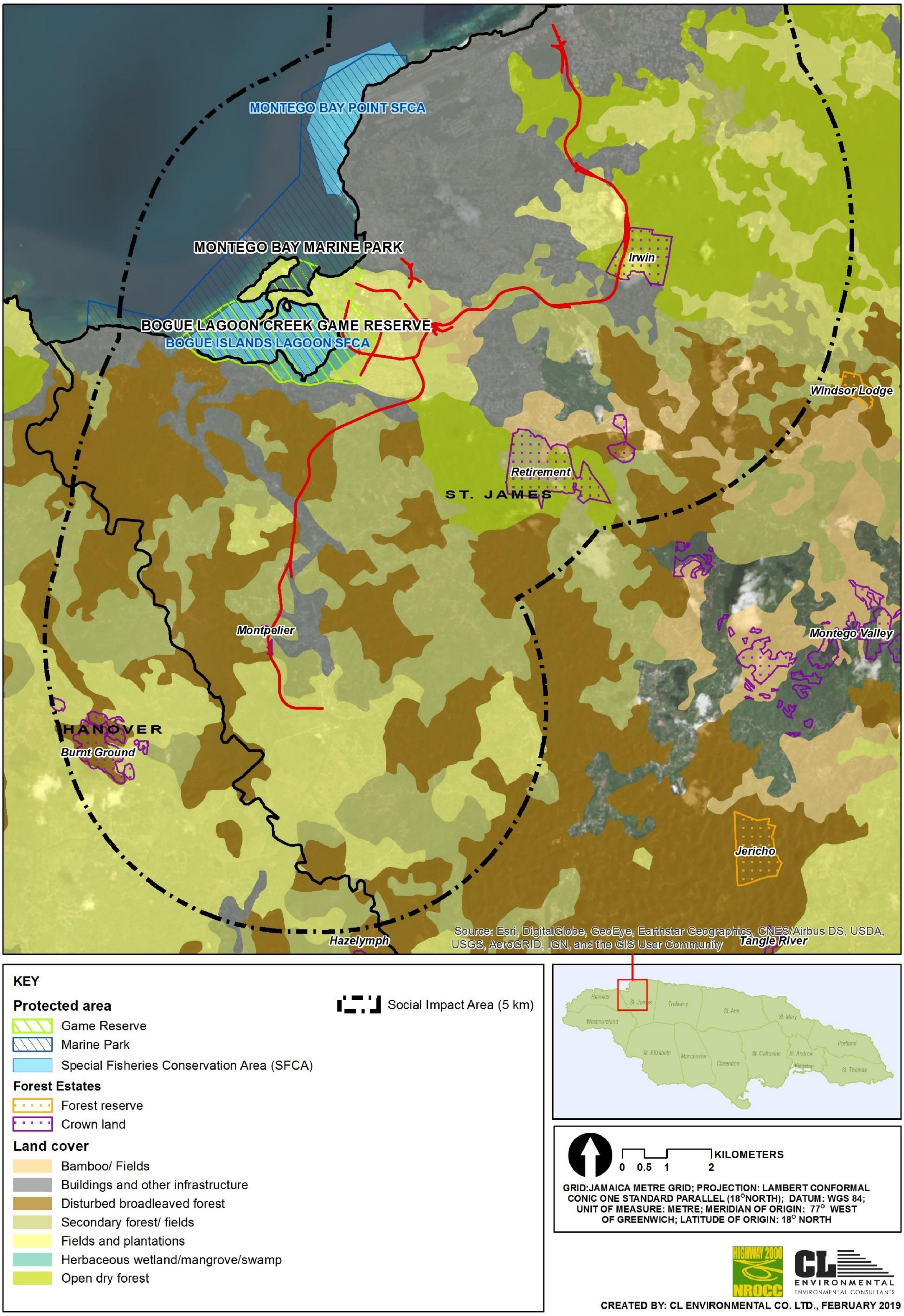
In addition to the tourist accommodations, numerous residential areas also exist throughout the SIA. In order to serve the resident and visiting populations, social and emergency services outlined previously, as well as other features typical of a city also exist with the SIA, such as retail stores, supermarkets, wholesales, restaurants, financial institutions, a market, churches, cemeteries, Wastewater Treatment Plant and Power Station. Hotel, public and fishing beaches are also located in the SIA.

Future developments include construction of the University of The West Indies, Western Campus, expansion of the Montego Bay port, a mix of commercial and residential buildings in the freeport area and an expansion of the tech park.

Within the greater study area, land cover is mixed; Figure 3-122 shows the spatial outlay of the main land cover areas:

- Bamboo and Fields
- Buildings and other infrastructures
- Fields and Secondary Forest
- Disturbed broadleaf forest
- Open dry forest - Tall (Woodland/Savanna)
- Fields: Herbaceous crops, fallow, cultivated vegetables
- Plantation: Tree crops, shrub crops, sugar cane, banana
- Mangrove forest

Of interest are areas of undisturbed forest and specifically mangroves and forest estates. Mangrove forests are located in Bogue (section 3.2.4) and are part of the Bogue Lagoon Creek game reserve (section 3.3.8.3.1); the southwestern end of the Montego Bay Perimeter Road alignment traverses these mangroves forests. Forest estates are located within the SIA and the proposed alignment traverses two of these, specifically Montpelier by the Long Hill alignment and Irwin by the Montego Bay Perimeter Road. These estates are crown lands and are not declared as protected areas (section 3.3.8.4).



Data sources: Protected areas (NEPA and MGI), land cover (Forestry Department, 1998) modified using satellite imagery shown on map.

Figure 3-122 Land use, forest estates and protected areas within the SIA

3.3.8.3 Protected Areas

Protected areas examined here include all areas of land or water protected by various laws in Jamaica, as well as international agreements, that fall within or in proximity to the project area; these include fish sanctuaries or Special Fishery Conservation Areas (SFCAs), protected areas (declared and proposed), national parks, forest reserves, marine parks, game reserves and national heritage and monuments. Figure 3-92 shows the location of protected areas in relation to the project; the following protected areas fall entirely or partially within the SIA:

- Bogue Lagoon Creek Game Reserve
- Montego Bay Marine Park (MBMP)
- Bogue Islands Lagoon SFCA
- Montego Bay Point SFCA

3.3.8.3.1 Bogue Lagoon Creek Game Reserve

A Game Reserve is a parcel of private land, body of water or area comprising both private land and water within which hunting is prohibited. The Bogue Lagoon Creek game reserve was established on 22 August 1997 under the Wild Life Protection Act (WLPA). The southwestern end of the Montego Bay Perimeter Road alignment transverses this reserve and West Green alignment touches its eastern boundary.

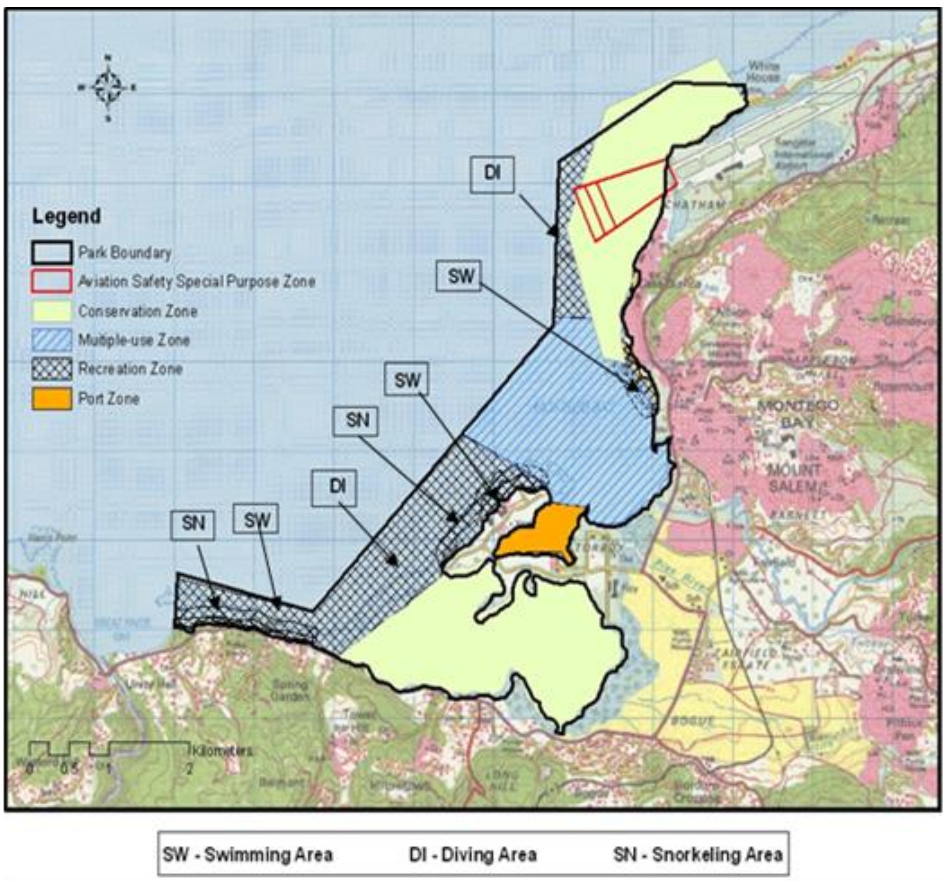
3.3.8.3.2 The Montego Bay Marine Park (MBMP)

The MBMP was declared under the NRCA Act on 5 June 1992. It encompasses the marine areas adjacent to Montego Bay, with a 9 km coastal boundary stretching from its northernmost point at White House, St. James (Sangster International Airport), stretching south past the Project Site, to the eastern extent of Great River Bay. It is 15.3 km^2 (1,530 ha) with distances from shore between 350 m and 2.3 km. A mixture of uses is present within the park, recreational and commercial activities such as fishing, tourism, shipping, diving, boating, swimming and beach walking are the main uses.

Although management regulations are in place, a zoning plan to further assist in the effective management of the area is yet to be approved (The Protected Areas Branch, National Environment and Planning Agency, 2013). For this reason, “The Montego Bay Marine Park Zoning Plan, 2013-2018” was created in 2013 by the Protected Areas Branch, NEPA with input from other branches at NEPA and the Montego Bay Marine Park Trust (MBMPT), the management body for the MBMP. The proposed plan provides the framework for the management of uses over a five-year period (2013-2018), within four major zones in which the 2km study area falls (Figure 3-123):

1. **Conservation Zone**: This zone encompasses the Bogue Islands Lagoon SFCA, and the Montego Bay SFCA. Both are ‘No Fishing’ areas reserved for the reproduction of fish populations.
2. **Recreation Zone**: This zone includes all areas used for recreational activities, specifically all recreational beaches and their respective swim areas, dive and snorkel sites. It is divided into two (2) Special Purpose Areas, namely i) Swimming Area and ii) Diving/Snorkelling Area

3. **Multiple-use Zone**: This zone includes all the areas outside the boundaries of the conservation and recreation zones. It has no further functional subdivisions but will allow for a range of specialized uses such as ship channels, fishing as well as recreational boating. This area was so designated based on traditional uses for commercial and recreational activities that are sustainable and consistent with the overall objectives of the Marine Park. It complements other marine park zones and by nature provides an integrated approach to the management of the Marine Park.
4. **Port Zone**: This zone is designated for the port/harbour activities and occupies the Site of the Montego Bay Yacht Club as well as the Terminals for cruise ships and commercial shipping. It allows for operation and maintenance of a port area and shipping channels and dredging for navigational purposes.



Source: NEPA (The Montego Bay Marine Park Zoning Plan, 2013-2018)

Figure 3-123 The proposed zonation of the MBMP

3.3.8.3.3 Special Fisheries Conservation Area (SFCA)

Special Fishery Conservation Areas are no-fishing zones reserved for the reproduction of fish populations. Their nature reserve statuses are declared under the Fishing Industry Act of 1975 and it is illegal to engage in any unauthorized fishing activities in the demarcated zones. The Bogue Island Lagoon, Montego Bay was established in 1979 and along with Bowen Inner Harbour, St Thomas, were the first two SFCAs to be declared. The Bogue Lagoon continues to serve as a critical nursery for juvenile fish and crustaceans in the Montego Bay area. The Montego Bay Perimeter Road alignment is located less than 200 metres east of the Bogue Island Lagoon SFCA. Montego Bay Point SFCA is located north of Bogue Island Lagoon SFCA and within the SIA, however further away from the proposed alignments.

3.3.8.4 Forest Estates

Forest Estates collectively encompass three descriptive types:

1) Forest reserves – Government and privately-owned lands that have been gazetted as Forest Reserves;
2) Forest Management Areas - Probate lands co-managed by the Forestry Department and gazetted as Forest Management Areas); and
3) Crown Lands - Lands transferred to the Forestry Department for management by the Commission of Lands).

Forest estates falling completely or partially within the SIA are all classified as crown lands (Figure 3-122) and are owned by the Government of Jamaica (Forestry Department, 2011); these are as follows: Retirement; Irwin; Montpelier; and Burnt Ground. The proposed alignment traverses two of these, specifically Montpelier by the Long Hill alignment and Irwin by the Montego Bay Perimeter Road. Of particular interest are Forest Reserves, which are considered protected areas; forest reserves are not located within the project SIA.

3.3.8.5 Zoning

The proposed alignments traverse the following Local Planning Area boundaries outlined in the Town and Country Planning (St James Parish) Provisional Development Order 2018:

- Montego Bay Local Planning Area (Inset No 1) (Figure 3-124)
    - Montego Bay Local Planning Area (Inset No 1.1) (Figure 3-125)
    - Montego Bay Local Planning Area (Inset No 1.2) (Figure 3-126)
- Anchovy Local Planning Area (Inset No 2) (Figure 3-127)

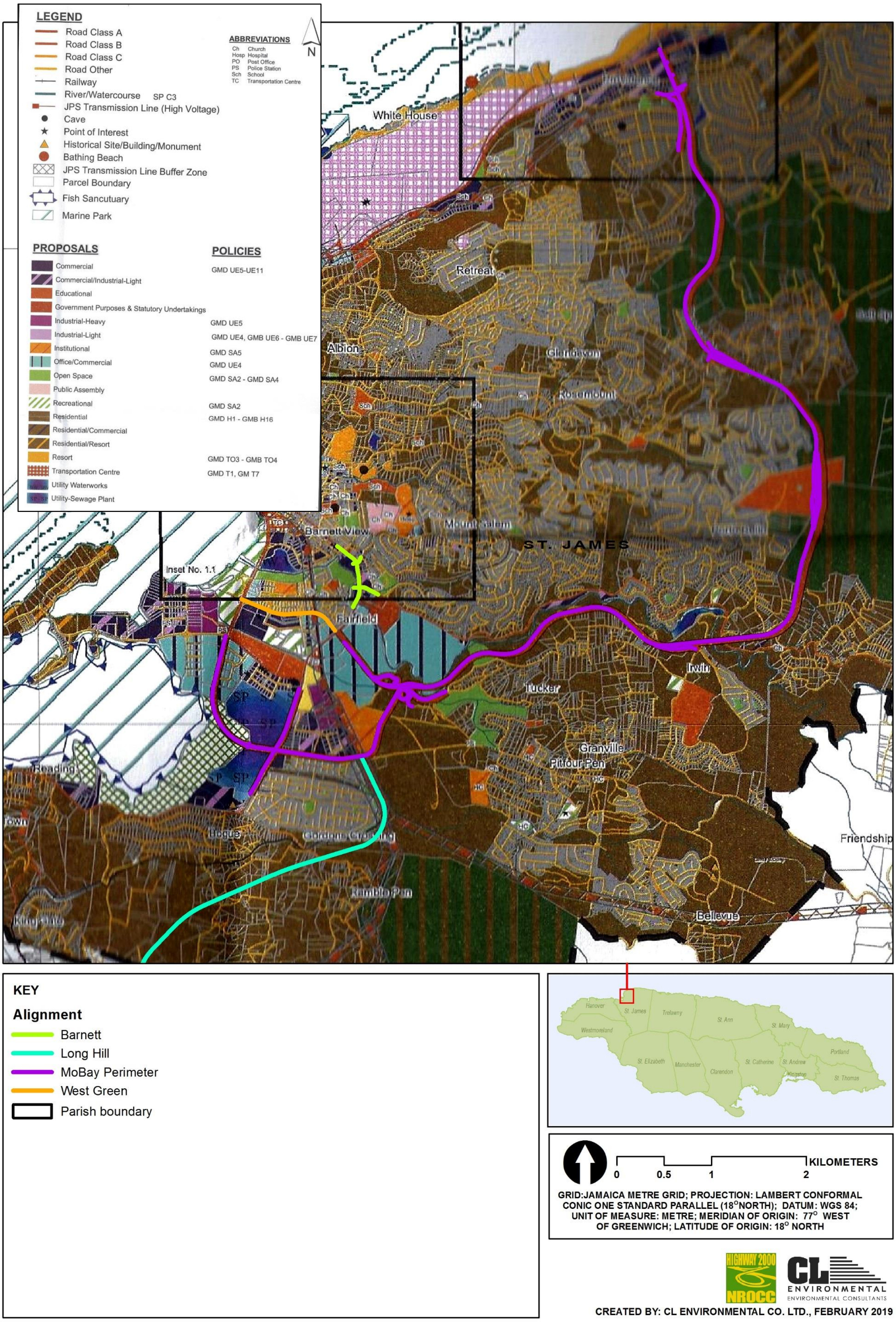


Figure 3-124 St James Dev Order -Montego Bay Local Planning Area (Inset No 1)

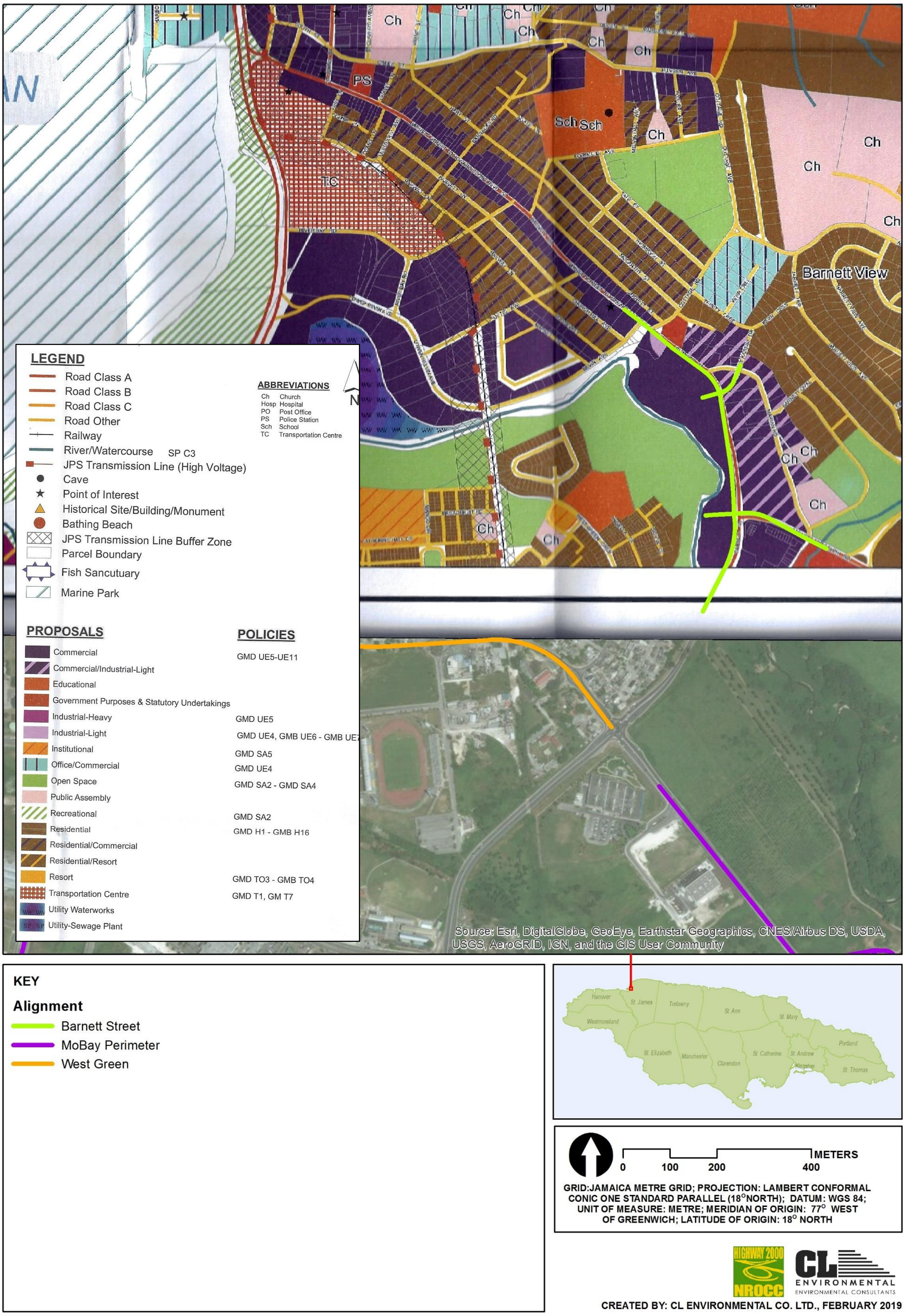


Figure 3-125 St James Dev Order Montego Bay Local Planning Area (Inset No 1.1)

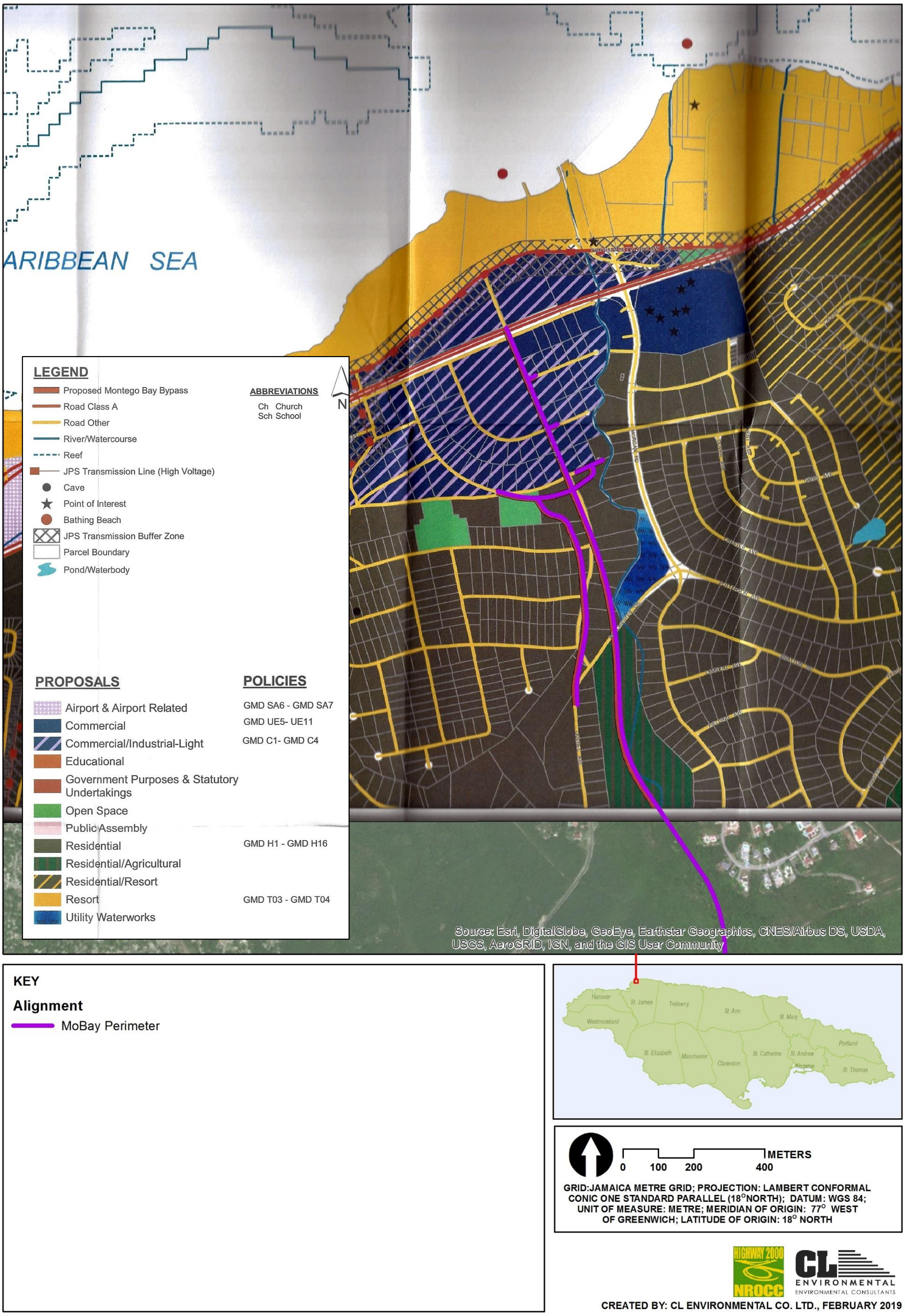


Figure 3-126 St James Dev Order Montego Bay Local Planning Area (Inset No 1.2)

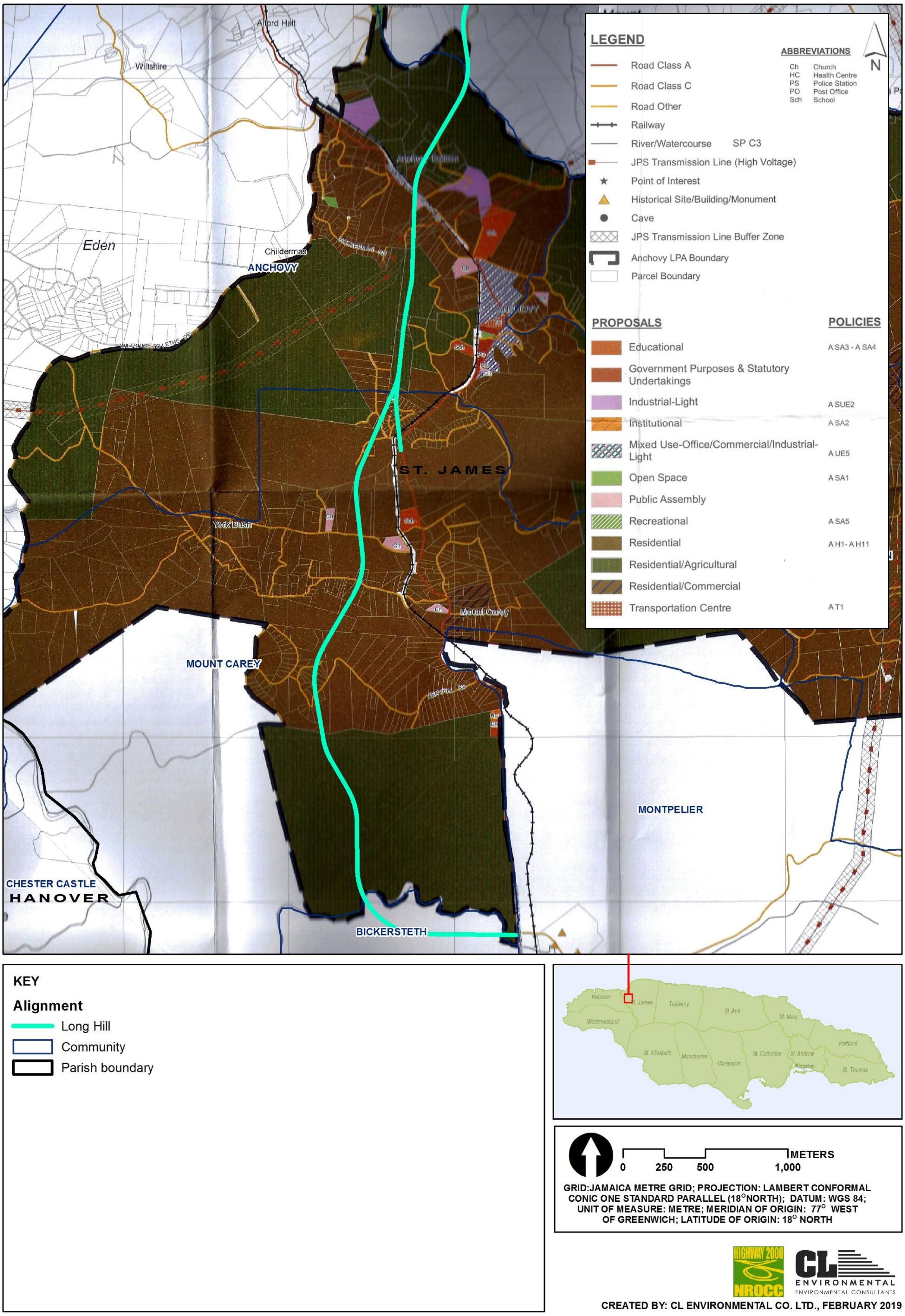


Figure 3-127 St James Dev Order - Anchovy Local Planning Area (Inset No 2)

3.4 ARCHAEOLOGICAL ENVIRONMENT

The Archaeology Division of Jamaica National Heritage Trust (JNHT) conducted an Archaeological Assessment of the proposed project and the following sections present the main findings from the associated report (Jamaica National Heritage Trust, 2019).

3.4.1 Methodology

A multi-faceted approach was used including oral history and documentary research, the zoning of the project area, archaeological field surveys and data processing.

3.4.1.1 Desk-Based Assessment

This is a thorough review of all the available written and graphic information relating to the area in order to identify the likely character, extent and relative quality of the actual or potential archaeological and architectural resources. It includes relevant historical documents, journals and books, aerial photographs and/or satellite imagery, maps and other contemporary data found in the nation's repositories such as the Island Record Office, National Archives, National Library of Jamaica, University of Technology (UTECH), University of the West Indies (UWI) and private collections. Web sites were also consulted.

- Historical documentation including, maps, plans, estate accounts, correspondence, titles, deeds, just to list a few.
- Published and unpublished results of any previous archaeological work on the site or in its vicinity.
- Satellite images and aerial photographs.

3.4.1.2 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.

3.4.1.3 Windshield

Survey of area done from the confinement of a motor vehicle

3.4.1.4 Field Walk Survey

In some areas a Field Walk survey was the archaeological technique employed to identify areas of pre-historic and/or historic activities and features.

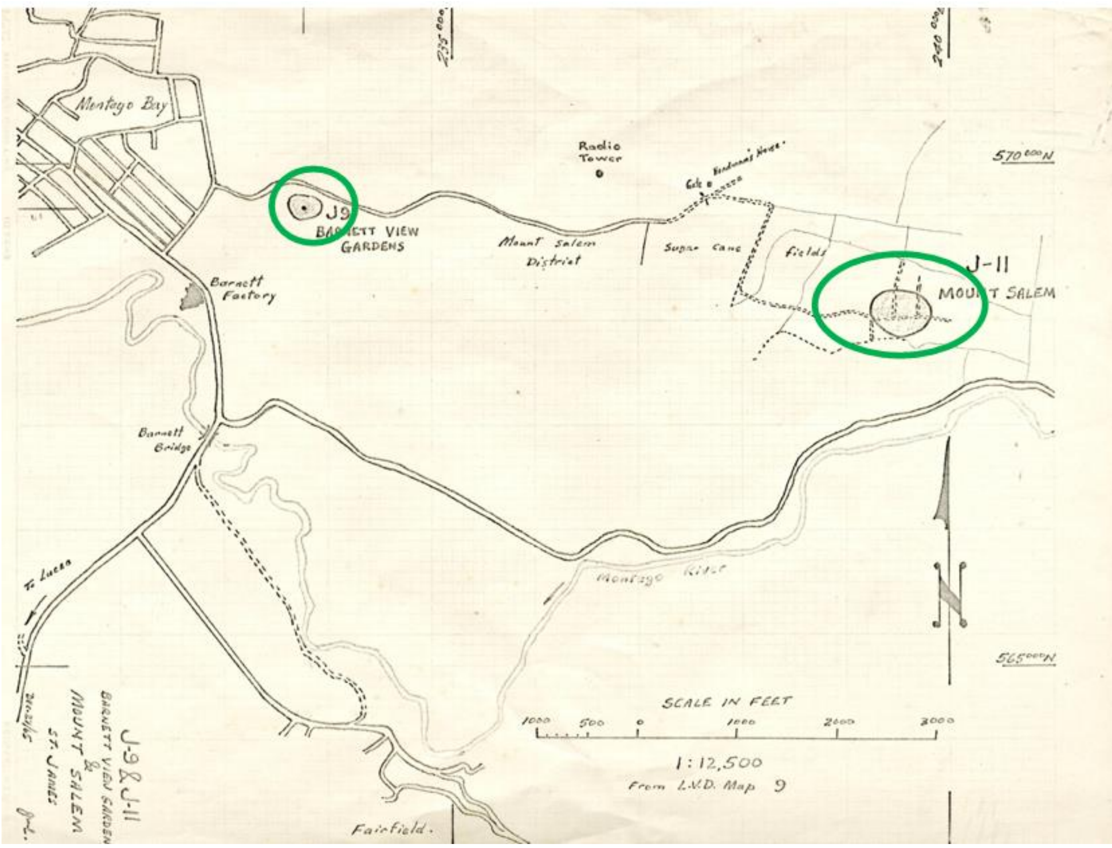
3.4.1.5 Recording and Analysis of Artefacts

All archaeological features, including artefacts, were recorded by means of sketches, digital photographs, GPS, survey, and field notes. Where artefact assemblages were identified, samples were collected and recorded for analysis. Preliminary analysis of artefacts was done to establish manufacture location and cultural association. Individuals familiar with the site were interviewed and this information noted to add to the data base on sites.

3.4.2 Desk-Based Assessment

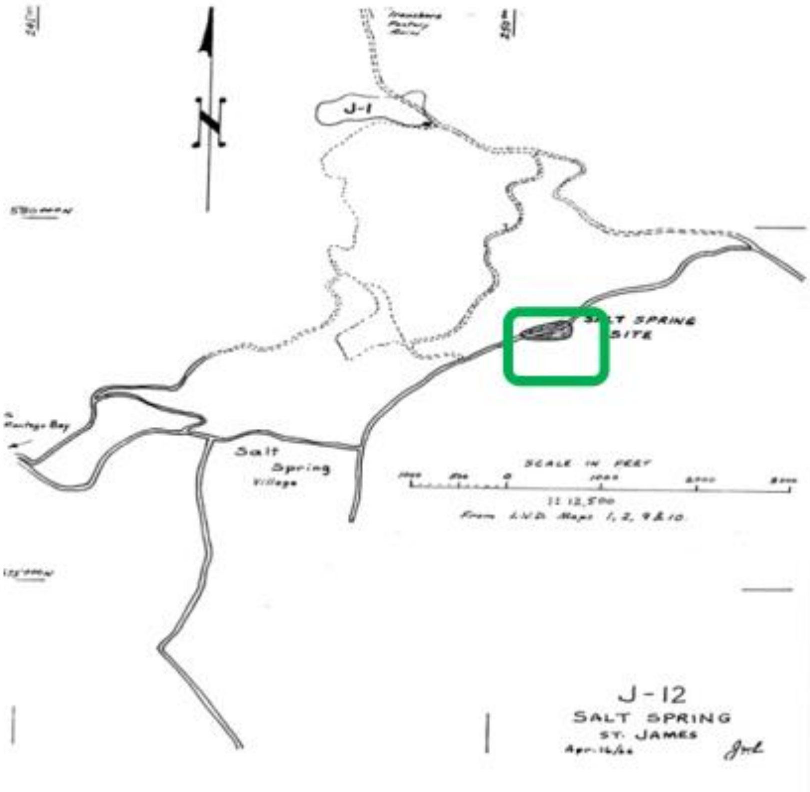
3.4.2.1 Taino Prehistoric Sites

The Taino commencing from ca. 710 AD are the first known inhabitants of the Montego Bay area. Christopher Columbus, who visited the area in 1494, noted that many Taino villages were in the vicinity (D.J.R. Walker 1992:268-272). Taino sites have been located at Fairfield, Salt Spring, Hartfield, Bogue, Bogue Beach, Barnet View Gardens, Mount Salem (Catherine Mount) (JNHT SMR) (Figure 3-128 through to Figure 3-132).



Source: (Jamaica National Heritage Trust, 2019)

Figure 3-128 Location of Barnett View Gardens and Mount Salem Taino sites in project area



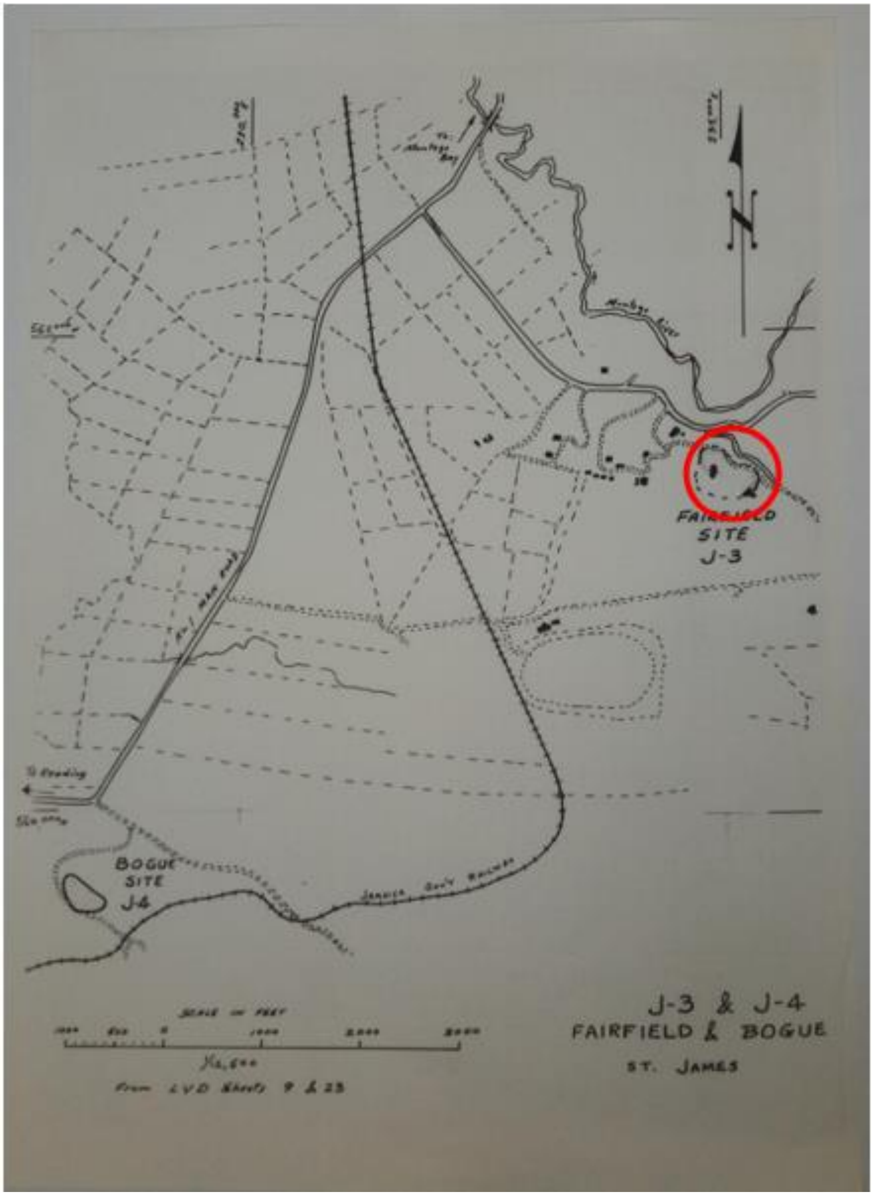
Source: (Jamaica National Heritage Trust, 2019)

Figure 3-129 Location of Salt Spring Taino site, mapped by Dr. James William Lee in 1966

3.4.2.1.1 Fairfield

Taino Fairfield (View) 154050E,-199800N MIDDEN c. 650-1500A.D

The important Taino settlement located here was first reported in 1931. In 1950 Prof. Robert Randolph Howard (1920-1965), Chairman of the Department of Anthropology, University of Wisconsin at Milwaukee, described the pottery as "quite distinctive from the usual Jamaican ware"; today classified as “Fairfield-type” pottery (carbon-dated AD 1180 ± 100). The site was more extensively excavated by Ronald L. Vanderwal in 1966; he found marine shells. The site was mapped by Dr. James William Lee in 1967. Excavations at the site in 2006 conducted by Dr. Philip Allsworth-Jones and Ivor Conolley, revealed intact deposits.

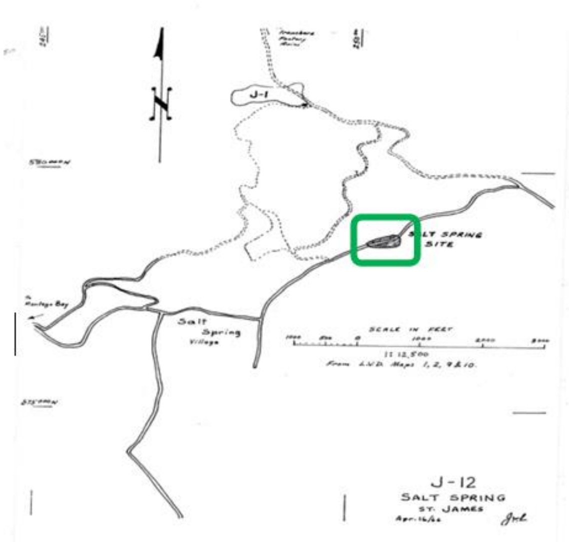


Source: (Jamaica National Heritage Trust, 2019)

Figure 3-130 Location of Faifield Taino site

3.4.2.1.2 Salt Spring

The Salt Spring site may be seen in , as mapped by Dr. James William Lee in 1966.

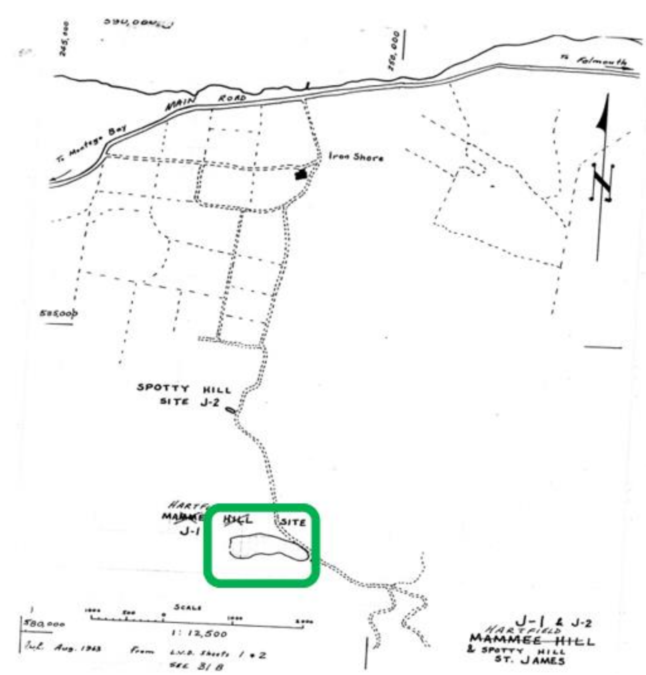


Source: (Jamaica National Heritage Trust, 2019)

Figure 3-131 Taino Site at Salt Spring

3.4.2.1.3 Hartfield

The Taino middens here were excavated by Ronald L. Vanderwal in 1966; it was said by him to be 8½ acres in extent with many shallow middens; he recovered many Indian Coney bones, and marine shells; and pottery.



Source: (Jamaica National Heritage Trust, 2019)

Figure 3-132 Location of Hartfield Taino site, mapped by Dr. James William Lee in 1963 and 1973

3.4.2.2 Historical Background (Settlers)

3.4.2.2.1 The Spanish

Christopher Columbus visited Montego Bay area in 1494 and named the port *El Golfo de Buen Tiempo ‘Fair weather gulf’.* When Columbus was about to leave one young Taino came up to the ships and begged the Spaniards to take him with them to their country. Columbus took him to Spain. The Spaniards hunted the herds of wild hogs that used to roam the hills and produced and exported “hog butter” or lard. The name Montego derives from the Spanish “Manteca” meaning lard, and Montego Bay is shown on some ancient maps as Lard Bay.

3.4.2.2.2 The British

The British captured the island in 1655 and by 1662 there were 10 precincts established in Jamaica. St. James formed in 1671 and in 1770 the parish was cut to form the new parish of Trelawny.

3.4.3 Site Assessment Results

The JNHT team identified historic ruins at Fairfield, Childermas, Wiltshire, Providence, Anchovy Bottom, Old and New Montpelier, Bridges at Barnett. Also identified were the Mt. Carey Baptist Church, and The Rocklands Bird sanctuary. Not all will be directly impacted as in most cases the proposed alignment is some distance away. Detailed descriptions of the potential impacts on these areas may be found in section 5.2.4.

3.4.4 Artefacts

The main objective of the finds inventory was to ascertain the number and variety of artefacts collected, and to assign a date range for the sites. The inventory exercise revealed the presence of two main material types, namely, clay and glass.

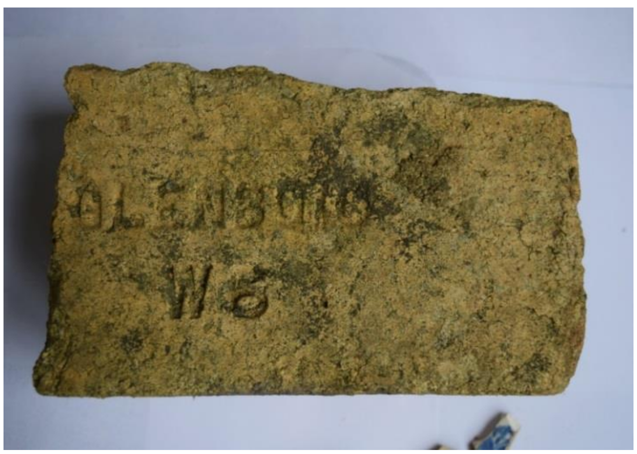
Artefacts are important analytical tools used by the archaeologists in a variety of ways. When found in context they can tell of the occupants’ lifestyle. For example, ceramics and glass are used as dating tools as well as providing other information. Bricks tell of the architecture of a period bricks can also tell of the ethnicity of the builder. Shells can indicate type of food sourced by the occupants of a site. Ceramics and glass tell of storage and consumption patterns and can also indicate trading patterns.

It should be noted that some cultural items made of perishable material for example; calabashes, baskets and clothing do not survive in humid conditions hence their absence from the archaeological record. It should also be noted that artefacts are mostly recovered as sherds.

The time period of the artefacts ranges from 1600’s to the 1800’s.

Source: (Jamaica National Heritage Trust, 2019)

Plate 3-84 Artefacts found on the Providence site and Anchovy Bottom



Source: (Jamaica National Heritage Trust, 2019)

Plate 3-85 Glenboig W6 –Scottish Brick-late 1800's

Source: (Jamaica National Heritage Trust, 2019)

Plate 3-86 Artefact descriptions: 1 - Brick; 2 - Bowl sherd –stoneware- 1620-1775; 3 - Bowl sherd-stoneware (Anchovy Bottom) 1620-1775; 4 - Plate – transfer print Pearlware 1775-1820; 5 - Wine Bottle sherd; 6 - Plate- Creamware 1762-1785; and 7 - Bowl- Creamware 762-1785

4.0 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

4.1 ENVIRONMENTAL IMPACT ASSESSMENT FRAMEWORK

4.1.1 Rationale and Basis

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 (Wood, n.d.):

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

4.1.2 Development Application and the EIA Process

4.1.2.1 General Procedures

The National Environment and Planning Agency (NEPA)[4] has been given responsibility for environmental management in Jamaica under the Natural Resources Conservation Authority Act

[4] NEPA represents a merger of the Natural Resources Conservation Authority (NRCA), the Town Planning Department (TPD)

(NRCA) Act of 1991. Since the promulgation of the NRCA Act, it has been strengthened by various supporting regulations that became effective in January 1997. The Environmental Permit and License System (P&L) is administered by NEPA through the Applications Section. It was introduced in 1997 to ensure that all developments meet required standards and negative environmental impacts are minimized. Under the NRCA Act of 1991, the NRCA has the authority to issue, suspend and revoke environmental permits and licenses, as well as the power to request EIAs for a permit or for any activity in a prescribed area (entire island of Jamaica) where it is of the opinion that the environment is likely to have adverse effects due to the activities.

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 advises if an EIA would be required for the proposed project and determines the scope of the EIA through proposed Terms of Reference (TORs). The TORs are proposed using NRCA guidelines and are ultimately approved by the NRCA. NRCA gives the approved final TORs for the proposed project; Appendix 1 shows those specific to this project.

The NRCA requires that the EIA include the following:

- A description of the present environment, i.e. physical, biological and social environment. This includes, for example, consideration of economic situations, cultural heritage and ecological preservation;
- A description of the significant impacts the environmental professionals expect the development to have on the environment, compared to the environment that would remain if there were no development. This will include indirect and cumulative impacts;
- An analysis of alternatives that were considered in order to consider means of minimising or eliminating the impacts identified above; and
- An Environmental Management Plan, which includes a Monitoring & Hazard Management Plan and an Auditing schedule.

The NRCA guidance on EIAs states that this process "should involve some level of stakeholder consultation in either focus groups or using structured questionnaires." A draft EIA is submitted to the developer to solicit the proponents' input into the description of the project (to check for accuracy of statements, and to enter into realistic discussions on the analysis of alternatives, as well as to inform the proponents of any other relevant legislation with which they must comply). Fourteen copies of the finalised draft are then submitted to NRCA, two to the client, and the consultant keeps one (17 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

and the Land Development and Utilization Commission (LDUC). Among the reasons for this merger was the streamlining of the planning application process in Jamaica.

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 Meeting(s) are then held (see Appendix 7 for the full guidelines on public participation in EIAs), 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.

4.1.2.2 Project-specific Progress

The Permit Application was submitted on 1 March 2018. It was decided that an EIA was required and for which the final TORs (Appendix 1) were used to guide the EIA approach. This document presents the initial findings of the EIA, which is currently underway.

4.2 NATIONAL LEGISLATION

4.2.1 Development Control

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

The Town and Country Planning Act (TCP Act) 1957 (Amended 1987) provides the statutory requirements for the orderly development of land through planning, as well as guidelines for the preparation of Development Orders. A Development Order is a legal document which is used to guide development in the area to which it applies, and the TCP Act is only applicable in an area where a Development Order exists. It constitutes land use zoning map/s, policy statements and standards relating to land use activities. Additionally, tree Preservation Areas and Conservation Areas (as specified areas the gazetted Development Orders) are two types of protected areas associated this Act. The Development Order relevant to this proposed is the **Town and Country Planning (St James Parish) Provisional Development Order 2018** (see section 4.2.1.1).

The TCP Act establishes the Town and Country Planning Authority, which in conjunction with the Local Planning Authorities (with regard to this project, the St. James Parish Council), are responsible for land use zoning and planning regulations as described in their local Development Orders. The TCP Act is administered by the National Environment and Planning Agency.

4.2.1.2 Parish Councils Act 1901 (Amended 2007)

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. As mentioned previously, the St. James Parish Council is the local planning authority with responsible for development within the study area for the proposed project.

4.2.1.3 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.

4.2.1.4 Local Improvement Act 1944

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

4.2.1.5 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.

4.2.1.6 Land Acquisition Act 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. 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.

Please see sections 5.2.3.11.2 and 6.3.3 for further detail regarding land acquisition.

4.2.1.7 Main Roads Act 1932

The Main Roads Act of 1932 details the legal basis pertaining to main roads and specifically looks 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.

4.2.1.8 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. 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.

4.2.1.9 Building Act 2016

The Building Act 2016 repeals the Kingston and St. Andrew Building Act and the Parish Councils Building Act and makes new provisions for the regulation of the building industry. It aims to facilitate the adoption and efficient application of national building standards (National Building Code of Jamaica) for ensuring safety in the built environment, enhancing amenities and promoting sustainable development. A "building" is described as a domestic building, a public building, a building of the warehouse class and any other physical structure, whether a temporary structure or not, any part of the structure, and any architectural or engineering product or work erected or constructed on, over or under land or the sea or other body of water. For the purposes of this Act, the KSAC (for the parishes of Kingston and St. Andrew), the Parish Council (any other parish and regarding this project, the St. James Parish Council) and the Municipal Council (for the Municipality) is designated as the Local Building Authority for the respective area.

4.2.1.10 Vision 2030

Vision 2030 is a National Development Plan for Jamaica, promoting four National Goals as well as associated National Outcomes for each goal, to be achieved by 2030, with the objective of developing Jamaica into a country with a vibrant and sustainable economy, society and environment; a high level of human capital development; greater opportunities and access to these opportunities for the population; and a high level of human security. Transport is one of the strategic priority areas of the Vision 2030 Jamaica - National Development Plan. It is one of thirty-one sector plans that form the foundation for Vision 2030 Jamaica.

The long-term development of the Transport Sector in Jamaica is guided by Visions, that for Land Transport in Jamaica is derived from the draft National Transport Policy 2007 and is as follows: "A safe, efficient and sustainable system of land transport that facilitates economic and social development through the movement of people, goods and services throughout Jamaica". The Transport sector goals and associated outcomes related to this project are as follows:

1.0:- A sustainable road transport system that serves the economic and social needs of the country
    1.1:- Properly constructed and maintained road network

1.2:- A public transportation system that facilitates the movement of people, goods and services throughout Jamaica in a safe and efficient manner
1.3:- Improved management of traffic on the road network
1.4:- A road transport system which accommodates non-motorized transport
1.5:- Increased provision and efficiency of road transport services.

4.2.2 Environmental Conservation

4.2.2.1 Protected Areas System Master Plan: Jamaica 2013 – 2017

The Protected Areas System Master Plan (PASMP) sets out guidelines for establishing and managing a comprehensive system of protected areas that supports national development by contributing to long-term ecological viability; maintaining ecological processes and systems; and protecting the country's natural and cultural heritage (National Environment and Planning Agency, n.d.). The PASMP is consistent with several national policies and plans, including the Policy for Jamaica's System of Protected Areas 1997 (section 4.2.2.2), the National Strategy and Action Plan on Biological Diversity in Jamaica (2003) and Vision 2030 Jamaica: National Development Plan (2009) (section 4.2.1.10). It is also a requirement under the Convention for Biological Diversity's (CBD's) Programme of Work for Protected Areas (PoWPA).

Existing protected area categories in Jamaica are listed in Table 4-1, Table 4-2 and Table 4-3. The NRCA/NEPA is responsible for areas declared/designated under the acts it administers, including the Wild Life Protection and Natural Resources Conservation Authority Acts (sections 4.2.2.4 and 4.2.2.3 respectively). In addition, a number of other government entities (such as the Forestry Department, Fisheries Division and Jamaica National Heritage Trust), local management entities, non-governmental entities, private sector and individuals are outlined as important role players as well. Indeed, responsibility for protected area management has been a shared endeavour and this collaborative approach to protected area management will continue under the PASMP (National Environment and Planning Agency, n.d.).

Table 4-1 Existing categories of protected areas in Jamaica (January 2012) - protected area system categories

Source: (National Environment and Planning Agency, n.d.)

CATEGORY	RESPONSIBLE AGENCY	LAW
Protected Area	Forestry Department: Water, Land, Environment and Climate Change (MWLECC)	Forest Act, 1996 and Forest Regulations
	National Environment and Planning Agency: MWLECC	NRCA Act, 1991
	NEPA: MWLECC	Beach Control Act, 1956
National Park	NEPA: MWLECC	NRCA Act, 1991
Marine Park	NEPA: MWLECC	NRCA Act, 1991
Environmental Protection Area	NEPA: MWLECC	NRCA Act, 1996
Forest Reserve	Forestry Department: MWLECC	Forest Act, 1996 and Forest Regulations

CATEGORY	RESPONSIBLE AGENCY	LAW
Special Fishery Conservation Area	Fisheries Division: Ministry of Agriculture and Fisheries	Fishing Industry Act, 1976
National Monument	Jamaica National Heritage Trust (JNHT) Ministry of Youth and Culture (MYC)	JNHT Act, 1985
Protected National Heritage	JNHT: MYC	JNHT Act, 1985
Game Sanctuary	NEPA (NRCA): MWLECC	Wild Life Protection Act, 1945
Game Reserve	NEPA (NRCA): MWLECC	Wild Life Protection Act, 1945

Table 4-2 Existing categories of protected areas in Jamaica (as at 1 January 2012) - other designations not considered part of the system

Source: (National Environment and Planning Agency, n.d.)

CATEGORY	RESPONSIBLE AGENCY	LAW
Tree Order Preservation	Local Authority (Town and Country Planning Authority): MWLECC and Local Government Department, through Parish Councils	Town and Country Planning Act, 1958
Conservation Area	NEPA (Town and Country Planning Authority, parish councils): MWLECC	Town and Country Planning Act, 1958
Protected Watershed	NEPA (NRCA): MWLECC	Watershed Act, 1963 Protection

Table 4-3 Existing categories of protected areas in Jamaica (January 2012) - international designations

Source: (National Environment and Planning Agency, n.d.)

CATEGORY	RESPONSIBLE AGENCY	CONVENTION
Ramsar Site	NEPA (NRCA): MWLECC	Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)
World Heritage Site (no existing sites, however submissions have been made)	Jamaica National Heritage Trust: MYC	World Heritage Convention

The following protected areas are highlighted owing to their proximity to the proposed project (Figure 4-1):

- **Bogue Lagoon Creek Game Reserve** - the southwestern end of the proposed road alignment transverses this reserve and the West Green alignment touches its eastern boundary.
- **Montego Bay Marine Park (MBMP)** - The proposed road is located less than 200 metres east of the MBMP south-eastern boundary.
- **Bogue Islands Lagoon SFCA** - The proposed alignment is located less than 200 metres east of the Bogue Island Lagoon SFCA.
- **Montego Bay Point SFCA** - Located north of Bogue Island Lagoon SFCA and further away from the proposed alignments.

Section 3.3.8.3 descries these areas in further detail.

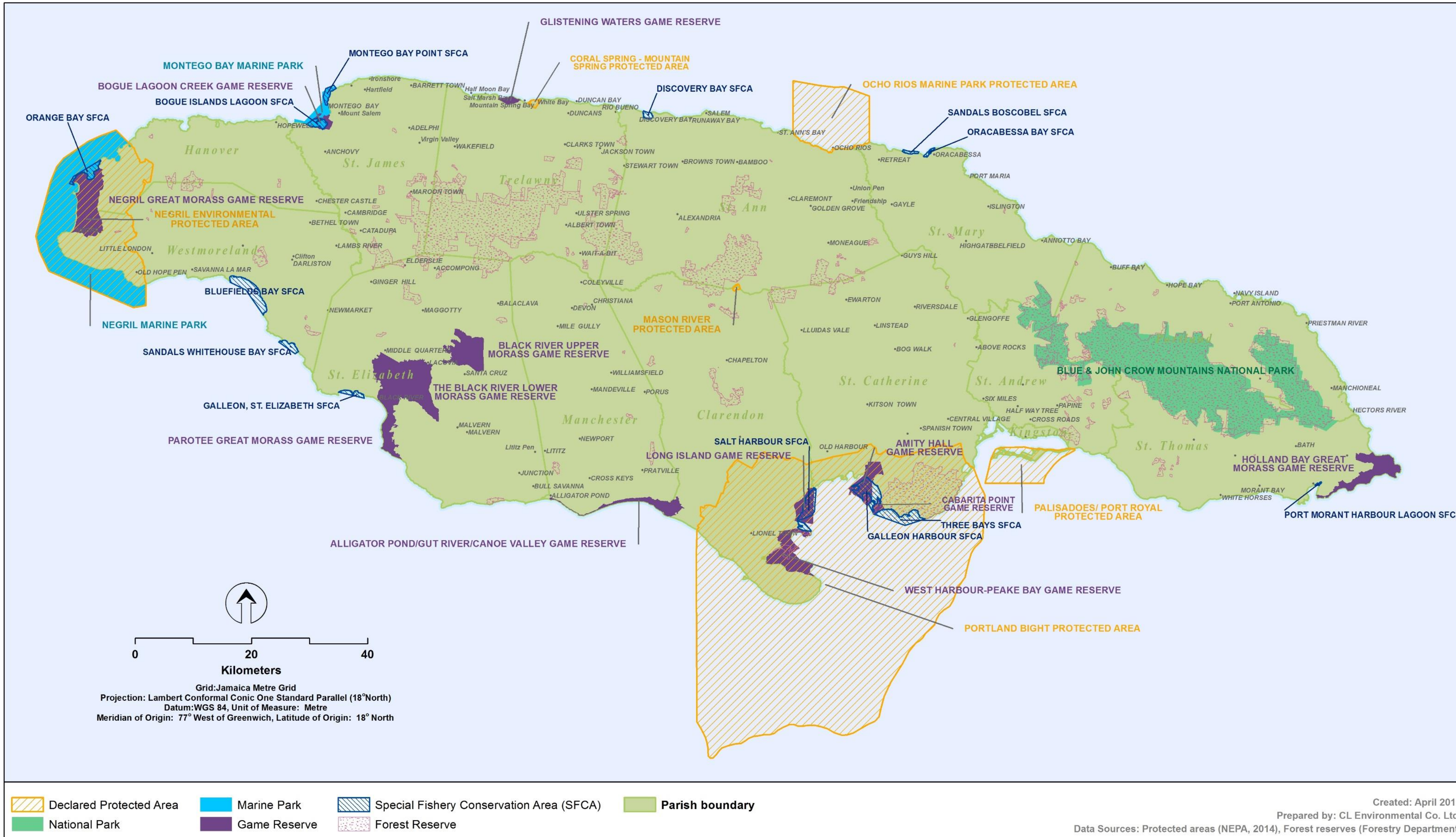


Figure 4-1 Protected areas system in Jamaica (excluding designations under the Jamaica National Heritage Trust and proposed areas not yet declared)

4.2.2.2 Policy for the National System of Protected Areas 1997

This legislative instrument is a White Paper and essentially proposes a comprehensive protected areas system for Jamaica. Six types of protected areas are proposed in order to encompass the diverse natural resources and landscape, and are comparable to those of the IUCN (International Union for Conservation of Nature) [5]:

1) National Nature Reserve/Wilderness Area (Equivalent to IUCN Category I)
2) National Park, Marine Park (Equivalent to IUCN Category II).
3) Natural Landmark/National Monument (Equivalent to IUCN Category III)
4) Habitat/Species Management Area (Equivalent to IUCN Category IV)
5) National Protected Landscape, or Seascape (Equivalent to IUCN Category V)
6) Managed Resource Protected Area (Equivalent to IUCN Category VI)

4.2.2.3 Natural Resources Conservation Authority Act 1991

The Natural Resources Conservation Authority Act (NRCA) is 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. 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. It also speaks to the designation of national parks, protected areas etc.

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*, as well as a number of regulations and orders including:

- *The Natural Resources (Permit and Licences) Regulations 1996 and* (Amendment) Regulations *2015;*
- *Natural Resources (National Parks) Regulations 1993 and (Amendment) Regulations 2003;*
- *The Natural Resources (Marine Parks) Regulations 1992, (Amendment) Regulations 2003,* and *(Amendment) Regulations, 2015;* and
- *The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order 1996* and *(Amendment) Order 2015.*

4.2.2.3.1 The Natural Resources Conservation (Permit and Licences) Regulations 1996 and (Amendment) Regulations 2015

A permit and licencing system was established under these regulations in order to control the undertaking of any new construction or development of a prescribed nature in Jamaica and the

[5] It should be noted that since the publication of the Policy for Jamaica's System of Protected Areas 1997, the IUCN has revised the categories system and guidelines (http://cmsdata.iucn.org/downloads/guidelines_for_applying_protected_area_management_categories.pdf)

handling of sewage or trade effluent and poisonous or harmful substances discharged into the environment.

4.2.2.3.2 The Natural Resources (Marine Park) Regulations 1992, the Natural Resources (Marine Park) (Amendment) Regulations 2003

The Natural Resources (Marine Park) Regulations are designed to achieve and maintain the sustainability of and protect the Marine Parks of Jamaica. It is an offence to use an area in a manner contrary to the zone. It is administered by the Natural Resources Conservation Authority (NRCA)/National Environment and Planning Agency (NEPA). The proposed project is located less than 200 metres east of the Montego Bay Marine Park (see section 3.3.8.3.2).

4.2.2.3.3 The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order 1996 and (Amendment) Order 2015

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. Section 9 of the NRCA Act declare the entire island and the territorial sea as a 'prescribed area', in which specified activities require a permit, and for which activities an environmental impact assessment may be required. The major amendment made in 2015 was the substitution of the Categories of Enterprises, Construction and Development (Column A), which lists the various activities, by category, for which a permit is required. As discussed previously, an EIA was required for the proposed project and this report fulfils one component of the EIA process.

4.2.2.3.4 The Natural Resources Conservation (Wastewater and Sludge) Regulations 2013

These regulations describe what are considered sensitive waters and declare water as either Class I or II. In relation to the proposed project and its location in proximity to the Bogue Sewage Ponds WW Treatment Plant (along Bogue Main Road and within 100 metres of the proposed alignments), these regulations speak to the treatment of wastewater and discharge of effluent, and the licensing requirements for the construction and operation of such facilities.

4.2.2.4 Wild Life Protection Act 1945 and Wild Life Protection (Amendment of Second and Third Schedules) Regulations 2016

The Wild Life Protection Act of 1945 is mainly concerned with the protection of specified faunal species and is the only statute in Jamaica specifically designated to this. This Act protects several rare and endangered faunal species and the Wild Life Protection (Amendment of Second and Third Schedules) Regulations 2016 provides substitutions for the Second and Third Schedules of the principal Act which lists these species. For these reasons, biological assessments were included as part of the EIA and as detailed further in section 3.2.1, fifteen endemic species encountered during terrestrial flora surveys and a number of endemic reptilian and amphibian species were recorded during the faunal surveys (section 3.2.2). Please see sections 5.2.2.1 and 5.2.2.2 for further detail regarding potential impacts mitigation measures recommended to ensure compliance with respective legislation.

The establishment of two types of protected areas, namely Game Sanctuaries and Game Reserves is authorized under this Act. As mentioned previously, the Bogue Lagoon Creek Game Reserve is traversed by the southwestern end of the proposed road alignment and the West Green alignment touches its eastern boundary (see section 3.3.8.3.1 for further detail).

4.2.2.5 The Fishing Industry Act 1975

The Fishing Industry Act 1975 is the overarching instrument relating to fishing activities within Jamaica. The Act speaks to registration and licensing, fisheries protection, prohibited activities and the declaration of an area as a fish sanctuary. Under the most recent Fishing Industry (Special Fishery Conservation Area) Regulations 2012, Special Fishery Conservation Areas (SFCAs), more commonly known as fish sanctuaries, are declared. There are currently 12 SFCAs declared.

The Montego Bay Perimeter Road alignment is located less than 200 metres east of the Bogue Island Lagoon SFCA. Montego Bay Point SFCA is located north of Bogue Island Lagoon SFCA and within the SIA, however further away from the proposed alignments. Please see section 3.3.8.3.3.

4.2.2.6 The Forest Act 1996

The 1996 Forest Act repealed the 1937 legislation and was the legal basis for the organisation 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). 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. There are also a set of *Forest Regulations (2001)* which are administered by the Forestry Department as well.

A "Forest Reserve" is defined to be any area of land declared by or under this Act to be a forest reserve. 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. Four forest estates fall completely or partially within 2 km of the project (Retirement; Irwin; Montpelier; and Burnt Ground); however, forest reserves do not exist within this study area. Section 3.3.8.4 provides further details, as well as section 5.0 for potential impacts and mitigation measures recommended to ensure compliance with respective legislation.

4.2.2.7 The Endangered Species (Protection, Conservation and Regulation of Trade) Act 2000 (Amended 2015)

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. The regulations associated with this Act were amended in 2015 and include updated fees for the various permits and certificates granted through this legislation.

4.2.2.8 Water Resources Act 1995

The Water Resources Act (1995) established the Water Resources Authority (WRA), which is authorized to regulate, allocate, conserve and manage the water resources of the island. 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.

4.2.2.9 Draft Policy and Regulation for Mangrove & Coastal Wetlands Protection

As outlined in this draft policy, the Government of Jamaica has adopted the policy and regulation in order to promote the management of coastal wetlands. The policy seeks to:

- Provide protection against dredging, filling, and other development;
- Designate wetlands as protected areas;
- Protect wetlands from pollution particularly industrial effluent sewage, and sediment;
- Ensure that all developments planned for wetlands are subject to an Environmental Impact Assessment (EIA);
- Ensure that traditional uses of wetlands are maintained.

Mangroves are found in the study area; please see section 3.2.4 for further detail and section 5.2.2.4 for mitigation measures recommended to ensure compliance with respective legislation.

4.2.2.10 Coastal Management and Beach Restoration Guidelines: Jamaica

These guidelines compliment Vision 2030 Jamaica and provide a tool for coastal stakeholders, including advice at the community level to ensure coastal management is undertaken in a sustainable way with consideration of wider impacts on the environment. Different management approaches are suggested for the coastline of Jamaica, which in turn influence the site-specific interventions considered appropriate. Progressive steps to follow from project inception through to design and obtaining planning permission for projects within the coastal zone are described. A number of design outcomes are required to be assessed to ensure that the intervention does not adversely affect the environment, is designed to be resilient and does not impact other sites along the coastal zone.

The adequacy of the governance structure and institutional base is considered a key aspect and the existence of national organisations with clear mandates, roles, responsibilities, and capacities is described as vital to the successful management of Jamaica's coastal resources.

4.2.2.11 The Jamaica National Heritage Trust Act 1985

The Jamaica National Heritage Trust Act established the Jamaica National Heritage Trust (JNHT) and has been in operation since 1985. The main goal is the preservation and protection of the country's national heritage. The Act 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.

JNHT was consulted and section 3.4 details their findings. Section 5.2.4 also describes potential impacts and recommended mitigation measures to ensure compliance with respective legislation.

4.2.3 Public Health & Waste Management

4.2.3.1 Water Quality Standards

The NRCA has primary responsibility for control of water pollution in Jamaica. National standards for ambient freshwater and marine water are shown in Table 4-4 and Table 4-5. For drinking water, World Health Organisation (WHO) standards are utilized and these are regulated by the National Water Commission (NWC). Standards for industrial and sewage discharge into rivers and streams are stipulated within the Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013.

Further information regarding water quality may be found in section 3.1.6. Section 5.2.1.4 also describes potential impacts and recommended mitigation measures to ensure compliance with respective legislation.

Table 4-4 Draft national ambient marine water quality standards for Jamaica, 2009

Source: National Environment and Planning Agency (NEPA)

Parameter	**Measured as**	**Standard Range**	**Unit**
Phosphate,	P*	0.001-0.003	mg/L
Nitrate,	N**	0.007-0.014	mg/L
BOD_5	O	0.0-1.16	mg/L
pH		8.00-8.40	
Total Coliform		2-256	MPN/100mL
Faecal Coliform		<2-13	MPN/100mL

*Reactive phosphorus as P
**Nitrates as Nitrogen

Table 4-5 Draft national ambient freshwater water quality standards for Jamaica, 2009

Source: National Environment and Planning Agency (NEPA)

Parameter	Measured as	Standard Range	Unit
Calcium	(Ca)	40.0-101.0	mg/L
Chloride	(Cl^-)	5.0- 20.0	mg/L
Magnesium	(Mg^{2+})	3.6- 27.0	mg/L
Nitrate	(NO_3^-)	0.1- 7.5	mg/L
Phosphate	(PO_4^{3-})	0.01 - 0.8	mg/L
Potassium	(K^+)	0.74- 5.0	mg/L
Silica	(SiO_2)	5.0- 39.0	mg/L
Sodium	(Na^+)	4.5- 12.0	mg/L
Sulfate	(SO_4^{2-})	3.0- 10.0	mg/L
Hardness	($CaCO_3$)	127.0-381.0	mg/L (as $CaCO_3$
Biochemical Oxygen Demand	(O)	0.8- 1.7	mg/L
Total Dissolved Solids		120.0-300	mg/L
pH		7.00- 8.40	
Conductivity		150.0-600	µS/cm

4.2.3.2 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" (McTavish). 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.

National guidelines (NEPA) used for noise levels are shown in Table 4-6; values for commercial, industrial and residential areas are specified.

Table 4-6 NEPA guidelines for daytime and night-time noise in various zones

ZONE	NEPA Daytime Guideline (dBA)	NEPA Night-time Guideline (dBA)
Commercial	65	60
Industrial	75	70
Residential	55	50

Noise surveys and modelling undertaken for this project are presented in sections 3.1.7, 5.2.1.5 and 5.3.1.3.

4.2.3.3 The Natural Resources Conservation Authority (Air Quality) Regulations, 2006

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. Part I of the NRCA Air Quality Regulations (2006) 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.

According to the Natural Resources Conservation Authority (Air Quality) Regulations, 2006:

> "significant impact", in relation to the impacts of sources on ambient air quality, means –:
>
> (a) the increment in the predicted average concentration of sulphur dioxide (SO_2), total suspended particulates (TSP), particulate matter less than ten microns (PM_{10}) or nitrogen dioxide (NO_2) is greater than an annual average of 20 μg/m³ or a 24-hour average concentration of 80 μg/m³; or
>
> (b) the increment in the predicted average concentration of CO is greater than 500 μg/m³ as an 8-hour average or 2000 μg/m³ as a 1-hour average.
>
> when such predictions are made using an approved air dispersion model.

Table 4-7 summarizes the Significant Impact Concentrations and the Jamaican National Ambient Air Quality Standards (JNAAQS) and Guideline Concentrations (GC).

Table 4-7 Significant Impact Concentrations and the Jamaican National Ambient Air Quality Standards (JNAAQS) and Guideline Concentrations (GC) for air quality

Pollutant	Avg. Period	Jamaican NAAQS or GC (μg/m³)	Significant Impact Concentration (μg/m³)
PM_{10}	24-hr	150	80
	Annual	50	20
TSP	24-hr	150	
	Annual	60	
NO_2	1-hr	400	
	24-hr	N/A	80
	Annual	100	20
SO_2	1-hr	700	
	24-hr	280	80
	Annual	60	20
CO	1-hr	40000	2000
	8-hr	10000	500
1,3 Butadiene	1-hr	0.04	
Acetaldehyde	1-hr	1250	
	24-hr	500	
Acrolein	1-hr	58.75	
	24-hr	23.5	
Benzene	Annual	1	
Benzo (a) pyrene	1-hr	0.00275	
	24-hr	0.0011	
Carbon Tetrachloride	1-hr	6	

Pollutant	Avg. Period	Jamaican NAAQS or GC (μg/m³)	Significant Impact Concentration (μg/m³)
	24-hr	2.4	
Chloroform	1-hr	1250	
	24-hr	500	
Ethylene Dibromide	1-hr	7.5	
	24-hr	3	
Formaldehyde	1-hr	162.5	
	24-hr	65	
Methylene Chloride	1-hr	550	
	24-hr	220	
Styrene	1-hr	2500	
	24-hr	1000	
Xylenes	1-hr	5750	
	24-hr	2300	
Vinyl Chloride	24-hr	1	
	Annual	0.2	
Arsenic	1-hr	0.75	
	24-hr	0.3	
Beryllium	Annual	0.0013	
Cadmium	1-hr	5	
	24-hr	2	
Chromium	1-hr	3.75	
	24-hr	1.5	
Cobalt	24-hr	0.12	
Copper	1-hr	125	
	24-hr	50	
Lead	1-month	N/A	
	3-month	2	
Manganese	Annual	119	
Mercury	1-hr	5	
	24-hr	2	
Nickel	1-hr	5	
	24-hr	2	
Selenium	24-hr	25	
	Annual	10	
Zinc	24-hr	12	

National standards for $PM_{2.5}$ do not exist; the U.S. Environmental Protection Agency standards are used for $PM_{2.5}$ and are as follows:

- 24-hour $PM_{2.5}$ = 35 μg/m³
- Annual $PM_{2.5}$ = 12 μg/m³

Further information regarding air quality compliance may be found in section 3.1.8.

4.2.3.4 The Clean Air Act 1964

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 premises 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.

4.2.3.5 Public Health Act 1985

The Public Health Act is administered by the Ministry of Health through Local Boards, namely the parish councils. *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 organisation 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 organisation 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.

4.2.3.6 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.

Section 3.3.6.4 provides details regarding waste management in the study area. Section 5.2.3.5 describes potential impacts and recommended mitigation measures to ensure compliance with legislation.

4.2.3.7 The Natural Resources (Hazardous Waste) (Control of Transboundary Movement) Regulations 2003

These regulations seek to implement the *Basel Convention on the Transboundary Movement of Hazardous Waste* and control transboundary movement and prevent the illegal trafficking of certain hazardous wastes. It is an offence to unlawfully dump or otherwise dispose of hazardous waste in areas under the jurisdiction of Jamaica. Waste resulting from the proposed project should be properly disposed of, and special attention should be paid to those considered hazardous under these regulations and as listed above.

4.3 REGIONAL AND INTERNATIONAL LEGISLATIVE AND REGULATORY CONSIDERATIONS

4.3.1 United Nations 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”.

Jamaica became a party to the CBD on April 6, 1995. 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.

4.3.2 Convention on Wetlands of International Importance especially as Waterfowl Habitat, "Ramsar Convention" 1971

The Ramsar Convention is an intergovernmental treaty that focuses on maintaining ecological wetland systems and planning for sustainable use of their resources. It was adopted on 2 February 1971 in Ramsar, Iran. The mission of the Convention was adopted by the Parties in 1999 and revised in 2005 - "the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world". Under Article 2.2 it is stated:

> Wetlands should be selected for the List on account of their international significance in terms of ecology, botany, zoology, limnology or hydrology” and indicates that “in the first instance, wetlands of international importance to waterfowl at any season should be included.

Jamaica became a contracting party on 7 February 1998 and has 4 sites covering a combined total of 37,847 hectares (378.47 km^2).

4.3.3 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES generally seeks to protect endangered plants and animals and owing to the cross boundary nature of animals and plants. This protection requires international cooperation. It aims to ensure that international trade of wild animal and plant species does not threaten the survival of the species in the wild, and it accords varying degrees of protection to over 35,000 species.

This convention was drafted in 1963 at a meeting of members of the International Union for Conservation of Nature (IUCN) and finalised in 1973. After being opened for signatures in 1973, CITES entered into force on 1 July 1975. Jamaica became a Party to CITES on June 22, 1997. In 2000, Jamaica enacted domestic legislation, the Endangered Species (Protection, Conservation and Regulation of Trade) Act, 2000 and Regulations to fulfil its obligations to CITES. The Management Authority for CITES in Jamaica is the Natural Resources Conservation Authority (NRCA). The Authority receives applications for permits and certificates to trade internationally in endangered species. The processing of applications is coordinated with the local Scientific Authority.

5.0 IDENTIFICATION AND ASSESSMENT OF POTENTIAL IMPACTS AND RECOMMENDED MITIGATION

5.1 IMPACT MATRICES

Impact matrices for the site preparation/construction and operational phases were created (Table 5-2 and Table 5-3). Each impact was assessed based on the following criteria, as indicated within each matrix and are grouped as Physical, Biological, Human/ Social and Heritage and Archaeological (Ogola, 2007):

- **Direction: -** This describes the nature of the potential impact. It can either be positive, negative or no impact of a particular activity (none).
- **Duration:** Environmental impacts have a temporal dimension and needs to be considered in an EIA. Impacts arising at different phases of the project cycle may need to be considered. See Table 5-1 for ranking technique utilised.
- **Magnitude:** This is defined by the severity of each potential impact and indicates whether the impact is irreversible or reversible and estimated potential rate of recovery. The magnitude of an impact cannot be considered large/high if the impact can be successfully mitigated. See Table 5-1 for ranking technique utilised.
- **Extent:** The spatial extent or the zone of influence of the impact should always be determined. An impact can be site-specific and limited to the project area and also within the locality of the proposed project; a regional impact that may extend beyond the local area; and a national impact affecting resources on a national scale which may also in some cases be trans-boundary (international). See Table 5-1 for ranking technique utilised.

It should be noted that the following were also taken into consideration during impact analysis:

- The Consultants' experience,
- Documented impacts from similar projects,
- The data collected,
- Analysis of the processes in the proposed project,
- Information generated from models,
- Concerns raised from stakeholders in the social surveys; and
- Discussions held among the EIA Study team.

Table 5-1 Ranking criteria utilised for duration, magnitude and extent of each potential impact

DURATION	**None (N)** – No temporal effect	**Short (S)** - Impacts lasting 0 – 10 years before recovery occurs. Impact does not persist after the activity ends.	**Medium (M)** - Impacts lasting 10 - 20 years before signs of recovery. Impacts on biological populations are not inter-generational.	**Long (L)** - Impacts are persistent and lasting over 20 years. Impacts on biological populations are over several recruitment cycles or generations of those populations.
MAGNITUDE	**None (N)** - No measurable change in availability of resources or function of systems. No measurable effect on people.	**Small (S)** - Changes in form and/or ecosystem function and/or a resource. The system maintains the ability to support ecosystem/ resource functions with only minor changes in community value and no overall loss/gain and is reversible. Only a small fraction of the local community is affected.	**Medium (M)** - Changes in form and/or ecosystem function and/or a resource. The system's ability to support ecosystem/ resource functions and economic benefit is affected but not lost and is reversible. Only a moderate fraction of the local community is affected.	**Large (L)** - Changes in form and/or ecosystem function and/or a resource. The system's ability to support ecosystem/resource functions and economic benefit is highly affected and irreversible. A large fraction of the local community is affected.
EXTENT	**None** – No spatial effect	**Local (L)** - Isolated effects within project site and its locality.	**Regional (R)** – Extended beyond local area/borders or offsite dispersion pathways.	**National (N)** - Widespread effect affecting the nation (and/or transboundary/international)

Table 5-2 Environmental impact matrix for site preparation and construction phase

CATEGORY		IMPACT	DIRECT/ INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT
			DIRECT	INDIRECT	POSITIVE	NONE	NEGATIVE			
Physical	Geotechnical (Mobay Perimeter Road)	Differential settlement and seismic induced liquefaction in coastal alluvial plain (Montego Bay Perimeter Road).	X				X	S	M	L
		Undercutting of fill slopes by Montego River and subsequent failure of embankment (Montego Bay Perimeter Road)	X				X	S	M	L
		Flooding and scouring where the road is located in the drainage channel of the Salt Spring Gut and its tributaries.		X			X	S	M	L
		Exposing the gypsum material to the elements could result in excessive erosion and degradation of the road slopes, embankment, and structure foundations.	X				X	S	M	L
		Rock falls in tall road cuts	X				X	S	M	L
		Differential settlement in association with karst solution features	X				X	S	M	L
		Potential for flooding upstream from the road and collapse of the road embankment		X			X	S	M	L
		Multiple organic and/or contaminated soil layers		X			X	S	M	L
	Geotechnical (Long Hill Bypass)	Flooding and scouring in area traversing the escarpment to the north of Anchovy		X			X	S	M	L
		Rock falls in tall road cuts	X				X	S	M	L
		Differential settlement in association with karst solution features	X				X	S	M	L
		Potential for flooding upstream from the road and collapse of the road embankment		X			X	S	M	L
		Multiple organic and/or contaminated soil layers		X			X	S	M	L
	Geotechnical (Barnett Street)	Erosion at 173+600 and 173+750 as a result of the proposed realigned section of the Montego River between 13+600 and 14+000	X				X	S	M	L
	Soil	Erosion and sediment loss resulting from vegetation removal		X			X	S	M	L
		Contamination from leaked hydraulic fuels, oils, etc.		X			X	S	M	L
	Drainage (Sinkholes)	Plugging of sinkholes in close proximity to alignments		X			X	S	M	R
		Recharge paths for surface run-off may be traversed by the alignment, decreasing the volume of run-off reaching the sinkholes.	X				X	S	M	R
		Surface run-off may become contaminated due to oil/fuel spills		X			X	S	S	R
	Water Quality	Pollution of Montego River from siltation, spillage, runoff etc.	X				X	S	S	R
	Noise	Noise impact on surrounding communities and construction workers	X				X	S	S	L
	Air Quality	Pollution generated from construction equipment and transportation of materials	X				X	S	S	L
		Fugitive dust from the construction areas and raw materials stored on or transported to site	X				X	S	S	L
	Vibration (West Green Ave.)	Vibration impact on persons residing nearby	X				X	S	M	L
		Vibration impact on houses/structures nearby	X				X	S	M	L
	Vibration (Mobay Perimeter Road and Long Hill bypass)	Vibration impact on persons residing nearby	X				X	S	S	L
		Vibration impact on houses/structures nearby	X				X	S	S	L
	Hazards - Flooding	Increased runoff volume downstream		X			X	S	M	L
		Increased erosion and scour		X			X	S	M	L
		Increased debris flow and sediments deposits downstream		X			X	S	M	L
		Increased concentration of contaminants		X			X	S	M	R
Biological	Terrestrial Flora	Habitat fragmentation and associated destructive issues (barriers to movement, division of continuous populations, increased incidence of fire and vulnerability to invasion by exotic and native pest species and diseases).		X			X	L	S	L
		Habitat Loss	X				X	L	M	L
		Accidental or intentional removal of important plant species and resulting decrease in diversity.	X				X	M	S	L
		Human encroachment, Urban Sprawl and Invasive resulting from land clearance		X			X	L	M	L
		Dusting and emissions from raw material storage and transportation	X					S	S	L
	Fauna	Habitat fragmentation		X			X	L	S	L
		Habitat Loss and Degradation	X				X	L	M	L
		Noise displacement	X				X	S	S	L
	Mangrove Community	Mangrove Loss from land clearance	X				X	L	M	L
		Sediment Loading		X			X	S	M	L
		Mangrove Prop Root Community degradation		X			X	S	S	L
	Benthic Community	Seagrass		X			X	S	S	R
		Meiofauna, filter feeders and fish		X			X	S	S	R
	Housing/ Residents	Displacement, relocation and resettlement of residents within cut and fill areas.	X				X	S	S	R

CATEGORY		IMPACT	DIRECT/ INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT
			DIRECT	INDIRECT	POSITIVE	NONE	NEGATIVE			
Human/ Social	Educational Facilities	Displacement of two schools within alignment	X				X	L	S	R
		Noise and dust nuisance on nearby schools within 100m of alignment	X				X	S	S	L
		Reduced Access	X				X	S	S	L
	Employment	Direct, indirect and induced job opportunity	X	X	X			S	M	N
	Water Supply	Groundwater (well) Contamination from roadway construction		X			X	M	M	R
		Groundwater contamination from on-site wastewater disposal		X			X	M	M	R
	Water Supply - NWC Distribution Network	Destruction of existing water supply pipelines	X				X	S	M	R
		Disruption of water supply	X				X	S	S	R
	Sewerage/Wastewater	Destruction of sewerage pipelines	X				X	S	M	R
		Disruption of sewerage services	X				X	S	S	R
	Solid Waste	Waste generation from on-site activities	X				X	S	S	R
	Telecommunications	Potentially impacted Infrastructure within 100m buffer from alignment	X				X	S	S	N
	Transportation	Existing road wear and tear from trucks		X			X	S	S	L
		Traffic disruption and congestion from trucks	X				X	S	S	R
		Dust pollution from trucks carrying material	X				X	S	S	L
		Accident/damage risk to other vehicles	X				X	S	M	L
	Health and Emergency	Occupational Health and safety of workers	X				X	S	M	L
		Community health and safety of residents	X				X	S	M	L
		Noise and dust pollution to health care facilities	X				X	S	S	L
		Disruption of access to health care facilities from road works	X				X	S	S	L
		Disruption of construction activities due to safety and security issues in volatile areas through which the alignment runs		X			X	S	M	N
	Recreational and Social	Displacement of two churches within alignment	X				X	L	S	R
		Noise and dust nuisance on nearby facilities within 100m of alignment	X				X	S	S	L
	Industry and Economy	Increased commercial activity	X		X			S	M	N
		Decreased commercial activity	X				X	S	M	N
		Displacement of shops/stalls and other commercial entities within alignment	X				X	L	M	R
	Tourism	Noise, dust and traffic nuisance	X				X	S	S	L
	Land Use	Southwestern end of Mobay Perimeter Road alignment traverses the Bogue Lagoon Creek Game Reserve	X				X	L	M	L
		West Green road works footprint touches eastern boundary of the Bogue Lagoon Creek Game Reserve	X			X		L	N	None
		Total of 573 land parcels impacted by proposed alignments	X				X	L	S	L
	Aesthetics	Reduced visual quality	X				X	S	S	L
Heritage and Archaeological	Historic Sites	Impact to historic houses/structures at Anchovy and Taíno site, Barnett Old Bridge, house and ruins at Providence.	X			X		N	N	None
		Impact to Fairfield Hotel	X				X	S	S	L
		Impact at Rocklands Bird Sanctuary.	X				X	S	S	L

Table 5-3 Environmental impact matrix for operation phase

CATEGORY		IMPACT	DIRECT/ INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT
			DIRECT	INDIRECT	POSITIVE	NONE	NEGATIVE			
Physical	Drainage and Stormwater	Blockage of drainage crossings may result in localized flooding or inundation		X			X	L	S	L
		Erosion and scouring of riverbed resulting from increased flow velocity from Montego River Realignment		X			X	L	S	L
		Sediment deposition around meanders of river channel resulting from erosion from Montego River Realignment		X			X	L	S	L
		Stormwater peak flows reduced upon reaching Bogue wetland		X			X	L	S	L
		Contamination and destruction of sinkholes and groundwater network		X			X	L	S	L
	Noise (Mobay Perimeter Road)	Proposed UWI Western Campus would have noise levels from the traffic (2021 and 2041) using the highway, above the NRCA day time noise standard (along the Mobay Perimeter Road)	X				X	L	S	L
	Noise (Long Hill bypass)	Six schools along the Long Hill bypass would have noise levels from the traffic (2021 and 2041) using the highway, above the NRCA day time noise standard	X				X	L	S	L
		Two churches along the Long Hill bypass had noise levels non-compliant with the NRCA night time standards for both the 2021 and 2041 traffic	X				X	L	S	L
	Noise (Barnett Street)	Three schools would have noise levels from the traffic (2021 and 2041) using the road above both the NRCA day and night time noise standards and One school non-compliant with the NRCA night time noise standard (in the vicinity of the Barnett Street road works)	X				X	L	S	L
		Catherine Hall Health Centre had noise levels non-compliant with the NRCA day and night time standards for the 2041 traffic (in the vicinity of the Barnett Street road works)	X				X	L	S	L
		Two churches had noise levels non-compliant with the NRCA night time standards 2041 traffic and once church had noise levels non-compliant with the NRCA night time standards for both the 2021 and 2041 traffic (in the vicinity of the Barnett Street road works)	X				X	L	S	L
	Noise (West Green Ave.)	Five (5) schools had noise levels from the traffic (2021 and 2041) using the road above both the NRCA day and night time noise standards (in the vicinity of the West Green Ave. road works)	X				X	L	S	L
		Only Catherine Hall Health Centre had noise levels non-compliant with the NRCA Day and Night time standards for both the 2021 and 2041 traffic (in the vicinity of the West Green Ave. road works)	X				X	L	S	L
		Holiness Born Again Church of Jesus Christ had noise levels non-compliant with the NRCA Day and Night time standards for both 2021 and 2041 traffic (in the vicinity of the West Green Ave. road works)	X				X	L	S	L
	Occupational Noise	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.	X				X	L	S	L
	Air Quality	Vehicular emissions effect on nearby residential population	X				X	L	S	L
		Exposure of toll booth workers to vehicle emissions throughout the course of their work shifts.	X				X	L	S	L
	Vibration (West Green Ave.)	Vibration impact on persons residing nearby	X				X	L	M	L
		Vibration impact on houses/structures nearby	X				X	L	M	L
	Vibration (Mobay Perimeter Road)	Vibration impact on persons residing nearby	X			X		N	N	None
		Vibration impact on houses/structures nearby	X			X		N	N	None
	Vibration (Long Hill bypass)	Vibration impact on persons residing nearby	X				X	L	S	L
		Vibration impact on houses/structures nearby	X			X		N	N	None
	Hazards - Landslides	The mid-section segment between chainages 12+800 and 18+000 is the most vulnerable length to landslides		X			X	L	S	L
	Climate Change and Flooding	Three (3) main channels contribute to flooding in their respective areas: Salt Spring Gully, North Gully and South Gully.		X			X	L	S	L
		Increased river velocity as a result of river realignment may lead to sediment deposition in the meanders of the river channel resulting in potential flooding.		X			X	L	S	L
Biological	Terrestrial Flora	Increased access resulting in Invasive plants and animal intrusion		X			X	L	M	R
		Increased access resulting in logging		X			X	L	S	L
	Fauna	Habitat Fragmentation		X			X	L	S	L
		Habitat Degradation		X			X	L	S	L
	Mangrove	Mangrove degradation from improper drainage design resulting in poor hydrological conditions		X			X	L	M	L
		Mangrove prop root community degradation		X			X	L	M	L
	Benthic Community	Seagrass		X			X	L	M	L
		Meiofauna, filter feeders and fish		X			X	L	M	L
Human/ Social	Housing/Residents	Improved access for development (residential, educational, recreational etc.)		X	X			L	M	N
		Noise and dust pollution of nearby existing residents	X				X	L	S	L
		Decreased aesthetics		X			X	L	S	L

CATEGORY	IMPACT	DIRECT/ INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT
		DIRECT	INDIRECT	POSITIVE	NONE	NEGATIVE			
Employment	Direct, indirect and induced job opportunity	X	X	X			L	S	N
	Increased investment from new traffic infrastructure	X		X			L	L	N
Transportation	Improved Level of Service	X		X			L	M	R
	Reduced traffic and delays	X		X			L	M	R
	Turning volumes may still result in some traffic build up on Howard Cooke Blvd.		X			X	L	S	L
Health and Emergency	Increase in traffic accidents as a result of speeding		X			X	L	S	L
	Light pollution impacts on nearby residences in the vicinity of Toll Plazas and Exit Ramps		X			X	L	S	L
	Natural hazards such as earthquakes, floods, fires		X			X	L	S	L
	Miscellaneous hazards such as stray animals, dead animals, fallen tree limbs, accumulation of dirt, gravel or other granular materials, oil spills etc.		X			X	L	S	L
Industry and Economy	Improved infrastructure to boost Agriculture industry	X		X			L	L	N
	Increased tourism opportunity from access to new points of interest	X		X			L	L	N
	Increased recreational opportunity from access to new points of interest	X		X			L	L	N
	Increased efficiency of movement of goods and services island-wide	X		X			L	L	N
	Increase in jobs and additional GDP and tax take	X		X			L	L	N
Land Use	Community Fragmentation and Accessibility		X			X	L	S	L
Aesthetics	Disruption of scenic landscape for Montego Bay Perimeter Road		X			X	L	S	L
	Disruption of scenic landscape for Long Hill Bypass		X			X	L	S	L
Impacted Structures	489 structures were mapped and deemed as impacted	X				X	L	M	N

5.2 SITE CLEARANCE/ CONSTRUCTION

5.2.1 Physical

5.2.1.1 Geotechnical

5.2.1.1.1 Montego Bay Perimeter Road

Road Segment 10+000 to 10+500
In association with the high-water table the sand layers have a high probability of liquefying during the major earthquake events. Such liquefaction could cause differential ground subsidence of the road during or shortly after an earthquake.

Road Segment 10+500 to 11+200
The geotechnical characteristics of this segment are in essence the same as those of the previous segment. The main difference between the two is that this segment has not been reclaimed and lacks the layer of calcareous sands and gravels fill raising the ground level above tidal influence. Reclamation will have to be part of the road construction. Waterlogged, with layers of loose sand, clays and partial decomposed organic material including peat, the allowable bearing capacity of Quaternary Swamp and Marsh Deposits is low (0.08MPa). Excessive settlements should be anticipated and addressed by the roadbed design. The highly compressible layer peat and partially decomposed organic material could be removed and replaced.

Road Segment 11+200 to 12+700
Between 11+300 and 11+600 the road alignment is located between 2 sewage ponds, which will have to be partially filled up to accommodate the road. Sludge layer which has likely over the years accumulated in it should be removed before filling it in.

Road Segment 12+700 to 14+800
This segment has no major geotechnical issues.

Road Segment 14+800 to 17+600
The road will be constructed by cutting and filling the slopes which form the left bank of the Montego River. The slopes along the river are about 15 degrees (27%). The cut slope will be in the Montpelier formation which consists of an alternation of fairly thick beds of chalk and bioclastic limestone and has an allowable bearing capacity ranging from 0.9 to 1.1 MPa. The slope stability of the Montpelier is generally good but rock falls must be anticipated to be on-going problem. A stepped slope excavation with a slope ratio of 1:1.00 to 1: 1.25 is proposed. The stepped slope design will help to control rock fall but other method to prevent rock falls may need to be applied. Where the fill slope reaches the river channel, river training works will have to be deployed to protect the base of the fill slope from lateral river erosion associated with from the Montego River.

At 15+300 the road alignment intersects with a small stream channel that drains the Irwin area. The cross drain will need to be installed that can not only manage the run-off but also bed-load associated with a major flash flood.

At 17+100 the road will cross the Montego River. About 38m above the river, the bridge will span the 125m wide valley floor. The bedrock of the Montpelier formation is exposed in the valley walls but in the river channel the bedrock is covered by a 7 to 10 thick alluvial deposits which include clays and gravels.

Small ephemeral stream draining the Porto Bello area intersect the road alignment at 17+400 and will have to be taken in account in the construction of the bridge and exit ramps.

Road Segment 17+900 to 21+300
The road alignment traverses in this segment relative rugged karst topography of steep hills and closed depressions. The Montpelier Formation, exposed over the entire length of this segment, has the same basic geotechnical characteristics as in the Montego River valley. To provide a consistent gradient for the construction of the road, the irregular karst topography will be cut and filled. The Slope stability is fairly good, but rock falls can be expected to be an on-going problem. The cut slopes proposed to be excavated as a stepped slope with a slope ratio of 1:1.00 to 1: 1.25.

Karst solution features are abundant but are not very well developed. Since the solution features are generally small in size, collapse of underground structures is not considered to be a major problem but cannot be rule out. Construction and maintenance crews need to look out for the presence and development of solution features. When encountered, these features need to be investigated and remediated as needed. While the drainage is mainly underground because of the high secondary permeability, several surface drainage channels do intersect with the road alignment at 18+500, 19+400, 20+000, 20+200 and 20+800. Although small and relative these drainage channels will have to be taken in account in the design of the road embankment.

Road Segment 21+300 to 24+650
The main geotechnical issue of this segment will be the drainage. The stream is ephemeral and carries only water during heavy rainfall. The drainage design will not only have to take in account the runoff but also the bed load under extreme rainfall condition. During extreme rainfall condition the secondary channel may deliver their load as high-density flow forcing the runoff to go where it is not intended to go.

Road Segment 24+650 to 24+900
This road segment has no particularly significant geotechnical issues and there are also no noteworthy hydrological or hydrogeological features or issues.

5.2.1.1.2 Long Hill Bypass

Road Segment 10+490 to 10+140
The main potential geotechnical issue is differential settlement.

Road Segment 10+140 to 6+200
The slope stability of the Montpelier is generally good but rock falls must be anticipated to be on-going problem where there are steep road cuts. Near the 9+300 mark the bypass road starts its steep climb across the 170m escarpment. The escarpment has an overall slope of 35 % (20°). If possible, the cut

slope should be excavated as a stepped slope with a slope ratio between 1:1.00 to 1: 1.25. Although slopes in the escarpment are steep, major slope stability problem are not expected to happen because the Montpelier Formation has a good internal drainage. Rock falls are expected to be the most likely slope failure, although small shallow rotational landslide have been known to occur where very thick chalk layer are exposed. Karst solution features should be anticipated in the alignment but even though they maybe abundant, the features are expected to be too small to cause significant problems.

The road alignment intersects with several short gullies. To prevent a catastrophic collapse of the road embankment similar to the 1979 failure of the railroad embankment, cross drains will have to be designed to accommodate the runoff and the sediment load caused by extreme rainfall events. However, the main geotechnical challenge will be to manage and control the drainage of the proposed Long Hill Bypass to prevent it to become another storm drain which deposits limestone debris at the foot of hill similar to what is now happens from time to time on the Anchovy to Reading main road.

Road Segment 6+200 to 1+900

Slope stability is in general not anticipated to be a significant problem in this section. The main geotechnical problems in this segment are related to the potential development of sinkholes and underground drainage in the fill areas causing differential settlement in the bypass road.

Road Segment 1+900 to 0+000

The main geotechnical issues in this section is the potential for differential settlement associate with the presence and potential development of karst features. The design of the bypass also has to take in account the ephemeral Anchovy Gully which intersects this road segment at 1+000 and at 0+100.

5.2.1.1.3 Barnett Street Upgrade

No major geotechnical issues are expected. The only cause of concern is the stability of the banks of the Montego River. Between mileposts 173+600 and 173+750 the river is very close to the road and tries to shift to east undercutting the slope which forms the right bank of the river. Special attention will have to be given to verify and ensure that the stability of these slopes cannot be affected during flood stages.

5.2.1.1.4 West Green Avenue Upgrade

No significant geotechnical problems are anticipated for these upgrade works.

RECOMMENDED MITIGATION

Design parameters and recommendations presented are preliminary and additional investigations and field verification of geotechnical conditions during construction by the designer's geotechnical engineer/geologist is required to support and verify detailed design of the project features. These additional geotechnical assessments will have to be done for both the Montego Bay Perimeter Road and the Long Hill Bypass in the next phase of the road design to finalize the location and sizing of cross drains, design of bridges, river training works, reclamation works and detailed slopes designs. All slope failures and Karst solution feature encountered during construction and maintenance works should be recorded and analysed to inform effective mitigation. The information on past failure and correction must be kept on record to inform future mitigation of recurring failures.

The potential geotechnical-related impacts and mitigation are outlined in Table 5-4 below.

Table 5-4 Geotechnical-related impacts and mitigation

Geotechnical Impact	Mitigation
Specific to Montego Bay Perimeter Road	
Differential settlement and seismic induced liquefaction in the coastal alluvial plain for the Montego Bay Perimeter Road.	Removal of the soft peat layer and the liquefiable sands layers. An alternative solution consists of a staged preload construction of the embankment with surcharging in combination with wick drains (Prefabricated Vertical Drains (PVD)) and dynamic compaction (which could include controlled blasting techniques).
Potential of undercutting of fill slopes by the Montego River and the subsequent failure of the embankment along the Montego River.	The toe of the fill slope can be protected from undercutting with gabions. The erosion of the fill slope by runoff from the road surface can be prevented by using a benched design. The erosion of the slope by interceptor drains taking the runoff from roadside drains can be prevented by directing the runoff from the road to a reinforced stepped or baffled drainage channel.
Flooding and scouring of the Montego Bay Perimeter Road where the road is located in the drainage channel of the Salt Spring Gut and its tributaries.	Ensuring that the constructed drainage channel is large enough to carry runoff and the sediment load of the Salt Spring Gut and its tributaries. The road surface of the Montego Bay Perimeter Road should be well above the peak discharge level of a 100-year flood at every point of the river channel taking in account the sediment load of the stream.
A large portion of the proposed alignment has thick cut sections through the gypsum rock layer. Exposing the gypsum material to the elements could result in excessive erosion and degradation of the road slopes, embankment, and structure foundations.	It is recommended to protect exposed gypsum layers to reduce erosion.
Common to Montego Bay Perimeter Road and Long Hill Bypass	
Rock falls in tall road cuts	There are many methods to prevent or mitigate rock fall, but to be effective they have to be tailor made for the specific situation at each location. A common generic solution is the use of rock fall drapery systems designed to guiding falling debris to a collection point at the toe of the slope. Other solutions are the use of stepped slope with wide benches as well as rock fall barrier and catch fences to keep the falling rocks off the road or from impacting nearby residences. Loose rocks can also be kept in place by covering the slope with wire mesh and anchoring the wire mesh to the slope.
Differential settlement in association with karst solution features for both the Montego Bay Perimeter Road and the Long Hill Bypass.	A staged preload construction of the embankment with surcharging can be used to reduce post construction settlement. If sinkhole, pipes or open fissures can be identified they need to be sealed before the staged construction is started.
At points where drainage channels intersect with the road, there is potential for flooding of the area upstream from the road and under extreme conditions, the collapse of the road	Ensuring that sufficient large cross drains are installed at every point where the road embankment intersects an existing drainage channel. Design of the cross drains should not only take in account the runoff but also the sediment load. Sediment traps could be installed upstream to prevent

Geotechnical Impact	Mitigation
embankment when the water pressure exceeds the strength the embankment.	the blocking of the cross drains under extreme rainfall conditions.
Multiple organic and/or contaminated soil layers were identified in the first half of the project alignment, STA K10+00 through K16+725. These layers were shown in the borings to range from 2 m to 7 m thick.	All contaminated soil layers should be remediated per local environmental requirement. For soft, compressible organic layers, alternatives include: 1. Removal and replacement 2. Partial removal and replacement with reinforced embankment construction 3. Ground improvement 4. Preloading/surcharge 5. Deep foundation supported embankments. Alternatives should be evaluated based on schedule, cost, long term road performance and risk. Secondly, proper permanent erosion control measure should be implemented along the Barnett River and the proposed diversion. The Barnett River is starting to erode its banks and destabilize the slope, where it runs parallel to the proposed alignment. Severe erosion in this area could compromised the stability of the roadway and structures.
Specific to Long Hill Bypass	
Flooding and scouring of the Long Hill Bypass in the segment traversing the escarpment to the north of Anchovy where the bypass starts its descent to Montego Bay	Use of turnout drains, which direct the runoff, at very point possible, away from the road towards a free draining sinkhole, or a depression that can be used as a retention basin and a sediment trap. The sediment load of the runoff which contributes to the scouring can further be reduced by controlling erosion of the cut slope by excavating benches or steps in the cut slope.
Specific to Barnett Street Upgrade Works	
The lateral erosional activity of the Montego River along the lower section of Barnett Street between 173+600 and 173+750 is a cause of concern because the peak discharge of the river at that location may increase as a result of the proposed realigned section of the Montego River between 13+600 and 14+000 and thus affect the long term stability of the road	These effects can be controlled by regular maintained river training works

5.2.1.2 Soil

5.2.1.2.1 Erosion and Sediment Loss

The potential for sediment loss is 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 methodology employed for estimating soil loss included adjusting two (2) of the parameters of the USLE soil loss map to reflect the construction of the highway. The first parameter was the soil erodibility factor (K) which was modified to reflect the surface texture of the soil changing due to the exposure caused by excavation. The second parameter is the vegetation and management factor (C) which was adjusted to reflect the soil exposure generated by continuously tilling the land. The results revealed that there is an expected increase in the soil loss rate per year for both catchments during the construction of the proposed highway. For the Flower Hill Gully catchment, it is estimated that there will be an increase of 0.35 Tons.acre/yr directly linked to the construction of the highway (Table 5-5). In regard to the Norwood Gully, it is estimated that there will be an increase of 0.69 Tons.acre/yr (Table 5-5).

Table 5-5 Summary of estimated sediment loss impacted by the construction of the highway

Catchment	Average Soil Loss (Ton.acre/yr)		Increased Soil Loss (Ton.acre/yr)	Increased Soil Loss (%)
	Pre-construction	During Construction		
Flower Hill Gully	20.42	20.77	0.35	1.7
Norwood Gully	22.17	22.86	0.69	3.1

RECOMMENDED MITIGATION

i. Remove trees only as would be necessary. Hence a proper procedure should be developed as to site preparation prior to project initiation. If possible, trees with trunks of DBH 20 cm and greater should be left intact.

ii. Employ erosion control techniques in susceptible areas. It is recommended, but not limited, that these areas be stabilized using following techniques:
   a. Soil Nailing
   b. Planting of Vegetation on slopes (see site rehabilitation planting details in section 6.3.4)
   c. Retaining Walls

iii. 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:
   - 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). 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.
   - Sedimentation basins, debris racks (for small culverts or openings) upstream of culverts that can be schedule for maintenance cleaning.

iv. 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.

5.2.1.2.2 Contamination

Stored fuels and the repair of construction equipment has the potential to leak hydraulic fuels, oils, etc. and thereby have the potential to contaminate the soil.

RECOMMENDED MITIGATION

i. Secondary containment for all bulk fuel/lubricant storage containers will be provide and will be of adequate size to contain the entire contents of the container plus sufficient freeboard to allow for precipitation. All secondary containments shall be constructed of impermeable materials to prevent infiltration of spilled or leaked contents onto the ground.
ii. Under no circumstance shall 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.
iii. Fine grained materials (sand, marl, etc.) shall 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.
iv. Provision of catch or diversion drains to divert surface flows from unsloped catchments around disturbed area prior to major works.
v. Installation of silt fences.
vi. Installation of coffer dams where necessary.
vii. 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.
viii. Vehicle refuelling facilities must be situated on impermeable surfaces served by an oil trap, run-off collection system. Sediment basins and oil water separators will be constructed to intercept storm water before it is discharged.

5.2.1.3 Drainage and Stormwater

5.2.1.3.1 Sinkholes and Groundwater Network

Impacts of the highway implementation on drainage features may include:

- Sinkholes within close proximity to the highway may become plugged. Consequently, the recharge area for the aquifers will decrease in size, affecting the productivity of wells located nearby.
- Recharge paths for surface run-off may be traversed by the alignment, decreasing the volume of run-off reaching the sinkholes.
- Surface run-off will become contamination due to oil spills. This problem may be more prone in areas where fuel stations are located.

Sinkholes may also cause severe damage to structures and even loss of human life if there is a sudden collapse. This is sometimes induced by natural or man-made activity such as the decline of the water table or irrigation and drainage being run into the ground.

Impact potential is more likely where there is a high concentration of sinkhole and wells. Of the fifty-two (52) sinkholes identified within 500m of the proposed alignment, 15 potential sinkholes were identified within the most critical 100m buffer zone, eight (8) of which were located directly along the proposed alignment (Table 5-6). These 8 potential sinkholes that directly intersect the alignment are most critical, as the alignment may require realignment to avoid these areas. Of the eight (8) identified sinkholes located along the proposed alignment, only three (3) were physically verified. Anecdotal surveys confirm that these sinkholes operate as predicted.

Table 5-6 Location of areas with a high concentrations of sinkholes and wells to be included the water resources risk management plan

Location	Chainage
1.5km South-West of Mount Carey	1+080 - 1+260
1km West of Mount Carey	2+700
0.5km East of Childermas	4+920 - 5+100
0.5km West of Anchovy Bottom	5+470 - 5+560
0.6km South of Torboy	10+300 - 10+500
0.5m North of Bogue	11+400 - 11-500
0.2m West of Barnet	No chainage available
0.9m West of Fairfield	No chainage available

RECOMMENDED MITIGATION

Mitigation of sinkholes typically consider both their role as a water resource and its state as a structural liability. Typically courses of action include the avoidance of sinkhole and sinkhole-prone areas (highway realignment), reduction of the activity that leads to the formation or deterioration of sinkholes and the special design of infrastructure to reduce vulnerability to sinkholes. Where sinkholes cannot be avoided it is imperative to mitigate against the hazard they may pose.

Overall, to ensure the groundwater network does not become contaminated or destroyed, a water resources risk management plan should be created for all water resources to be affected. This should be done in conjunction with Water resources Authority's approval of the measures to mitigate against adverse groundwater contamination during both the construction and operational phases of the highway.

To ensure groundwater 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. This must be done in conjunction with Water Resources Authority's approval of the measures to mitigate against adverse impacts during both the construction and operational phases. In keeping with the recommendation for a Water Resource Risk Management Plan, a dedicated mapping exercise should be undertaken to identify all vulnerable sinkholes and other water resources. This detailed assessment of the water resources along the final alignment and preparation of a Risk Management Plan must be undertaken.
ii. 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.
iii. 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 (Appendix 10).

iv. 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.
v. No sinkhole within established 100m buffer zones be blocked or covered with earth preventing or significantly altering the surface/sub-surface drainage pattern.
vi. The NWA should assess the designs of the detention area and the holding pond to ensure capacity of the detention pond(s) is adequate to detain storm water runoff and the adequacy of the holding pond to contain both storm water discharges.
vii. A geotechnical survey should be conducted along the alignment of the highway to confirm whether or not there are caverns and caves in the sub-surface that may affect construction or pose a possible risk of collapse. This geotechnical survey should be done before any excavation or mitigation activities on the possible sinkholes take place.

5.2.1.4 Water Quality

Raw materials, for example sand and marl, used in the construction of the proposed highway will be stored at the staging area; ground and surface water quality may be prone to increased suspended solids from run-off from road construction activities. Stored fuels and the repair of construction equipment have the potential to leak hydraulic fuels, oils, etc and thereby have the potential to compromise water quality as well.

The proposed roadway will traverse in close proximity to the Montego/Barnett River, and as such, the possibility of pollution of this water resource exists in the form of siltation, oil/fuel/lubricant runoff and spillage.

RECOMMENDED MITIGATION

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.
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. Silt fences may also be utilized to prevent siltation.
iii. Raw materials that generate dust should be covered or wetted frequently to prevent them from becoming air or waterborne.
iv. Raw material and 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 bunds to contain the volume being stored in case of accidental spillage.
vi. In terms of transporting equipment, the paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.
vii. 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.

viii. The trucks should be parked on the proposed site until they are off loaded.
ix. Vehicle refuelling facilities must be situated on impermeable surfaces served by an oil trap, run-off collection system. Sediment basins and oil water separators should be constructed to intercept storm water before it is discharged.

5.2.1.5 Noise

Site clearance for the proposed highway project necessitates the use of heavy equipment to carry out the job, including bulldozers, backhoes, jackhammers, etc. Additionally, there is a possibility that blasting may be carried out. These activities and required equipment possess the potential to have a direct negative impact on the noise climate.

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 5-7. The noisiest periods of highway construction are typically the ground clearing and earthwork phases.

Table 5-7 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

RECOMMENDED MITIGATION

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 earmuffs. Workers experiencing prolonged noise levels 70 - 80 dBA should wear earplugs.

5.2.1.6 Air Quality

Site preparation comprises various activities such as excavation and land clearing (digging, loading and removal of material by trucks), as well as the storage of raw materials (for example sand and marl) that may potentially have a two-fold direct negative impact on air quality. The first impact is air pollution generated from the construction equipment and transportation of materials. The second is fugitive dust from the proposed construction areas and raw materials stored on or transported to site (potential for materials to become airborne). Fugitive dust has the potential to affect the health of construction workers, the resident population and the vegetation.

Blasting is also an activity that is expected to be concentrated in the mountainous areas. Fragments of rocks will be propelled into the air by explosions. 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.

RECOMMENDED MITIGATION

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.
v. 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.
vi. With specific regard to stockpile areas, during the construction process it is recommended that material stockpiles be kept at locations within 1 km of the proposed alignment (Table 5-8 and Figure 5-1). The suggested locations below were selected based on proximity to existing residential development, the area and composition of the land available, volume of material to be stored and the nature of the material to be stored.

Table 5-8 Summary of recommended stockpile areas

Chainage(m)	Location
20+650	Salt Spring
19+000	Porto Bello
16+780	Irwin
15+180	Tucker
13+570	Fairfield
9+740	Bogue
6+900	Mount Parnassus
4+894	Anchovy
2+420	Mount Carey

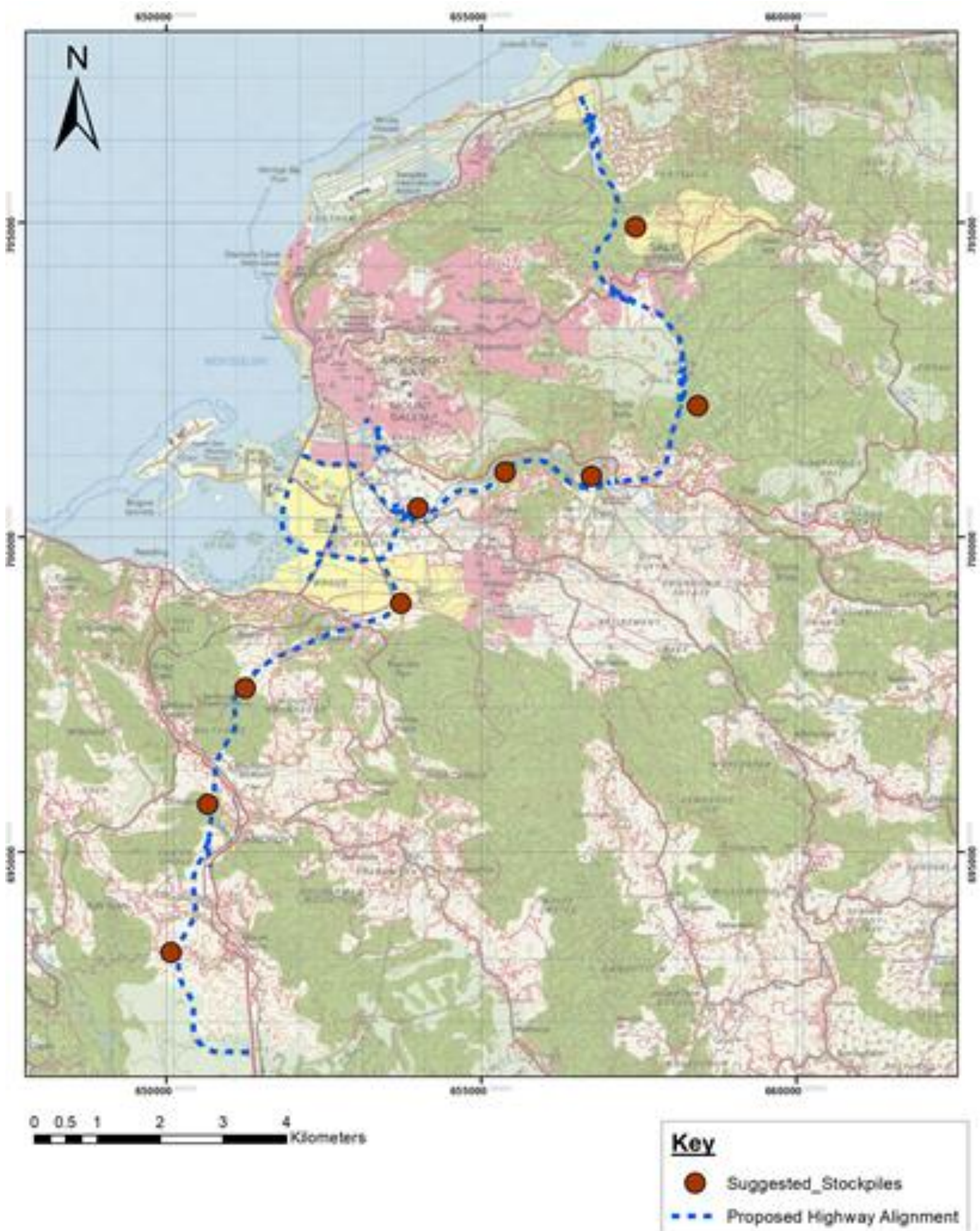


Figure 5-1 Recommended stockpile areas (<1km)

5.2.1.7 Vibration

Construction activities can result in various degrees of ground vibration; this is dependent on the type of equipment used and the methodologies employed. Vibrations may be caused by blasting and will impact on structures within proximity to blast sites. Vibration has the potential to interfere with persons normal routines/activities. This can become more acute if the community has no understanding of the extent and duration of the construction. This can lead to misunderstandings if the contractor is insensitive by the communities although he may believe he is in compliance with the required conditions/ordinances.

5.2.1.7.1 West Green Avenue

The closest residential receptors to the proposed upgraded West Green Avenue will range from 0.3 metres to 3 metres after road works are completed. The vibration impact was predicted on the four (4) closest receptors (houses which would be 0.3m, 0.5m, 1.7m and 3m away), with the use of nine (9) primary pieces of construction equipment. Construction vibration impact readings are displayed in Table 5-9 for the four (4) closest houses.

Results show that persons residing inside of these houses would perceive vibrations from construction activities to be bothersome and unpleasant (see Table 5-10 for descriptive effects for different levels of vibration). The vibratory roller has the highest vibration emission of all the equipment listed. From a building standpoint, there is potential for architectural damage and minor structural damage of houses located 0.3m and 0.5m from the proposed roadway. For the houses located 1.7m and 3m from the proposed roadway, there is the potential for architectural damage of buildings with plastered ceilings and walls.

Table 5-9 Predicted vibration levels at four closest receptors along West Green Avenue, in PPV mm/sec

CONSTRUCTION EQUIPMENT	RECEPTOR VIBRATION (PPV mm/sec)			
	0.3 m	0.5 m	1.7 m	3 m
Vibratory Roller	242.85	137.83	35.85	19.20
Bulldozer	45.28	25.70	6.68	3.58
Excavator	45.28	25.70	6.68	3.58
Jack Hammer	12.35	7.01	1.82	0.98
Back Hoe	45.28	25.70	6.68	3.58
Loaded Dump Truck	41.16	23.36	6.08	3.25
Frontend Loader	45.28	25.70	6.68	3.58
Grader	45.28	25.70	6.68	3.58
Paver	41.16	23.36	6.08	3.25

The effects of construction vibration (both on humans and buildings) is summarized in Table 5-10.

Table 5-10 Effects of Construction Vibration

PEAK PARTICLE VELOCITY (mm/sec)	EFFECTS ON HUMANS	EFFECTS ON BUILDINGS
< 0.127	Imperceptible	No effect on buildings
0.127 – 0.381	Barely perceptible	No effect on buildings
0.508 – 1.27	Level at which continuous vibrations begin to annoy in buildings	No effect on buildings
2.54 – 12.7	Vibrations considered unacceptable for people exposed to continuous or long-term vibration	Minimal potential for damage to weak or sensitive structures

PEAK PARTICLE VELOCITY (mm/sec)	EFFECTS ON HUMANS	EFFECTS ON BUILDINGS
12.7 – 25.4	Vibrations considered bothersome by most people, however tolerable if short-term in length	Threshold at which there is a risk of architectural damage to buildings with plastered ceilings and walls. Some risk to ancient monuments and ruins.
25.4 – 50.8	Vibrations considered unpleasant by most people	U.S. Bureau of Mines data indicates that blasting vibration in this range will not harm most buildings. Most construction vibration limits are in this range.
>76.2	Vibration is unpleasant	Potential for architectural damage and possible minor structural damage

5.2.1.7.2 Montego Bay Perimeter Road

Some of the closest residential receptors to the proposed Montego Bay Perimeter Road range from 31 metres to 50 metres after road works are completed. The vibration impact was predicted on these five (5) receptors (houses which would be 31m, 35m, 38m, 40m and 50m away), with the use of eleven (11) primary pieces of construction equipment, including blasting operations. Construction vibration impact readings are displayed in Table 5-11 for the five (5) houses.

Results show that persons residing inside of these houses would perceive vibrations from construction activities to be unacceptable if exposed to it for continuous periods. Apart from the pile driving and blasting, the vibratory roller has the highest vibration emission of the equipment listed. From a building standpoint, the vibratory roller should have no effect on any building structures at this distance.

However, if any blasting is to be conducted near these houses located these distances from the proposed alignment, vibrations would be considered bothersome by most persons, even if short term in length. From a building standpoint, there would be risk of architectural damage to buildings with plastered ceilings and walls and also some risk to any ancient monuments and ruins. Houses in Salt Spring, located 50m away, would be at minimal risk for damage to weak or sensitive structures.

Pile driving will most likely take place during bridge construction, for example, in the vicinity of Irwin where a bridge is proposed to be constructed over the Montego River. Vibrations from pile driving activities would be considered unacceptable for persons in the closest residential receptor in Irwin located 38 metres away, if exposed to it for continuous periods. From a building standpoint, houses would be at minimal risk for damage to weak or sensitive structures.

Table 5-11 Predicted vibration levels at five closest receptors along the Montego Bay Perimeter Road

CONSTRUCTION EQUIPMENT	RECEPTOR VIBRATION (PPV mm/sec)				
	Montego Hill (31m)	Fairfield (35m)	Irwin (38m)	Coral Gardens (40m)	Salt Spring (50m)
Vibratory Pile Driver	3.48	3.04	2.78	2.64	2.06
Vibratory Roller	1.47	1.28	1.17	1.11	0.87
Bulldozer	0.27	0.24	0.22	0.21	0.16
Excavator	0.27	0.24	0.22	0.21	0.16
Jack Hammer	0.07	0.07	0.06	0.06	0.04

CONSTRUCTION EQUIPMENT	RECEPTOR VIBRATION (PPV mm/sec)				
	Montego Hill (31m)	Fairfield (35m)	Irwin (38m)	Coral Gardens (40m)	Salt Spring (50m)
Back Hoe	0.27	0.24	0.22	0.21	0.16
Loaded Dump Truck	0.25	0.22	0.20	0.19	0.15
Frontend Loader	0.27	0.24	0.22	0.21	0.16
Grader	0.27	0.24	0.22	0.21	0.16
Paver	0.25	0.22	0.20	0.19	0.15
Blasting	18.63	16.31	14.9	14.14	11.03

FAIRFIELD GREAT HOUSE

The Fairfield Great House is the closest historical/cultural structure to the proposed alignments and lies at a distance of 41 metres from the cut and fill area of the alignment.

Apart from pile driving and blasting, the vibratory roller has the highest vibration emission of the equipment listed. From a building standpoint, the vibratory roller should have no effect on the Fairfield Great House at this distance. If pile driving is to be conducted, there would be minimal risk for damage to weak or sensitive structures. However, if any blasting is to be conducted, there would be some risk of architectural damage to any ancient monuments and ruins.

5.2.1.7.3 Long Hill Bypass

Some of the closest residential receptors to the proposed Long Hill Bypass range from 15 metres to 20 metres after road works are completed. The vibration impact was predicted on these three (3) receptors (houses which would be 15m, 18m and 20m away), with the use of eleven (11) primary pieces of construction equipment, including blasting operations. Construction vibration impact readings are displayed in Table 5-12 for the three (3) houses.

Results show that persons residing inside of these houses would perceive vibrations from construction activities to be unacceptable if exposed to it for continuous periods. Apart from the pile driving and blasting, the vibratory roller has the highest vibration emission of the equipment listed. From a building standpoint, there is minimal potential for damage to weak or sensitive structures as a result of the vibratory roller at this distance.

However, if any blasting is to be conducted near these houses located these distances from the proposed alignment, vibrations would be considered unpleasant by most persons. From a building standpoint, the U.S. Bureau of Mines data indicate that blasting vibration in this range will not harm most buildings.

Table 5-12 Predicted vibration levels at three closest receptors along the Long Hill Bypass

CONSTRUCTION EQUIPMENT	RECEPTOR VIBRATION (PPV mm/sec)		
	Mount Carey (15m)	Bogue (18m)	Anchovy (20m)
Vibratory Pile Driver	7.79	6.33	5.59
Vibratory Roller	3.28	2.67	2.36
Bulldozer	0.61	0.50	0.44
Excavator	0.61	0.50	0.44
Jack Hammer	0.17	0.14	0.12

CONSTRUCTION EQUIPMENT	RECEPTOR VIBRATION (PPV mm/sec)		
	Mount Carey (15m)	Bogue (18m)	Anchovy (20m)
Back Hoe	0.61	0.50	0.44
Loaded Dump Truck	0.56	0.45	0.40
Frontend Loader	0.61	0.50	0.44
Grader	0.61	0.50	0.44
Paver	0.56	0.45	0.40
Blasting	41.72	33.93	29.97

RECOMMENDED MITIGATION

i. Conducting pre-blast crack surveys which documents the existing status of structures (homes and residences) within 500m of the alignment.
ii. Executing pre-blast 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.
iii. Design considerations and project layout:
    - Route loaded trucks away from residential streets if possible. Select streets with the fewest homes if no alternatives are available.
    - Operate earth-moving equipment as far away from vibration-sensitive sites as possible.
iv. Sequence of operations:
    - Phase demolition, earth-moving and ground-impacting operations so as not to occur in the same time period. Unlike noise, the total vibration level produced could be significantly less when each vibration source operates separately.
    - Avoid night-time activities. People are more aware of vibration in their homes during the night-time hours.
v. Alternative construction methods:
    - Avoid impact pile driving where possible in vibration-sensitive areas. Drilled piles or vibratory pile driving causes lower vibration.
vi. Ensure blasting is conducted by a licenced blaster
vii. Have regular meetings or devise a communication strategy to inform the residents and businesses of construction and blasting activities.

5.2.1.8 Hazard Vulnerability

5.2.1.8.1 Flooding

During the construction phase of the proposed highway, it is expected that runoff from the highway may be concentrated to the existing drainage infrastructure (that is, before the necessary proposed drainage features described in section 2.3.1.4 are erected). As a result, the following potential impacts expected:

- Increased runoff volume downstream increases the probability of intense flooding to areas with inadequate drainage systems. The additional flow decreases the time it takes for the flood plain to be flooded and increases runoff time.

- Increased erosion and scour as a result of increased flow velocities downstream.
- Increased debris flow and sediments deposits downstream. The increased debris may aggravate the existing drainage issues, resulting in even more intense flooding.
- Increased concentration of contaminants such oil and other vehicular fluids from the passage of vehicles along the proposed road surface.

RECOMMENDED MITIGATION

It is recommended that a full hydrological study of the drainage system and a flood plain assessment of the affected areas be undertaken in order to provide more detailed simulations necessary to guide flood prevention and reduction measures. Techniques for reducing erosion, flooding and sediment movement are as follows:

i. Routine maintenance and cleaning of the existing drainage infrastructure, with increased frequency during the rainy periods of the year.
ii. Installation of Gabion Units, Reno mattresses and revetments as a means of effective erosion and scour control. These should be implemented in strategic areas, which are most susceptible to scour and erosion.
iii. Implementation of check dams which are small dams, temporary or permanent, constructed across a channel or drainage ditch. They also lower the rate of debris flow during storm events.
iv. Sedimentation basins, debris racks (for small culverts or openings) upstream of culverts that can be maintained by scheduled cleaning.
v. 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.

5.2.2 Biological

5.2.2.1 Terrestrial Flora

Overall, the vegetation located in the lowland areas (West Gate Hills, Barnett Street and Bogue Village) 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. In the highland areas with contiguous woodland (such as Montpelier, Green Pond and Quebec), habitat fragmentation and the loss of endemic species are the two main ecological threats posed by the planned roadway development Other impacts include increased surface runoff of rainwater and sediment; the encouragement of urban sprawl and increased human intrusion into previously untouched areas.

5.2.2.1.1 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.

RECOMMENDED MITIGATION

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.

5.2.2.1.2 Accidental or Intentional Removal of Important Plant Species

The study areas along Montego Bay Perimeter Road and Long Hill Bypass could be considered species rich with an indigenous component, important to the local environment and the natural history of the country. Over 208 plant species were encountered along the Montego Bay Perimeter Road and Long Hill Bypass; several were fern and epiphytic species and 15 endemics, most occurring along the Montego Bay Perimeter Road segment. The most commonly occurring endemic was the palm *Roystonea altissima* (Mountain Cabbage), occurring in five of 13 sites (Table 5-13). No endemic or ecologically threatened species were found along West Green or Barnett Street alignments.

Table 5-13 Flora species endemic or of national importance (highlighted in green) to Jamaica located along proposed alignments

Location	Scientific name	Common name	Growth form
FAIRFIELD	*Cordia bullata*		Shrub
	Roystonea altissima	Mountain Cabbage	Tree
	Zamia sp.		Shrub
QUEBEC	*Cordia bullata*		Shrub
	Eugenia amplifolia		Tree
	Galactia pendula		Climber/Twiner
	Lisianthius longifolius	Jamaican Fuchsia	Shrub
	Paullinia barbadensis	Supple Jack	Climber/Twiner
	Thrinax parvifolora	Broom Thatch	Tree
GREN POND	*Cordia bullata*		Shrub
	Eugenia amplifolia		Tree
	Hohenbergia sp.		Epiphyte
	Hylocereus triangularis	God Okra	Epiphyte
	Paullinia barbadensis	Supple Jack	Climber/Twiner
MONTEGO HILLS	*Sabal jamaicensis*	Bull Thatch	Tree
MONTPELIER	*Roystonea altissima*	Mountain Cabbage	Tree
	Serjania laevigata		Climber/Twiner
	Roystonea altissima	Mountain Cabbage	Tree
MOUNT CAREY	*Eupatorium triste*	Old Woman's Bitter Bush	Shrub
	Paullinia barbadensis	Supple Jack	Climber/Twiner
	Roystonea altissima	Mountain Cabbage	Tree
ANCHOVY TO BOGUE HILLS	*Eugenia amplifolia*		Tree
	Hibiscus elatus	Blue Mahoe	Tree
	Hohenbergia sp.		Epiphyte
	Hylocereus triangularis	God Okra	Epiphyte
	Piper amalago var. nigrinodum	Black Jointer	Tree
	Rytidophyllum tomentosum	Search-me-Heart	Herb
RESIDENTIAL	*Roystonea altissima*	Mountain Cabbage	Tree

RECOMMENDED MITIGATION

i. The removal of the endemic species should be avoided.
ii. 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.

iii. The development should be fenced to impede human and livestock access to the adjacent vegetation through which the highway runs.
iv. Relocation of the highway, alternate to location C, should be considered.

5.2.2.1.3 Human Encroachment, Urban Sprawl and Control of Invasive Species

The study site, although disturbed, is species rich. 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 further intrusion of invasive plant and animal species into the development site and more importantly into the surrounded protected area.

RECOMMENDED MITIGATION

i. A proper plan should be developed concerning transportation routes and storage for equipment and material. These networks should be kept simple.
ii. A buffer area should be established and maintained between the project area and the surrounding limestone forest.
iii. Fencing of exposed points to human and ruminant entry should reduce their intrusion.
iv. Proper planning regarding access points to the construction site should be established.
v. Further planning will be required for the establishment of development zones within nearby lands, villages and towns. This should be directly controlled or prohibited development of nearby areas.

5.2.2.1.4 Storage and Transportation of Raw Materials

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

RECOMMENDED MITIGATION

See sections 5.2.1.2, 5.2.1.4 and 5.2.1.6 for measures recommended to reduce contamination of soil, air and water resources.

5.2.2.2 Fauna

The following are main impacts on fauna:

- Habitat Fragmentation

  The fragmentation of the ecosystem will particularly affect wildlife which have to negotiate, tolerate or cope with the natural barriers (Southerland, 1994). In this project the wildlife which could be affected includes reptiles (snakes, lizards), amphibians, mammal and invertebrates (land snails and insects). Impacts include:

- May increase the discontinuity in the spatial patterning of resource availability, affecting the conditions for species occupancy, and ultimately individual fitness.
- Erode genetic diversity and increase inbreeding.
- Loss of interior or area-sensitive species.
- Increase abundance of weed species.
- Increase mortality of animals who try to cross the highway.

- Degradation and Loss of Natural Habitat
  The remaining natural habitat quality and function may be impacted by the proposed project, as a result of both direct and direct impacts which may result in, reductions in biodiversity, resources and general shifts in community dynamics, suitability and sustainability. These impacts may be short term or long term. Habitat degradation may arise from the following potential impacts:
  - Introduction of exotic and or invasive alien species.
  - Vegetation removal, both planned and unplanned.
  - The replacement of forest trees with grasses and shrubs will create habitat for non-forest specialist species and reduce the habitat for forest specialist species including eliminating nesting.
  - Additional developments in surrounding areas.
  - Noise from construction of the highway will scare away some of the wildlife. For example, birds and other wildlife that communicate by auditory signals may be at a disadvantage near roads.
  - Use of artificial lights at night may disturb resting animals.
  - The highway including service roads used in the construction have created easy access to pristine and undisturbed areas.
  - Cumulative impacts where the highway development is provided as a stimulus to secondary development and ultimately local economic enhancement. This will cause an indirect loss of the natural habitat.

The above impacts have a greater effect on highly specialized populations, endemic species and species with conservation status. Endemic species and in particular Amphibians and reptiles may be negatively impacted by habitat loss and or fragmentation, insects, birds and mammals (bats) may also be impacted. The endemic reptilian and amphibian species (Table 5-14) are of special concern due the limited data of the known distribution and populations sizes. Some species have been listed under the IUCN Red List categories, Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) species; those endemics found within the survey areas considered threatened include:

- *Eleutherodactylus cundalli* (Jamaican Rock Frog) - Vulnerable.
- *Eleutherodactylus luteolus* (Masked Frog) - Endangered
- *Osteopilus marianae (*Jamaican Yellow Treefrog) - Endangered
- *Osteopilus wilder* (Green tree frog) - Endangered

The invertebrate fauna was likely improvised due to sampling during the dry season. Endemic species were found to be locally common and generally associated with disturbed areas along the proposed alignment

The closest cave known to have bats is located 553.4 metres away from the proposed Barnett Street upgrade component (Sewell Cave, Figure 3-84). Other caves situated within 1 kilometre of the alignment are not known to have bats present.

Table 5-14 Endemic fauna encountered during surveys

	FAMILY	SPECIES
BUTTERFLIES	Satyridae	*Calisto zangis*
	Nymphalidae	*Mestra Dorcas*
LAND SNAILS FROM WOODLAND	Annulariidae	*Annularia mitis*
		Parachondria sp.
	Camaenidae	*Pleurodonte (Dentellaria) invalida*
		Pleurodonte lucerna
		Thelidomus aspera
	Helicinidae	*Helicinia neritella neritella*
	Neocyclotidae	*Cyclchittya chittyi*
	Orthalicidae	*Orthalicus undatus*
	Sagdidae	*Aerotrochus mcnabianus*
		Sagda spei
		Hyalosagda arboreiodes
	Subulinidae	*Allopeas gracile*
LAND SNAILS FROM SECONDARY LIMESTONE FOREST	Annulariidae	*Annularia fimbriatula*
		Annularia mitis
	Bulimulidae	*Drymaeus immaculatus*
	Camaenidae	*Thelidomus aspera*
		Pleurodonte invalida
	Helicinidae	*Helicinia neritella neritella*
		Lucidella (Perenna) foxi
		Eutrochatella pulchella
	Neocyclotidae	*Cyclochittya chittyi*
		Cyclojamaicia bondi
	Sagdidae	*Hyalosagda arboreoides*
		Sagda spei
	Subulinidae	*Allopeas gracile*
	Urocoptidae	*Spirostemma simile*
		Urocoptis aspera.
TERRESTRIAL BIRDS	Annulariidae	*Annularia mitis*
		Parachondria sp.
	Camaenidae	*Pleurodonte (Dentellaria) invalida*
		Pleurodonte lucerna
		Thelidomus aspera
	Helicinidae	*Helicinia neritella neritella*
	Neocyclotidae	*Cyclchittya chittyi*
	Orthalicidae	*Orthalicus undatus*
	Sagdidae	*Aerotrochus mcnabianus*
		Sagda spei
		Hyalosagda arboreiodes
	Subulinidae	*Allopeas gracile*
WETLAND BIRDS	Jamaican Euphonia	*Euphonia Jamaica*
	Jamaican lizard cuckoo	*Coccyzus vetula*

	FAMILY	SPECIES
	Jamaican Mango	*Anthracothorax mango*
	Jamaican Oriole	*Icterus leucopteryx*
	Jamaican Pewee	*Contopus pallidus*
	Jamaican Tody	*Todus*
	Jamaican Vireo	*Vireo modestus*
	Jamaican Woodpecker	*Melanerpes radiolatus*
	Olive-throated parakeet	*Eupsittula nana*
	Orange Quit	*Euneornis campestris*
	Red-billed Streamertail	*Trochilus polytmus*
	Sad Flycatcher	*Myiarchus barbirostris*
	Stolid flycatcher	Myiarchus stolidus
	White-chinned Thrush	*Turdus aurantius*
	Yellow-shouldered Grassquit	*Loxipasser anoxanthus*
REPTILES	*Celestus crusculus*	Jamaican Galliwasp
	Anolis garmani	Jamaican Giant Anole
	Anolis grahami	Jamaican Turquoise Anole
	Anolis lineatopus	Jamaican Gray Anole
	Anolis opalinus	Bluefields Anole
	Anolis sagrei	Brown Anole
	Anolis valencienni	Jamaican Twig Anole
	Aristelliger praesignis	Croaking lizard, Cochran's croaking gecko
	Sphaerodactylus argus	Ocellated geckos
	Sphaerodactylus goniorhynchus	Jamaican Forest Dwarf Gecko
	Sphaerodactylus richardsoni	Northern Jamaica Banded Dwarf Gecko
	Typhlops jamaicensis	Jamaican Blindsnake
AMPHIBIANS	*Eleutherodactylus cundalli*	Jamaican Rock Frog
	Eleutherodactylus luteolus	Masked Frog
	Osteopilus marianae	Jamaican Yellow Treefrog
	Osteopilus ocellatus	Jamaican Laughing Treefrog
	Osteopilus wilder	*Green tree frog*

RECOMMENDED MITIGATION

i. Preserve sensitive communities and ecosystem and remove as little vegetation as possible.

ii. Protect endemic, rare, ecological important species. A monitoring programme and mitigative measures should be put in place to identify these sensitive habitats if encountered during the construction phase (vegetation removal, earth moving and road building) of the project. Sightings of rare or unknown species should be reported. Similarly, any new caves, sinkholes or other distinctive features should be reported, and these areas assessed before any additional modifications take place.

iii. Incorporate at regular intervals engineering solutions to facilitate any natural migration/ movement processes within the area e.g. tunnels and bridges.

iv. Monitor and limit the encroachment outside the footprint, especially in less disturbed areas. in particular.

v. Fences should be used to limit the access of humans, livestock and invasive species.

vi. The use of noise reducing equipment should be utilized whenever possible.

vii. Excessive noise producing activities (such as blasting), should be done outside the peak bird foraging hours (ideally done between 10 am – 4 pm).

viii. There should be periodic wetting throughout the construction zone to control dust.
ix. Construction materials such as sand and marl should be kept covered where possible.

5.2.2.3 Broadleaf Forest

The Forestry Policy of Jamaica, 2015 stated that all Closed Broad Leaf Forest are to be Held in Public Trust for the People of Jamaica.

A large percentage of forests in Jamaica are in disturbed and degraded states, and the 2001 Forest Policy recognized that only about 8% of the island can be properly described as closed broadleaf forest, with little evidence of human disturbance. In order to protect the country's unique biodiversity and allow future generations to enjoy these national forest treasures, it is important that these undisturbed forest areas are preserved and held in trust for the people of Jamaica. To build the enabling framework for forest conservation and protection of Jamaica's important biodiversity, the Government of Jamaica is committed to retaining this existing 8% of closed broadleaf forest in its natural state for the benefit of existing and future generations (Forestry Department of Jamaica, 2015).

The alignments traverse areas designated as forest estates that are populated by disturbed broadleaf forest. The potentially impacted areas (Figure 5-2 - Figure 5-3) are as follows:

- Total area of impacted broadleaf forest along Long Hill Bypass is 347,341.9 sq. m (34.7 hectares), of which 7,736.2 sq. m (0.77 hectares) is crown land.
- Total area of impacted broadleaf forest along Montego Bay Bypass is 324,895.5 sq. m (32.5 hectares), of which 101,981.4 sq. m (10.2 hectares) is crown land.

RECOMMENDED MITIGATION

NROCC, in consultation with the Forestry Department of Jamaica will identify suitable lands specifically for a Reforestation Plan, as part of the overall Replanting and Rehabilitation program for the project (see section 6.3.4). The Forestry department will determine the species and method for each identified area. A detailed monitoring and management program will also be created as part of the mitigation process, in order to ensure long term success of target areas.

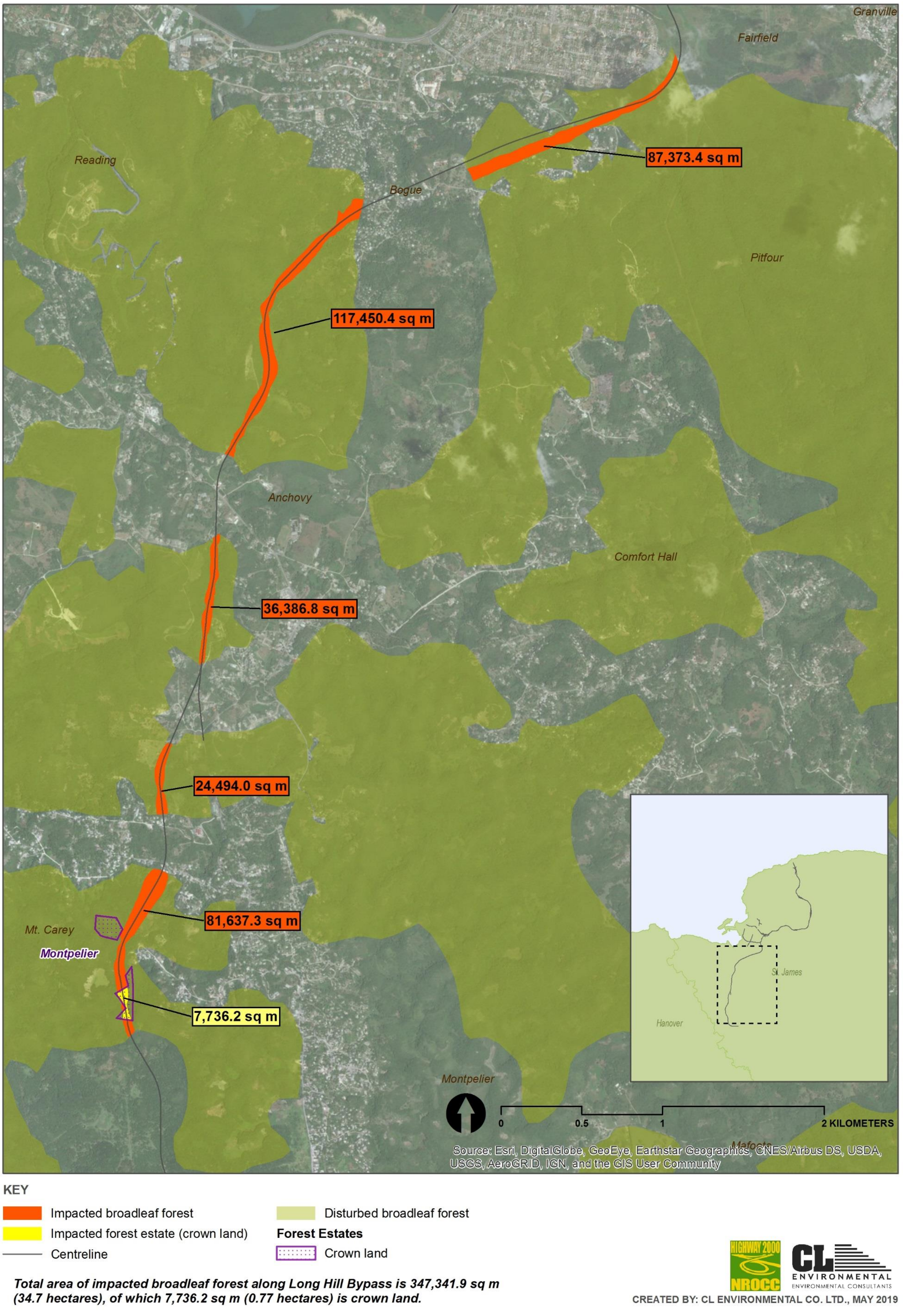


Figure 5-2 Potentially impacted broad leaf forest and crown lands along the proposed Long Hill alignment

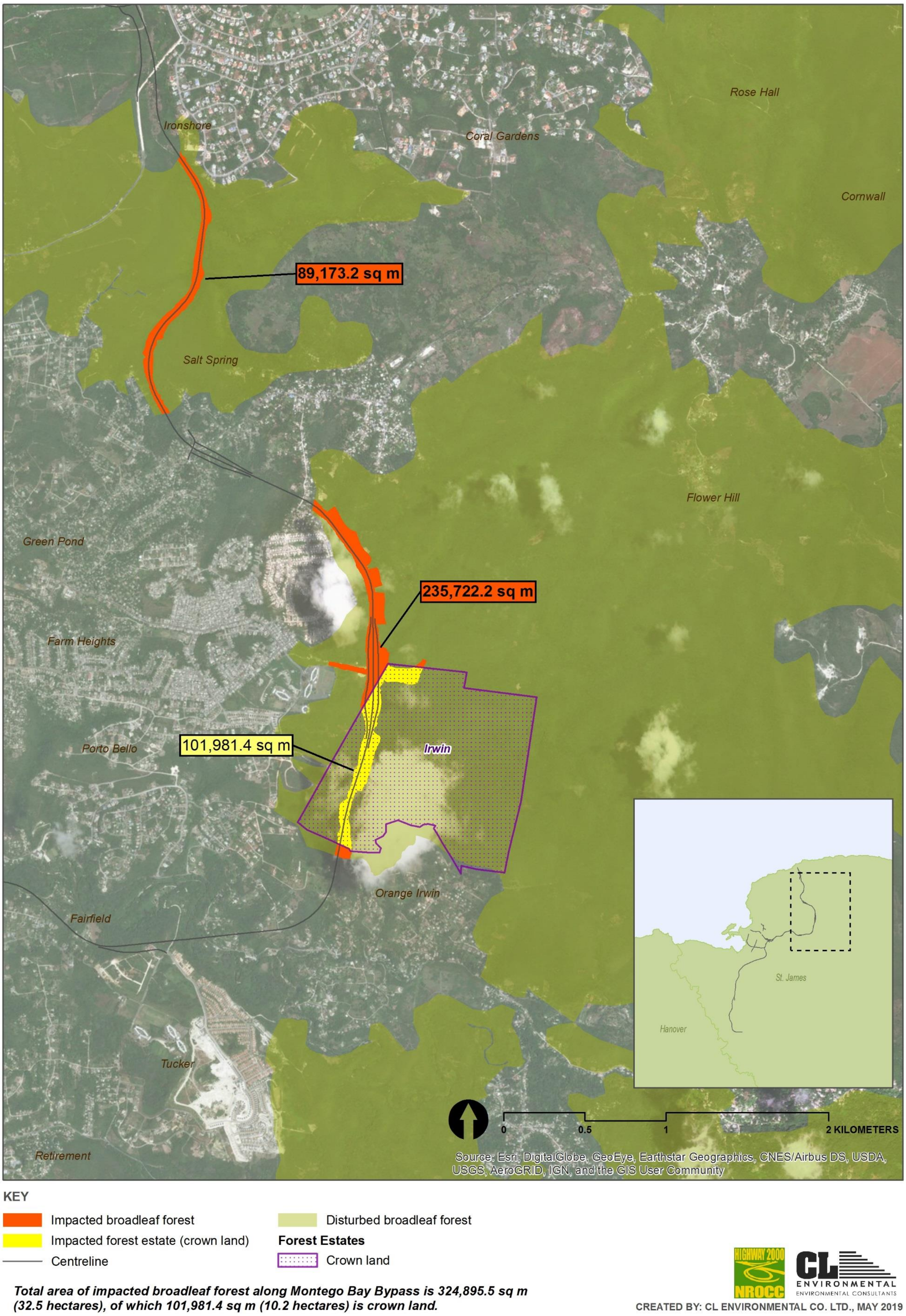


Figure 5-3 Potentially impacted broad leaf forest and crown lands along the proposed Montego Bay Bypass alignment

5.2.2.4 Mangrove Community (Bogue Lagoon)

5.2.2.4.1 Mangrove Loss

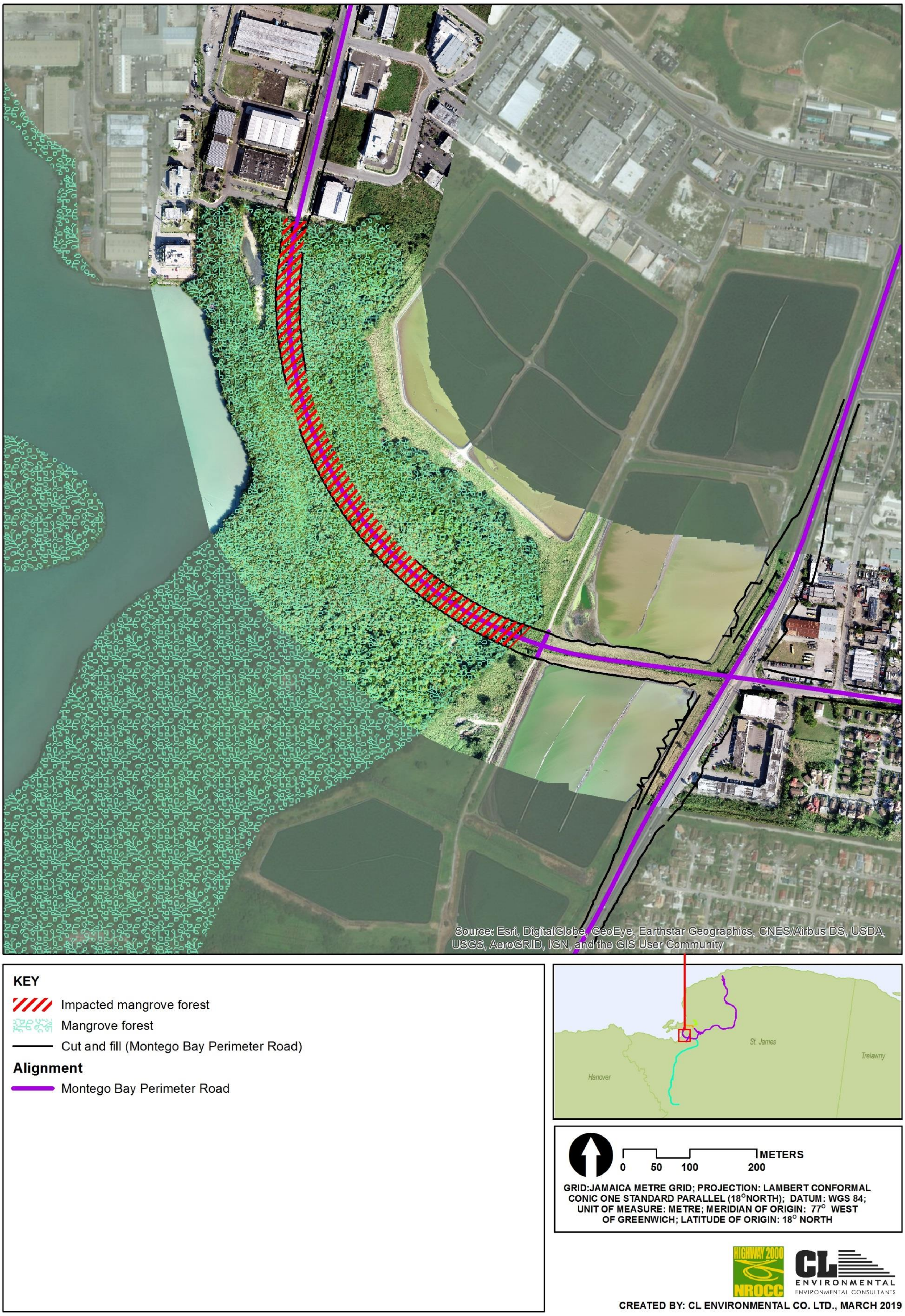
Over 30,000m^2 of the mangrove forest were surveyed. Based on the density of trees recorded in each zone, tree density was recorded for each sector. The mean tree density derived from all areas was **0.180625** mangrove trees per square meter. The proposed Montego Bay bypass route through the mangrove forest at Bogue/Freeport will impact an area of **27,090.02 m^2** mangrove (2.71 hectares) and thus potentially displace **4,893** mangrove trees and seedlings (*impacted area x mean tree density*) (Figure 5-4).

Based on field trip observations and historical data, the mangrove forest may provide the following ecosystem services which may be negatively impacted:

- Providing a floodplain and freshwater retention area for 3 large outflows/storm drains from the city of Montego Bay.
- Filtration of solid waste associated with these storm drains
- Filtration of nutrient/sewage waste associated with the storm drains and neighbouring sewage treatment ponds.
- Provides a buffer for Bogue lagoons, for improperly treated/disposed sewage effluent from the NWC Sewage treatment plant
- Nutrient uptake within the forest, preventing chronic eutrophication in the Bogue Lagoon and coral reefs north of this area (West of Secrets hotel). This reef is a primary snorkelling and glass-bottom boat tour attraction used by many hotels and operators.
- Provision of bird, crab, snail and insect habitat and feeding grounds.
- Provision on a nursery for juvenile fish.
- Provide recreational uses (mangrove tours, bird watching) offered by the Montego Bay Marine Park.
- Buffer for storms and severe weather events, protecting the Freeport and Bogue areas from high waves and winds.
- Improvement of property values at Bogue area, providing an aesthetically pleasing view overlooking the mangrove forest

5.2.2.4.2 Sediment Loading

Increased sediment loading during construction of highway alignment (CH10+500 – CH11+400) from construction activity is possible. The wetlands heath and function maybe negatively impacted by excess sedimentation and deposition construction material.



Data sources: Mangrove area digitised manually using satellite imagery shown in map

Figure 5-4 Map showing potentially impacted mangrove forest

5.2.2.4.3 Mangrove Prop Roots

The prop root community including all roots at varying degrees of colonization and composition may be impacted by sedimentation and smothering, habitat fragmentation/loss, increased water turbidity and suspended solids and some species loss. There are sensitive species on the prop roots including, bivalves, filter feeders and other sessile species. Fish and invertebrates associated with the prop roots may also be impacted. The proposed project is located within the boundaries of the Fish sanctuary and requires strict mitigation activities.

RECOMMENDED MITIGATION

The following mitigation measures are recommended to reduce the impacts (as described in previous Sections 5.2.2.4.1, 5.2.2.4.2 and 5.2.2.4.3) of roadway construction on the Freeport mangrove forest:

i. Roadway should be constructed with ample culverts to maintain the tidal connectivity of the mangrove forest. Culverts should be designed in-keeping with expected tidal fluctuations and account for sea-level rise
ii. A minimum of 150m distance from the shoreline should be maintained in the roadway's immediate impact.
iii. Construction areas should be properly marked/cordoned off and monitored by personnel to prevent/reduce accidental mangrove tree destruction.
iv. Use of turbidity barriers/silt screens around the work area so as to contain sediments and prevent them from dispersing. Construction activities should only continue when these barriers are fully operational, that is, placed correctly, calm to moderate sea conditions and without damage. The silt screens should encircle the areas and be deep enough to contain the plumes, so that plumes will not travel in the direction of the prevailing currents.
v. Run-off from the associated highway construction should not be channelled directly into the lagoon; but diverted to the west of the highway where the extensive mangrove forest system may act as a buffer.
vi. NROCC has identified lands in Falmouth which are being proposed as a mitigation site (mangrove replanting) for mangroves lost as a result of the proposed project. Please see proposed mitigation site in Figure 5-5 below.

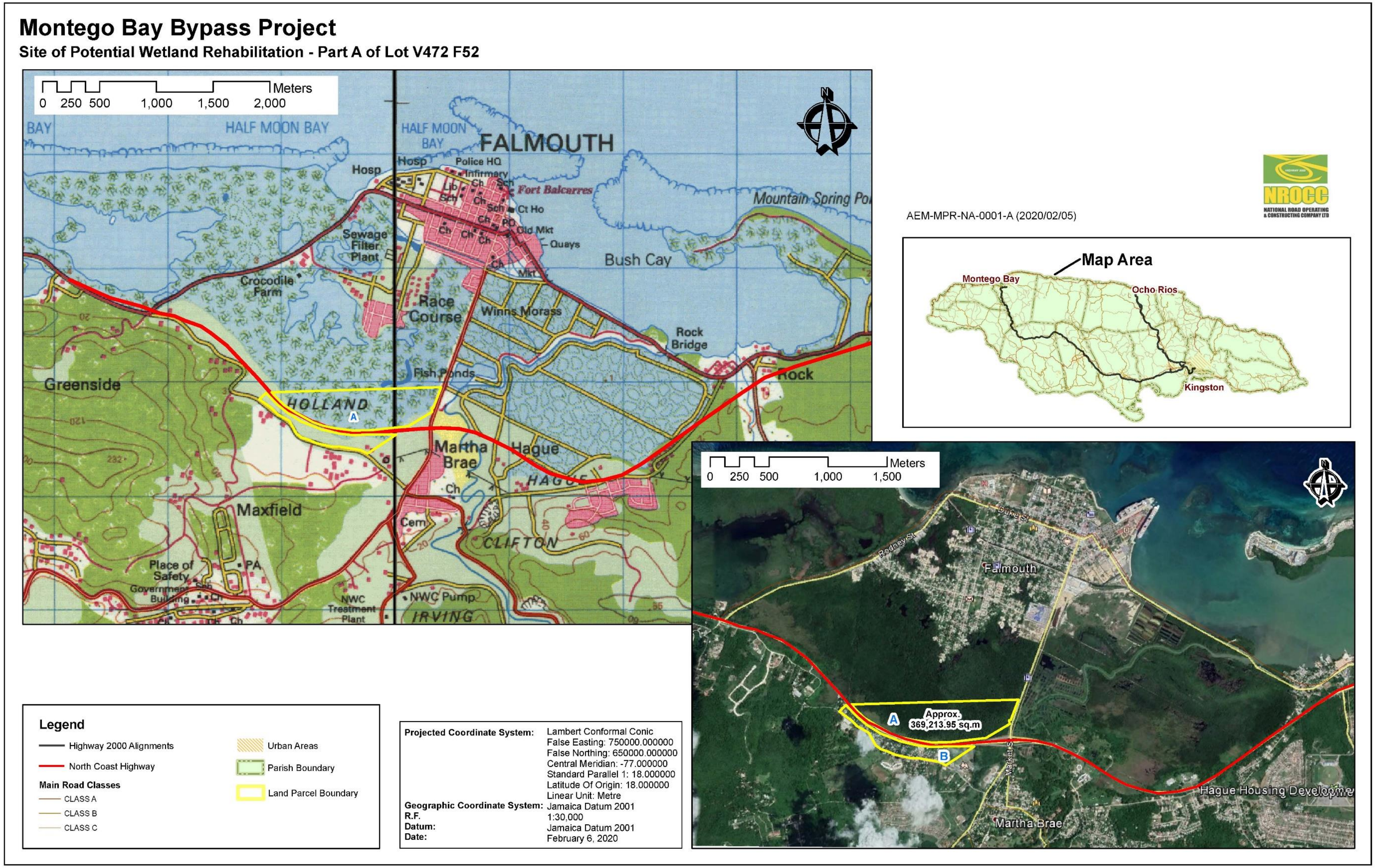


Figure 5-5 Proposed Mangrove Rehabilitation site located in Falmouth, Trelawny

5.2.2.4.4 Existing Mangrove Rehabilitation Sites

Adjacent (north) of the alignment exists a mangrove rehabilitation site, which is currently being monitored by a team from the University of the West Indies. The rehabilitation site is likely to be negatively impacted by construction works, in the form of accidental destruction from heavy equipment.

RECOMMENDED MITIGATION

i. Rehabilitations site areas should be properly marked/cordoned off and monitored by personnel to prevent/reduce accidental destruction.

5.2.2.5 Benthic Community

The surrounding benthic community is limited; however, seagrass beds and mangroves are found nearby within the fish sanctuary and should be protected. Meiofauna and in particular filter feeders, surface and subsurface species may be impacted by excess sedimentation. Fish may also be impacted.

RECOMMENDED MITIGATION

i. Use of turbidity barriers/silt screens around the work area so as to contain sediments and prevent them from dispersing. Construction activities should only continue when these barriers are fully operational, that is, placed correctly, calm to moderate sea conditions and without damage. The silt screens should encircle the areas and be deep enough to contain the plumes, so that plumes will not travel in the direction of the prevailing currents.

5.2.3 Human/ Social

5.2.3.1 Housing/ Residents

Residences situated within the road construction cut and fill areas will be directly impacted and considered for relocation. These structures were surveyed in detail as part of the Impacted Structure Survey (see Section 5.4). Displacement and resettlement of residents have the potential to lead to financial burdens on affected residents if new housing is to be acquired, as well as social and emotional effects stemming from the disruption of existing social relationships and adjustment to a new social environment (See Section 6.3.3).

Residential areas in proximity of the road works will also be potentially affected by noise, dust, traffic disturbances (local road closures, detours, reduced level of service) and safety hazards associated with the proposed works (see sections 5.2.1.5, 5.2.1.6, 5.2.3.7 and 5.2.3.8).

The percentage of residences in relation to total structures to be directly impacted as a result of the proposed project are as follows:

- Barnett Street: 0%
- Long Hill Bypass: 66.1%
- Montego Bay Perimeter Road: 40.4%
- West Green: 1.4%

More details can be seen in Section 5.4.

RECOMMENDED MITIGATION

i. Compliance with the Resettlement and Relocation Plan (see section 6.3.3 and Appendix 13). Where it will be necessary to relocate persons, NROCC will involve the affected persons in the process from the start so as to make the transition a comfortable and easier one.
ii. See recommended mitigation for noise disturbances, air pollution, disrupted traffic flow and community safety in sections 5.2.1.5, 5.2.1.6, 5.2.3.7 and 5.2.3.8.

5.2.3.2 Educational Facilities

Eagles Wing Elementary & Early Learners (7A Bogue Industrial Estate) and Viris Whylie Basic School (Bogue Hill) fall within or closely border the cut and fill areas along the proposed alignments and will likely be directly impacted by the proposed road works (Figure 5-6). In addition, seven schools are situated within 100 metres of the proposed alignments (Table 5-15); these schools have the potential to be impacted by noise and dust resulting from construction activities (see sections 5.2.1.5 and 5.2.1.6). Access to these locations may also be disrupted owing to road works (see section 5.2.3.7).

Table 5-15 Potentially impacted schools, those in red fall within or closely border cut and fill areas

Data source: (Social Development Commission, 2019)

NAME	ADDRESS	PRINCIPAL	DESCRIPTION
College of Health Sciences - Caribbean School of Nursing UTECH	2 Cottage Close, Montego Bay, St. James	Andrea Atterbury	# of Classrooms: 4 Classrooms, # of students enrolled: 200 Students, # of Teachers: 14 Teachers, School Recognised by MOE: Recognized by MOE, Condition: Very Good
Eagles Wing Elementary & Early Learners	7A Bogue Industrial Estate	Mrs. Conswello Ricketts	# of Classrooms: 7 Classrooms, School Capacity: 95 Students, # of Teachers: 8 Teachers, School Recognised by MOE: Recognized by MOE, Condition: Good
Fundaciones	Shop 16, Bogue City Centre		School Recognised by MOE: Recognized by MOE, Condition: Good
John Joyce Early Childhood	P.O. #2 Box 1879, Montego Bay		7 classrooms, 7 teachers, recognised by MOE. The building is in a good condition
Little Genius Pre-school	Catherine Hall, Montego Bay #1 P.O.	Angella Lewis	4 teachers, 4 classrooms
Olympus Academy	Lot 12 Bogue Industrial Estate	Akeisha Christie-Wain Wright	# of Classrooms: 5 Classrooms, School Capacity: 95 Students, # of Teachers: 9 Teachers, School Recognised by MOE: Recognized by MOE, Condition: Good

NAME	ADDRESS	PRINCIPAL	DESCRIPTION
Simba Academy	Bogue Village	Ms Anne Downie 876-313-0175	# of Classrooms: 4 Classrooms, School Capacity: 30 Students, # of Teachers: 4 Teachers, School Recognised by MOE: Recognized by MOE, Condition: Good
St. Peter, St. Claver Anthony	Trinity Cresent Mount Salem, P.O. #2 Montego Bay		2 classrooms, 2 teachers
Viris Whylie Basic School	Bogue Hill, Bogue	Mrs. Whyte 876-326-3483	# OF Classrooms: 3 Classrooms; School Capacity: 200 Students; # of Teachers: 4 Teachers; School Recognised by MOE: Recognized by MOE; Condition: FAIR

RECOMMENDED MITIGATION

i. See recommended mitigation for noise disturbances, air pollution and disrupted traffic flow in sections 5.2.1.5, 5.2.1.6 and 5.2.3.7.

iii. If schools are to be relocated, compliance with the Resettlement and Relocation Plan (see section 6.3.3 and Appendix 13).

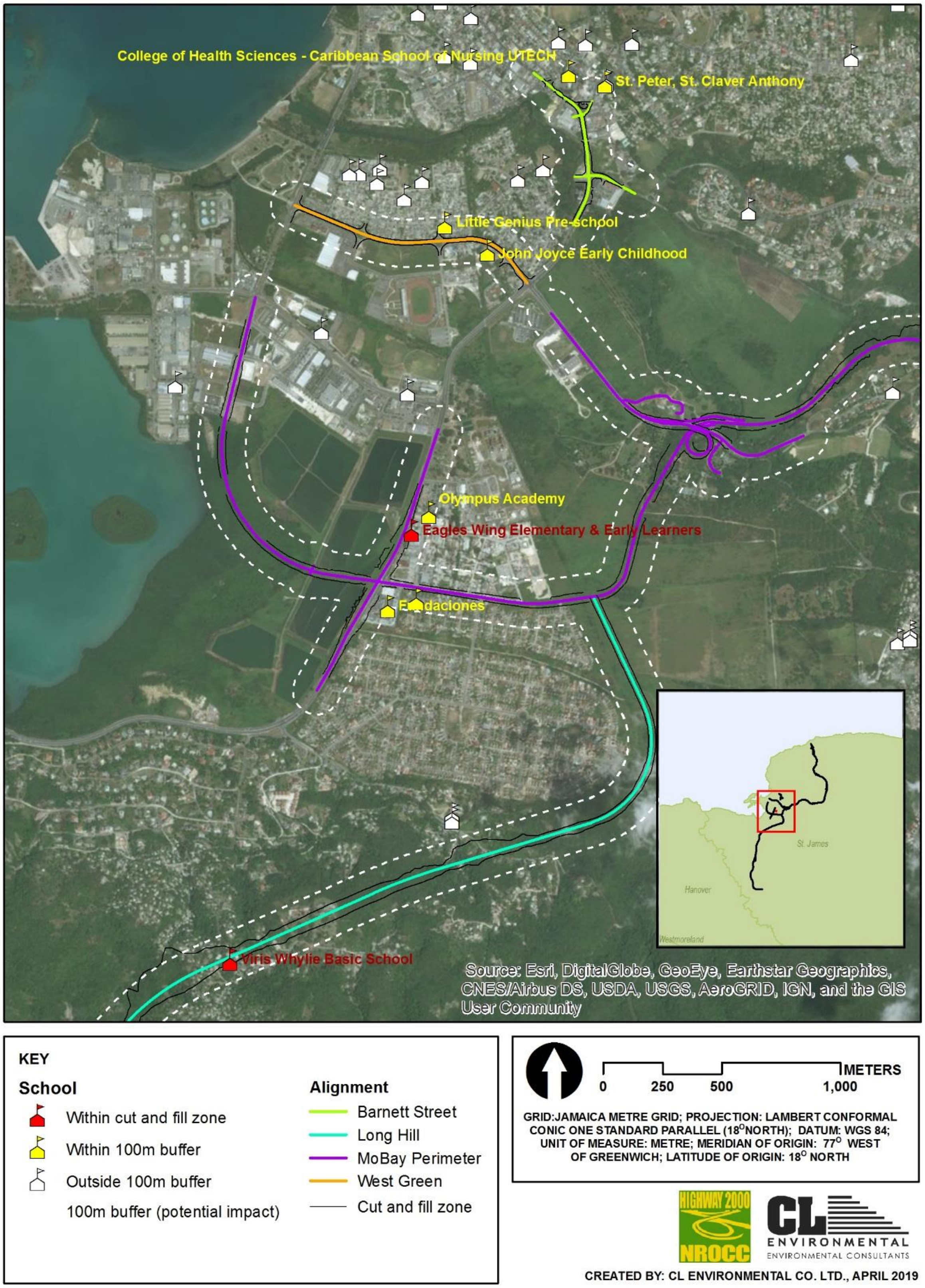


Figure 5-6 Potentially impacted schools

5.2.3.3 Employment

Potential job opportunities will directly arise from site clearance/ construction phases. As described previously, the relatively high proportion of the population within the SIA attaining a secondary education, as well as tertiary education suggests that the labour pool is relatively educated. Further, skillsets of persons within the adjoining communities include construction skills. As such, there should be no problem in obtaining non-technical workers from the communities within the area.

In addition to the potential direct employment, 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. Indirect jobs 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.

RECOMMENDED MITIGATION

No mitigation required.

5.2.3.4 Water Supply and Wastewater Disposal

5.2.3.4.1 Impacted Infrastructure

In order to identify potentially impacted infrastructure, a buffer of 100 metres was utilised to identify water supply infrastructure (for which GIS data available) located within this distance from the proposed alignment (Figure 5-7).

WELLS

Within the 100m buffer, two wells were identified and are considered a concern (Table 5-16, Figure 5-7). That operated by the National Water Commission in Fairfield is active and in use by the company (Plate 5-1). The well located in Bogue and is operated by Barnett Estates. Though the wells do not directly intersect the proposed alignment it is possible to have contamination of the ground water during the construction and operational phases of the highway. Wells outside the 100-metre buffer are less likely to be affected, however consideration must be made as contaminated groundwater can make its way to the aquifers of the wells.

Table 5-16 Potentially impacted wells within 100m of the proposed alignment

Location	Distance from alignment (m)	Owner	Depth (m)
Fairfield	25	National Water Commission	77.72
Bogue	24	Barnett Estates	76.2

Plate 5-1 Well owned by JPS Bogue Power Plant, found within 100 metres of the proposed alignment

SPRINGS

Springs are not located within 100 metres of the proposed alignment.

NWC POTABLE FACILITIES

The following three NWC facilities are located within 100 metres of the proposed alignments (Figure 5-7).:

- Bogue Hill Storage Tank
- Bogue Hill #2 Relift Station
- Fairfield Deep Well Production Well (mentioned previously)

NWC WASTEWATER FACILITIES

The following two NWC facilities are located within 100 metres of the proposed alignments (Figure 5-7):

- Barnett WW Relift Station
- Bogue Sewage Ponds WW Treatment Plant (along Bogue Main Road)

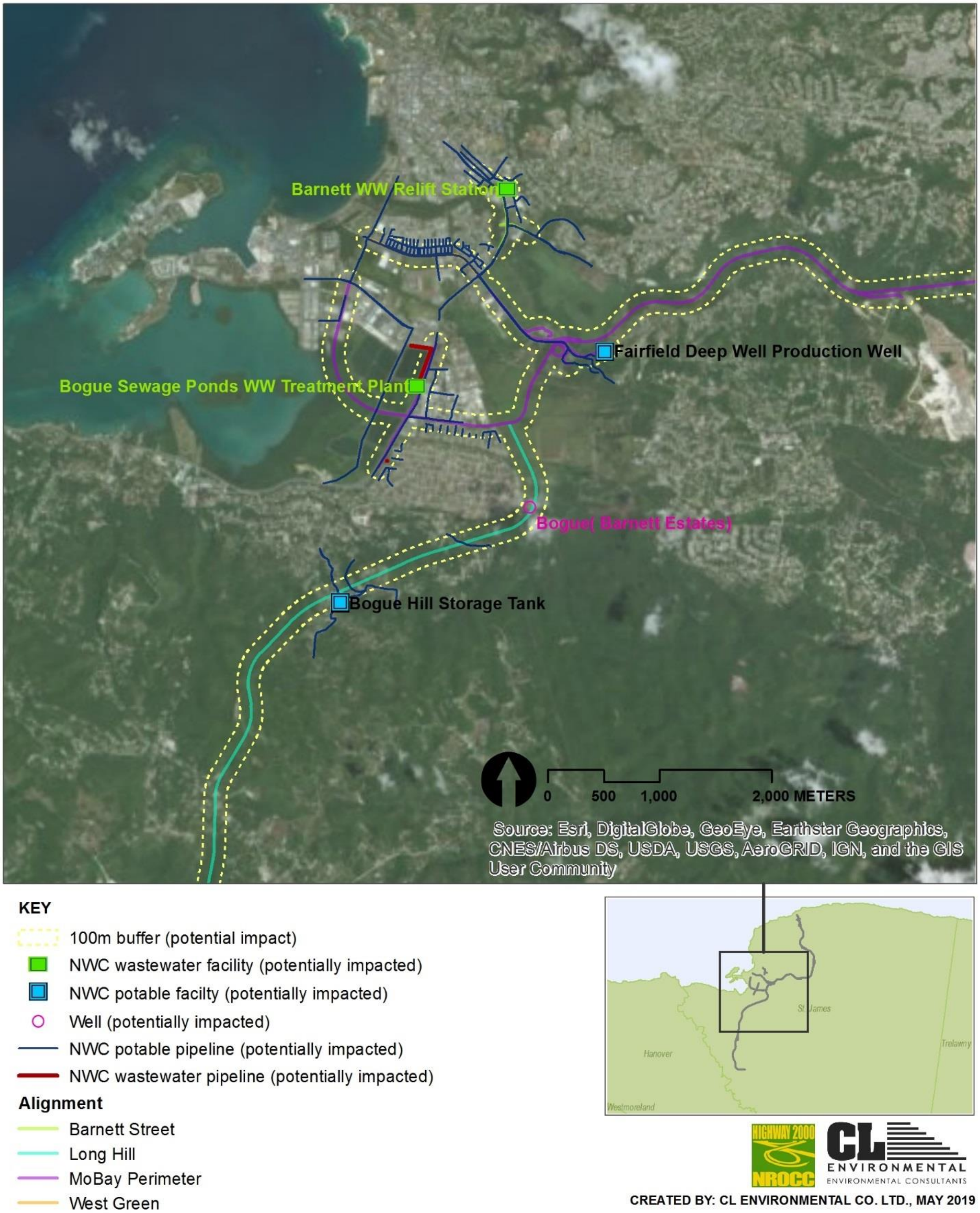


Figure 5-7 Potentially impacted water and wastewater infrastructure within 100 metres of the proposed alignment

NWC DISTRIBUTION NETWORK

Overall, potential impacts on the existing water supply system may include:

a. Destruction of both water supply and sewerage pipelines that currently exist within the environs.
b. Disruption of water supply and/or sewerage service to consumers for an extended period of time and/or total isolation of some communities from the pipeline network.
c. Incur additional construction costs.

Specific locational impacts are as follows:

Anchovy to Montpelier

a) In Anchovy and Mount Carey; chainage 5 + 460 – water distribution network will be affected.
b) Mount Carey to Montpelier; chainage 0 + 000 – water distribution network will be affected.

Ramble Hill to Bogue Hill

a) Crossing at Ramble Hill road; chainage 8 + 950 – water transmission and distribution network will be affected.
b) At Bogue Hill, chainages 7 + 747, 7 + 749, and 7 + 866 - water distribution network and lift station will be affected.

Fairfield Intersection to Barnett Street & West Green

a) From Fairfield intersection to Barnett Street - water transmission, distribution and sewer network will be affected.
b) Fairfield to Howard Cook through West Green - water transmission, distribution and sewer network will be affected.

Alice Eldemire to Bogue Road

a) At Chainage 10 + 000 southward along the existing commercial subdivision road – Existing 150mm water distribution pipelines will be affected.
b) Chainage 11 + 600 along the sewage pond road – if the road is maintained at the same grade access around the ponds will be severed. Impact on the 750mm water transmission main running north/south on pond road.
c) Intersection with Bogue Road - several water and sewage pipeline as well as sewer pumps station infrastructure will be affected.
d) Along Temple Gallery road – water and sewer pipelines will be affected.

Fairfield to Adelphi Main Road

a) Chainage 13 + 400 crossing Fairfield main road – 300mm water pipeline will be affected.
b) Chainage 15 + 900 water distribution network in this area 100mm will be affected.
c) Chainage 17 + 000 water distribution network along Adelphi main road will be affected.

Adelphi Main Road to Salt Spring

a) Chainage 17 + 600 water distribution network and possibly lift-station will be affected.
b) Chainage 20 + 650 & 21 + 400 water distribution network will be affected.

Salt Spring to Ironshore/North Coast Highway

a) Chainage 24 + 900 water transmission and distribution network will be affected.

RECOMMENDED MITIGATION

Both water supply and sewage conveyances are essential to the communities in the vicinity of the proposed project area. To ensure that these services are maintained, and the impacts are minimized, constant dialogue with NWC will be maintained re design and implementation and steps can be taken to mitigate or minimize the impact, such as those listed below:

i. Re-alignment of the water supply and sewage conveyance pipelines where possible, as the construction of the highway will intersect several major pipelines.
ii. All existing pipeline infrastructure should be located before construction, in order to ensure that care is taken in these areas during construction.
iii. Pipes deemed susceptible to damage that cannot be re-aligned may be sleeved in concrete to protect from impact damage.

With regard to wells and groundwater water resources:

iv. As described previously in response to potential impacts on sinkholes (section 5.2.1.3.1), to ensure the groundwater network does not become contaminated or destroyed, a water resources risk management plan should be created for all water resources to be affected, and this includes manmade structures such as wells. This should be done in conjunction with Water Resources Authority's approval of the measures to mitigate against adverse groundwater contamination during both the construction and operational phases of the highway.
v. In the event that a well will be directly impacted and become vulnerable to being polluted or its recharge paths interrupted, sealing a well and its recharge paths may be considered if the risk of groundwater pollution is too great.

5.2.3.4.2 Construction Camp/Site Yard

The location of the construction camp/site yards have not yet been determined however, associated activities and potential impacts must be considered. 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.

RECOMMENDED MITIGATION

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.

5.2.3.5 Solid Waste Generation and Disposal

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.

RECOMMENDED MITIGATION

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.

5.2.3.6 Telecommunication

In order to identify potentially impacted telecommunication infrastructure, a buffer of 100 metres was utilised. GIS data was only available for Flow infrastructure and the following are those facilities located within 100 metres of the proposed alignments Figure 5-8; Figure 3-109):

- 1 service switch (Fairfield)
- 6 service cabinets
- 580 poles
- 33 mobile sites
- 33 manholes
- 233 distribution panels

CREATED BY: CL ENVIRONMENTAL CO. LTD., MAY 2019

Figure 5-8 Potentially impacted Flow infrastructure within 100 metres of the proposed alignment

5.2.3.7 Transportation

Trucks that will carry construction material to and from quarry locations and suppliers will have an impact on the existing traffic conditions and also result in road wear and tear. The Perimeter leg of the bypass will see the most disruption as vehicles will have to traverse the business district to get to different sites of the proposed alignment. All roads within the central business district are severely affected by pedestrian activity and illegal parking activities by motorists and delivery personnel. To reduce traffic congestion and risk of dust pollution by trucks carrying construction fill, it is recommended that they utilize routes for material delivery in off-peak hours. This would allow for more efficient delivery operations. For sections of the new alignment that are not accessible from main roads, existing village roads will be improved, or temporary haulage roads constructed.

Proposed alignment will comprise of six (6) interconnected road sections with four interchanges and two mainline toll stations. Traffic volumes at existing roads near the interconnected sections will then be diverted to the new alignment after the project is complete. A forecast of diverted traffic volumes to the respective thoroughfares estimate that up to 14,000 vehicles per day will be diverted from each section into the corridor. Any works along the existing roadways (Barnett Street and West Green Avenue) as well as where the new alignment will join up to existing roads, will have some impact on the commuting traffic and adjoining communities.

RECOMMENDED MITIGATION

Specific potential impacts and mitigation measures as a result of site preparation and construction activities are listed in Table 5-17.

Table 5-17 Construction traffic impacts and mitigation

Traffic Impact	Mitigation
Site preparation and construction activities that reduce lane capacity or cause side friction along the main road will impact on traffic flow in the localized areas that works are taking place and can cause backlogs in traffic in adjoining communities and areas.	Construction activities should be scheduled with peak traffic flows and directions in mind. For example, heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage. Where possible, hoarding can be used to mitigate against rubber-necking. Side friction can be reduced with adequate buffer between work areas and travel lanes where the space is available.
Project traffic and delivery of materials may cause delays to commuting traffic.	Schedule deliveries to the site during off-peak times and store materials in locations that reduce localize traffic within the construction zone. The employer's requirements as part of the contract includes specified MOT off-peak periods. Paths of the planned roadways should be used, rather than creating temporary pathways.
Detour routes may cut through small communities and subdivisions.	Attention needs to be placed on the local users of the subdivision/local roads that may be used as detours to adequately mitigate against the effects of increased traffic in these areas. Mitigation can include: • Providing verge/sidewalks as appropriate to separate pedestrians from vehicles

Traffic Impact	Mitigation
	• Providing additional flaggers and signage in the vicinity of schools and civic centres that generate significant pedestrian traffic.
Weight of heavy vehicles, both for the project and external industrial activity can contribute to the deterioration of the existing roads. Local detour routes can be especially susceptible to rapid deterioration by an increase in truck traffic.	A scale should be placed on site to ensure the trucks transporting material for the project are within the appropriate weight limits. A maintenance plan must be put in place to address the deterioration of local roads that are used as detours.
Increased risk of accidents or damage to vehicles caused by objects falling from construction vehicles.	Ensure vehicles are covered and not overloaded.
Roads and access points along the corridor will be directly impacted by the construction.	Maintenance of traffic plans for all existing roads and driveways must be detailed in the Traffic Management Plan (TMP). Adequate and appropriate road signs should be erected to warn road users of the construction activities. For example, reduced speed near the construction site. The use of flagmen should be employed to regulate traffic flow.

5.2.3.8 Health and Emergency

5.2.3.8.1 Occupational Health and Safety

Construction of the proposed highway has the potential for accidental injury, whether major or minor. For example, construction works may entail workers being suspended in the process and this has the potential for increased construction accidents. Fugitive dust has the potential to affect the health of construction workers. Additionally, there may be some blasting in preparing the site for the construction along sections of the highway segments.

RECOMMENDED MITIGATION

i. The provision of lifelines, personal safety nets or safety belts and scaffolding for the construction workers (if necessary)
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
iii. Ensuring that workers wear personal protective equipment (hard hats, reflective vests, safety shoes, eye protection etc.)
iv. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.
v. 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.
vi. There should be onsite first aid kits and arrangement for a local nurse and/or doctor to be on call for the construction site.
vii. Make prior arrangements with local health care facilities such as health centres or the hospitals to accommodate any eventualities
viii. Material Safety Data Sheets (MSDS) should be stored onsite.
ix. 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.

x. Trench Excavation

- A trench 1.2m or more in depth must have a means of egress (ladders/ stairways/ramps) and should be located at 8m intervals.
- Excavated materials must be stored 0.6m or more from the open trench (not to be measured from the crown of the spoil).
- Spoil should be placed so that the channels rainwater and other runoff water away from the excavation.
- Take precautions regarding Tension Cracks
  - Tension cracks usually form at a horizontal distance of 0.5 to 0.75 times the depth of the trench.
  - Sliding or sloughing may occur as a result of tension cracks. [6]

5.2.3.8.2 Community Health and Safety

As mentioned previously, blasting is expected to be concentrated in the mountainous areas. 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.

RECOMMENDED MITIGATION

There are many methods to prevent or mitigate rock fall, but to be effective they have to be tailor made for the specific situation at each location. A common generic solution is the use of rock fall drapery systems designed to guiding falling debris to a collection point at the toe of the slope. Other solutions are the use of stepped slope with wide benches as well as rock fall barrier and catch fences to keep the falling rocks off the road or from impacting nearby residences. Loose rocks can also be kept in place by covering the slope with wire mesh and anchoring the wire mesh to the slope.

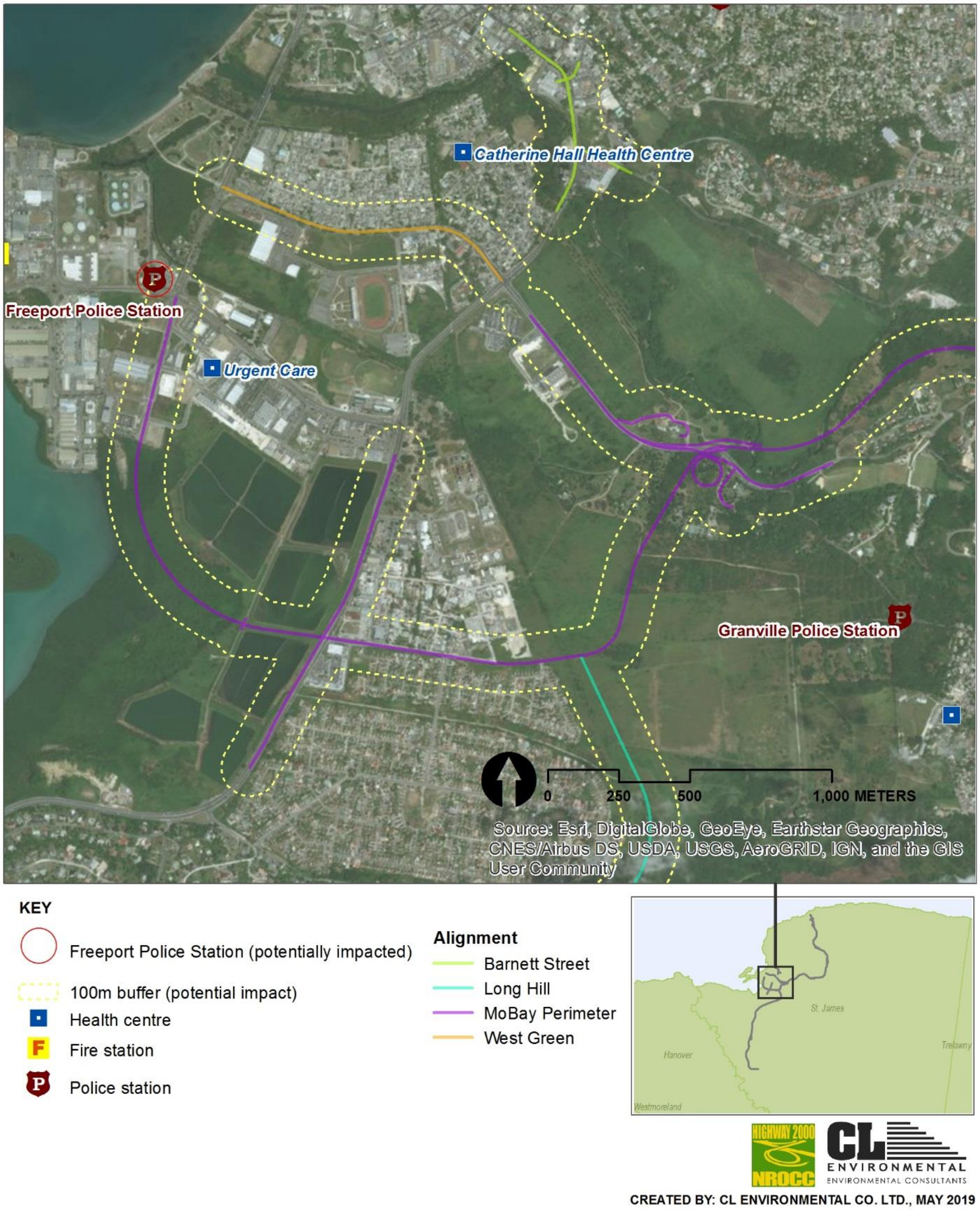
5.2.3.8.3 Health and Emergency Facilities

Of all health and emergency locations examined (health centres, hospitals, fire stations and police stations), only one police station (Freeport) is located within 100 metres of the proposed location (Figure 5-9). Potential impacts to this station include noise and dust nuisances. Access to all health and emergency facilities may be disrupted owing to road works (see section 5.2.3.7).

RECOMMENDED MITIGATION

See recommended mitigation for noise disturbances, air pollution and disrupted traffic flow in sections 5.2.1.5, 5.2.1.6 and 5.2.3.7.

[6] Worker Health and Safety Guidelines as per OSHA #510 Construction Industry Standard 29 CFR Part 1926.



Data source: Health centres, police stations (Social Development Commission, 2019); hospitals, fire stations (Mona GeoInformatics Institute)

Figure 5-9 Potentially impacted emergency services within 100 metres of the proposed alignment

5.2.3.8.4 Safety and Security

The volatile nature of some of the work areas such as Salt Spring, may cause disruption in the day to day construction while in the area.

RECOMMENDED MITIGATION

i. Secure areas with police during construction hours.

5.2.3.9 Recreational and Social

Of the 117 recreational facilities located within the SIA, including community centres, playfields, cinemas, recreational beaches and attractions (Figure 3-113 and Figure 3-114), none are situated within the impacted cut and fill areas for road construction (Figure 5-10). However, two churches, namely Rehoboth Faith Word Fellowship Ministries Church and Abundant Life Church are located within the proposed cut and fill areas and may be directly impacted by the proposed works (Figure 5-11). Twelve recreational facilities/ attractions (Table 5-18), 9 churches (Table 5-19) and one post office (Montego Bay 2 Post Office, 120 Barnett Street, Montego Bay) are within 100 metres of the proposed alignment and may be potentially impacted by noise, dust and disrupted access (see sections 5.2.1.5, 5.2.1.6 and 5.2.3.7).

Table 5-18 Recreational facilities located within 100 metres of the proposed alignment

Date source: (Social Development Commission, 2019)

	Name	Address
1	Westgate Hills Playfield	West Gate Hill
2	Community Park	Fairfield
3	Fairfield Theatre	Fairfield
4	Rastafari Indigineous Village Museum	Riverside Drive, Irwin, P.O. #2 Montego Bay
5	Gallery of West Indian Art	11 Fairfield Road, Westgreen, P.O. # 2 Montego Bay
6	Supreme Ventures	104 Barnett Street, Montego Bay, St. James
7	John Swaby Entertainment	Catherine Hall, Montego Bay # 1 P.O.
8	Catherine Hall Entertainment Centre	Catherine Hall, Montego Bay # 1 P.O.
9	The Studio Montego Bay	Shop 7 Bogue City Centre
10	TCM Group	14 Bogue Industrial Estate
11	Palms Entertainment Park	Lot 9 Bogue Industrial Estate
12	Supreme Ventures	3 bogue Industrial Estate

Table 5-19 Churches located within 100 metres of the proposed alignment (those within cut and fill zone in red)

Date source: (Social Development Commission, 2019)

	Name	Address
1	Holiness Born Again Church	Box 1879, P.O. #2 Montego Bay
2	Holy Trinity	Miriam Way, Montego Bay # 2 P.O.
3	Carey Village AME Zion Church	Carey Village, Mt. Carey, Anchovy P.O. St. James
4	Bay Life Baptist Church	16 Bogue Industrial Estate
5	Bogue United Full Gospel	3 Bogue Industrial Estate
6	Bogue Hill Seventh Day Adventist Temple	Bogue Hill, Bogue
7	Bogue Hill Baptist Church	Bogue Hill, Bogue
8	Rehoboth Faith Word Fellowship Ministries Church	Bogue Hill, Bogue

	Name	Address
9	Abundant Life Church	Anchovy P.O. St. James

RECOMMENDED MITIGATION

See recommended mitigation for noise disturbances, air pollution and disrupted traffic flow in sections 5.2.1.5, 5.2.1.6 and 5.2.3.7.

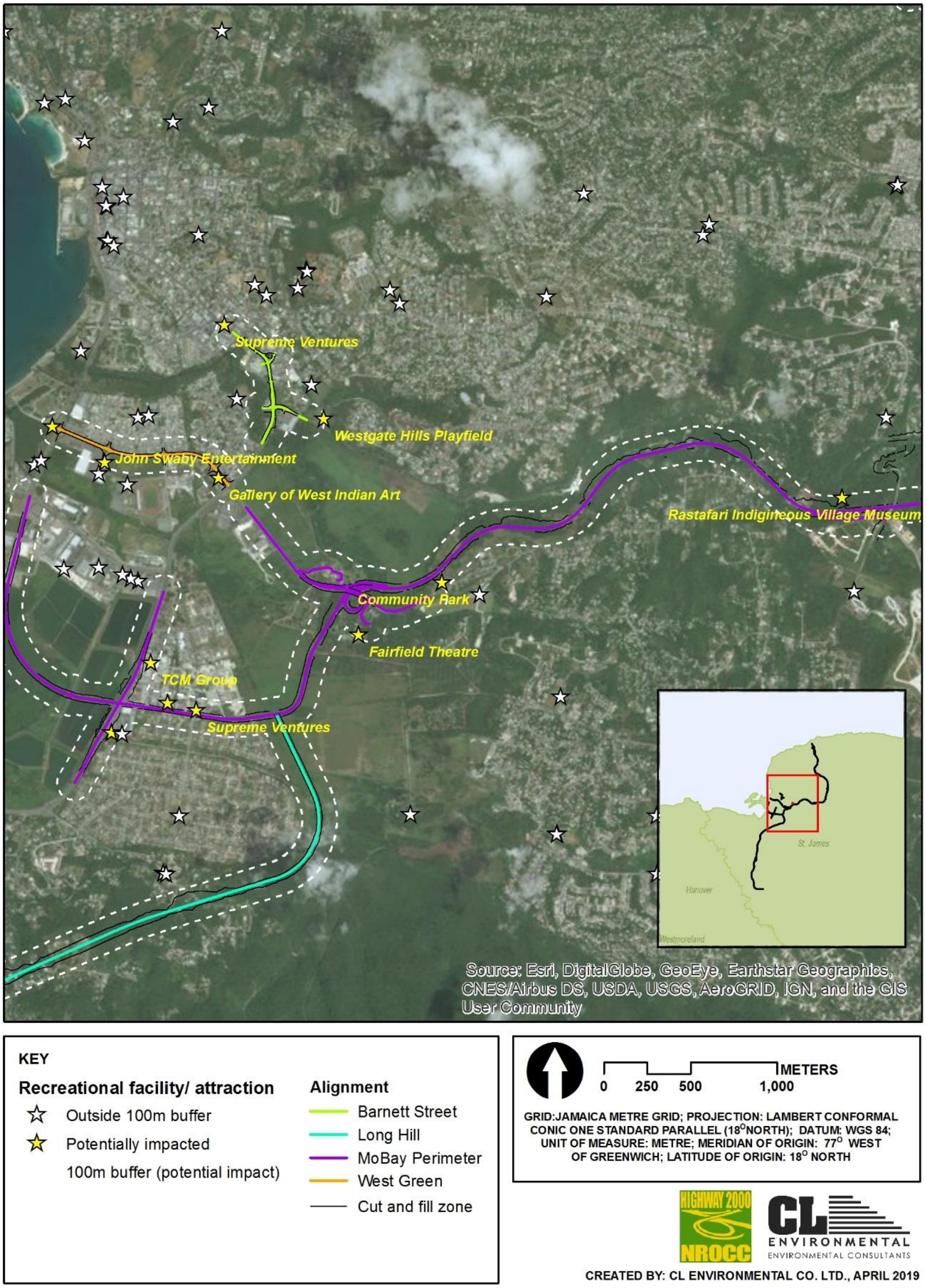


Figure 5-10 Potentially impacted recreational facilities within 100 metres of the proposed alignment

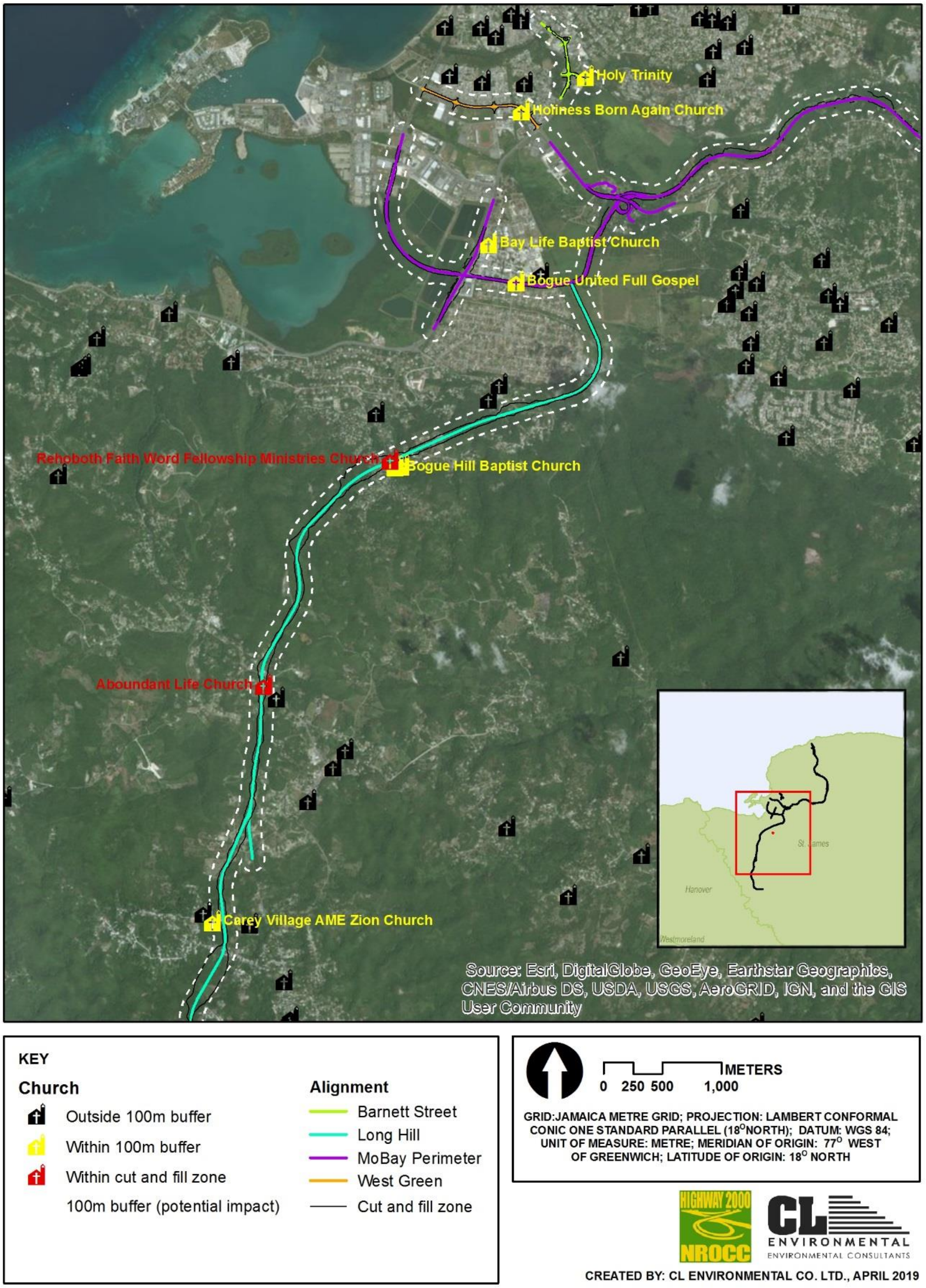


Figure 5-11 Potentially impacted churches within 100 metres of the proposed alignment

5.2.3.10 Industry and Economy

5.2.3.10.1 Commercial Activity

There is the potential for an increase as well as a decrease in commercial activity in the project area. A potential increase in commercial activity would be represented in the form of increased sales from food and beverages to construction crew while a potential decrease would be represented in the form of decreased access by the public to certain areas due to construction activities.

Additionally, commercial entities within the alignment's impact area may have to be relocated and these businesses may have difficulty in obtaining new locations and may potentially lose clients. Shops stalls and other commercial entities were surveyed in detail as part of the Impacted Structure Survey (see Section 5.4).

RECOMMENDED MITIGATION

i. See recommended mitigation for disrupted traffic flow in section 5.2.3.7.
ii. If commercial entities are to be relocated, compliance with the Resettlement and Relocation Plan (see section 6.3.3).

5.2.3.10.2 Tourism

During construction tourism may be impacted by increased traffic congestion, noise, dust and a decrease in the viewshed.

RECOMMENDED MITIGATION

Mitigation would include proper traffic management, and the appropriate noise and air quality mitigation as outlined in sections 5.2.1.5, 5.2.1.6 and 5.2.3.7.

5.2.3.11 Land Use

5.2.3.11.1 Protected Areas and Zoning

The southwestern end of the Montego Bay Perimeter Road alignment transverses the Bogue Lagoon Creek game reserve and West Green alignment touches its eastern boundary.

RECOMMENDED MITIGATION

i) The developers should also be aware of all planning and protected area boundaries. Further, it should be ensured that construction workers and activities are sensitive to the natural and man-made systems existing within the zones and protected areas.

5.2.3.11.2 Land Acquisition

The cut and fill of the proposed alignments will potentially impact the following land parcels (Table 5-20):

- Montego Bay Bypass: 329 parcels, totalling 986,396.4 sq. m (243.7 acres) (Figure 5-12)

- West Green and Barnett: 39 parcels, totalling 16,278.8 sq. m (4.0 acres) (Figure 5-13)
- Long Hill: 205 parcels, totalling 1,128,140.2 sq. m (278.8 acres) (Figure 5-14)

Table 5-20 Land parcels potentially impacted by proposed alignments, summarised by scheme

	Scheme name	No. parcels	Subtotal
Montego Bay Bypass	*Unnamed*	7	**329**
	BELLEFIELD	1	
	BELLEFIELD ESTATE	6	
	BOGUE ESTATE	8	
	BOGUE INDUSTRIAL EST	1	
	BOGUE INDUSTRIAL ESTATE	15	
	BOGUE INSUDTRIAL ESTATE	1	
	BOGUE SWAMP	1	
	BOGUE VILLAGE	19	
	FAIRFIELD	1	
	FAIRFIELD-RIVERSIDE	1	
	FAIRFIELD / TUCKER	8	
	FAIRFIELD ESTATE	8	
	GREEN POND	3	
	IRONSHORE	11	
	IRWIN	99	
	IRWIN (RESERVED ROAD)	1	
	IRWIN ESTATE	29	
	MEADOWS OF IRWIN	3	
	MONTEGO WEST VLG PH 1	2	
	PROVIDENCE	28	
	PROVIDENCE BLCK 2	1	
	PROVIDENCE BLK 3 SECT 2	3	
	PROVIDENCE BLOCK 2	2	
	SALT SPRING	70	
Long Hill	*Unnamed*	1	**205**
	ANCHOVY	61	
	BELLEFIELD ESTATE	32	
	BELVIEW	3	
	BOGUE HILL	27	
	CATHERINE MOUNT MOUNTAIN	2	
	CHILDERMAS	14	
	FUSTIC GROVE	6	
	MONTEGO WEST VLG PH 1	3	
	MONTPELIER	3	
	MONTPELIER ESTATE	22	
	MONTPELIER P O	1	
	MOUNT CAREY	11	
	P 12 (Park) Bogue Village	1	
	RAMBLE HILL	18	
West Green and Barnett	*Unnamed*	7	**39**
	CATHERINE HALL	23	
	CATHERINE HALL ESTATE	1	
	FAIRFIELD / TUCKER	2	
	MONTEGO BAY	3	
	TORBAY	1	

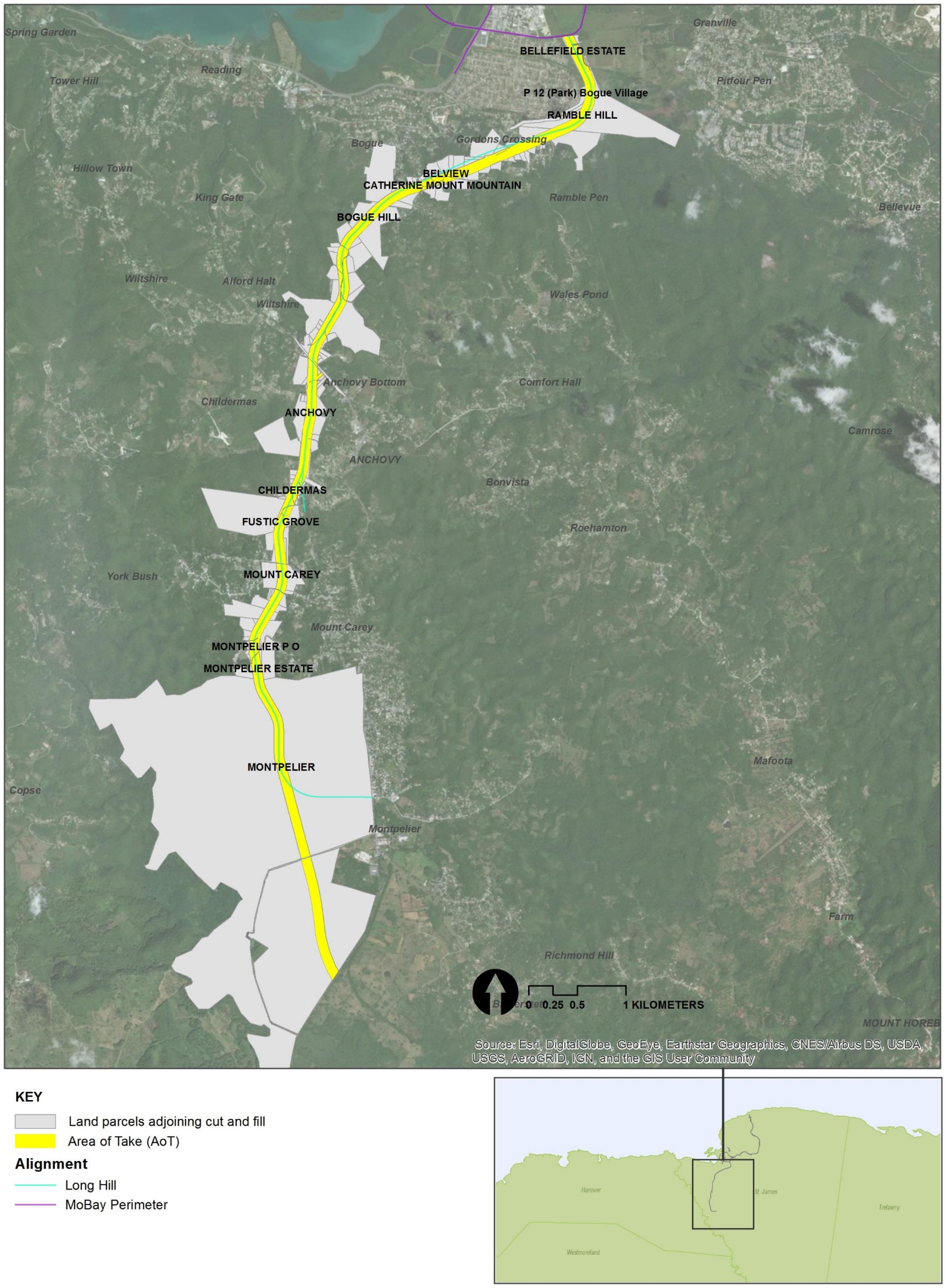
	Scheme name	No. parcels	Subtotal
	WESTGATE	2	
			Total no. of parcels = 573

RECOMMENDED MITIGATION

i) Measures should be taken to ensure that during the land acquisition phases, land parcels along the highway and or in proximity are not land locked.
ii) Compliance with the Resettlement and Relocation Plan (see section 6.3.3).

Figure 5-12 Land parcels potentially impacted by the proposed alignments showing the Area of Take, Montego Bay Bypass

Figure 5-13 Land parcels potentially impacted by the proposed alignments showing the Area of Take, Wrest Green and Barnett Street



CREATED BY: CL ENVIRONMENTAL CO. LTD., MAY 2019

Figure 5-14 Land parcels potentially impacted by the proposed alignments showing the Area of Take, Long Hill

5.2.3.12 Visual Quality/ Aesthetics

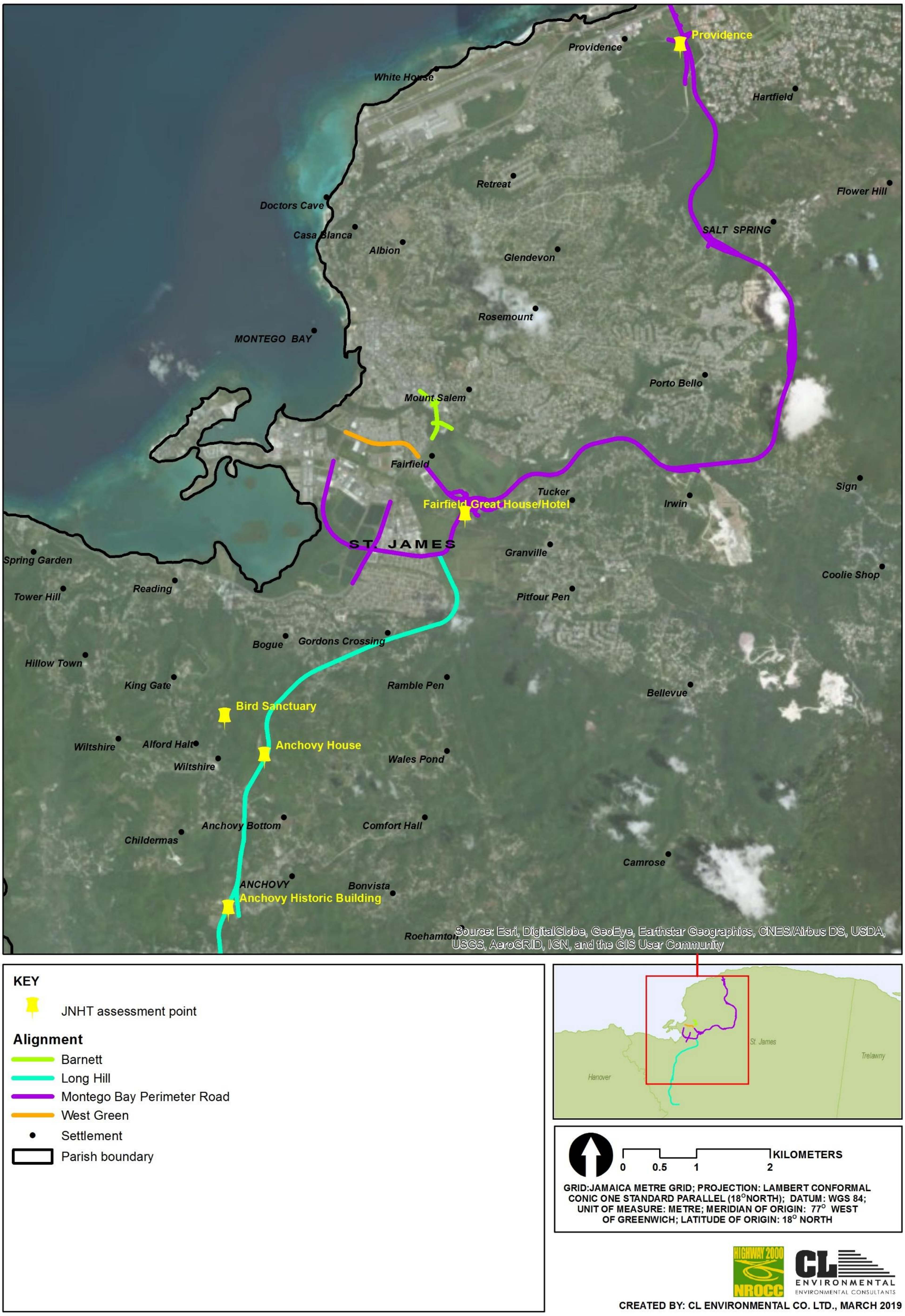
The construction of the proposed alignments will result in reduced visual quality

RECOMMENDED MITIGATION

i. Ensure work areas are maintained properly during construction.

5.2.4 Heritage and Archaeological

The Taíno site identified in the records such as Fairfield has been impacted by recent housing development. This is also the fate of the Green Pond property house compound. The places that may be potentially impacted by the proposed highway and upgrades are houses at Anchovy, Fairfield Hotel and Taíno site, Barnett Old Bridge, house and ruins at Providence. Indirect impact may occur with the Rocklands Bird Sanctuary. Impacted sites of archaeological/ cultural significance identified by JNHT are shown in Figure 5-15.



Source: Assessment points (JNHT)

Figure 5-15 Areas of interest for the archaeological and heritage assessment conducted by JNHT

5.2.4.1 Providence

Historically the providence Estate produced sugar. A windmill and an animal mill provided the motive power for the estate. In the year 1831 the estate had 184 enslaved persons living in the slave village. The proposed alignment will traverse the property directly impacting a dilapidated house (Figure 5-16, Plate 5-2) and water tank (706501.44 N 656436.23 E). This property belongs to Derrick Morgan.

Figure 5-16 Impacted house at Providence

Plate 5-2 House lying in direct path of proposed highway at Providence

The highway will join the north coast road at Providence and will traverse the area that contained the Providence works and Slave Village. Remnants of structures were identified. This area will be directly impacted by the highway construction (Plate 5-3, Plate 5-4). The Flankers community is located on a section of the Providence Estate. Several commercial buildings and the RIU Palace Hotel are also on this property; however, these are not impacted directly.

Plate 5-3 Remnants of buildings –possibly works at Providence

Plate 5-4 House built by Morgan for his hotel workers

5.2.4.2 Barnett

The proposed alignment will traverse sections of Barnet Estate; it should be noted that the historic sugar works were demolished in earlier road construction. However, the historic bridge at Barnett will be impacted by the construction of the proposed alignment (701302.28 N 653352.82 E).

Plate 5-5 Historic bridge at Barnett

5.2.4.3 Fairfield

The proposed highway will traverse the historic Fairfield Estate. The Taino site (700052.32 N 653911.61 E) and the Fairfield Great House/ Hotel (700165.29 N 653755.39 E) (Plate 5-7) may be directly impacted. The distance from Fairfield Great House to the proposed road is 41 m. The Theatre and other historic structures may suffer impact from vibrations during construction.

Figure 5-17 Fairfield structures in relation to road alignment

Plate 5-6 Impacted structure at Fairfield

Plate 5-7 Fairfield Great House/ Hotel

A housing development is also now under construction (Plate 5-8). It should be noted that a section of this housing development may be demolished to accommodate the Montego Bay Bypass.

Plate 5-8 Construction of housing development at Fairfield

Plate 5-9 Area of Fairfield Taino site under preparation for housing

5.2.4.4 Anchovy

At Anchovy, several modern domestic structures will be impacted; this includes a blue house at 696893.84 N 651039.54 E (Plate 5-10).

Plate 5-10 Structure in direct path of the proposed highway

5.2.4.5 Rockland's Bird Sanctuary

The proposed highway may have an indirect impact on the bird sanctuary as construction noise may disturb the birds.

5.2.4.6 Green Pond

The Green Pond Great House was recently demolished to make way for a housing scheme built by National Housing Trust at 702520.31 N 657692.99 E (Plate 5-11). The Tharp family owned the estate during the 18th and 19th centuries and four tombs belonging to family members are on the Green Pond High School compound (Plate 5-12). The Green Pond Sugar works was not positively identified during the survey; however, it is suspected that it lay close to the spring. The proposed highway will traverse this area.

Plate 5-11 Newly built housing development in the area of the Green Pond property house

Plate 5-12 Tombs belonging to the Tharp family at Green Pond

5.2.4.7 Sign

The proposed highway will impact directly on the current road and the river.

5.2.4.8 Other Areas of Interest

The proposed highway will **not** impact the following areas of archaeological/ cultural interest:

- Great House at Sign
- Childermas Works
- Historic buildings on New Montpelier Estate and Old Montpelier
- Historic ruins at Anchovy Bottom

- Historic structure and artefacts at Wiltshire (owned by the Addison family).

Further, no historic structures were found along the proposed alignment at Bogue Hill, Porto Bello or Salt Spring (it should be noted that the survey was curtailed due to ongoing criminal activity in the area).

RECOMMENDED MITIGATION

Many of the historic and archaeological sites fall outside the alignment. Care should be taken on these estates as slave villages did not have monumental structures. Any vestiges of cultural material unearthed on these estates should be collected and examined. It should be noted that in case archaeological features are found within and outside the development, the JNHT will evaluate and record the features and collect any such cultural material found. Several sugar works were located along the banks of the Montego River and with the proposal to reconfigure the river, a watching brief is recommended for this area when this work is undertaken.

Mitigation action for areas to be impacted are outlined below. The Archaeology Division has no objection to the proposed development pending that the recommendations are taken into consideration.

Providence

i. Monitoring is to be conducted during clearing and excavation stages especially in the slave village and works areas.
ii. Acquisition of land and relocation of affected persons.
iii. Take measures to reduce dust and noise pollution so as not to affect commercial areas.
iv. Drainage to be addressed so as to avoid flooding of areas as a result of increased surface run off due to road construction.

Barnett Estate

i. Monitoring is to be conducted during clearing and excavation stages especially in the works areas.

Barnett Historic Bridge

i. Shifting of alignment to avoid damage to bridge should be considered.

Fairfield

i. Due to the fact that Taino artefacts were found in the area, monitoring is to be conducted during clearing and excavation stages.
ii. Acquisition of land and relocation of affected persons.
iii. Take measures to reduce dust and noise pollution.
iv. Drainage to be addressed so as to avoid flooding of areas as a result of increased surface run off due to road construction.
v. It should be considered to shift proposed alignment to the east thus avoiding hotel compound, Taíno site and housing development.

Anchovy

i. Acquisition of land and relocation of affected persons.
ii. Take measures to reduce dust and noise pollution.
iii. Drainage to be addressed so as to avoid flooding of areas as a result of increased surface run off due to road construction.
iv. Construct bridges or underpass to allow for access where community is separated by highway.

Mt. Carey Baptist Church

i. Take measures to reduce dust and noise pollution.
ii. Construct bridges or underpass to allow for access where community is separated by highway.

Rockland's Bird Sanctuary

i. Take measures to reduce dust and noise pollution.

Green Pond

i. Monitoring is to be conducted during clearing and excavation stages.

Sign

i. A bridge should be constructed in the area for access.
ii. Take measures to reduce pollution of river.
iii. Drainage to be addressed so as to avoid flooding of the area.

5.3 OPERATION

5.3.1 Physical

5.3.1.1 Fog

Fog has affected many human activities, such as travel, which in this case is important for the both the safety and wellbeing of vehicle operators and pedestrians.

Fog formation potential exists in Montpelier, Mount Carey, Anchovy, Irwin and Fairfield.

RECOMMENDED MITIGATION

i. Ensure that adequate signage is placed along the road/highway providing the users of the road fog area warning.
ii. Public education on what steps are to be taken when encountering fog along the roadway especially in high speed areas so as to prevent accidents.

5.3.1.2 Drainage and Stormwater

5.3.1.2.1 Drainage Crossings

River crossings and gullies in the vicinity of the proposed alignment will cause a requirement for adequately designed drainage structures. According to the 2018 NROCC drainage report there are over fifty (50) designed drainage structures along the alignment between Whittier Village and Bogue/ Alice Eldemire. The Long Hill Bypass segment however has not had sufficient considerations for its drainage and so the area was assessed independently. For the assessment, GIS datasets were used to identify locations where existing rivers, gullies and drains intersect the proposed alignment. There were twelve (12) crossings were identified. Of the twelve (12) identified crossings in the segment of the alignment six (6) were verified physically based on accessibility. However, anecdotal information was acquired as near as possible to the sites.

The presence of river crossings, gullies and drains mean that these areas will facilitate the flow of water during a rainfall event. Therefore, any construction that seeks to disrupt the natural or constructed path for the flow of water will need to consider alternative drainage paths so as to prevent localized flooding or inundation.

RECOMMENDED MITIGATION

Mitigating the effects of existing rivers, gullies and drainage crossings in the vicinity of the alignment will call for ensuring adequate drainage structures are designed. Adequacy of drainage is determined by considering the capacity of the existing drainage, the intensity and volume rainfall in the area, runoff rates and the capacity for increase due to climate change.

5.3.1.2.2 Montego River Realignment

Assessment of the post realignment river network revealed an average velocity of 7.1 m/s upstream of the realignment area. This a very slight 1.4% increase when compared to the pre-realignment velocity in the same area, which can be attributed to the reduction in resistance as a result of the realignment exercise. Further along the river network in the vicinity of Barnett Estates, there was an average velocity of 5.8 m/s, downstream of the proposed realignment location, which equates to a 5% increase when compared to the pre realignment velocity. The section of the river network at the Barnett Street Bridge showed a velocity of 5.6 m/s, or a 4% increase in average velocity. Further along the river alignment, in proximity of the West Gate Shopping Centre the simulation showed a velocity of 5.8 m/s, representing a 5% increase in average velocity. The section of the river network that runs along the West Green Housing Scheme showed a velocity of 6.4 m/s, or a 4% increase in average velocity. Finally, in the proximity of the Charles Gordon Market the simulation showed a velocity of 6.6 m/s, or a 4% increase in average velocity. Figure 5-18 shows a plan view of the river network, with the assessed areas highlighted, and Figure 5-19 shows the velocities along the assessed section of the Montego River network after the realignment exercise has been conducted.

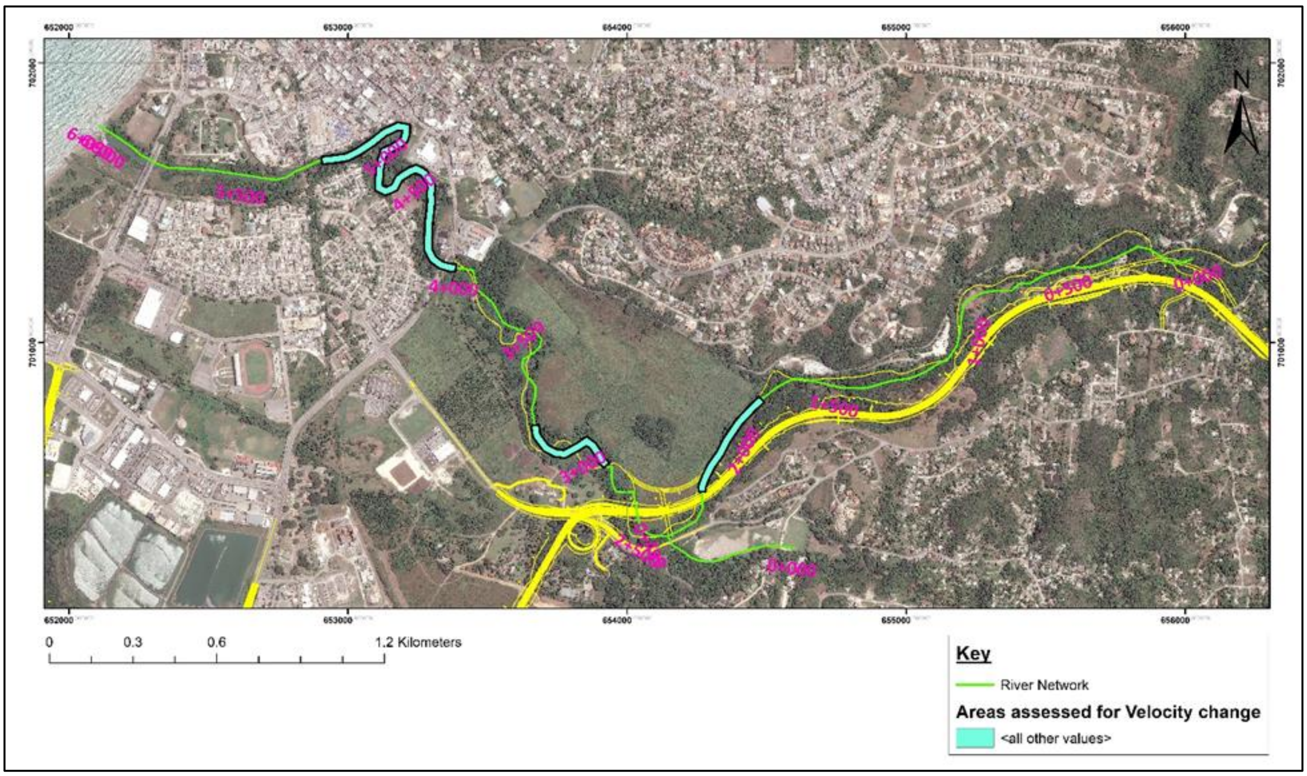


Figure 5-18 Plan view of river network, with assessment areas highlighted

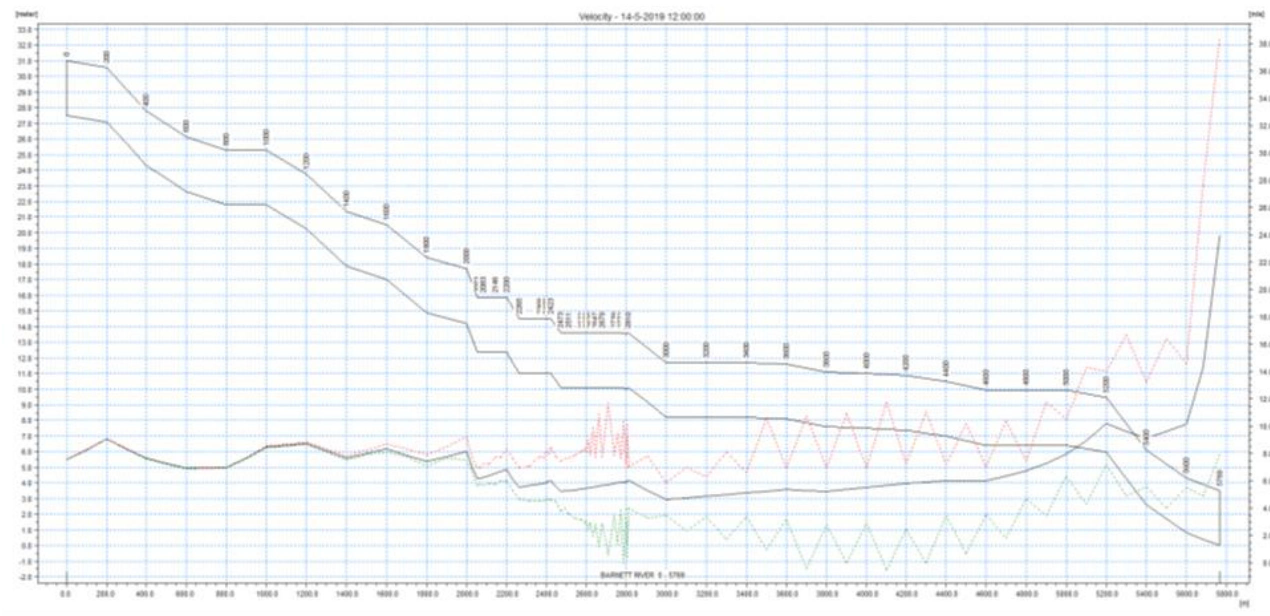


Figure 5-19 Graph showing velocities along the Montego River: Post-Realignment

Table 5-21: Table showing average velocities Post Realignment

Chainage	Velocity (m/s)		%-Change	Description of Location
	Pre-Realignment	Post Realignment		
1+800 - 2+200	7.0	7.1	**1%**	Tucker/Irwin (Upstream)
2+800 - 3+200	5.5	5.8	**5%**	Barnett Estates (Downstream)
4+200 – 4+300	5.4	5.6	**4%**	Barnett Street Road Bridge (Downstream)
4+300 – 4+500	5.5	5.8	**5%**	West Gate Shopping Centre (Downstream)
4+500 – 5+000	6.1	6.4	**4%**	West Green Housing Scheme (Downstream)
5+000 – 5+200	6.3	6.6	**4%**	Charles Gordon Market (Downstream)

The increase in velocity is expected to have minimal impacts on the river network as the increase is generally insignificant in the areas highlighted upstream and downstream of the realignment area. However, it must be considered that as the velocity increases along the river alignment, the more susceptible the bed of the channel is to scour as the materials are more easily dislodged by the higher energy currents. The banks of the channel can also be affected by varying degrees of erosion.

With increased erosion and scour, substantial or not, sediment and debris movement downstream is inevitable and often translates to material being deposited downstream. Sediment of this nature is deposited areas where the flow loses energy, particularly around the meanders of the channel. As this material is deposited, the natural flow of the channel is disrupted often resulting in flooding and varying degrees of erosion.

RECOMMENDED MITIGATION

It is recommended that once the designs are finalized, a full hydrological study of the river alignment is conducted. When this study is complete there will be a clearer picture of the necessary measures for the river realignment exercise. However, some broad-based techniques for reducing erosion, flooding and sediment movement are:

Erosion and Scouring

i. Installation of Gabion Units, Reno mattresses and revetments as a means of effective erosion and scour control. These should be implemented in strategic areas, which are most susceptible to scour and erosion.

Plate 5-13 Reno Mattress installed along River

Plate 5-14 Revetment installed along banks of river

Debris Flow

i. 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). 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 5-15 An example of a check dam

ii. Sedimentation basins, debris racks (for small culverts or openings) upstream of culverts that can be maintained by scheduled cleaning.
iii. 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.

5.3.1.2.3 Wetland

The flows generated from the catchment will pass through the wetland area prior to final discharge (Figure 5-20). The wetland area receives the catchment which will cause the water levels in the swamp to fluctuate as it passes through. The wetland will be drained by balancing culverts where it will be discharged to sea. On passing through the basin, the storm water will spread out in the basin and reduce the peak flow out of the basin as some of the volume flowing in will be stored and a negligible amount lost to evaporation. The relationship between inflow and outflow is therefore:

Inflow = Outflow + Storage

The SCS hydrographs developed for the peak runoff for the catchment used as the input hydrograph for the basin. From this hydrograph and the contour data, the storage versus the depth relationship was developed and the outflow estimated.

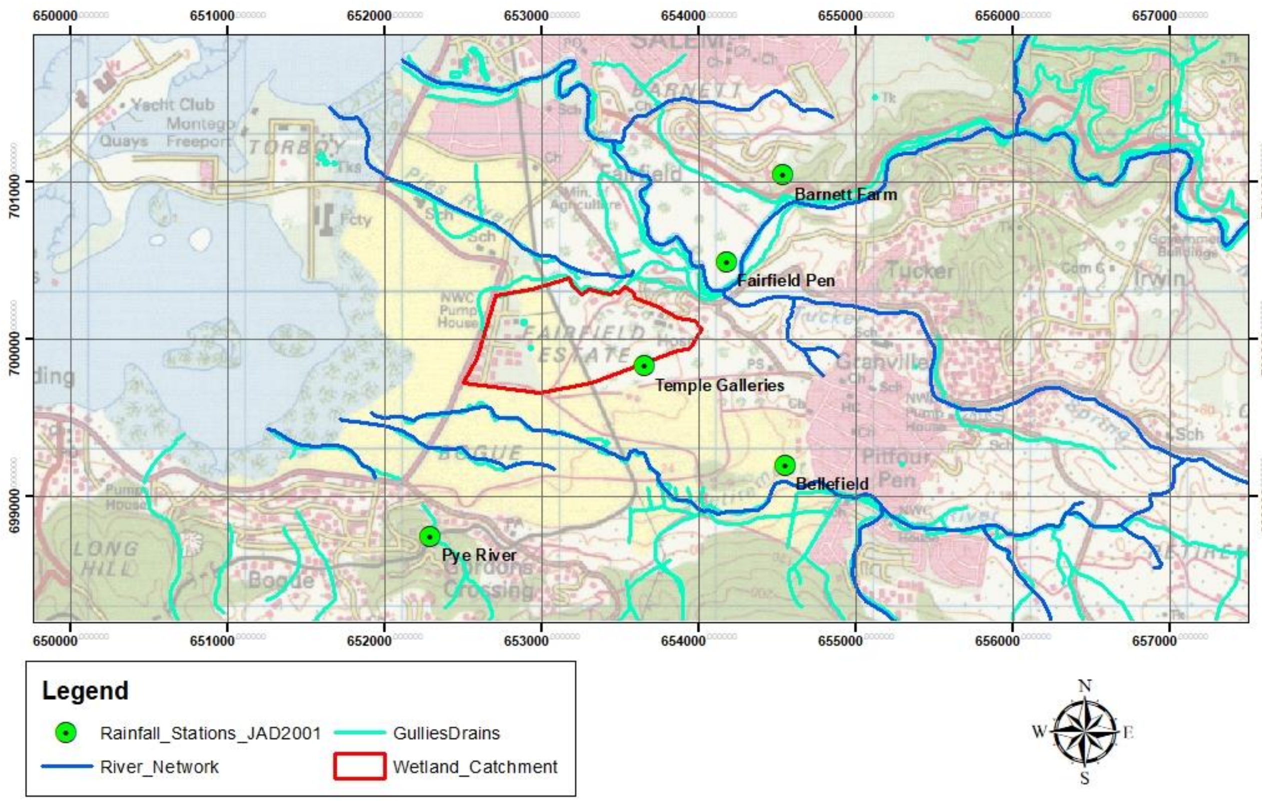


Figure 5-20 Showing the boundaries of the wetland delineated catchment

As shown in Table 5-22, the proposed highway alignment (CH10+500 – CH11+400) will not hinder the peak flows associated with the wetland. Based on the analysis, it was observed that the proposed balancing culverts for wetland will convey the 100yr peak flow with an estimated surcharge of 0.89m. The configuration of the discharge culverts – four (4) 1.5m pipes will allow the flow from the wetland out to sea while minimizing water storage within the wetland area. The resulting peak flows at the final discharge point (to sea) are shown below. In addition, the water depth above the final discharge culverts will reach a maximum of 1.54m.

Table 5-22 Summary of hydraulic calculations for wetland balancing culverts

Catchment Area (Ha)	Peak flow into Wetland (m3/s)	Capacity of Balancing Culverts (m3/s)	Estimated Surcharge (m)
70	63.26	87.5	**0.89**

5.3.1.2.4 Sinkholes and Groundwater Network

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:

RECOMMENDED MITIGATION

i. 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.
ii. 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.
iii. No sinkhole within the 50m and 100m buffer zones be blocked or covered with earth preventing or significantly altering the surface/sub-surface drainage pattern.
iv. A geotechnical survey should be conducted along the alignment of the highway to confirm whether or not there are caverns and caves in the sub-surface that may affect construction or pose a possible risk of collapse. This geotechnical survey should be done before any excavation or mitigation activities on the sinkholes take place.
v. The developers should consider installing a combination of wetland detention basins, oil separators (Plate 5-16- Filling station forecourt separatorPlate 5-16) 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 5-16- Filling station forecourt separator

5.3.1.3 Noise Modelling

SoundPlan 8.1 was used to conduct the noise modelling for this study. Within SoundPlan, the Road Traffic Noise Model – FHWA; 2004 (TNM 2.5) was used to conduct the predictions. The first step was to select the standards that were going to be used to run the model. Within the standard, temperature was set at 30.0 °C, the relative humidity at 82 % and air pressure 1013.3 mbar.

5.3.1.3.1 Model Calibration

The noise model was calibrated for Montego Bay Perimeter Road, Long Hill Bypass, Barnett Street and West Green Upgrades. Calibration was done using the following assumptions. The traffic and traffic composition was assumed to be the 2018 traffic count for Montego Bay Perimeter Road, 2016 Traffic count for Long Hill Bypass, 2017 traffic counts for Barnett Street and West Green Avenue. An average speed of 50 km h^{-1} was used. The results were then compared to the measured data at the locations. A difference of 3 dBA was considered adequate to accept the model as being accurate (calibrated).

The noise stations used for Montego Bay Bypass were Stations 5 and 7, for Long Hill Bypass was Station 5, for Barnett Street was Station B2 and for West Green Avenue station WG1. These stations were close to the existing roadway. The results indicated good agreement; therefore, the model can be accepted as calibrated (Table 5-23).

Table 5-23 Noise model calibration results for Montego Bay Perimeter road, Long Hill Bypass, Barnett Street and West Green Avenue upgrades

LOCATION	ACTUAL NOISE LEVEL (dBA)	PREDICTED NOISE LEVEL (dBA)	DIFFEERNCE (dBA)
Montego Bay Perimeter (Stn. 5)	51.6	51.2	-0.4
Montego Bay Perimeter (Stn. 5)	62.5	59.5	-3.0
Long Hill Bypass (Stn. 5)	50.8	48.6	-2.2
Barnett Street (Stn. B2)	63.0	63.4	+0.4
West Green Ave. (Stn. WG1)	68.0	65.7	-2.3

5.3.1.3.2 Modelled Noise Results

Predicted results from the model have indicated that for Montego Bay Perimeter Road (N2, N7 and N8) and Long Hill Bypass (N4 and N6), Barnett Street Dualization (B1 and B2) and West Green Dualization (WG1 and WG2) had noise levels non-compliant with the NEPA standard for both day and night-time from traffic operating along the proposed highway and road improvements for 2021. For 2041, the same stations were non-compliant for day and night-times, with the addition of Stations N5 and N6 (Montego Bay Perimeter Road), Stations N1 and N2 (Long Hill Bypass) and the same stations as 2021 for (Barnett Street and West Green Dualizations) (Table 5-24 to Table 5-29 and Figure 5-21 to Figure 5-28).

Table 5-24 Predicted noise levels for Montego Bay Perimeter Road for 2021

STATION	PREDICTED (Leq)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
N1	47.1	49.4	43.2	55	50
N2	58.3	60.6	54.3	55	50
N3	45.5	47.8	41.6	55	50
N4	44.3	46.6	40.4	55	50
N5	52.2	54.5	48.2	55	50
N6	52.2	54.5	48.2	55	50
N7	60.3	62.6	56.4	55	50
N8	63.0	65.3	59.2	65	60

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-25 Predicted noise levels for Montego Bay Perimeter Road for 2041

STATION	PREDICTED (Leq)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
N1	50.0	52.3	46.0	55	50
N2	61.1	63.4	57.1	55	50
N3	48.4	50.7	44.5	55	50

STATION	PREDICTED (Leq)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
N4	47.2	49.5	43.3	55	50
N5	55.1	57.4	51.2	55	50
N6	55.1	57.4	51.1	55	50
N7	63.3	65.6	59.3	55	50
N8	66.7	69.0	62.6	65	60

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-26 Predicted noise levels for Long Hill Bypass for 2021

STATION	PREDICTED (dBA)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
N1	62.1	64.4	58.2	65	60
N2	52.3	54.6	48.4	55	50
N3	49.4	51.7	45.6	55	50
N4	58.2	60.5	54.4	55	50
N5	48.8	51.1	44.9	55	50
N6	63.1	65.4	59.3	55	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-27 Predicted noise levels for Long Hill Bypass for 2041

STATION	PREDICTED (dBA)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
N1	64.3	66.6	60.4	65	60
N2	54.5	56.8	50.6	55	50
N3	51.7	54.0	47.8	55	50
N4	60.5	62.8	56.6	55	50
N5	51.1	53.4	47.2	55	50
N6	65.4	67.7	61.5	55	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-28 Predicted noise levels for Barnett Street and West Green Avenue to Fairfield Road Dualization for 2021

STATION	PREDICTED (dBA)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
B1	64.3	66.5	60.4	45	40
B2	65.7	68.0	61.8	65	60
WG1	64.9	67.2	61.0	55	50
WG2	63.9	66.2	60.0	55	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-29 Predicted noise levels for Barnett Street and West Green Avenue to Fairfield Road Dualization for 2041

STATION	PREDICTED (dBA)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
B1	66.3	68.6	62.4	45	40
B2	68.1	70.3	64.2	65	60
WG1	67.1	69.4	63.3	55	50
WG2	66.2	68.4	62.3	55	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

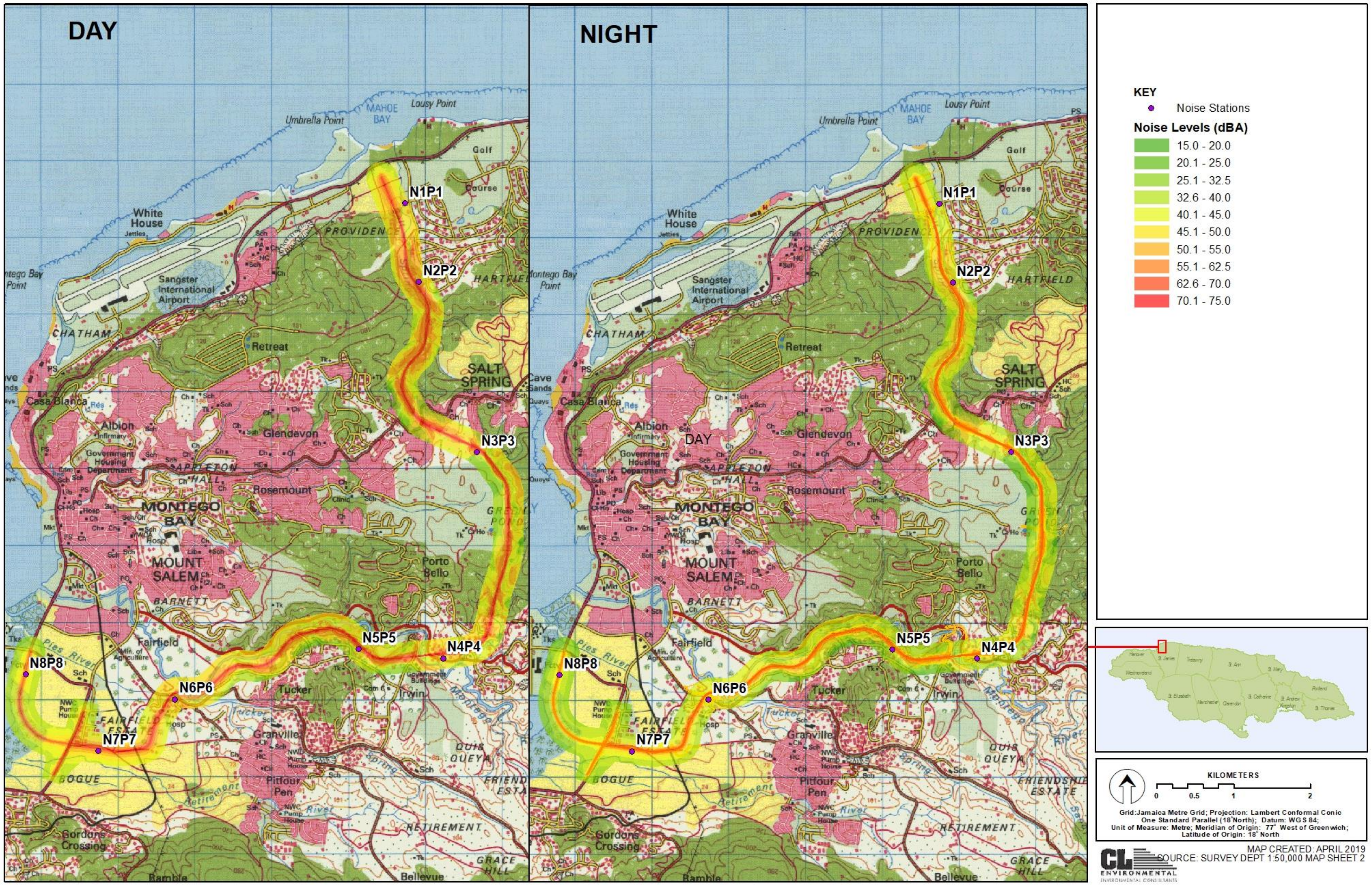


Figure 5-21 Montego Bay Perimeter Road day and night-time noise levels in dBA (2021)

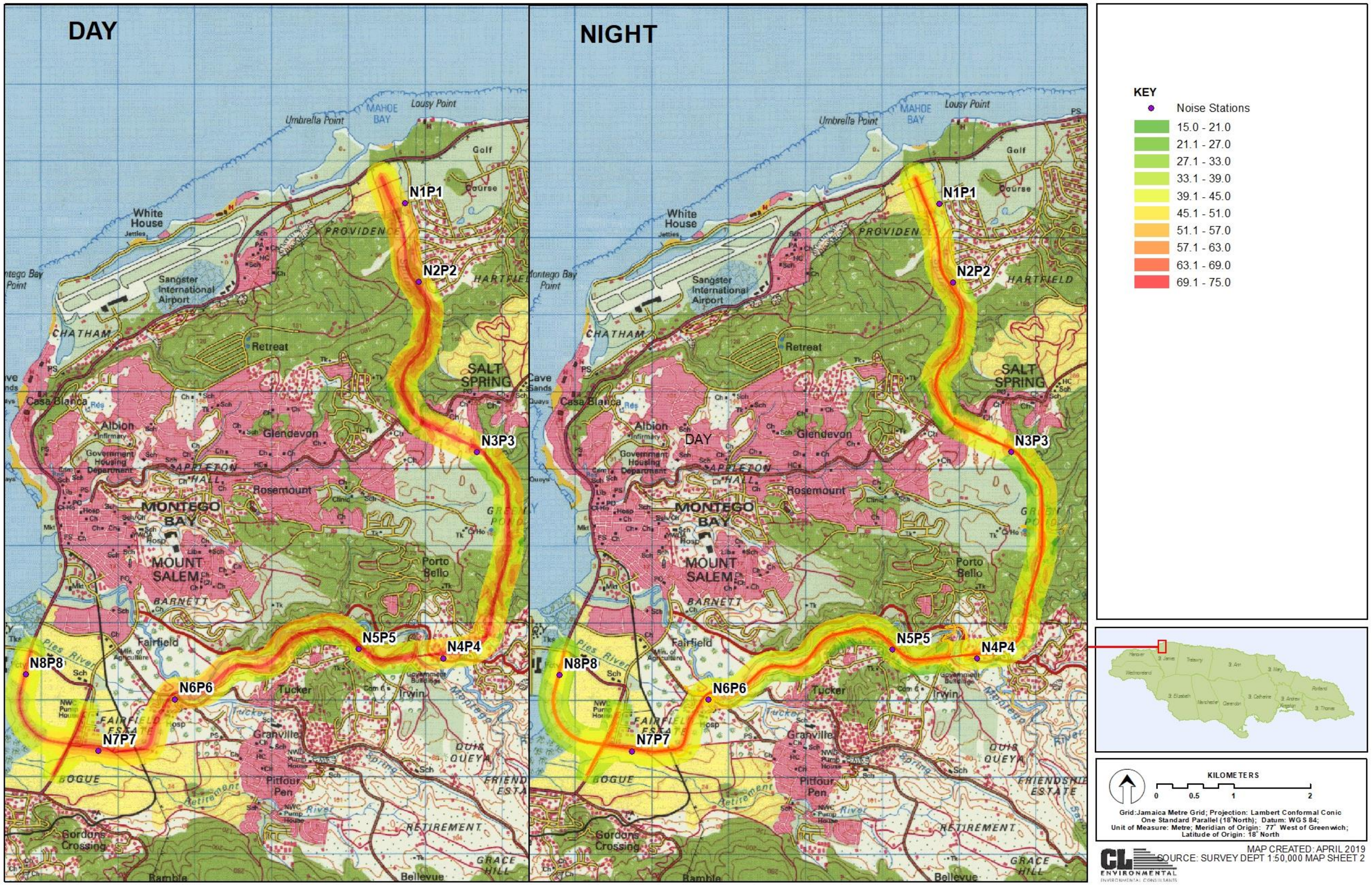


Figure 5-22 Montego Bay Perimeter Road day and night-time noise levels in dBA (2041)

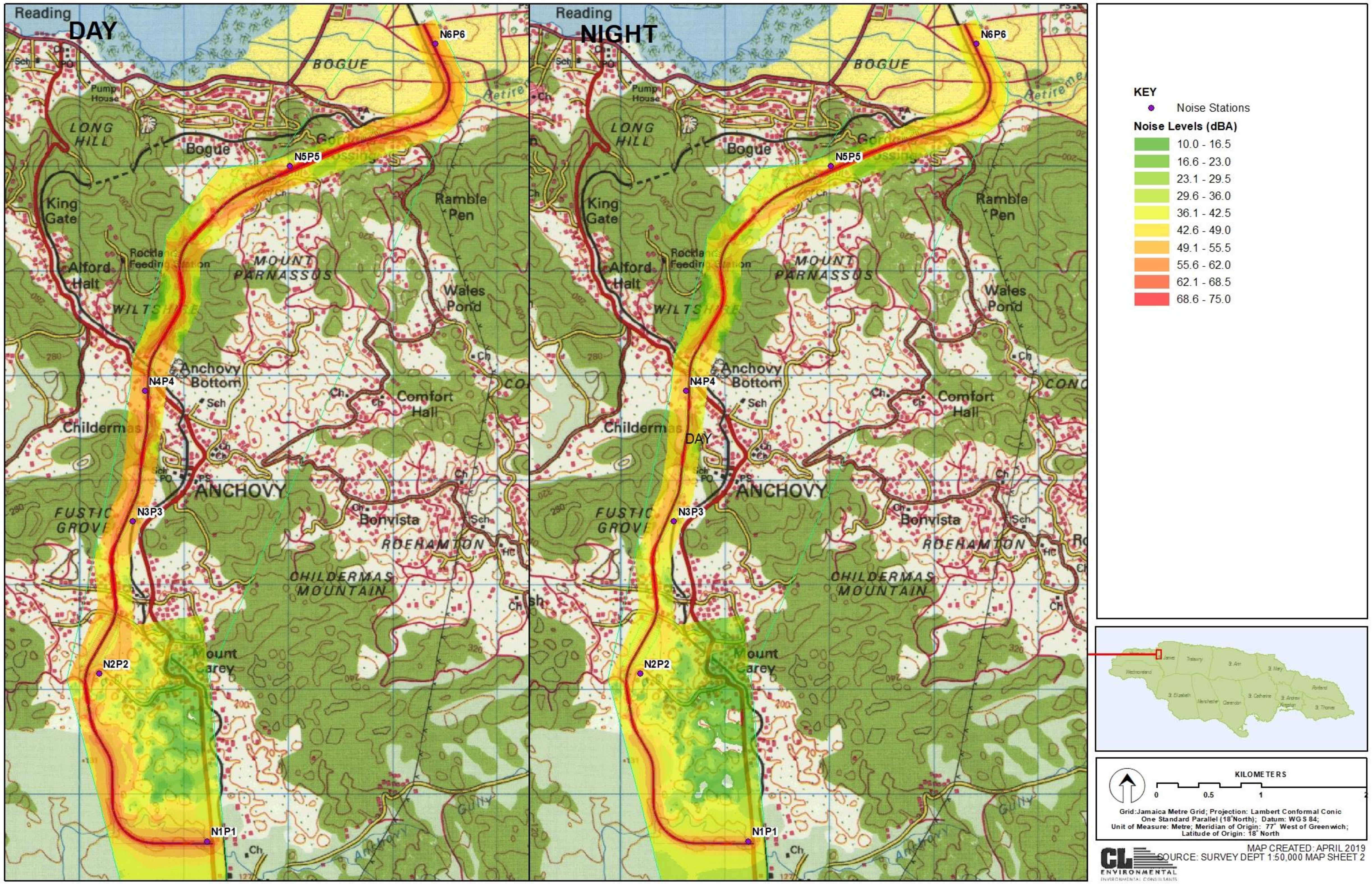


Figure 5-23 Long Hill By Pass day and night-time noise levels in dBA (2021)

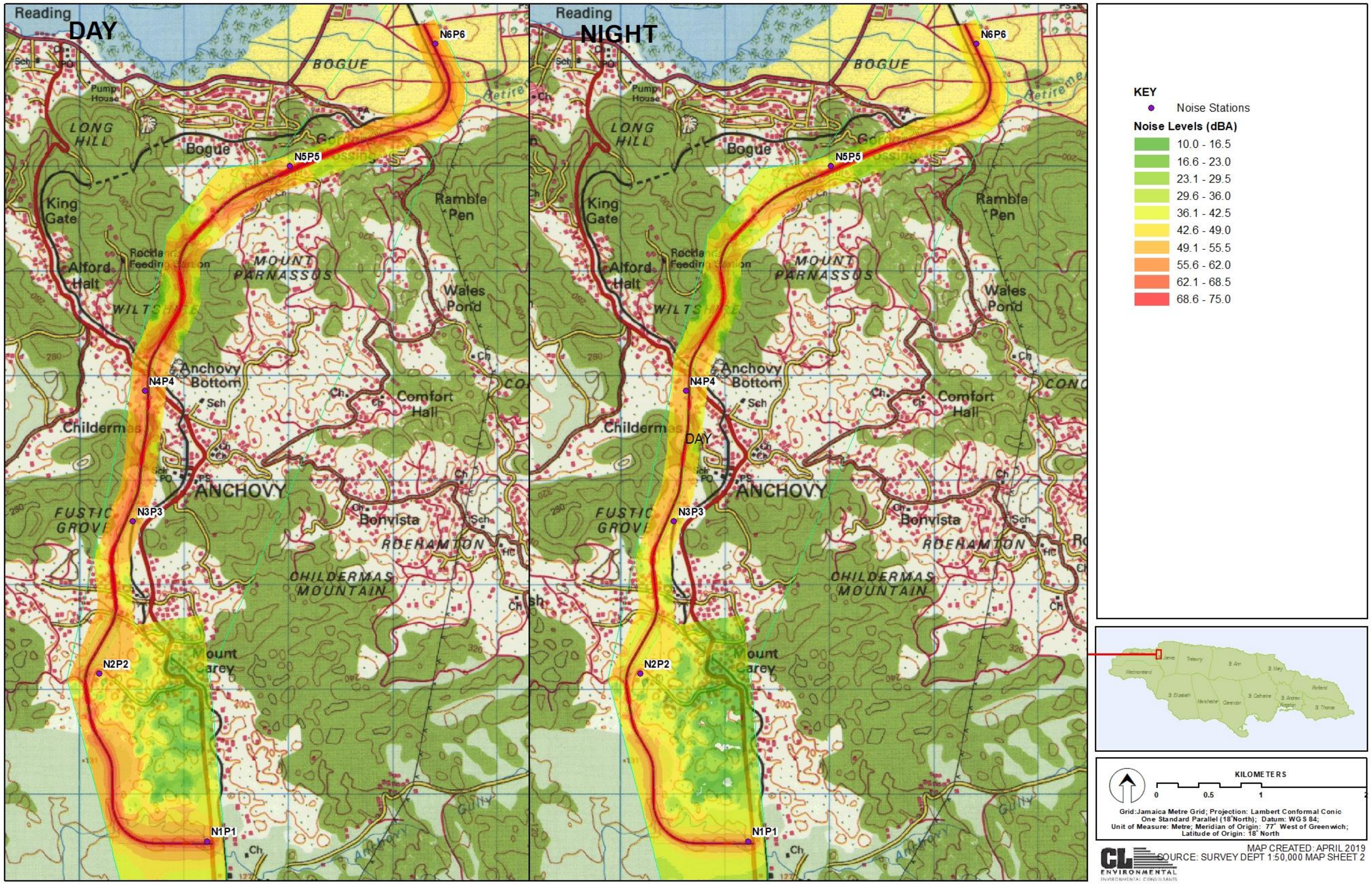


Figure 5-24 Long Hill By Pass day and night-time noise levels in dBA (2041)

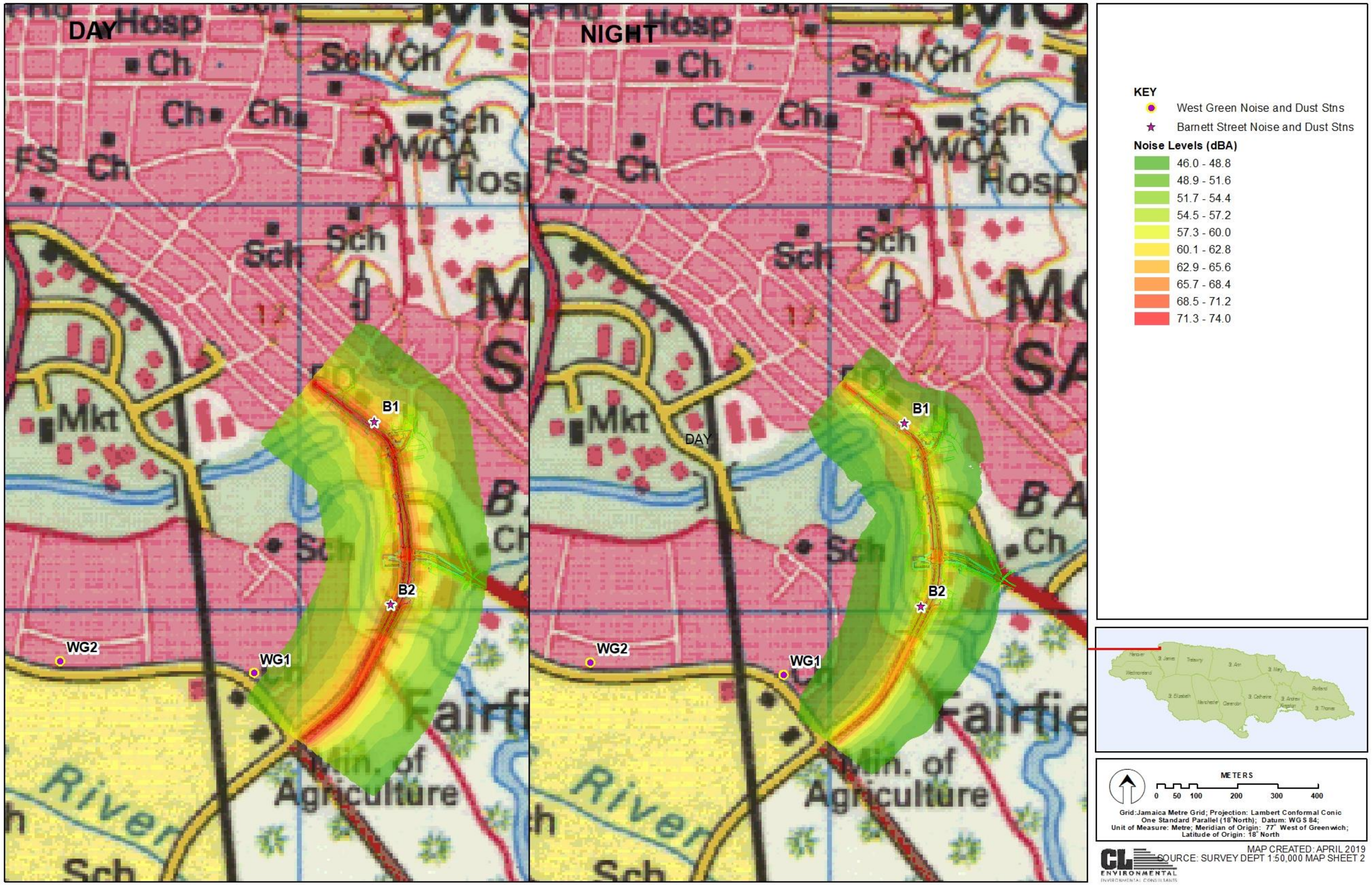


Figure 5-25 Barnett Street dualization day and night-time noise levels in dBA (2021)

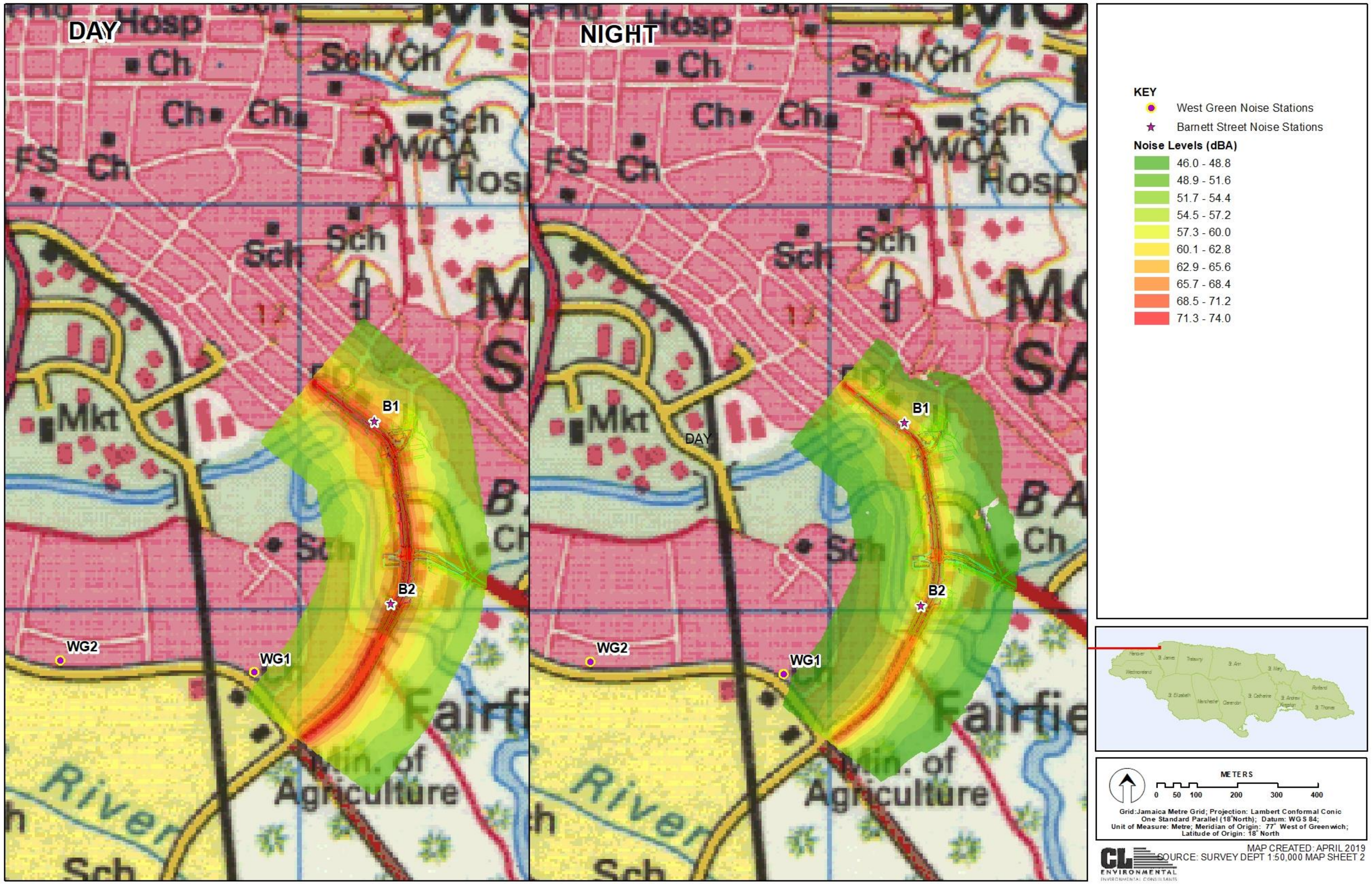


Figure 5-26 Barnett Street dualization day and night-time noise levels in dBA (2041)

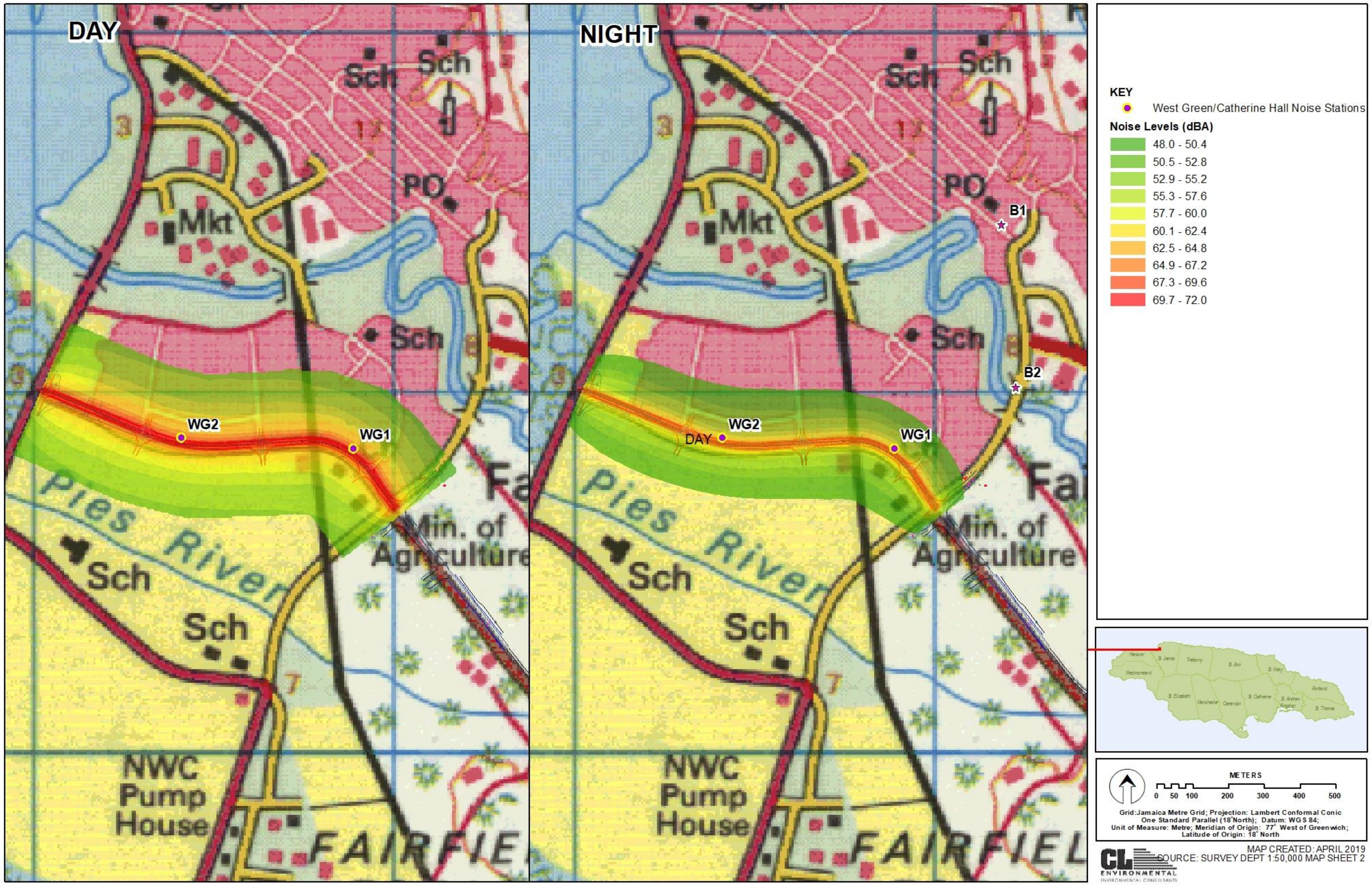


Figure 5-27 West Green dualization day and night-time noise levels in dBA (2021)

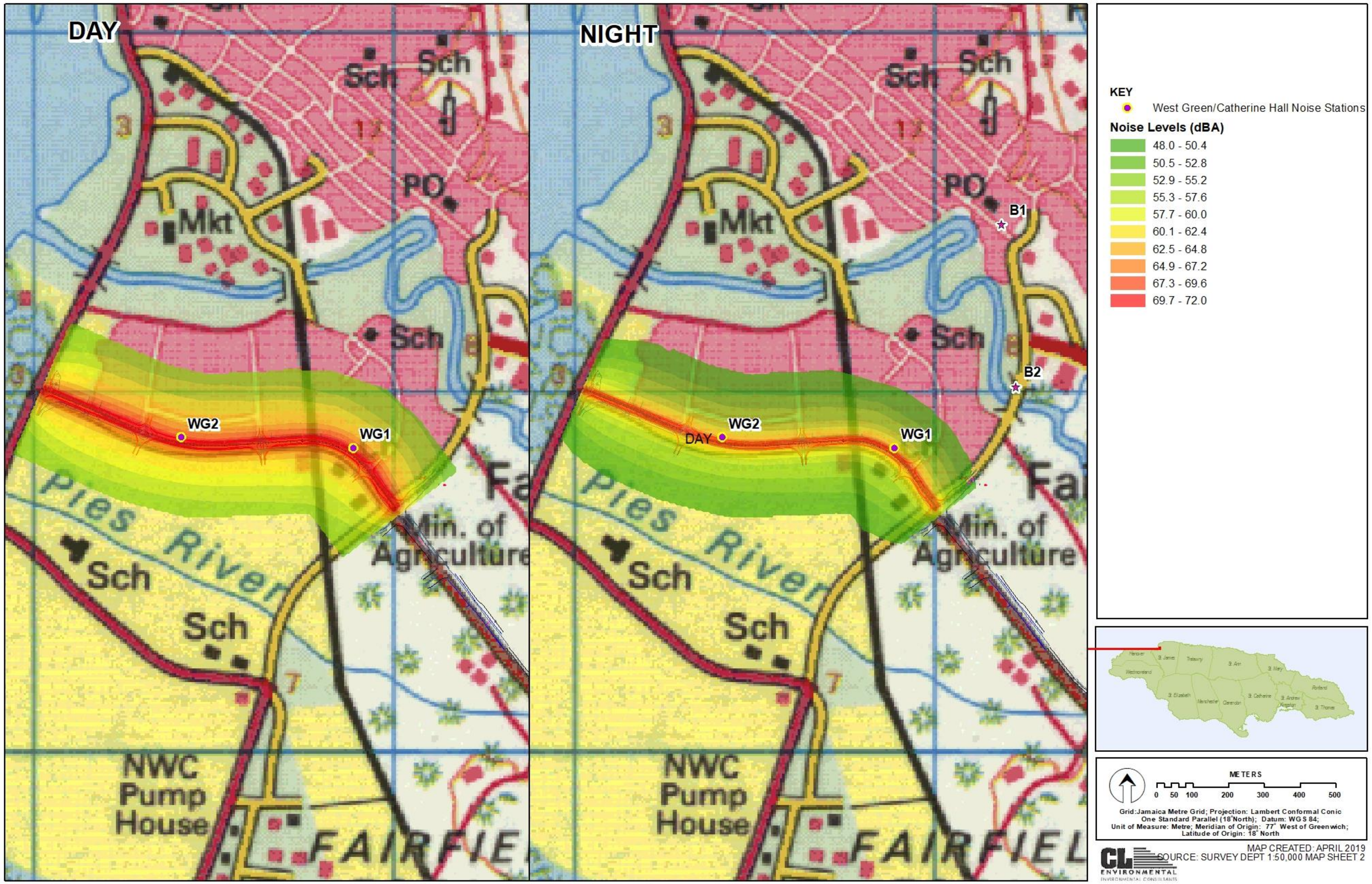


Figure 5-28 Barnett Street dualization day and night-time noise levels in dBA (2041)

5.3.1.3.3 Sensitive Receptors

A total of 79 sensitive receptors along Montego Bay Perimeter road, Long Hill Bypass road, Barnett Street and West Green / Catherine Hall dualization were assessed for noise impact from the proposed alignments. The sensitive receptors investigated were schools, health centres, hospitals and churches.

MONTEGO BAY PERIMETER ROAD

Schools

Twenty-five (25) schools were assessed along the proposed Montego Bay Perimeter road alignment. The results indicated that only the proposed University of the West Indies Western Campus would have noise levels from the traffic (2021 and 2041) using the highway above the NRCA day-time noise standard (Table 5-30). Figure 5-24). The day-time standard was used as it is not anticipated that schools will be opened for teaching at nights.

Table 5-30 Noise levels (day-time) for schools assessed for the Montego Bay Perimeter Road for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA DAY-TIME STANDARD (dBA)
Granville Day Care	23.4	24.8	45
Rosemount Day Care	28.0	30.9	45
Catherine Hall Day Care	29.1	32.1	45
Holy Family Day Care	16.1	19.1	45
Holiday Inn Kidspree Centre	36.6	37.7	45
Pat's Nursery	27.5	30.5	45
Comfort Day, Care Centre	38.1	41.0	45
St. Neva's Day Care Centre	29.3	32.3	45
Ideal Child Care	28.9	31.9	45
Kidz World	38.1	41.1	45
Howard Cooke Primary	24.7	27.6	45
Herbert Morrison High	32.0	35.0	45
Salt Spring All Age	27.9	29.8	45
Bogue Hill All Age	40.6	42.0	45
Corinaldi Primary	28.0	31.0	45
Catherine Hall Primary & Infant	28.6	31.5	45
Open Bible	19.1	22.2	45
Salt Spring	24.7	27.5	45
Hartfield Primary & Jnr. High	28.7	31.0	45
DRB Grant	24.5	27.5	45
Irwing High	21.9	26.1	45
Irwing All Age	22.4	26.5	45
Green Pond Primary	29.5	32.4	45
Green Pond High	29.0	31.9	45
University of the West Indies Western Campus*	57.6	62.1	45

NB: Values highlighted in red are non-compliant with the NRCA Standard
** - Future development*

Health Centres and Hospitals

A total of 4 health centres and no hospitals were assessed for noise impact from the traffic along the proposed Montego Bay Perimeter road alignment using the 2021 and 2041 traffic. All health centres had noise levels compliant with the NRCA day and night-time standards for both the 2021 and 2041 traffic (Table 5-31 and Table 5-32).

Table 5-31 Noise levels (day-time) at health centres and hospitals assessed for the Montego Bay Perimeter Road for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA DAY-TIME STANDARD (dBA)
Granville Health Centre	26.5	29.3	55
Green pond Health Centre	28.5	31.5	55
Mount Salem Health Centre	34.3	37.2	55
Catherine Hall Health Centre	30.7	33.7	55

Table 5-32 Noise levels (night-time) at health centres and hospitals assessed for the Montego Bay Perimeter Road for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA NIGHT-TIME STANDARD (dBA)
Granville Health Centre	20.3	23.1	50
Green pond Health Centre	23.2	25.2	50
Mount Salem Health Centre	28.0	31.0	50
Catherine Hall Health Centre	24.5	27.4	50

Churches

Five (5) churches were assessed for noise impact from the traffic along the proposed Montego Bay Perimeter road alignment using the 2021 and 2041 traffic. All churches assessed had noise levels compliant with the NRCA night-time standards for both the 2021 and 2041 traffic (Table 5-33).

Table 5-33 Noise levels (day-time) at churches assessed for the Montego Bay Perimeter Road for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA NIGHT-TIME STANDARD (dBA)
Salt Spring Church 1	40.0	42.0	50
Salt Spring Church 2	26.3	29.2	50
Salt Spring Church 3	33.9	36.8	50
Salt Spring Church 4	29.6	32.4	50
Salt Spring Church 5	39.7	41.4	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

LONG HILL BYPASS

Schools

Six (6) schools were assessed along the proposed Long Hill Bypass road alignment. The results indicated that Bogue Hill All Age, Anchovy Pre and Infant School and the proposed University of the West Indies Western Campus would have noise levels from the traffic (2021 and 2041) using the highway above the NRCA day-time noise standard (Table 5-34). The day-time standard was used as it is not anticipated that schools (except the University) will be opened for teaching at nights.

Table 5-34 Noise levels (day-time) for schools assessed for the Long Hill Bypass for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041(dBA)	NRCA DAY-TIME STANDARD (dBA)
Anchovy High	38.8	41.0	45
Anchovy Primary	35.1	37.4	45
Bogue Hill All Age	47.4	49.6	45
Herbert Morrison High	29.6	31.8	45
Anchovy Pre and Infant School	54.2	56.5	45
University of the West Indies Western Campus	46.3	49.3	45

NB: Values highlighted in red are non-compliant with the NRCA Standard

Health Centres and Hospitals

One (1) health centre and no hospitals were assessed for noise impact from the traffic along the proposed Long Hill Bypass road alignment using the 2021 and 2041 traffic. The health centre had noise levels compliant with the NRCA day and night-time standards for both the 2021 and 2041 traffic (Table 5-35 and Table 5-36).

Table 5-35 Noise levels (day-time) at health centres and hospitals assessed for the Long Hill Bypass for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA DAY-TIME STANDARD (dBA)
Mount Carey Health Centre	19.7	21.9	55

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-36 Noise levels (night-time) at health centres and hospitals assessed for the Long Hill Bypass for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA NIGHT-TIME STANDARD (dBA)
Mount Carey Health Centre	13.5	15.7	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

Churches

Five (5) churches were assessed for noise impact from the traffic along the proposed Long Hill Bypass road alignment using the 2021 and 2041 traffic. Unnamed Churches 3 – 5 had noise levels non-compliant with the NRCA night-time standards for both the 2021 and 2041 traffic (Table 5-37).

Table 5-37 Noise levels (day-time) at churches assessed for the Long Hill Bypass for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA NIGHT-TIME STANDARD (dBA)
Mount Carey Baptist Church	40.4	42.0	50
Unnamed Church 1	35.1	37.3	50
Unnamed Church 2	23.9	26.2	50
Unnamed Church 3	56.9	59.2	50
Unnamed Church 4	68.5	70.8	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

BARNETT STREET DUALIZATION

Schools

Twenty-five (25) schools were assessed in proximity to the proposed Barnett Street dualization alignment. The results indicated that Ideal Child Care, St. Neva's Day Care Centre and Catherine Hall Primary and Infant schools would have noise levels from the traffic (2021 and 2041) above both the NRCA day and night-time noise standards, and Mount Salem Primary and Junior High non-compliant with the NRCA night-time noise standard (Table 5-38). The day-time standard was used as it is not anticipated that schools (except the University) will be opened for teaching at nights.

Table 5-38 Noise levels (day-time) for schools assessed for the Barnett Street dualization for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041(dBA)	NRCA DAY-TIME STANDARD (dBA)
Catherine Hall All Age	48.2	50.4	45
Catherine Hall Day Care	42.5	44.7	45
Holy Family Day Care	39.7	42.0	45
Ideal Child Care	47.2	49.4	45
Kidz Paradise	29.0	31.1	45
Mama's Day Care Centre	35.2	37.6	45
Pat's Nursery	45.0	47.2	45
St. Neva's Day Care Centre	51.5	53.8	45
Wee Care Day Care	31.0	33.3	45
Barracks Road Primary	31.4	34.1	45
Catherine Hall Primary & Infant	48.2	50.4	45
Challenge	27.8	30.3	45
Corinaldi Primary	35.6	37.8	45
DRB Grant	39.0	41.2	45
Faith Basic	30.0	32.4	45
Herbert Morrison High	37.6	39.9	45
Howard Cooke Primary	39.0	41.2	45
Montego Bay Infant	31.7	34.1	45
Mount Salem Primary & Jnr. High	37.5	45.5	45
Pilgrim Ho	34.9	37.4	45
R'way Lane	37.1	39.4	45
Salvation Army	36.8	39.4	45
St James High	30.3	32.7	45
Wee Care	28.2	30.6	45
University of the West Indies Western Campus	37.4	39.6	45

NB: Values highlighted in red are non-compliant with the NRCA Standard

Health Centres and Hospitals

Two (2) health centre and a hospital were assessed for noise impact from the traffic along the proposed Barnett Street dualization alignment using the 2021 and 2041 traffic. Only Catherine Hall Health Centre had noise levels non-compliant with the NRCA day and night-time standards for the 2041 traffic (Table 5-39 Table 5-40 and Table 5-41).

Table 5-39 Noise levels (day-time) at health centres and hospitals assessed for the Barnett Street dualization for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA DAY-TIME STANDARD (dBA)
Catherine Hall Health Centre	54.8	57.0	55
Mount Salem Health Centre	37.8	40.0	55
Cornwall Regional Hospital	29.0	31.1	55

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-40 Noise levels (night-time) at health centres and hospitals assessed for the Barnett Street dualization for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA NIGHT-TIME STANDARD (dBA)
Catherine Hall Health Centre	48.6	50.8	50
Mount Salem Health Centre	31.6	33.8	50
Cornwall Regional Hospital	22.8	24.9	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

Churches

Two (2) churches were assessed for noise impact from the traffic along the proposed Barnett Street dualization road alignment using the 2021 and 2041 traffic. Holiness Born Again Church of Jesus Christ had noise levels compliant with the NRCA night-time standards for the 2021 but non-compliant with the 2041 traffic (Table 5-41). Holy Trinity Church had noise levels non-compliant with the NRCA night-time standards for both the 2021 and 2041 traffic (Table 5-41).

Table 5-41 Noise levels (day-time) at churches assessed for the Barnett Street dualization for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA NIGHT-TIME STANDARD (dBA)
Holiness Born Again Church of Jesus Christ	49.1	51.4	50
Holy Trinity Church	51.5	53.7	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

West Green / Catherine Hall Dualization
Schools

Twelve (12) schools were assessed in proximity to the proposed West Green / Catherine Hall dualization alignment. The results indicated that Catherine Hall Day Care, Ideal Child Care, Catherine Hall Primary and Infant, DRB Grant and Howard Cooke Primary schools would have noise levels from the traffic (2021 and 2041) using the road above both the NRCA day and night-time noise standards (Table 5-42). The day-time standard was used as it is not anticipated that schools (except the University) will be opened for teaching at nights.

Table 5-42 Noise levels (day-time) for schools assessed for the West Green / Catherine Hall dualization for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041(dBA)	NRCA DAY-TIME STANDARD (dBA)
Catherine Hall Day Care	56.4	58.7	45
Holy Family Day Care	34.1	36.3	45
Ideal Child Care	56.6	58.9	45
Pat's Nursery	38.4	40.6	45
St. Neva's Day Care Centre	39.5	41.8	45
Catherine Hall Primary & Infant	46.8	49.0	45
DRB Grant	47.3	49.5	45
Herbert Morrison High	43.3	45.5	45
Howard Cooke Primary	47.0	49.2	45
R'way Lane	38.6	40.8	45
Salvation Army	37.5	39.7	45
University of the West Indies Western Campus	37.8	40.0	45

NB: Values highlighted in red are non-compliant with the NRCA Standard

Health Centres and Hospitals

One (1) health centre and a hospital were assessed for noise impact from the traffic along the proposed West Green / Catherine Hall dualization alignment using the 2021 and 2041 traffic. Only Catherine Hall Health Centre had noise levels non-compliant with the NRCA Day and Night-time standards for both the 2021 and 2041 traffic (Table 5-43 and Table 5-44).

Table 5-43 Noise levels (day-time) at health centres and hospitals assessed for the West Green / Catherine Hall dualization for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA DAY-TIME STANDARD (dBA)
Catherine Hall Health Centre	57.6	59.9	55
Mount Salem Health Centre	34.3	36.5	55

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-44 Noise levels (night-time) at health centres and hospitals assessed for the West Green / Catherine Hall dualization for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA NIGHT-TIME STANDARD (dBA)
Catherine Hall Health Centre	51.5	53.7	50
Mount Salem Health Centre	28.1	30.3	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

Churches

Two (2) churches were assessed for noise impact from the traffic along the proposed West Green / Catherine Hall dualization road alignment using the 2021 and 2041 traffic. Holiness Born Again Church of Jesus Christ had noise levels non-compliant with the NRCA Day and Night-time standards for both 2021 and 2041 traffic (Table 5-45).

Table 5-45 Noise levels (day-time) at churches assessed for the West Green / Catherine Hall dualization for 2021 and 2041 traffic

RECEIVERS	NOISE LEVELS – 2021 (dBA)	NOISE LEVELS – 2041 (dBA)	NRCA NIGHT-TIME STANDARD (dBA)
Holiness Born Again Church of Jesus Christ	62.8	65.0	50
Holy Trinity Church	40.4	42.6	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

5.3.1.3.4 Recommended Mitigation

Two main noise mitigation strategies are recommended:

i. Conduct annual noise assessment to determine if the traffic from the highway is having a negative impact on the environment.
ii. Where necessary, noise mitigative structures should be put in place, such as noise barriers, noise berms, etc. In the same regard, adequate provision should be made to implement noise barriers for both existing developments and approved subdivisions.

The exceedances of NEPA's noise level standards at sensitive receptors from traffic noise necessitate noise mitigation. One mitigation strategy is to build noise walls to shield the affected facility from the noise source (traffic). In an effort to look at a long-term mitigation strategy the predicted noise levels from the 2041 traffic was used in the design of the walls. Preliminary noise walls were designed and optimized using SoundPlan 8.1 with the height limit for the walls set at a maximum of 8m. The resultant noise levels with mitigative noise walls are reported in Table 5-46 to Table 5-61. The dimensioned walls have resulted in the compliance of NEPA's noise standards.

Another mitigative strategy is to do noise insulation of the affected buildings (e.g. reducing gaps in doors, windows, walls or installing double pane windows) where possible. These strategies might have to be used to achieve compliance as some of the designed walls have wall heights that are considered unrealistic (e.g. >8m).

It is important to note that the noise walls discussed here are preliminary as two critical factors need to be defined for any finalization of the designs. The first is the as built road elevation and the second, the baseline noise climate at the locations. It is common knowledge that Jamaica is a noisy country and although there are established zonal noise standards rarely if at any time are these standards met. It is therefore recommended that the + 3dBA above ambient noise climate guideline be used to design the noise walls. This will help in refining the noise wall heights and lengths. The proposed guideline is in keeping with the fact that a person with average hearing will not perceived an increase in noise of 3 dBA or less. This is supported by the IFC and World Bank 3 dBA rule in which it states that a noise from a source should not result in an increase in baseline noise levels by more than 3 dBA at the nearest receptor from the source.

The changes in the noise climate along the various alignments using the 2041 traffic with mitigative noise walls installed are illustrated in Figure 5-29 to Figure 5-32.

MONTEGO BAY PERIMETER ROAD

Table 5-46 Noise levels (day-time) for schools assessed for the Montego Bay Perimeter road for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041 (dBA) MITIGATED	NRCA DAY-TIME STANDARD (dBA)
Granville Day Care	24.8	22.8	45
Rosemount Day Care	30.9	34.6	45
Catherine Hall Day Care	32.1	29.1	45
Holy Family Day Care	19.1	28.4	45
Holiday Inn Kidspree Centre	37.7	35.2	45
Pat's Nursery	30.5	28.2	45
Comfort Day, Care Centre	41.0	28.0	45
St. Neva's Day Care Centre	32.3	28.5	45
Ideal Child Care	31.9	31.0	45
Kidz World	41.1	32.5	45
Howard Cooke Primary	27.6	28.8	45
Herbert Morrison High	35.0	31.2	45
Salt Spring All Age	29.8	25.9	45
Bogue Hill All Age	42.0	37.0	45
Corinaldi Primary	31.0	23.7	45
Catherine Hall Primary & Infant	31.5	29.3	45
Ramble Hill	41.9	36.8	45
Open Bible	22.2	26.5	45
Hartfield Primary & Jnr. High	31.0	27.2	45
DRB Grant	27.5	28.7	45
Irwing High	26.1	25.4	45
Irwing All Age	26.5	25.9	45
Green Pond Primary	32.4	24.5	45
Green Pond High	31.9	29.8	45
University of the West Indies Western Campus*	62.1	51.7	45

Table 5-47 Noise levels (day-time) at health centres and hospitals assessed for the Montego Bay Perimeter road for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041 (dBA) MITIGATED	NRCA DAY-TIME STANDARD (dBA)
Granville Health Centre	29.3	28.2	55
Green pond Health Centre	31.5	29.8	55
Mount Salem Health Centre	37.2	35.0	55
Catherine Hall Health Centre	33.7	33.8	55

Table 5-48 Noise levels night-time) at health centres and hospitals assessed for the Montego Bay Perimeter road for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS– 2041 (dBA) MITIGATED	NRCA NIGHT-TIME STANDARD (dBA)
Granville Health Centre	23.1	21.9	50
Green pond Health Centre	25.2	23.5	50
Mount Salem Health Centre	31.0	28.7	50
Catherine Hall Health Centre	27.4	27.5	50

Table 5-49 Noise levels (day-time) at churches assessed for the Montego Bay Perimeter road for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041 (dBA) MITIGATED	NRCA NIGHT-TIME STANDARD (dBA)
Salt Spring Church 1	42.0	40.9	50
Salt Spring Church 2	29.2	25.5	50
Salt Spring Church 3	36.8	29.7	50
Salt Spring Church 4	32.4	31.4	50
Salt Spring Church 5	41.4	41.5	50

LONG HILL BYPASS

Table 5-50 Noise levels (day-time) for schools assessed for the Long Hill Bypass road for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041 (dBA) MITIGATED	NRCA DAY-TIME STANDARD (dBA)
Anchovy High	41.0	27.0	45
Anchovy Primary	37.4	33.9	45
Bogue Hill All Age	49.6	45.5	45
Herbert Morrison High	31.8	28.1	45
Anchovy Pre and Infant School	56.5	41.8	45
University of the West Indies Western Campus	49.3	46.3	45

Table 5-51 Noise levels (day-time) at health centres and hospitals assessed for the Long Hill Bypass road for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041 (dBA) MITIGATED	NRCA DAY-TIME STANDARD (dBA)
Mount Carey Health Centre	21.9	19.6	55

Table 5-52 Noise levels (night-time) at health centres and hospitals assessed for the Long Hill Bypass road for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041 (dBA) MITIGATED	NRCA NIGHT-TIME STANDARD (dBA)
Mount Carey Health Centre	15.7	13.4	50

Table 5-53 Noise levels (day-time) at churches assessed for the Long Hill Bypass road for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041 (dBA) MITIGATED	NRCA NIGHT-TIME STANDARD (dBA)
Mount Carey Baptist Church	42.0	39.9	50
Unnamed Church 1	37.3	37.3	50
Unnamed Church 2	26.2	22.3	50
Unnamed Church 3	59.2	43.5	50
Unnamed Church 4	70.8	48.4	50

BARNETT STREET

Table 5-54 Noise levels (day-time) for schools assessed for the Barnett Street dualization for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041 (dBA) MITIGATED	NRCA DAY-TIME STANDARD (dBA)
Catherine Hall All Age Primary & Infant	50.4	48.1	45
Catherine Hall Day Care	44.7	41.8	45
Holy Family Day Care	42.0	42.0	45
Ideal Child Care	49.4	44.8	45
Kidz Paradise	31.1	30.5	45
Mama's Day Care Centre	37.6	35.1	45
Pat's Nursery	47.2	46.6	45
St. Neva's Day Care Centre	53.8	53.4	45
Wee Care Day Care	33.3	30.0	45
Barracks Road Primary	34.1	32.3	45
Challenge	30.3	29.4	45
Corinaldi Primary	37.8	36.2	45
DRB Grant	41.2	40.0	45
Faith Basic	32.4	30.4	45
Herbert Morrison High	39.9	38.4	45
Howard Cooke Primary	41.2	40.1	45
Montego Bay Infant	34.1	32.3	45
Mount Salem Primary & Jnr. High	45.5	39.8	45
Pilgrim Ho	37.4	34.7	45
R'way Lane	39.4	37.5	45
Salvation Army	39.4	37.2	45
St James High	32.7	32.6	45
Wee Care	30.6	30.1	45
University of the West Indies Western Campus	39.6	39.1	45

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-55 Noise levels (day-time) at health centres and hospitals assessed for the Barnett Street dualization for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041 (dBA) MITIGATED	NRCA DAY-TIME STANDARD (dBA)
Catherine Hall Health Centre	57.0	46.8	55
Mount Salem Health Centre	40.0	39.8	55
Cornwall Regional Hospital	31.1	31.0	55

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-56 Noise levels (night-time) at health centres and hospitals assessed for the Barnett Street dualization for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041 (dBA) MITIGATED	NRCA NIGHT-TIME STANDARD (dBA)
Catherine Hall Health Centre	50.8	40.6	50
Mount Salem Health Centre	33.8	33.6	50
Cornwall Regional Hospital	24.9	24.8	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-57 Noise levels (day-time) at churches assessed for the Barnett Street dualization for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041 (dBA) MITIGATED	NRCA NIGHT-TIME STANDARD (dBA)
Holiness Born Again Church of Jesus Christ	51.4	45.5	50
Holy Trinity Church	53.7	53.6	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

WEST GREEN / CATHERINE HALL DUALIZATION

Table 5-58 Noise levels (day-time) for schools assessed for the West Green / Catherine Hall dualization for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041(dBA)	NOISE LEVELS – 2041(dBA) MITIGATED	NRCA DAY-TIME STANDARD (dBA)
Catherine Hall Day Care	58.7	48.7	45
Holy Family Day Care	36.3	31.1	45
Ideal Child Care	58.9	49.1	45
Pat's Nursery	40.6	34.3	45
St. Neva's Day Care Centre	41.8	35.3	45
Catherine Hall Primary & Infant	49.0	42.9	45
DRB Grant	49.5	41.6	45
Herbert Morrison High	45.5	45.1	45
Howard Cooke Primary	49.2	41.5	45
R'way Lane	40.8	33.6	45
Holiness Basic School	63.5	58.2	45
Salvation Army	39.7	33.5	45
University of the West Indies Western Campus	40.0	39.5	45

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-59 Noise levels (day-time) at health centres and hospitals assessed for the West Green / Catherine Hall dualization for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041(dBA) MITIGATED	NRCA DAY-TIME STANDARD (dBA)
Catherine Hall Health Centre	59.9	58.5	55
Mount Salem Health Centre	36.5	29.7	55

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-60 Noise levels (night-time) at health centres and hospitals assessed for the West Green / Catherine Hall dualization for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041(dBA) MITIGATED	NRCA NIGHT-TIME STANDARD (dBA)
Catherine Hall Health Centre	53.7	52.3	50
Mount Salem Health Centre	30.3	23.5	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-61 Noise levels (day-time) at churches assessed for the West Green / Catherine Hall dualization for 2041 traffic compared with the predicted noise levels with proposed noise walls installed

RECEIVERS	NOISE LEVELS – 2041 (dBA)	NOISE LEVELS – 2041(dBA) MITIGATED	NRCA NIGHT-TIME STANDARD (dBA)
Holiness Born Again Church of Jesus Christ	65.0	55.6	50
Holy Trinity Church	42.6	38.5	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

5.3.1.3.5 Occupational Noise

There are no data for worker noise exposure for highways 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.

RECOMMENDED MITIGATION

An annual noise exposure survey should be conducted to determine the impact of traffic noise on toll booth workers. Noise levels measured should be compared with Occupational Safety and Health Administration (OSHA) Hearing Conservation and Permissible Exposure Limit (PEL) and the American Conference of Industrial Hygienists (ACGIH) recommended levels.

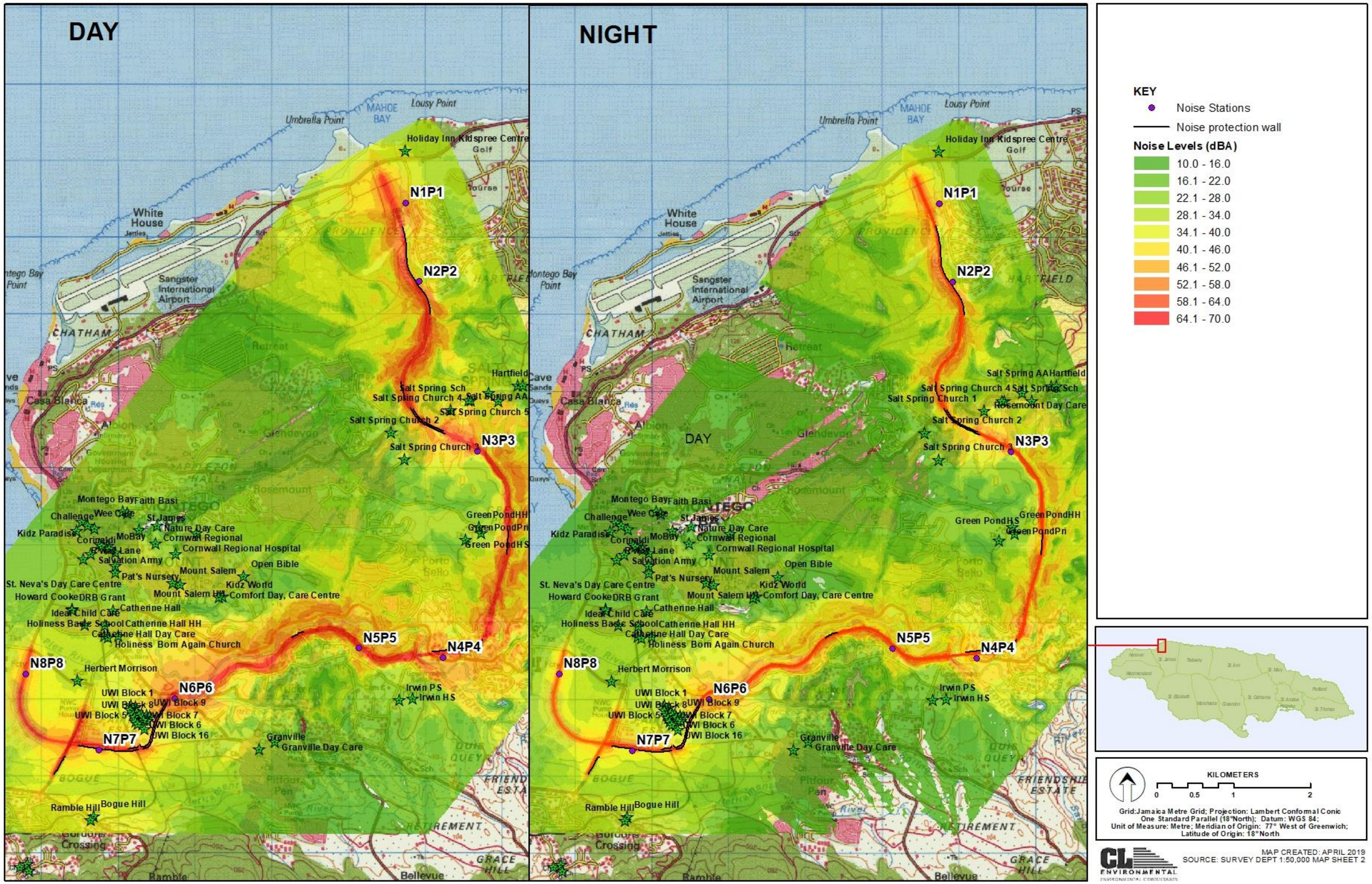


Figure 5-29 Montego Bay Perimeter road (using 2041 traffic) noise emissions with mitigative noise walls installed

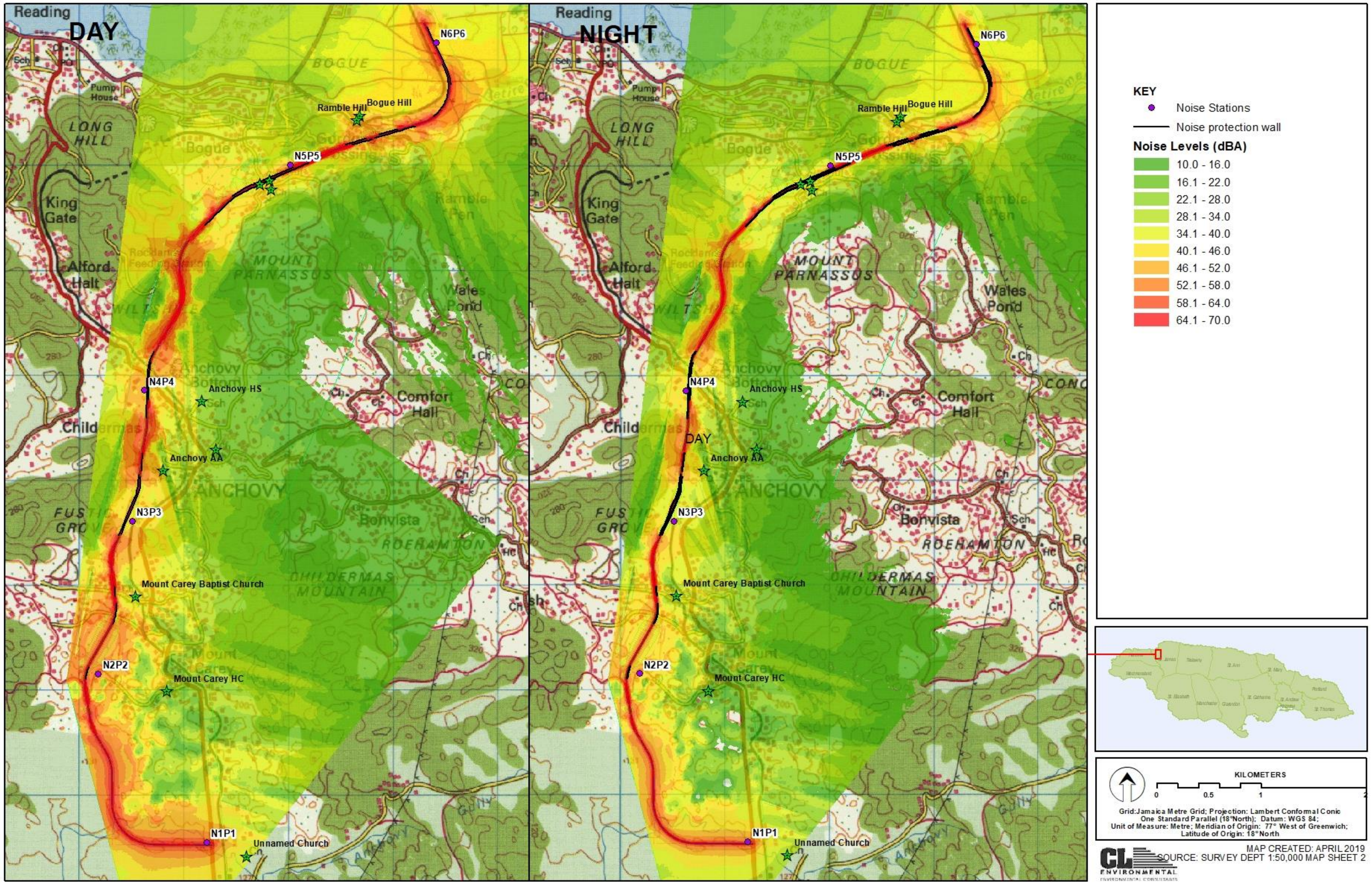


Figure 5-30 Long Hill Bypass (using 2041 traffic) noise emissions with mitigative noise walls installed

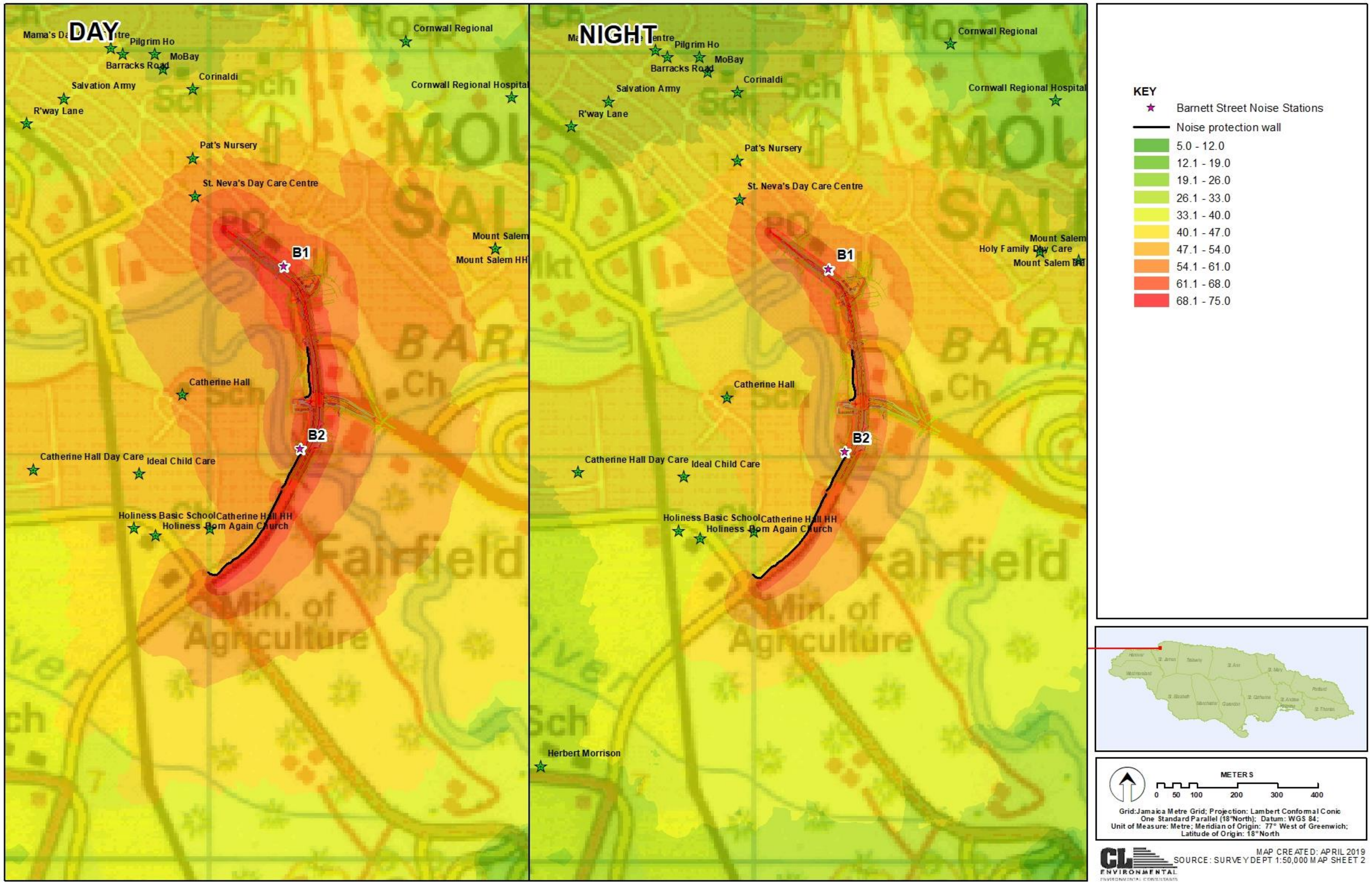


Figure 5-31 Barnett Street upgrade (using 2041 traffic) noise emissions with mitigative noise walls installed

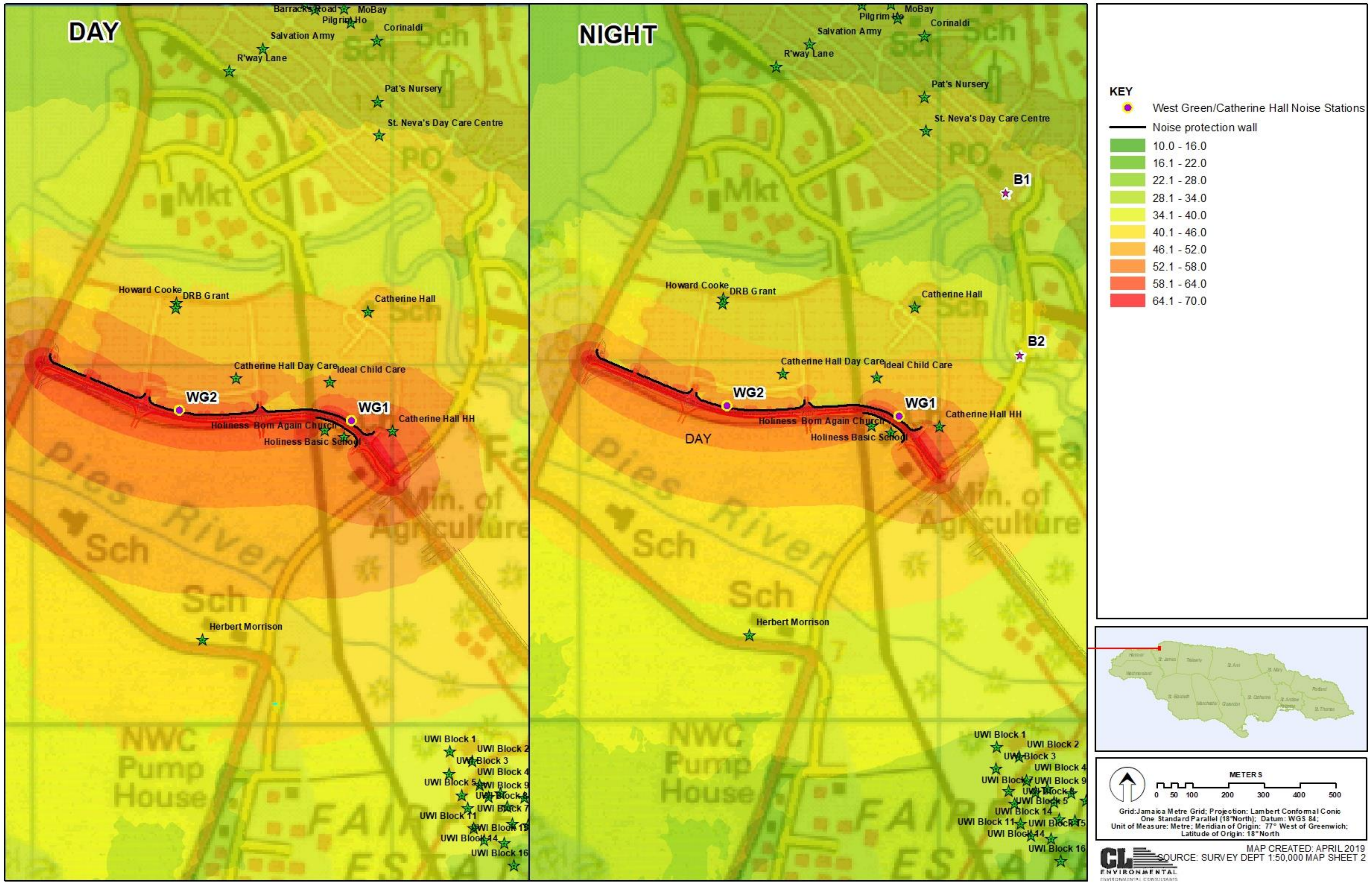


Figure 5-32 West Green Avenue upgrade (using 2041 traffic) noise emissions with mitigative noise walls installed

5.3.1.4 Air Quality

The potential for vehicular emissions from this project negatively affecting air quality to an extent where health of nearby residents may also be negatively impacted, is low.

It should be noted that vehicular emissions are highest at the time of vehicle start up in the morning (cold start). This is due to the fact that the first few minutes of driving generate higher emissions because the emissions-control equipment has not yet reached its optimal operating temperature (U.S. Environmental Protection Agency). Also, emission rates are higher during stop-and-go, congested traffic conditions than free flow conditions operating at the same average speed.

5.3.1.4.1 Occupational Air Quality

Due to vehicles slowing down and stopping at toll booths during commute, there is increased exposure by toll booth workers to vehicle emissions throughout the course of their work shifts. This exposure may result in short or long term negatively impacted health.

RECOMMENDED MITIGATION

An annual air emissions exposure survey should be conducted to determine the impact of vehicle emissions on toll booth workers. Concentrations of SO_2, NO_x, CO, $PM_{2.5}$ and PM_{10} should be measured and compared with Occupational Safety and Health Administration (OSHA) standards and guidelines.

5.3.1.5 Vibration

Occasionally, transportation agencies receive complaints from residents living near roads about annoying or even structurally damaging traffic-induced vibration.

Traffic-induced vibration is either ground-borne vibration or air-borne vibration or a combination of both. Site specific factors influence vibration levels. These include the characteristics of the highway traffic flow, unevenness of pavement surface, transmission path between the source and the receiver, and building parameters. In extreme circumstances, traffic-induced ground-borne vibration may be perceptible to residents living near roads. However, it is very unlikely to result in damage to residential buildings. Air-borne vibration may increase sound levels inside residences due to the resonance of light building components. The vibration of these components can also contribute to the feeling of vibration inside a room (Hajek J, Chris T. Blaney and David K. Hein, 2006).

Ground-borne vibration is caused by the dynamic impact forces of tyres on the pavement surface that can propagate and excite footings and foundation walls below ground. Vibration of footings and foundation walls can induce vibration in other building components below or above ground. Air-borne vibration is caused by low frequency sound that can excite building components above ground.

There are three basic types of dynamic tyre forces acting on the pavement surface simultaneously (Figure 5-33). These are:

1) ***Impact forces of the individual parts of the tyre tread***. The impact frequency of these forces on the pavement, at highway speeds, is typically in the range of 800 to 1500 Hz, depending on

the pavement macrotexture and on the tyre tread pattern. Although the forces associated with the individual parts of the tyre tread are significant producers of pavement-tyre noise, their contribution to the ground-borne vibration is negligible.

2) ***Impact forces linked to the unsuspended mass of the vehicle***. The unsuspended vehicle mass is the mass below the vehicle suspension system, mainly axles, wheels, and tyres. At highway speeds, a specific part of the tyre comes into contact with the pavement surface about 10 to 15 times per second. This frequency is related to the frequency of the tyre bounce (also called axle hop).
3) ***Impact forces linked to the fundamental frequency of trucks***. At highway speeds, a typical 5-axle tractor semi-trailer has the fundamental frequency of the suspended mass of about 1 or 2 Hz. Thus, the suspended mass (the part of the truck supported by the suspension system) heaves up and down about 1 or 2 times per second as the truck moves at highway speeds. When the truck heaves down, its static weight on the pavement increases due to the dynamic motion component.

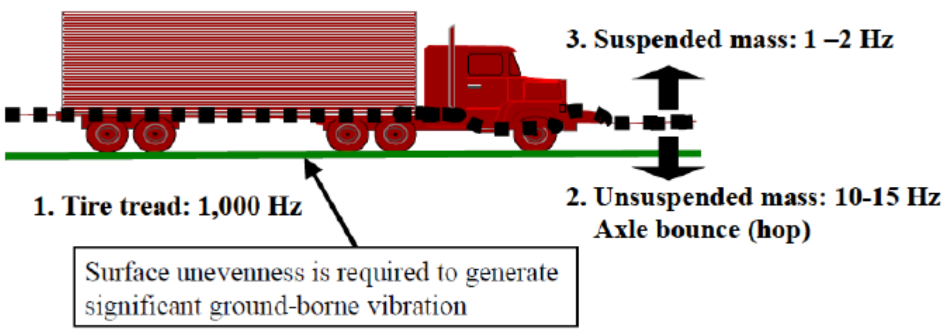


Figure 5-33 Source of vibration caused by a truck

The three types of tyre impact forces interact and produce ground-borne vibration with the dominant frequency, at highway speeds, between 10 and 15 Hz. Air-borne vibration is caused by low frequency sound, produced by engines and exhaust systems of large diesel trucks, which can excite building components above ground. The fundamental frequency of truck exhaust systems (engine combustion and firing) is typically 50 to 200 Hz, and this frequency may correspond to the fundamental frequency of light building components.

There is a correlation between the way people perceive highway noise and highway traffic induced vibration. With the increase of sound level, the number of people who complain about high noise level increases and so does the number of people who complain about vibration. Sound and vibration caused by the same source also interact. For example, sound may result in vibration of a window pane and the pane may rattle, or, in an extreme case, ground-borne vibration can vibrate room surfaces, such as a floor, and produce ground-borne noise in the form of rumbling sound.

5.3.1.5.1 West Green Avenue

There is a potential for vibration nuisance from vehicular traffic traversing West Green Avenue, particularly from the heavy-duty vehicles. The vibration impact was predicted on the same four (4) closest receptors (houses which would be 0.3m, 0.5m, 1.7m and 3m away), using a loaded truck as the operating equipment/vehicle.

Results showed that the PPV vibration values at the four locations (0.3m, 0.5m, 1.7m and 3m away) were: 41.16 mm/sec., 23.36 mm/sec., 6.08 mm/sec. and 3.25 m/sec. respectively.

When compared to the standards as outlined in Table Table 3-32 and Table 3-33, from a building standpoint, the vibration levels predicted have minimal potential to cause damage to weak and sensitive structures (for houses 1.7m and 3m away), while there is potential for architectural damage of buildings with plastered ceilings and walls (for houses 0.3m and 0.5m away). From a human standpoint, persons residing inside of these houses would perceive vibrations to be bothersome and unpleasant especially if continuous.

Compared to what is currently being experienced by some residents living along West Green Avenue, predicted vibration levels from the loaded truck will be worst after the road improvements, due to the proximity of the houses to the road.

5.3.1.5.2 Montego Bay Perimeter Road

The vibration impact was predicted on the same five (5) closest receptors (houses which would be 31m, 35m, 38m, 40m and 50m away) using a loaded truck as the operating equipment/vehicle. Results showed that the PPV vibration values at the five locations (31m, 35m, 38m, 40m and 50m away) all had values between 0.15 and 0.25 mm/sec. At this level, vibration would have no effect on the structures and persons residing inside these houses would barely perceive the vibration.

5.3.1.5.3 Long Hill Bypass

The vibration impact was predicted on the same three (3) closest receptors (houses which would be 15m, 18m and 20m away) using a loaded truck as the operating equipment/vehicle. Results showed that the PPV vibration values at the three locations (15m, 18m and 20m away) all had values between 0.4 and 0.56 mm/sec. At this level, vibration would have no effect on the structures, however, persons residing inside these houses may begin to get annoyed.

RECOMMENDED MITIGATION

i. Ground-borne vibration induced by highway traffic can be effectively controlled by the maintenance of smooth roadway surfaces.
ii. The solution for air-borne vibration is increasing the sound transmission loss of exterior walls, doors and windows, tightening of loose elements of a building or a room, and making the interior of rooms more sound absorbing.
iii. Erect signs reminding drivers of the heavy-duty vehicles not to use their engine brakes unnecessarily.

iv. Reduction of the speed limit along West Green Avenue so as to have minimal vibration impact by trucks.

5.3.1.6 Hazard Vulnerability

5.3.1.6.1 Landslides

It was identified that over the 25km length of the proposed highway alignment, the mid-section segment between chainages 12+800 and 18+000 is the most vulnerable length to landslides. In total, there have been twenty-two (22) locations along the proposed highway alignment identified as being susceptible to landslides. Of the twenty (20) visited susceptible landslide areas, only a few showed visible signs of past landslides or a likelihood of its occurrence in the future. While the other sites may not show visible signs, other factors such as the geology and presence of a fault area may invisibly influence and affect the susceptibility.

RECOMMENDED MITIGATION

i. 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 bore hills, 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.
ii. The implementation 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.
iii. Re-profiling the slope with the purpose of improving stability by either reducing the slope angle or cutting benches into the face of the soil. There are three options: Balanced cut and fill, full bench cut or through cut.
iv. 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:
v. Constructing rockfall protection mesh systems, for example catch fences, rockfall drapery or rockfall netting, which are made from high-tensile steel wire.
vi. The implementation of soil erosion preventative measures, for instance, geomats, geogrids or brushwood mats, as water near the surface of the hillside may cause the erosion of surface material.

5.3.1.6.2 Climate Change and Flooding

Several areas contiguous to the alignment presently experience flooding as a result of the rivers/gullies that cross the alignment. From the interviews conducted, it can be concluded that three (3) main channels contribute to flooding in their respective areas: Salt Spring Gully, North Gully and South Gully. Significant floodplain encroachment has occurred for the mentioned channels and as a result infrastructure in close proximity is at high risk of flooding during high-intensity rainfall or storm events.

The highway construction will interrupt the natural storm flow pattern and further exacerbate the flooding problems being experienced; densely populated areas will be particularly vulnerable. Additionally, climate change impacts identified within the context of the highway include increase runoffs caused by more intense storms.

RECOMMENDED MITIGATION

Overall, in order to more precisely determine the impact of the flooding in each area, it is recommended that a full hydrological study of the associated flood plains be conducted. The study will provide greater detail on the impact of flooding along the alignments, as well as provide guidance for appropriate mitigation techniques used.

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:
    a. 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;
    b. The 100-year return period rainfall event under wet antecedent conditions should be considered
    c. 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.
    d. Verification of hydrological model with WRA stream gauge data were 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. 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 for the re-alignment of the Montego River, 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 before construction.
iv. Stormwater drainage systems should be maintained meticulously to minimize the chances of blockage due to debris.
v. Implementation of erosion control, sedimentation and debris flow mitigation measures upstream of the affected areas.
vi. 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
vii. 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
viii. Create larger openings in relation to drainage and culverts to allow a greater volume of water to flow or escape.

5.3.2 Biological

5.3.2.1 Flora

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 surrounded protected area. Increased access to these vegetated areas (mangroves included) could also result in increased logging.

RECOMMENDED MITIGATION

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 to reduce intrusion.
iii. Proper planning regarding access points should be established.
iv. Further policy planning will be required for the establishment of development zones within nearby lands, villages and towns.

5.3.2.2 Fauna

See section 5.2.2.2 for descriptions and recommended mitigation for the following impacts:

1. Habitat Loss and Fragmentation
2. Habitat Degradation

5.3.2.3 Mangrove Community (Bogue Lagoon)

Further mangrove degradation may occur if proper drainage and hydrology associated with the proposed roadway is not implemented, resulting in changes in water levels and water salinity necessary for the mangrove forest to thrive. This also includes the existing UWI mangrove rehabilitation sites to the north of the alignment.

The prop root community may be affected by changes the general degradation and loss of mangroves as well as changes in drainage and other environmental factors.

RECOMMENDED MITIGATION

i. Highway should be constructed with ample culverts to maintain the tidal connectivity of the mangrove forest. Culverts should be designed in-keeping with expected tidal fluctuations and account for sea-level rise
ii. Overflow of raw/poorly treated sewage should be avoided from nearby NWC plant, in addition to sewage sources from storm drains should be eliminated.
iii. Run-off from the highway should not be channelled directly into the lagoon; but diverted to west of the highway where the extensive mangrove forest system may act as a buffer.

See also recommended mitigation under section 5.2.2.4.

5.3.2.4 Benthic Community

The surrounding benthic community may be impacted by the general degradation and changes in the natural environment.

RECOMMENDED MITIGATION

See recommended mitigation under section i.

5.3.3 Human/ Social

5.3.3.1 Housing/ Residents

The proposed alignments have the potential to open up access to new areas for housing/residential development, and similarly increased access to educational facilities, commercial enterprises and recreation amenities. On the other hand, increased noise, dust and light pollution, and aesthetics are potential impacts for residents situated in proximity to the new alignments (see sections 5.3.1.4, 5.3.1.5, 5.3.3.4.2 and 5.3.3.7).

RECOMMENDED MITIGATION

See recommended mitigation for noise, air and light pollution and aesthetics in sections 5.3.1.4, 5.3.1.5, 5.3.3.4.2 and 5.3.3.7.

5.3.3.2 Employment

There is the potential for an increase employment during the operation phase. In addition, the improvement of the traffic infrastructures will attract more investments, which is favourable for creating more jobs for the areas impacted by the project.

RECOMMENDED MITIGATION

No mitigation required.

5.3.3.3 Transportation

As part of the feasibility report and preliminary design for an alternative route around the central business district (CBD) in Montego Bay, future network scenarios were analyzed with traffic grown by a factor of 1.35 to reflect a 1.3% growth rate for 23 years (Stanley Consultants Inc., 2014). A trip generation analysis was also done for all pending and approved developments in close proximity to the proposed bypass.

If a bypass to the central business district was built (proposed Montego Bay Perimeter Road), based on the current projections from the origin-destination (OD) study, the through volumes along Elegant Corridor, Queens Drive, Howard Cooke Boulevard and Alice Eldemire would be reduced by 100-400 vehicles in the AM peak. The OD study suggested OD pairs that were likely to use the bypass, then a stochastic (Kirchhoff) model was developed to estimate the route choice based on the level of congestion along the existing road. Based on this model only 33% of the demand chose to use the local roads during the congested times. The volumes that were therefore able to use the bypass were reduced by 33% to account for the drivers who would still choose the more congested route. Table

Table 5-62 shows the estimated peak hour capture rate and volumes for the highway based on the OD survey.

Table 5-62 Estimated peak hour bypass capture per surveyed location

Source: (Stanley Consultants Inc., 2014)

Survey Location	% Able to Use Bypass	% Capture	AM Peak Hour Volume	Capture Volume
Bogue	14%	9%	3039	285
Fairfield	19%	13%	1749	223
Ironshore	27%	19%	2026	384
Salt Spring	26%	18%	1262	227
Porto Bello	16%	11%	848	91

In additional to these projections, additional diverted trips were projected in the OD study based on cruise shipping and increases in hotel rooms west of Montego Bay. The OD estimated an additional 817 vehicle trips per day in 2040. A K-factor if 0.1 was assumed to convert these daily trips to AM peak hour trips.

Table 5-63 shows a comparison of the 2040 No-Build scenario with the 2040 network with the trips diverted to the proposed bypass, but without additional improvements to the network beyond the intersections to accommodate the bypass road. Delays are generally reduced and there are obvious improvements in LOS with the addition of a Montego Bay Bypass. Through volumes on Howard Cooke Boulevard, Alice Eldemire Drive, Queens Drive and Gloucester Avenue will be reduced and these reductions will mitigate against the impact of the future growth in through volumes at all intersections along these corridors. The Bypass, however, may not significantly impact the turning volumes at these intersections. With the decreased demand for green time on the through movements, additional time can be allocated to the protected turning movements which will improve the performance of those lane groups.

Table 5-63 Network performance of no-build versus proposed bypass

	2040 No-Build with Programmed Improvements		2040 with Bypass	
	LOS	Control Delay (s)	LOS	Control Delay (s)
Howard Cooke/Alice Eldemire	F	323.7	F	130.9
Howard Cooke/West Green	F	142.7	E	58.1
Alice Eldemire/Bogue	F	145.7	B	12.2
Barnett Street/Fairfield	F	99.8	F	100.2
Howard Cooke/Lower Bevin	F	143.8	F	85.1
Bogue Road/Temple Gallery	F	241.8	D	Overpass
Howard Cooke/Barnett Street	F	81.1	C	26.2
Howard Cooke/Market Street	F	157.5	E	72.2
Howard Cooke/Gloucester/Queens	F	189.8	D	54.0
Barnett Street/Porto Bello	F	112.9	F	105.5

Queens Drive/Leaders Avenue	D	39.7	D	39.7
Elegant Corridor/Providence	F	103.1	D	44.9
Elegant Corridor/Morgan Road	F	132.4	F	115

RECOMMENDED MITIGATION

No mitigation required for the proposed project.

However in addition to the proposed project, the following recommendations may be considered to alleviate the problem of reducing roads to single-lane traffic to facilitate parking, stopping, waiting and delivery of goods in the CBD:

i. Parking and delivery solutions be explored to alleviate congestion within the CBD. The Bay West Shopping Plaza is a major bottle neck on Harbour Street however there is no chance to add any additional parking on site. With this major parking issue as well as the prevalence of on-street parking in no-parking areas, a parking structure close to the Bay West Shopping Plaza would be recommended.
ii. Opening up Market Street to reduce the short weaving sections on other streets and the blockages on Market Street and Harbour Street.
iii. Traffic signals coordinated in the CDB to create platoons and limit queue lengths to allow signals to operate more efficiently.
iv. Due to the high number of turning manoeuvres at all intersections on Howard Cooke Boulevard, roads directly connected to Howard Cooke must be kept clear from illegal parking, as well as queue spillbacks from intersections within the City centre for Howard Cooke Boulevard to operate more efficiently.

5.3.3.4 Health and Emergency

5.3.3.4.1 Vehicular Accidents

Upon completion, the improved road will likely cause an increase in vehicular speeds. The increase in speeds will decrease the travel time, increase capacity and increase efficiency of the road network, however it may also result in an increase in traffic crashes.

RECOMMENDED MITIGATION

Mitigation against an increase in crashes from an increase in vehicular speeds can be addressed with design elements such as rumble strips, adequate marking and signage, and a continued police presence and surveillance. Traffic signal warrants should be conducted taking into consideration increased vehicle speeds and the speed differentials on the side roads. Several traffic calming techniques can also be considered at intersections to improve safety including rumble strips, roundabouts, surface texture, turning movement diverters, and chicanes.

5.3.3.4.2 Light Pollution

The following section is an excerpt taken from the *U.S. Department of Transportation – Federal Highway Administration (FHWA) Lighting Handbook,* 2012.

Driving or walking on, or across, a roadway is less safe in darkness than in a lit area, due to the reduced visibility of hazards and pedestrians. Though the number of fatal crashes occurring in daylight is about the same as those that occur in darkness, only 25 percent of vehicle-miles travelled occur at night. Because of that the night-time fatality rate is three times the daytime rate. Being able to adequately see the road/street ahead and observe conflicting traffic and the behaviour of other highway users is integral to the driving task. Lighting significantly improves the visibility of the roadway, increases sight distance, and makes roadside obstacles more noticeable to the driver, and therefore more avoidable. Studies have shown a reduction in night-time fatal crashes of up to 60% with the use of roadway lighting (Norweigan University of Science and Technology, 2009).

The possibility of lighting along the proposed Montego Bay Perimeter Road and Long Hill Bypass Alignments may be at the exit ramps and toll plazas. Toll plazas have not been included in the design plans; however, areas have been identified where toll plazas can be located. Lighting provides the benefit of improving safety for motorists and pedestrians; however, it also has a larger impact on our night-time environment. Ongoing research demonstrates the impact of lighting at night as it relates to human health.

Light trespass (obtrusive lighting) is defined by three major interrelated elements. The three elements are:

1. **Spill light:** Light that falls outside the area intended to be lit, resulting in potential discomfort and annoyance.
2. **Glare:** Light that is viewed at the light source (luminaire), which reduces one's visibility. Glare occurs when light is scattered in the human eye, resulting in a visual haze, thus reducing visibility.
3. **Sky Glow:** Light reflected from the light source, road or other surfaces up into the atmosphere. Sky glow in effect reduces one's ability to view stars in the night sky by casting unwanted light into the atmosphere. Though this is not a safety or security issue, however, international groups such as the International Dark-sky Association (IDA) have mounted strong campaigns to reduce sky glow and protect visibility of the night sky. Sky glow will also affect persons who partake in recreational stargazing.

The two most likely impacts from toll plaza and exit ramp lighting on surrounding residents are: Spill Light and Sky Glow.

Figure 5-34 illustrates these three light trespass scenarios.

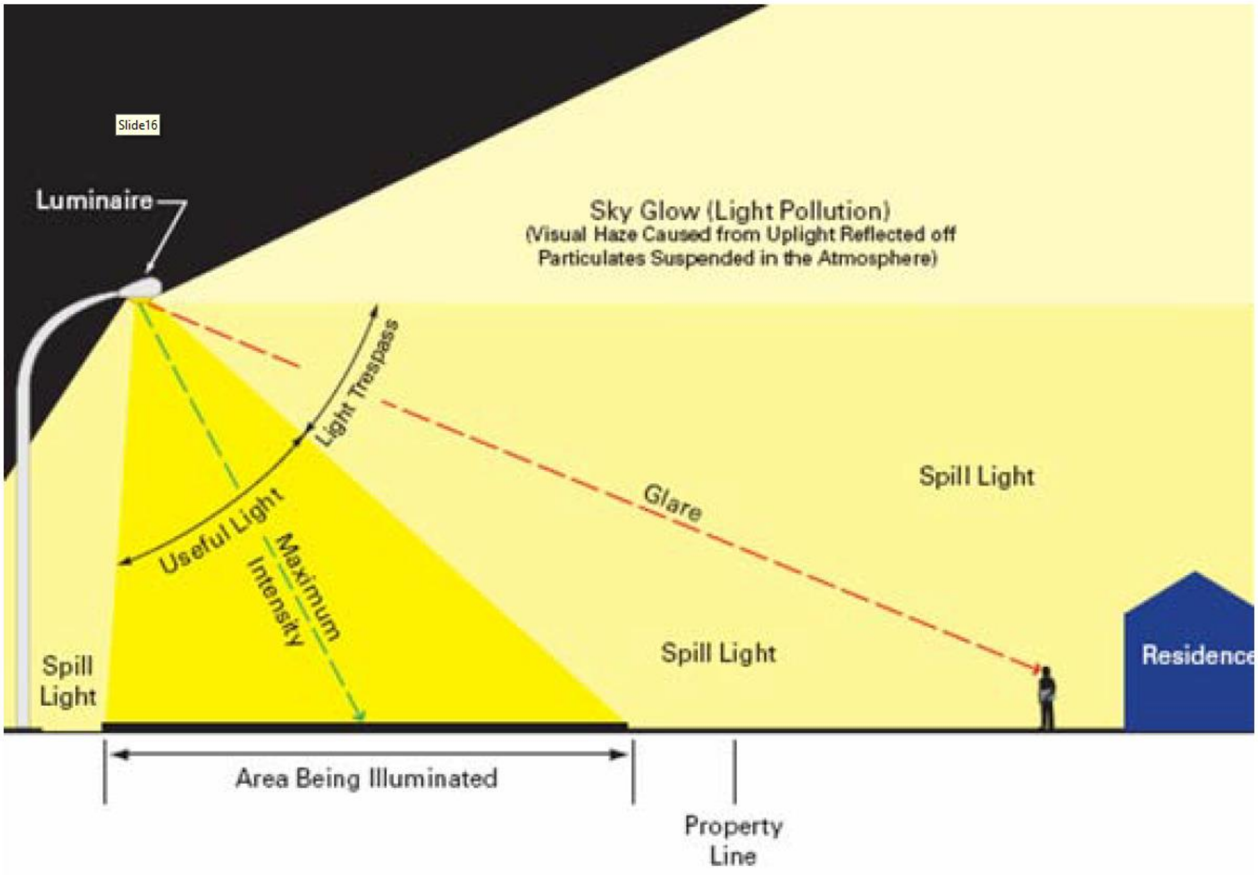


Figure 5-34 Diagram demonstrating the types of obtrusive lighting: Spill Light, Glare and Sky Glow

RECOMMENDED MITIGATION

Maintaining an effective balance between the reduction of light trespass and the provision of quality, beneficial lighting requires thoughtful design and the selection of luminaires with cut-off or full cut-off optical systems. The amount of glare generated by a luminaire is strongly influenced by the intensity emitted at angles close to the horizontal. Lighting design with full cut-off optics will typically reduce skyglow and spill lighting. Moreover, it will reduce glare from the luminaire on and off the roadway, thus improving overall visibility for motorists.

The **Luminaire Classification System (LCS)** has been developed to define luminaire distribution and efficiency better. The LCS defines a method of evaluation and comparison of outdoor luminaires. It provides a basic model which defines maximum lumens within defined angles within primary areas. The primary LCS areas are forward light, back light, and up-light zones as defined in Figure 5-35 (top left). Each of these zones is further broken into solid angles within the area. An example of the forward light zone is shown in Figure 5-35 (top right). The benefit of this system is that it allows a designer to better select the optimal optics for a given application while at the same time reducing light trespass impacts and sky glow.

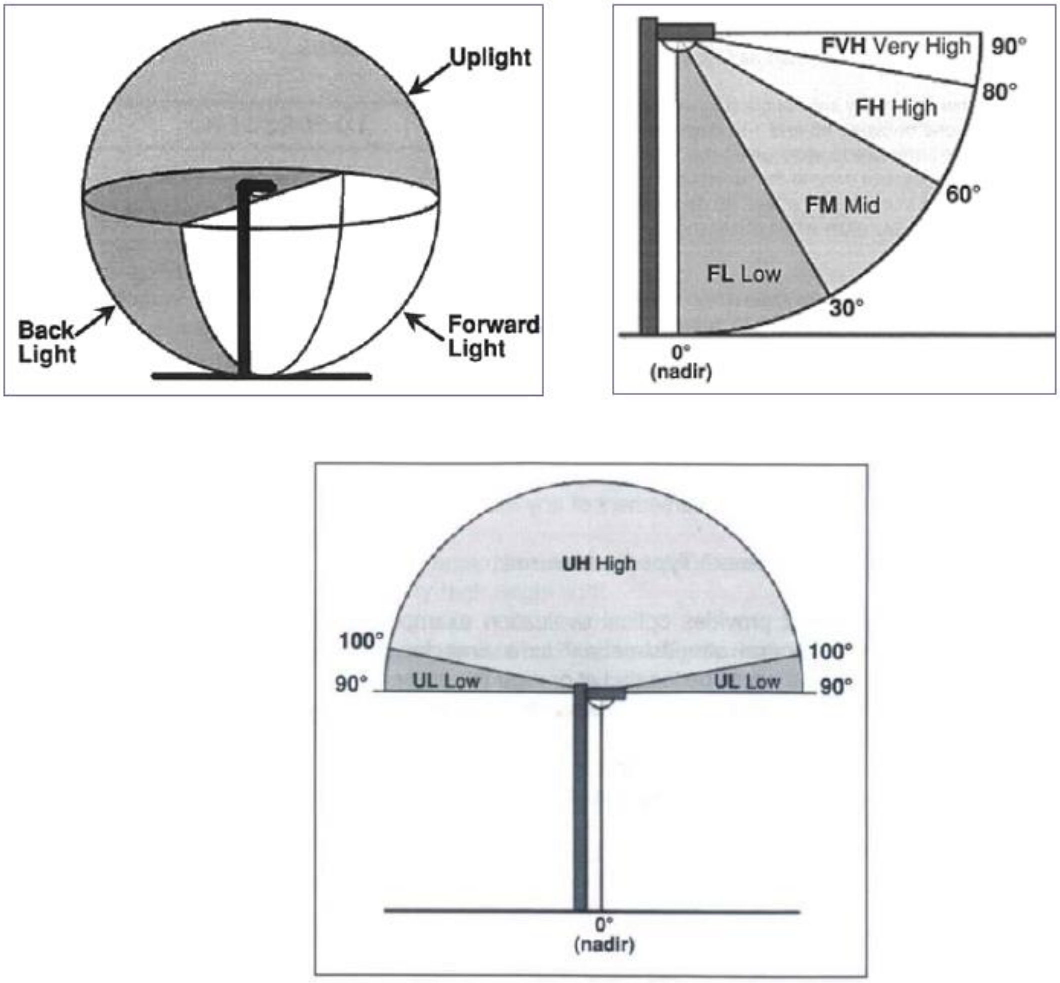


Figure 5-35 Lamp Lumen Zones and Front Light Zones

It is important to note that the reduction or elimination of light trespass must never take precedence over the provision of adequate roadway lighting. Lighting the area adjacent to roadway travel lanes (typically within or adjacent to the road right of way) can benefit a driver's peripheral vision. This can also provide better visibility of crossroads and sidewalks. Lighting the area adjacent to the road can also help in the detection of large animals that may pose a safety hazard. Balancing the needs of the road user with any potential impacts of the lighting system on surrounding residences and occupants, can be difficult for many roadway types, but the issue needs to be approached holistically.

5.3.3.4.3 Disasters

There is a potential for the highway to be impacted by natural or man-made disasters such as earthquakes, floods, fires and accidents. Other miscellaneous hazards that may result in potential accidents include; stray animals, dead animals, fallen tree limbs, accumulation of dirt, gravel or other granular materials, oil spills, pavement/surface defects (potholes, deformations, edge drops), missing or damaged safety barrier/guard rail/fencing at a critical location and abandoned/damaged vehicles.

RECOMMENDED MITIGATION

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).
iii. On-call emergency highway operators to attend to any situation that may result in potential accidents (dead animals, fallen tree limbs, gravel, sand, oil spill etc).

5.3.3.5 Industry and Economy

5.3.3.5.1 Tourism

With the tourism sector expected to grow at 3.8% per annum (Jamaica Tourist Board, 2015), there is also expected to be a continued growing demand on the transportation infrastructure. This project has the potential to meet this demand and open up access to new reactional points of interest whilst providing a better transportation experience for visitors. The proposed alignments will also certainly allow for more effective movement of goods and services within the tourism industry.

RECOMMENDED MITIGATION

No mitigation required.

5.3.3.5.2 Economic Returns

After project completion, the road network of Montego will be improved, and the social-economic development of the areas covered by the project will be enhanced. The construction of the new road in this Project will improve the traffic capacity and service level of the road, facilitating the transportation of goods from the airport to the surrounding areas and the business travel, and promoting the regional economic development. The short-lived inconvenience of the construction will be far out shunned when compared to the transportation and economic benefits after the road improvement.

The Economic Feasibility conducted for this project included an economic evaluation using the World Bank's Highway Development and Management model (HDM-4) and other methodologies in order to arrive at a coherent economic result (Stanley Consultants Inc., 2018). One of the primary steps in such analyses is the definition of at least one scenario which contains at least one "do-something" alternative and one "do-nothing" alternative to compare to. In the case of this project, two scenarios, which are the Base Case (Gloucester Ave restricted) and a Sensitivity Scenario (Gloucester Ave is open for traffic) were specified. Each of these have one do-nothing alternative, and 2 do-something alternatives. From an economic feasibility standpoint, the Base Case is almost feasible, with an Economic Internal Rate of Return (EIRR)[7] of 11.6%, NPV of -3.0 million US dollars, with a high FYRR of 14.6% (i.e. the project should not be delayed) (Stanley Consultants Inc., 2018). In order to achieve

[7] Internal Rate of Return (IRR) - a common economic index which evaluates the rate of return of a given capital investment.
Net Present Value (NPV) - a given investment, shows, in simple terms, whether that investment is economically feasible or not.
First Year Rate of Return (FYRR) - used for timing investments (i.e., when to invest) and is equal to the first year of benefits, divided into the full discounted costs

these benefits, Gloucester Ave must remain restricted, and it will be necessary to perform routine maintenance and periodic maintenance on the Perimeter Road. The sensitivity analysis revealed the necessity of Gloucester Ave remaining restricted, since the opening of Gloucester Ave causes a significant reduction in benefits, due to the decrease in the speed differential between the do-nothing alternative (no Perimeter Road) and do-something alternative (Perimeter Road constructed). Additional cost increases or decreases in benefits worsen the Project's situation in terms of economic feasibility.

Based on the Consultant's labour supply impact model, a small increase in jobs and additional GDP and tax take from the implementation of this project is expected. This impact has been estimated, conservatively, at an additional $0.8 million US dollar in GDP (per year), with an additional annual tax revenue of $0.2 million resulting from jobs created as a result of this Project (Stanley Consultants Inc., 2018).

RECOMMENDED MITIGATION

As take from the Economic Feasibility report, the following was recommended (Stanley Consultants Inc., 2018):

i) Constructing the Perimeter Road with an opening year of 2022.
ii) If possible, reducing the construction cost marginally, from $142.6 million to about $138.9 million, spread over 4 years (2018-2021).
iii) Examining alternatives to allow additional capacity in 2030-1 in the area of Queens Drive. This is in light of our expectation of Queens Drive being at full capacity by that time, under a 2.6% annual growth rate assumed in the analysis.

Moreover, under current H - M-4 defaults in use in Jamaica, possible high road deterioration has been observed in the existing network. The current assumption of 4-year construction period might cause lessening of benefits. It was therefore recommended to perform an HDM-4 calibration study of the existing road network.

5.3.3.6 Land Use

5.3.3.6.1 Community Fragmentation and Accessibility

The communities of Anchovy, Bogue, Catherine Hall, Fairfield, Green Pond, Ironshore, Montego Bay Business District, Montpelier, Mt. Carey, Orange Irwin, Pitfour, Porto Bello, Salt Spring, Seven Rivers, Tucker and West Green adjoin the proposed road works. Along the alignment, there exist a number of access points including road intersections, vehicular accesses and pedestrian accesses. The alignments currently go through communities on the existing road and new alignments are primarily routed around communities. The proposed alignment will potentially fragment communities and has the potential to negatively impact movement across the corridor.

RECOMMENDED MITIGATION

Construction and use of access points including road intersections, vehicular accesses and pedestrian accesses will have to be utilized as the link between these fragmented communities.

5.3.3.6.2 Change in Land Use

No direct change in land use is expected from the road traversing through the various communities. No direct access will be provided to the highway except at the interchanges and as such, land use should remain the same.

RECOMMENDED MITIGATION

No mitigation reuired

5.3.3.7 Visual Quality/ Aesthetics

The construction of the new road alignments (Montego Bay and Long Hill) and upgrades to West Green and Barnett Street have the potential to improve aesthetics owing to the introduction of well-designed structures and vegetation during site rehabilitation (see section 6.3.4).

Newly built structures also have the potential to block scenic views and disrupt otherwise perceived scenic landscape views before the construction of the highway. In order to examine this potential impact of the proposed highway alignments 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 alignments will be from surrounding residential areas.

The following towns were represented as point locations (observer points) and assigned an offset height of 1.75 metres (~ 5 feet 9 inches) in order to account for the average height of an observer at each point:

- Montego Bay ByPass
    - Salt Spring
    - Ironshore
    - Porto Bello
    - Tucker
    - Catherine Hall
- Long Hill
    - Bogue
    - Anchovy
    - Mount Carey

The resulting viewsheds, showing areas along the proposed alignments that are visible from each point are illustrated in Figure 5-36 through to Figure 5-43. Overall, the Long Hill alignment is not as visible from surrounding areas modelled when compared with those for the Montego Bay Bypass. Residents in Anchovy will likely view more of the newly constructed Long Hill road than those in proximity to the Bogue and Mount Carey observer points. Unlike residents at observer points in Salt Spring, Porto Bello, Tucker and Catherine Hall, persons in Ironshore will not be able to see the Montego Bay Bypass from the input observer point.

The following assumptions and limitations should be borne in mind when interpreting the viewshed results:

- Some observer points are situated in relatively complex terrain and as such a single point may not always represent the view from all areas in the area.
- Engineered road heights were not used 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.

RECOMMENDED MITIGATION

The Restoration and Rehabilitation Plan as outlined in Section 6.3.4 will aid in the scenic value after the first few months of completion of road construction. In addition, the creation of scenic/ photo viewpoints form new road alignment for road users and observers will increase visual quality.

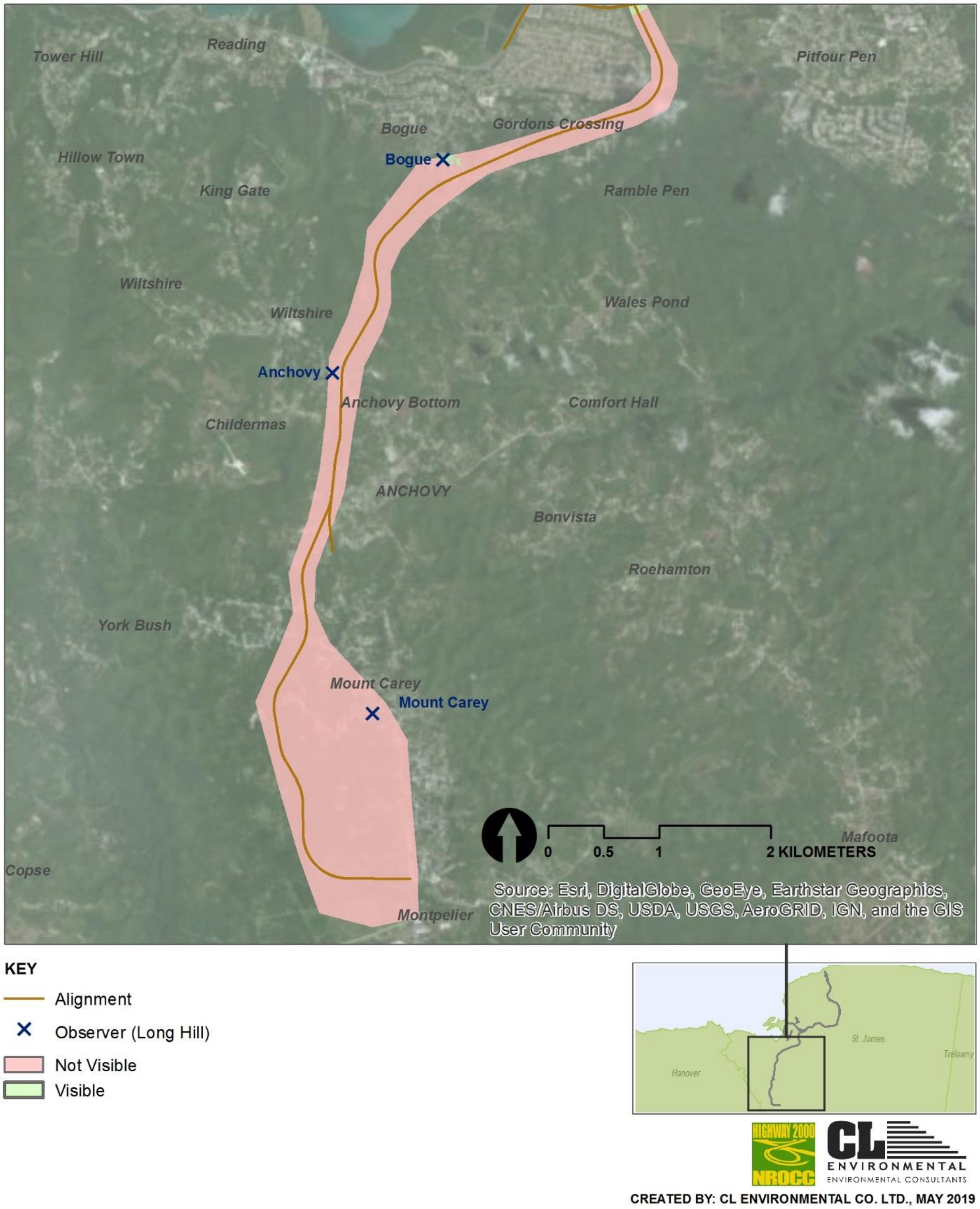


Figure 5-36 Viewshed of proposed Long Hill alignment from Bogue

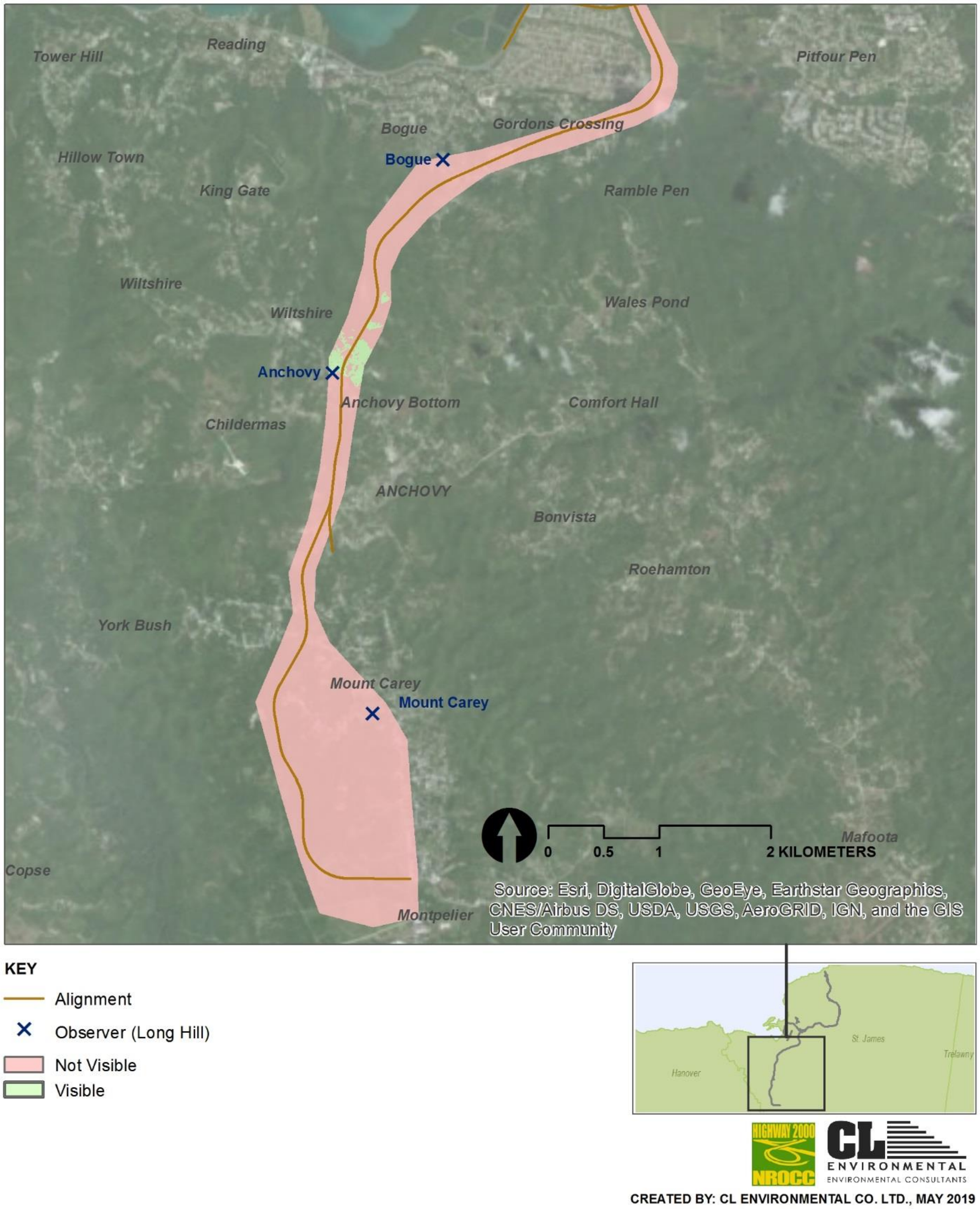


Figure 5-37 Viewshed of proposed Long Hill alignment from Anchovy

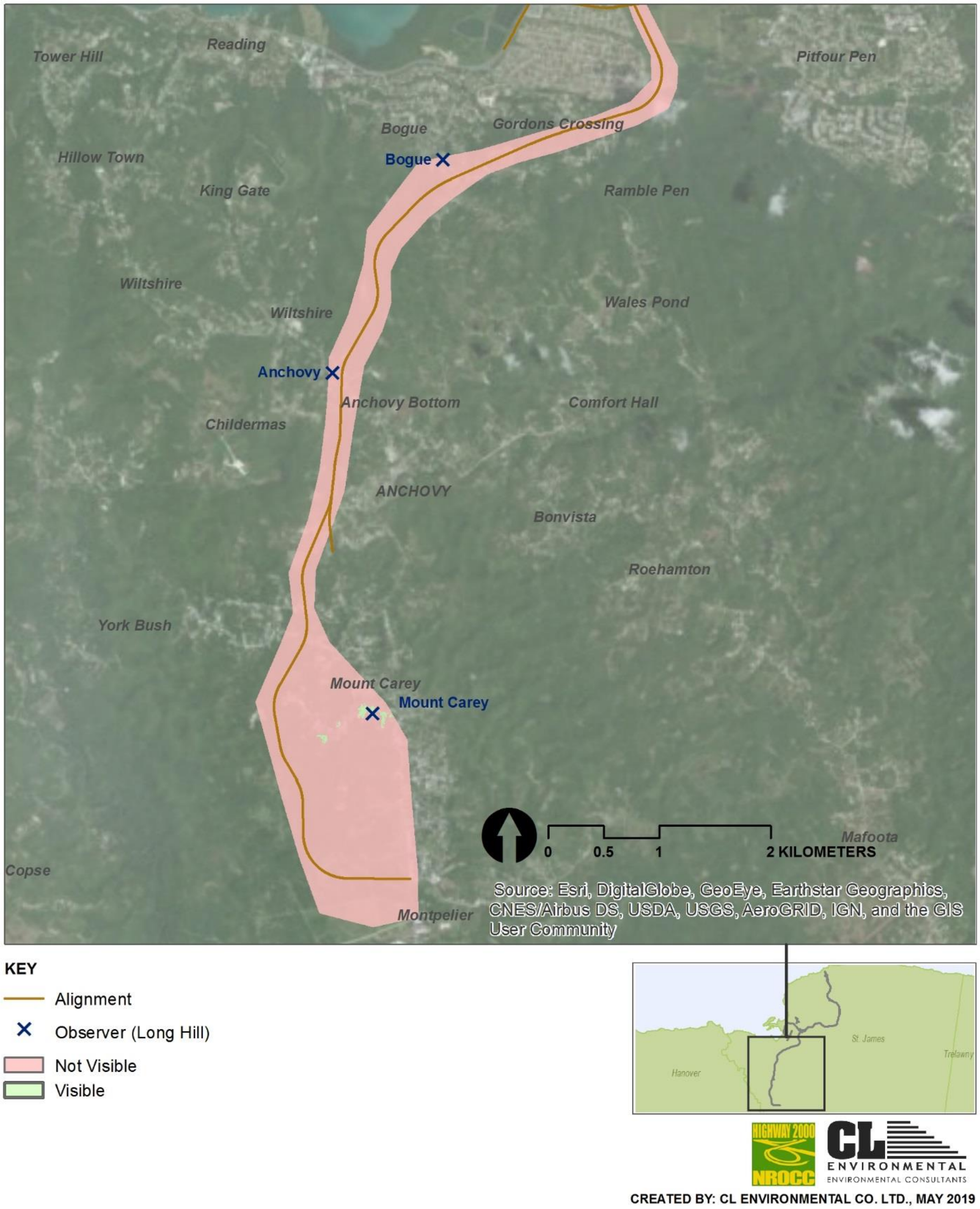


Figure 5-38 Viewshed of proposed Long Hill alignment from Mount Carey

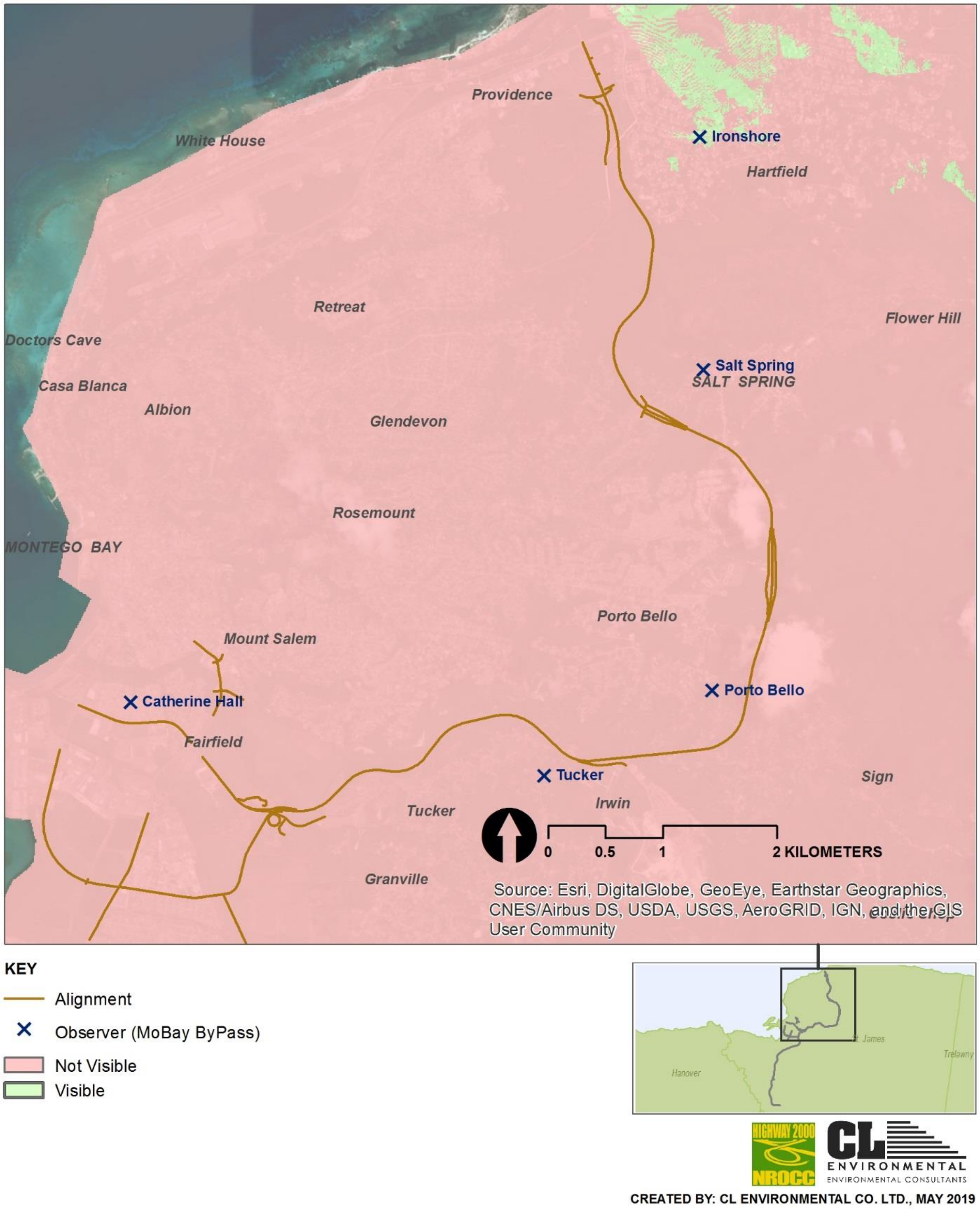


Figure 5-39 Viewshed of proposed Montego Bay Bypass alignment from Ironshore

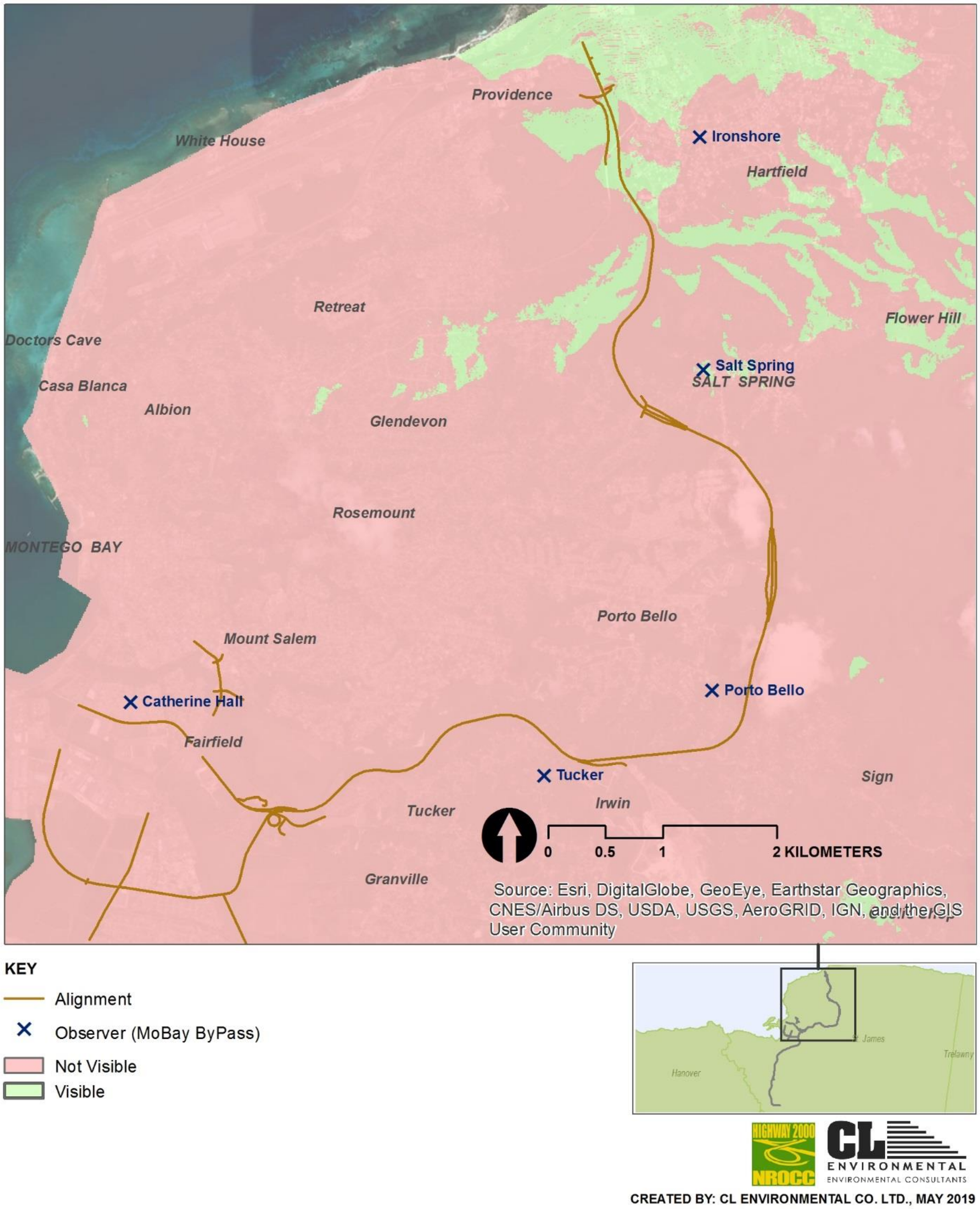


Figure 5-40 Viewshed of proposed Montego Bay Bypass alignment from Salt Spring

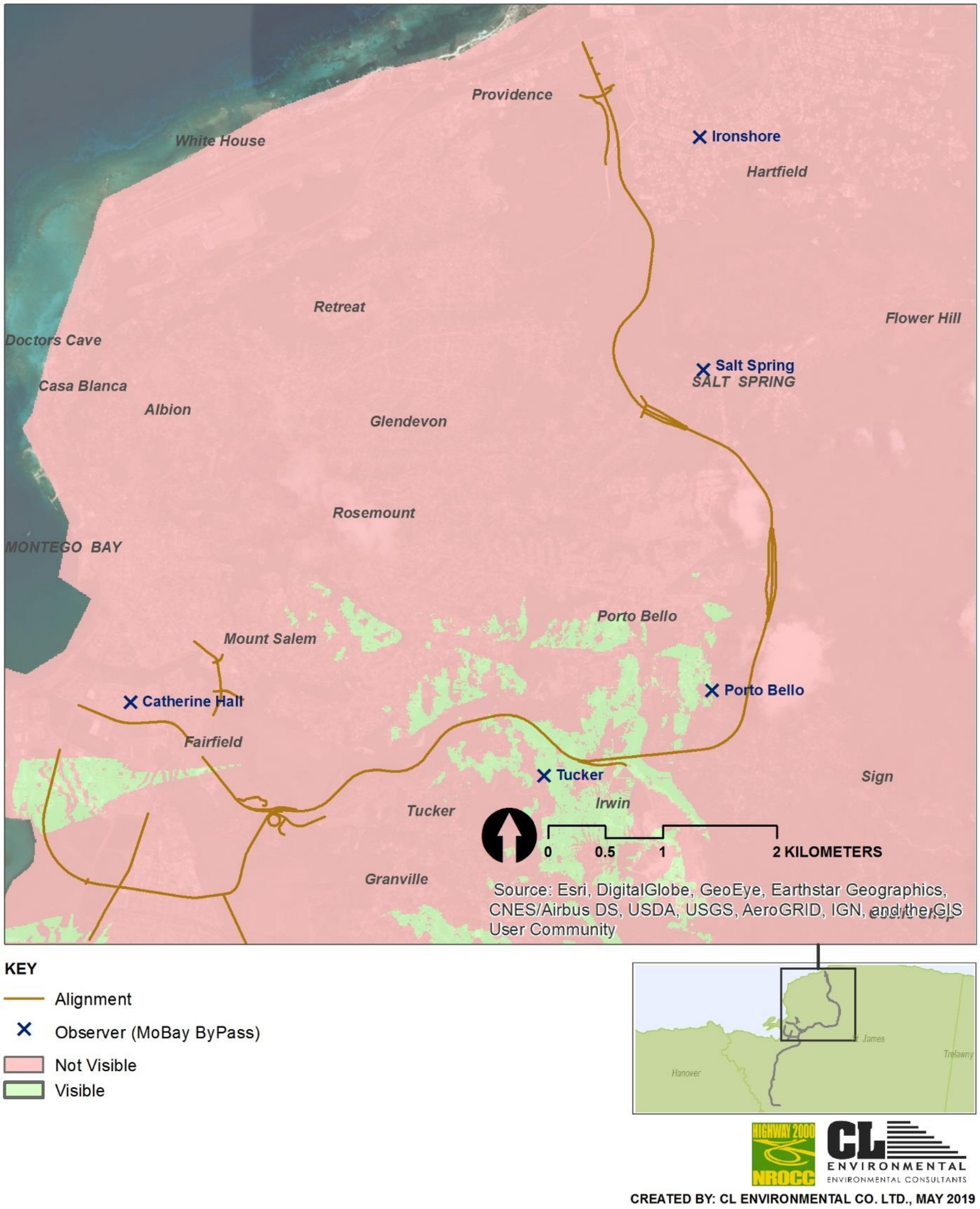


Figure 5-41 Viewshed of proposed Montego Bay Bypass alignment from Porto Bello

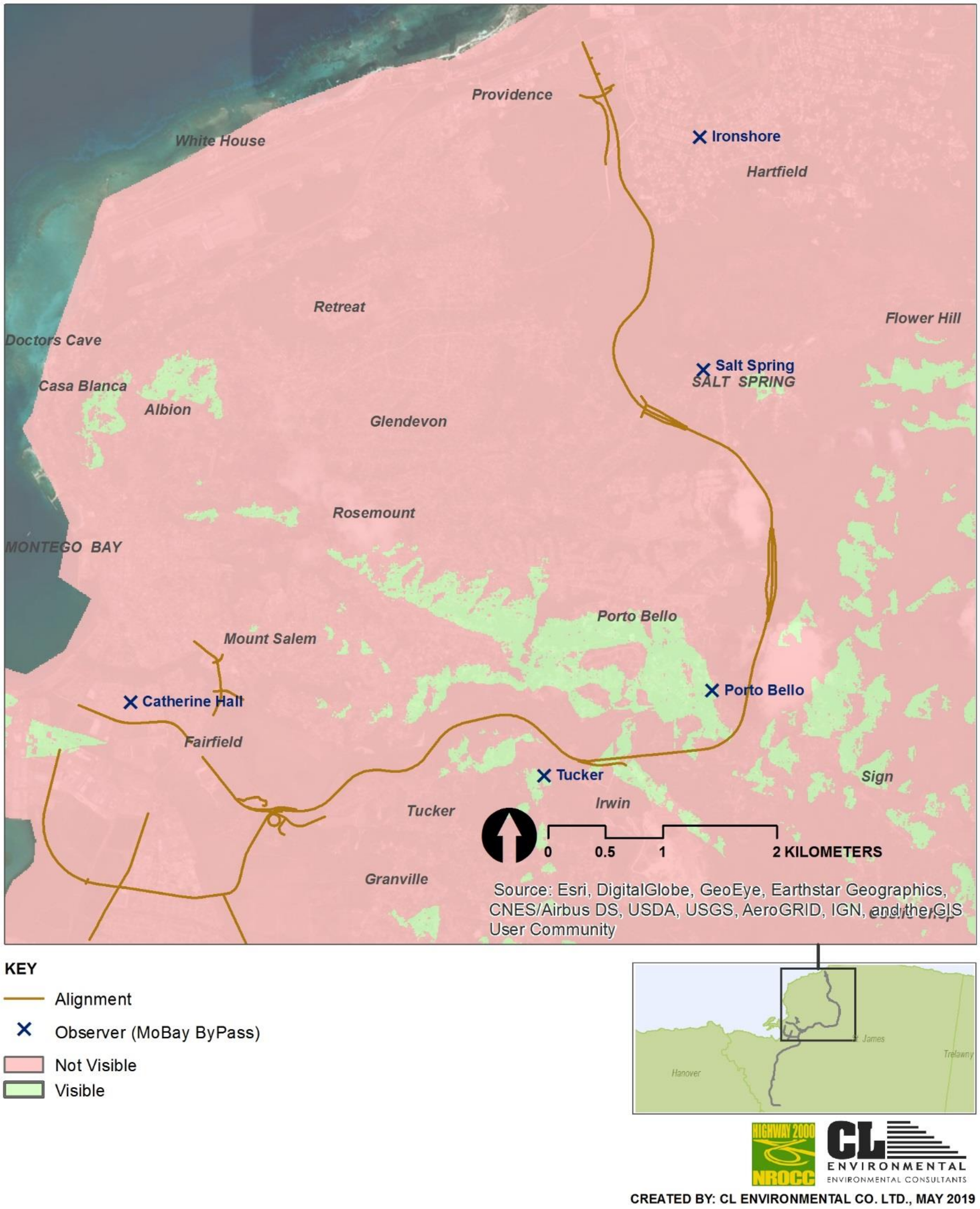


Figure 5-42 Viewshed of proposed Montego Bay Bypass alignment from Tucker

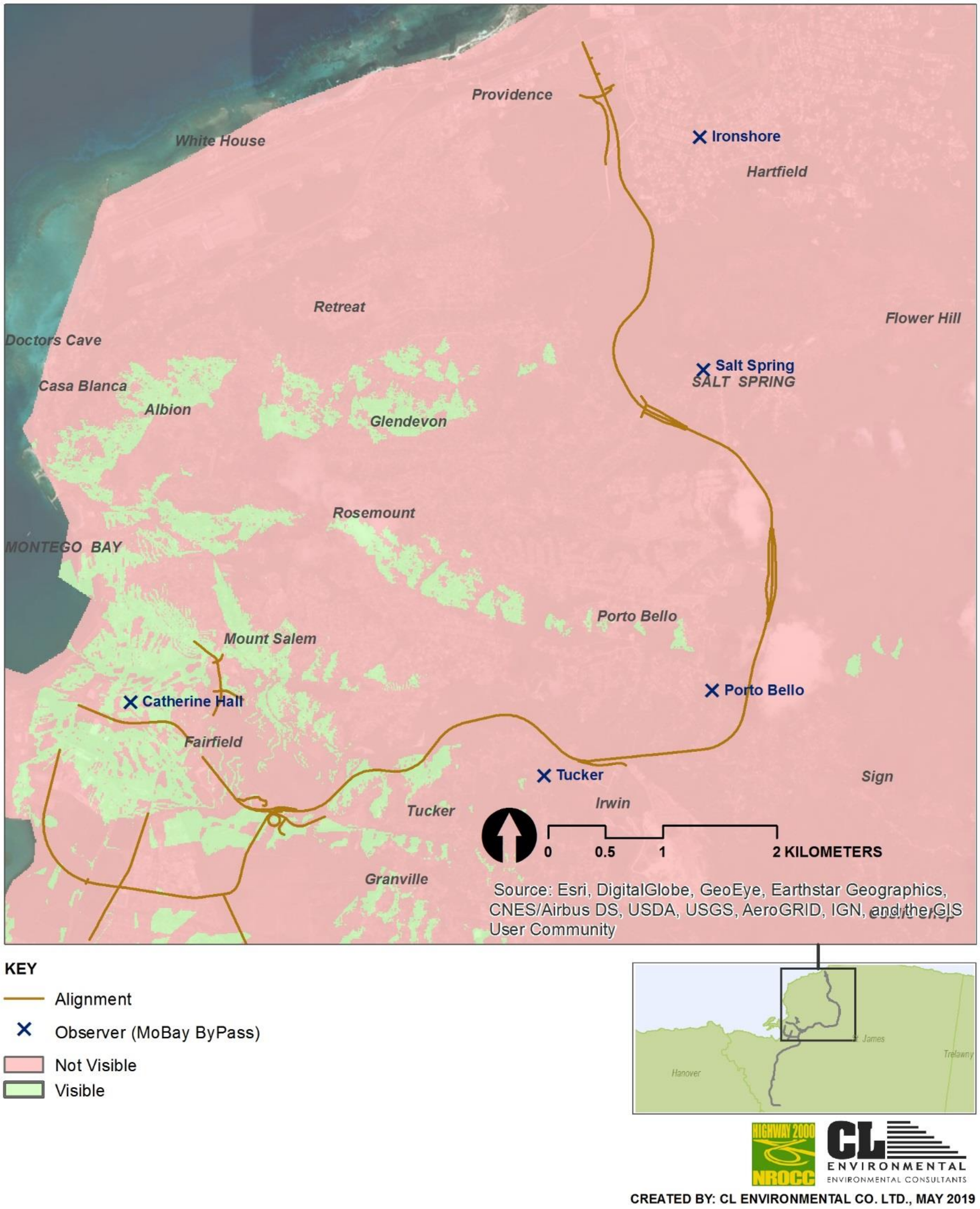


Figure 5-43 Viewshed of proposed Montego Bay Bypass alignment from Catherine Hall

5.4 IMPACTED STRUCTURE SURVEY

5.4.1 Aim and Methods

The overall aim of an Impacted Structure Survey is to identify and characterise the structures to be impacted by the proposed development. The specific objectives are as follows:

- Create a geospatial database inclusive of impacted structures and associated attribute information such as building type, materials and condition; number of occupants and building and lot use.
- Acquire photographs of each impacted structure.
- Prepare an analytical report showcasing statistical analyses and spatial mapping.

Geographic Information Systems (GIS) and Global Positioning Systems (GPS) technologies were considered paramount to the exercise. The recording of coordinates for each structure via GPS formed the basis of the geospatial database, to which all associated non-spatial attribute information was linked in a GIS. It should be noted that for the purposes of this study, a structure was defined to be a physical built entity, with the main distinction being between houses and shops/stalls. Often smaller structures such as bus stops, gardens, fowl coups, farms, pig pens or sports fields exist in association with another structure or independently, and these structures were also noted and categorised. Descriptive information included type and condition of building material, age of house, shop/stall clientele, views on relocation etc.

5.4.2 Preliminary Findings

During March, April and June 2019, a total of 489 structures were mapped and deemed as impacted during the survey:

- Barnett Street: 13 (Figure 5-44)
- Long Hill: 180 (Figure 5-45)
- Montego Bay Bypass: 225 (Figure 5-46)
- West Green: 71 (Figure 5-47)

A comprehensive report outlining the characteristics of each impacted structure is being prepared as a separate deliverable.

A description of the categories of impacted structures is shown in Table 5-64 and a breakdown of the numbers and types of structures impacted for each of the road segments can be seen in Table 5-65 to Table 5-68 below.

Table 5-64 Categories of impacted structures

Entity type	Description
Residence/ Household	All residences including houses, apartments etc.
Commerce/ Retail	Commercial/ retail enterprises, businesses and other money-earning establishments, e.g. shops, stalls, restaurants, bars, garages, barbers, business offices etc.
Other	All other not considered residential or commercial, e.g. church, school, bus stop, pig pen, car park, fence etc.
Building foundation/ Unfinished structure	Building construction is incomplete.
Not discerned	Structure construction is complete; however, the type cannot be discerned.

Table 5-65 Numbers and types of structures impacted along Barnett Street

Structure type		Number
Residence		0
Commerce/retail		0
Unfinished Structure/ Building Foundation		0
Not discerned		0
Other	Car park	4
	Fence	3
	Bus stop	2
	Sidewalk	2
	Garbage storage area	1
	Wall	1
Total		**13**

Table 5-66 Numbers and types of structures impacted along Long Hill Bypass

Structure type		Number
Residence		119
Commerce/retail		5
Unfinished Structure/ Building Foundation		11
Not discerned		6
Other	Fowl coop	14
	Storeroom	5
	Fence	4
	Church	3
	Graves	3

Structure type		Number
	Farm	2
	School	2
	Car park	1
	Kitchen and bathroom	1
	Pig pen	1
	Rabbit coop	1
	Seating area	1
	Wall	1
Total		**180**

Table 5-67 Numbers and types of structures impacted along Montego Bay Bypass

Structure type		Number
Residence		91
Commerce/retail		31
Unfinished Structure/ Building Foundation		20
Not discerned		13
Other	Storage	11
	Wall	10
	Animal rearing/ pet	9
	Fence	5
	Graves	5
	Foot path	4
	Not specified	4
	Farm	3
	water tank	3
	Car park	2
	Driveway entrance	2
	sewage plant infras	2
	Sidewalk	2
	Bathroom	1
	Bus stop	1
	Church	1
	container	1
	Garage	1
	Kitchen	1
	School	1
	Stairway	1
Total		**225**

Table 5-68 Numbers and types of structures impacted along West Green Avenue

Structure type		Number
Residence		1
Commerce/retail		6
Unfinished Structure/ Building Foundation		0
Not discerned		0
Other	Bus stop	1
	Car park	19
	Culvert	3
	Fire hydrant	2
	Foot path	16
	Garden	1
	Light post	5
	Manhole	1
	Stairway	7
	Wall	9
Total		**71**

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Figure 5-44 Impacted structures along Barnett Street alignment

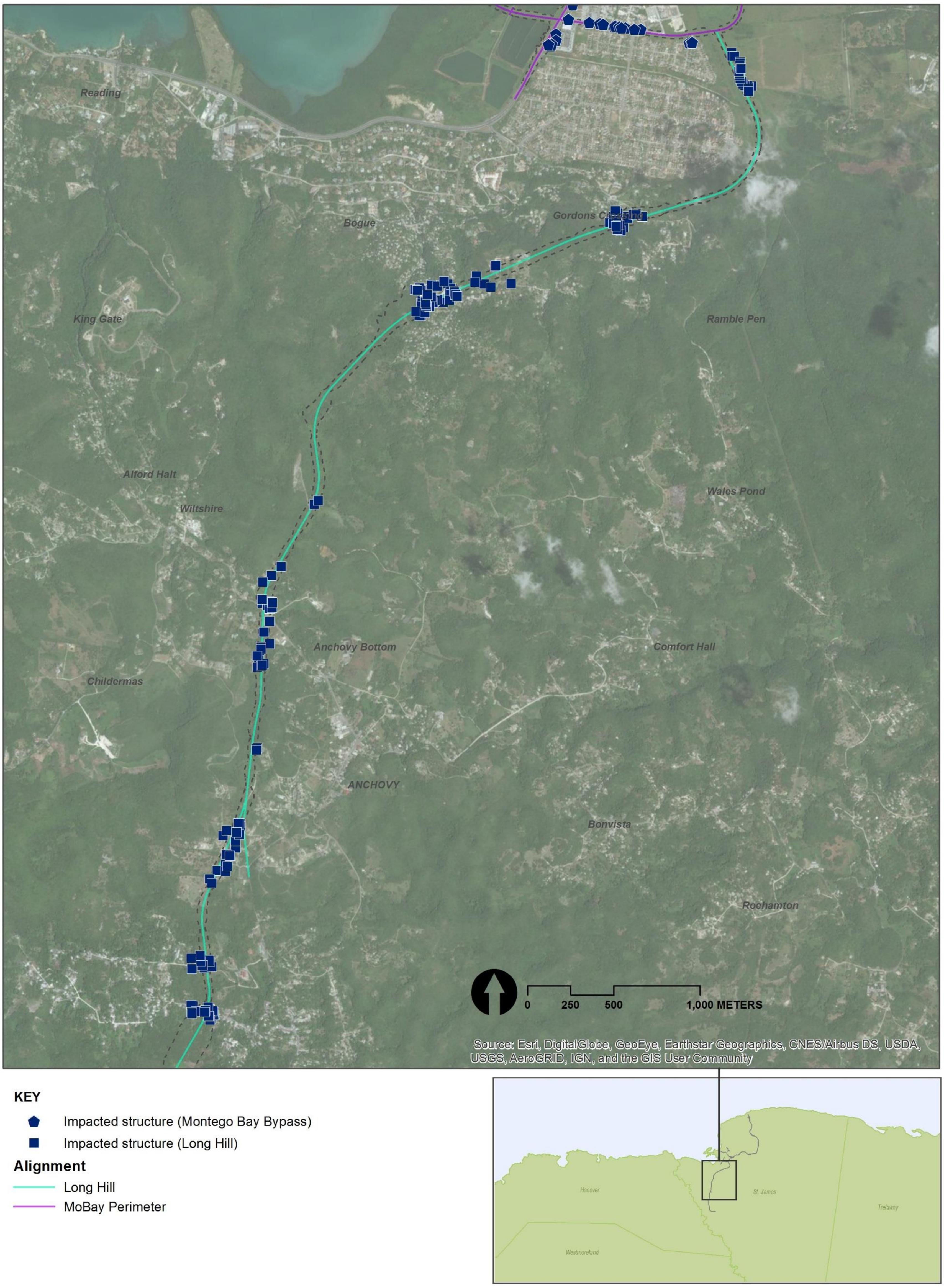

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Figure 5-45 Impacted structures along Long Hill alignment

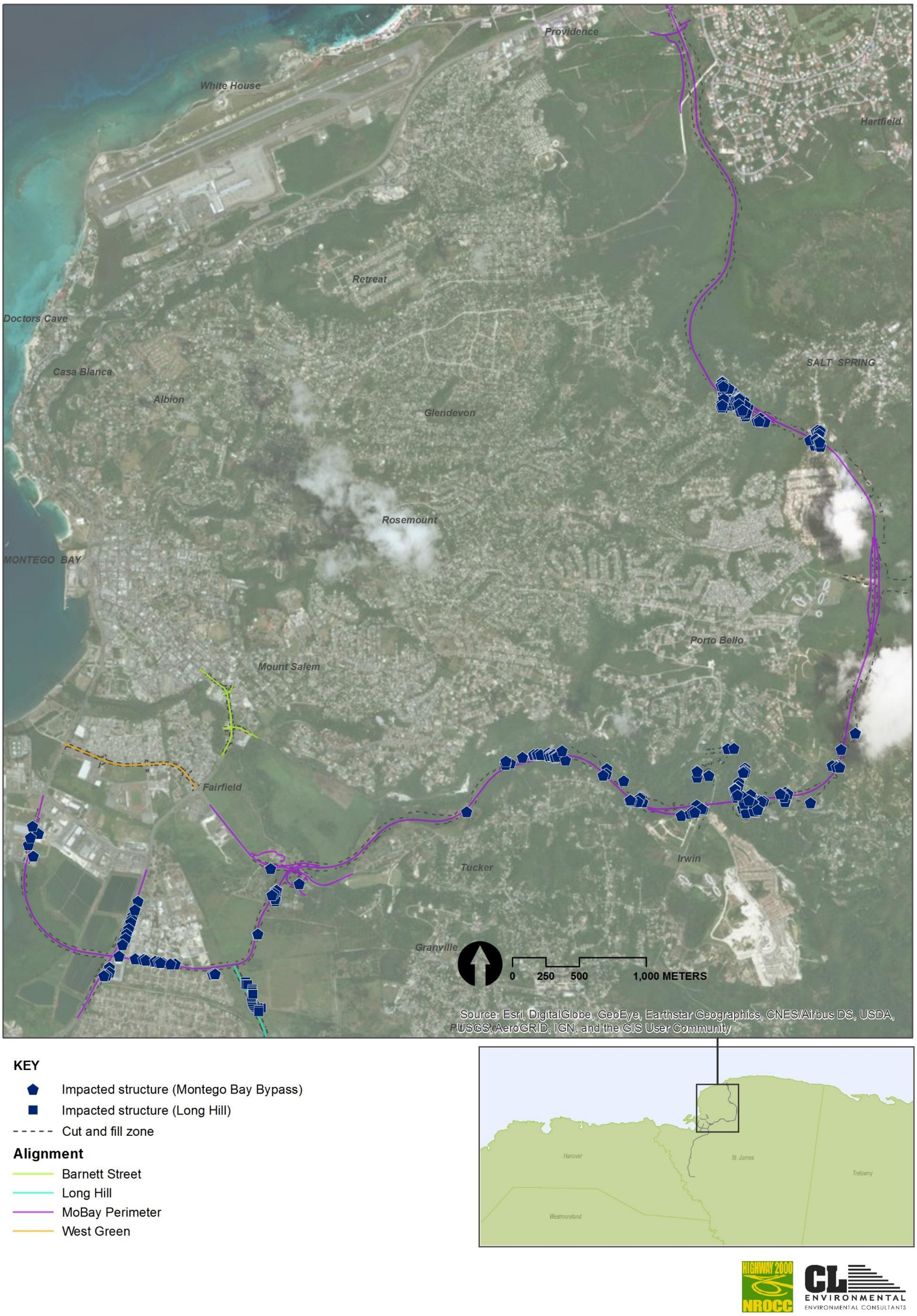
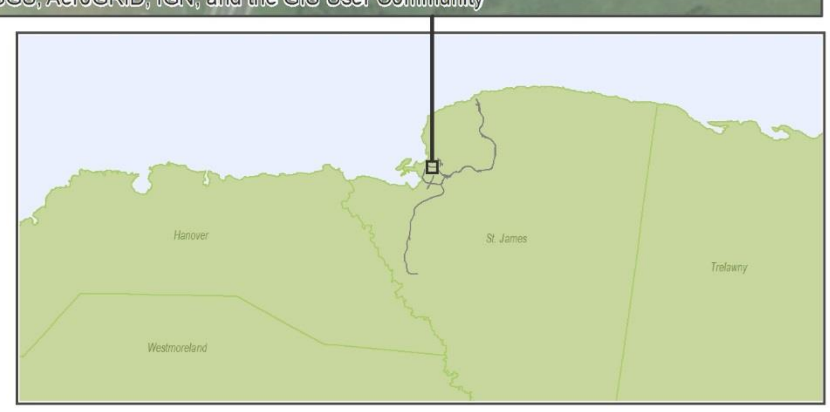


Figure 5-46 Impacted structures along Montego Bay alignment



CREATED BY: CL ENVIRONMENTAL CO. LTD., MAY 2019

Figure 5-47 Impacted structures along West Green alignment

5.5 CUMULATIVE IMPACTS

5.5.1 Noise

The cumulative noise levels (with or without noise mitigation) were calculated for areas where the baseline noise levels were taken. The results of which are reported in Table 5-69 to Table 5-76. The results indicated that there are some stations were the cumulative noise will be in non-compliance with the NRCA standard. However, where the noise walls were installed the levels indicated an overall reduction when compared with the without mitigation scenario.

It is also important to note that some of these stations already had noise levels (baseline noise levels) in excess of the NRCA noise standard and in some instances the cumulative noise levels will be within 3 dBA increase meaning that it would not, or barley perceived by individuals.

Table 5-69 Cumulative noise levels for Montego Bay Perimeter road without noise mitigation

STATION	BASELINE (Leq)			PREDICTED WITHOUT NOISE MITIGATION (Leq)			CUMUATIVE WITHOUT NOISE MITIGATION (Leq)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
N1	N/A	N/A	N/A	50.0	52.3	46.0	N/A	N/A	N/A	55	50
N2	48.8	49.6	46.7	61.1	63.4	57.1	61.3	63.6	57.5	55	50
N3	40.7	41.7	38.3	48.4	50.7	44.5	49.1	51.2	45.4	55	50
N4	N/A	N/A	N/A	47.2	49.5	43.3	N/A	N/A	N/A	55	50
N5	51.6	53.0	48.0	55.1	57.4	51.2	56.7	58.7	52.9	55	50
N6	57.8	58.3	52.9	55.1	57.4	51.1	59.7	60.9	55.1	55	50
N7	62.5	64.2	55.6	63.3	65.6	59.3	65.9	68.0	60.8	55	50
N8	61.5	63.3	54.6	66.7	69.0	62.6	67.8	70.0	63.2	65	60

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-70 Cumulative noise levels for Montego Bay Perimeter road with noise mitigation

STATION	BASELINE (Leq)			PREDICTED WITH NOISE MITIGATION (Leq)			CUMUATIVE WITH NOISE MITIGATION (Leq)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
N1	N/A	N/A	N/A	49.3	51.6	45.3	N/A	N/A	N/A	55	50
N2	48.8	49.6	46.7	41.1	43.4	37.1	49.5	50.5	47.2	55	50
N3	40.7	41.7	38.3	48.0	50.3	44.0	48.7	50.9	45.0	55	50
N4	N/A	N/A	N/A	51.1	53.4	47.1	N/A	N/A	N/A	55	50
N5	51.6	53.0	48.0	55.0	57.3	51.0	56.6	58.7	52.8	55	50
N6	57.8	58.3	52.9	54.3	56.6	50.3	59.4	60.5	54.8	55	50
N7	62.5	64.2	55.6	44.3	46.6	40.3	62.6	64.3	55.7	55	50
N8	61.5	63.3	54.6	66.7	69.0	62.6	67.8	70.0	63.2	65	60

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-71 Cumulative noise levels for Long Hill Bypass road without noise mitigation

STATION	BASELINE (Leq)			PREDICTED WITHOUT NOISE MITIGATION (Leq)			CUMUATIVE WITHOUT NOISE MITIGATION (Leq)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
N1	67.9	69.1	64.8	64.3	66.6	60.4	69.5	71.0	66.1	65	60
N2	54.7	56.3	49.0	54.5	56.8	50.6	57.6	59.6	52.9	55	50
N3	64.8	66.2	60.5	51.7	54.0	47.8	65.0	66.5	60.7	55	50
N4	53.4	54.8	48.9	60.5	62.8	56.6	61.3	63.4	57.3	55	50
N5	50.8	52.6	41.9	51.1	53.4	47.2	54.0	56.0	48.3	55	50
N6	64.6	66.6	45.2	65.4	67.7	61.5	68.0	70.2	61.6	55	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-72 Cumulative noise levels for Long Hill Bypass road with noise mitigation

STATION	BASELINE (Leq)			PREDICTED WITH NOISE MITIGATION (Leq)			CUMUATIVE WITH NOISE MITIGATION (Leq)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
N1	67.9	69.1	64.8	65.5	67.8	61.6	69.9	71.5	66.5	65	60
N2	54.7	56.3	49.0	53.6	55.9	49.7	57.2	59.1	52.4	55	50
N3	64.8	66.2	60.5	39.7	42.0	35.8	64.8	66.2	60.5	55	50
N4	53.4	54.8	48.9	45.5	47.8	41.6	54.1	55.6	49.6	55	50
N5	50.8	52.6	41.9	52.1	54.4	48.2	54.5	56.6	49.1	55	50
N6	64.6	66.6	45.2	46.6	48.9	42.7	64.7	66.7	47.3	55	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-73 Cumulative noise levels for Barnett Street without noise mitigation

STATION	BASELINE (Leq)			PREDICTED WITHOUT NOISE MITIGATION (Leq)			CUMUATIVE WITHOUT NOISE MITIGATION (Leq)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
B1	67.0	68.0	65.0	66.3	68.6	62.4	69.7	71.3	66.9	65	60
B2	63.0	64.0	59.0	68.1	70.3	64.2	69.3	71.2	65.3	65	60

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-74 Cumulative noise levels for Barnett Street with noise mitigation

STATION	BASELINE (Leq)			PREDICTED WITH NOISE MITIGATION (Leq)			CUMUATIVE WITH NOISE MITIGATION (Leq)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
B1	67.0	68.0	65.0	66.3	68.6	62.4	69.7	71.3	66.9	65	60
B2	63.0	64.0	59.0	65.9	68.2	62.0	67.7	69.6	63.8	65	60

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-75 Cumulative noise levels for West Green Avenue without noise mitigation

STATION	BASELINE (Leq)			PREDICTED WITHOUT NOISE MITIGATION (Leq)			CUMUATIVE WITHOUT NOISE MITIGATION (Leq)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
WG1	68.0	69.0	66.0	67.1	69.4	63.3	70.6	72.2	67.9	55	50
WG2	66.0	67.0	63.0	66.2	68.4	62.3	69.1	70.8	65.7	55	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

Table 5-76 Cumulative noise levels for West Green Avenue with noise mitigation

STATION	BASELINE (Leq)			PREDICTED WITH NOISE MITIGATION (Leq)			CUMUATIVE WITH NOISE MITIGATION (Leq)			NRCA STANDARD (dBA)	
	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	24 Hours	7 a.m. – 10 p.m.	10 p.m. – 7 a.m.	Day	Night
WG1	68.0	69.0	66.0	60.1	62.4	56.2	68.7	69.9	66.4	55	50
WG2	66.0	67.0	63.0	52.8	55.1	48.9	66.2	67.3	63.2	55	50

NB: Values highlighted in red are non-compliant with the NRCA Standard

5.5.2 Air Quality

It is expected that vehicular traffic along the proposed new alignments will increase the level of particulate, NO_x and SO_2. However, the impact is expected to be minor.

It is also important to note that emissions are highest at the time of vehicle start up in the morning (cold start). This is due to the fact that the first few minutes of driving generate higher emissions because the emissions-control equipment has not yet reached its optimal operating temperature (U.S. Environmental Protection Agency). This effect would be largely reduced in rural areas where there is a low concentration of local traffic. Also, emission rates are higher during stop-and-go, congested traffic conditions than free flow conditions operating at the same average speed.

Given the above explanations, the potential for vehicular emissions from this project negatively affecting air quality to an extent where human respiratory health may also be negatively impacted is low.

5.6 RESIDUAL IMPACTS

The previous sections described the potential impacts that would occur as a result of different phases of the project and how the proposed mitigation measures would contribute to minimising or eliminating the impacts. Not all impacts can be fully mitigated and therefore residual impacts will be experienced by the environmental and social receptors affected by the project.

5.6.1 Air Quality

Fugitive dust and exhaust emissions from motor vehicles have the potential to affect the health of the resident population. PM2.5 particulates specifically, which showed high concentrations prior to commencement of project, may continue to be high or even higher due to increased vehicle usage of new highway. Fine PM2.5 particles are airborne pollutants that fall below 2.5 micrometres in diameter. 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. In this case, any residential burning or motor vehicle exhaust emissions would contribute to elevated PM2.5 particulate concentrations.

5.6.2 Noise

The proposed project has the potential to be a noise nuisance during both the construction and the operational phases. Even with the proper mitigative steps, short-term impacts of varying duration such as truck engines, truck engine brakes and loud horn honking will be a nuisance to nearby residential communities.

5.6.3 Heritage and Cultural

Sections of proposed project area have dense vegetation cover. When this vegetation is removed from the proposed site, there is a high probability of finding prehistoric and historic cultural material. However, there is the possibility that they may be destroyed by heavy machinery and equipment during the site clearance process.

6.0 ENVIRONMENTAL MANAGEMENT AND MONITORING PROGRAMME

6.1 ENVIRONMENTAL MANAGEMENT SYSTEM

An Environmental Management System (EMS) is an important tool which can be used to assist operations managers in meeting current and future environmental requirements and challenges. It can be used to measure a company's operations against environmental performance indicators, thereby helping the company to reach its environmental targets. A good management system will integrate environmental management into a company's daily operations, long-term planning and other quality assurance systems.

It is therefore recommended that several parameters be monitored before, during and after the project implementation to record any negative construction impacts and to propose corrective or mitigation measures. The suggested parameters include but not limited to the following:

1. Noise
2. Dust
3. Traffic and Transportation
4. Water Quality
5. Solid Waste and Wastewater
6. Raw Material Storage and Transport
7. Health and Safety
8. Equipment Maintenance
9. Drainage
10. Community Management

6.1.1 Site Preparation and Construction Phase

- Daily inspection of site clearance activities to ensure that they are following the proposed plan and to ensure that site drainage system is not impacting on any waterways. Check and balance can be provided by NEPA and the Parish Council.

  Person(s) appointed by NROCC 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, BOD total suspended solids, faecal coliform and oil and grease. 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$ 320,000 per monitoring exercise for all proposed alignments.

- 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 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.

  Client 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$500,000 for all proposed alignments.

- 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. Any organization with the capability to conduct monitoring of the listed parameters should be used to perform this exercise. Client 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$385,000 for all proposed alignments.

- 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 Client 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 areas so as to prevent traffic congestion along existing roads.

  Person(s) appointed by the Client 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 Client 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 at the campsite should also be monitored.

  Person(s) appointed by the Client 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 Client or Ministry of Health 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 the Client 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 Client 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. Person(s) appointed by the Client may perform this exercise. NEPA and the Client should perform spot checks to ensure compliance. Monitoring should be conducted daily to ensure major disruption to the public transport is avoided.

- Where possible, construction crews should be sourced from within the study area. This will ensure that the local community will benefit from the investment.

  Person(s) appointed by the Client may perform this exercise.

  No additional cost is anticipated for this exercise.

- Wherever individuals (residents, business owners etc.) are negatively affected by the construction activities of the proposed highway these persons may address their issues through a grievance programme setup by NROCC. These issues can be raised orally or in writing to: NROCCs' Construction Manager/Supervisor or NROCCs' Chief Executive Office or his Designate. A log will be created to keep track of these issues and to ensure that these are responded to. It is the objective of NROCC to respond to all issues raised within a reasonable timeframe.

6.1.2 Operational Phase

- The integrity of the road structures should be conducted every two (2) years.

  This should be done by a qualified person. NROCC or their appointed person should conduct these inspections. No additional cost is anticipated for this exercise.

- An Annual noise survey should be conducted at the same locations as during the EIA construction phases for purposes of comparison. Any organization with the capability and equipment to conduct noise monitoring should be used to perform this exercise. The noise survey is estimated to cost approximately J$500,000.

- A survey of the effect of noise and air emissions (from vehicles and vehicle exhaust etc.) on tollbooth workers should be undertaken annually. Any organization with the capability and equipment to conduct such monitoring should be used to perform this exercise. The noise exposure survey is estimated to cost approximately J$150,000 while the air emissions exposure survey is estimated to cost approximately J$200,000.

6.2 REPORTING REQUIREMENTS

6.2.1 Ambient Noise

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 the Client within two weeks after completion of testing.

The Client shall distribute the report within four (4) weeks of testing being completed to NEPA.

In the event that emissions do not meet the required criteria, investigations shall be carried out and corrective actions were necessary taken and a re-test shall be scheduled at the earliest possible time and a new report submitted. Reports will be maintained on file for a minimum of three years.

6.2.2 Ambient Particulates

A report shall be prepared by a Contracted Party during construction of the Highway. The report will summarize the results of the particulates monitoring. This report will provide information relative to $PM_{2.5}$ and PM_{10} concentrations.

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. Particulates measured to be compared with the NEPA Air Quality PM_{10} Standards and US EPA $PM_{2.5}$ Standards.
vi. Evaluation of data, discussions and statement giving a professional opinion of the emissions impact on the employees.

The report shall be submitted to the Client within four weeks after completion of testing.

The Client shall distribute the report within four (4) weeks of testing being completed to NEPA.

In the event that emissions do not meet the required criteria, investigations shall be carried out and corrective actions were necessary taken and a re-test shall be scheduled at the earliest possible time and a new report submitted. Reports will be maintained on file at the plant for a minimum of three years.

6.2.3 Tollbooth Worker Noise Exposure

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 the Client within two weeks after completion of testing.

The Client shall distribute the report within four (4) weeks of testing being completed to NEPA.

In the event that emissions do not meet the required criteria, investigations shall be carried out and corrective actions were necessary taken and a re-test shall be scheduled at the earliest possible time and a new report submitted. Reports will be maintained on file for a minimum of three years.

6.2.4 Tollbooth Worker Air Emissions Exposure

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 air exposure monitoring. This report will provide information relative to SO_2, NO_x, CO, $PM_{2.5}$ and PM_{10} concentrations.

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. Emissions measured to be compared with the applicable Occupational Safety and Health Administration (OSHA) standards and guidelines.
vi. Evaluation of data, discussions and statement giving a professional opinion of the emissions impact on the employees.

The report shall be submitted to the Client within four weeks after completion of testing.

The Client shall distribute the report within four (4) weeks of testing being completed to NEPA.

In the event that emissions do not meet the required criteria, investigations shall be carried out and corrective actions were necessary taken and a re-test shall be scheduled at the earliest possible time and a new report submitted. Reports will be maintained on file at the plant for a minimum of three years.

6.2.5 Water Quality

A report shall be prepared by a Contracted Party during construction of the Highway. It shall include the following data:

i. Dates, times and places of test.
ii. Weather condition during sampling.
iii. A defined map of each location with distance clearly outlined in metric.
iv. Test Method used.
v. Parameters measured (BOD, TSS, NO3, PO4, Faecal coliform, oil and grease, salinity, dissolved oxygen, turbidity)
vi. Results
vii. Water quality results will be compared with NEPA Marine and Freshwater Guidelines.
viii. Conclusions

The report will be submitted to the Client within two weeks of the monitoring being completed.

The Client shall distribute the report within four (4) weeks of testing being completed to NEPA.

In the event that the water quality does not meet the required criteria, investigations shall be carried out and corrective actions were necessary taken and a re-test shall be scheduled at the earliest possible time and a new report submitted.

Reports will be maintained on file at the plant for a minimum of three years.

6.3 OTHER RELATED STUDIES AND PLANS

6.3.1 Risk Assessment

The first step in Risk Assessment is identifying the major hazards; that is, gathering and analysing data on meteorological, hydrological, geological and other hazards in terms of their nature, frequency and magnitude. These hazards can be natural or man-made or a combination of both. Assessing and characterising each by triggering factors, degree of severity, spatial occurrence, duration of the event and their relationship is what gives rise to the risk assessment.

The risk assessment matrix used to characterize the overall risk is given in Table 6-1. Overall assessed risk levels result from a combination of low, medium and high severity of occurrence and probability of occurrence. Resulting risk considered as "HIGH" is denoted by a red box, "MEDIUM" risk by yellow and "LOW" risk by green. The Risk Assessment undertaken for all natural and man-made hazards is given in Table 6-2. It should be noted that priority hazards include: Flooding, Landslide, Earthquake and Accidents.

Table 6-1 Risk Assessment matrix for combined low, medium and high probability of occurrence and severity of consequences

Severity of Consequences			
High	MEDIUM RISK	HIGH RISK	HIGH RISK
Medium	LOW RISK	MEDIUM RISK	HIGH RISK
Low	LOW RISK	LOW RISK	MEDIUM RISK
	Low	*Medium*	*High*
		Probability of Occurrence	

** Overall assessed risk levels include HIGH (red), MEDIUM (yellow) and LOW risk (green).*

Table 6-2 Risk Assessment

HAZARD	RISK RATING	PROBABILITY	SEVERITY	COMMENTS
HURRICANES	MEDIUM	Seasonally June- November	May seriously damage infrastructure, property and individuals	Hurricanes and storms are expected to increase in severity over time
LANDSLIDES	MEDIUM	Sections along the alignment are prone to landslides	May cause result in property damage and harm to individuals	Over the 25km length of the proposed highway alignment, the mid-section segment between chainages 12+800 and 18+000 is the most vulnerable length to landslides
SINKHOLES	MEDIUM	Sinkholes increase the probability of landslides along the alignment	May result in loss of use and or damage, to roadway, property and individuals. Sinkholes may cause severe damage to structures and even loss of human life if there is a sudden collapse	Of the fifty-two (52) sinkholes identified within 500m of the proposed alignment, 15 potential sinkholes were identified within the most critical 100m buffer zone, eight (8) of which were located directly along the proposed alignment. These 8 potential sinkholes that directly intersect the alignment are most critical, as the alignment may require realignment to avoid these areas
EARTHQUAKES	LOW	Road Segment 10+000 to 10+500: In association with the high-water table the sand layers have a high probability of liquefying during the major earthquake events. Such liquefaction could cause differential ground subsidence of the road during or shortly after an earthquake.	Liquefaction may result in ground subsidence and loss of use and or damage, to roadway, property and individuals	There are no major fault zones near the project sites. The closest active faults near the project site are the Duanevale Fault zone and the Montpelier-New-Market Fault zone which intersects near Montego Bay and has respectively an E-W and NNW- SSE orientation.

HAZARD	RISK RATING	PROBABILITY	SEVERITY	COMMENTS
FLOODING	LOW	Likely to occur during heavy rainfall event.	May result in property damage	Three (3) main channels contribute to flooding in their respective areas: Salt Spring Gully, North Gully and South Gully. Significant floodplain encroachment has occurred for the mentioned channels and as a result infrastructure in close proximity is at high risk of flooding during high-intensity rainfall or storm events. Increased river velocity as a result of river realignment may lead to sediment deposition in the meanders of the river channel resulting in potential flooding. Project features are designed to help reduce flooding
ACCIDENTS	MEDIUM	Accident probability is medium given speeding potential	Road accidents range from severe to mild. Accidents may result in loss of use, property damage and loss of life	Roadway will be designed to reduce accident potential.
SPILLS	MEDIUM	Oil and other material spills may occur, especially in the event of an accident (overturned truck etc.)	May result in loss of use and or damage, to roadway, disruptions in flow, accidents and other blockages	On-call emergency highway operators to attend to any situation that may result in potential accidents
OBSTRUCTIONS	MEDIUM	Obstructions along the roadway are likely to be common	May cause result in property damage, loss of use and harm to individuals	Obstructions that may result in potential accidents include; stray animals, dead animals, fallen tree, shredded tyre, limbs, accumulation of dirt, gravel or other granular materials, oil spills, pavement/surface defects (potholes, deformations, edge drops), missing or damaged safety barrier/guard rail/fencing at a critical location and abandoned/damaged vehicles.
FIRES	LOW	There is low probability of fires along the roadway	Fires may result in mild to severe damage	The cause and extent of the fire along with the response time of emergency services will dictate the severity of the impacts of the fire. With regard to bush fires, none of the respondents indicated that the proposed corridor was affected by fire.

6.3.2 Emergency Response Plan

The Emergency Response Plan will be designed to describe the organizing, coordinating and directing of available resources in order to respond to various natural and man-made disasters and situations. The risk analysis study described in section 6.3.1, as well as related impacts and mitigation (Section 5.0) should be used as a reference in the preparation of the Emergency Response Plan. Hazards to be considered include the following:

- Natural Disasters
    - Hurricane
    - Earthquake
    - Flooding
    - Fire
    - Landslide
- Civil Unrest and Riots
- Bomb Threats and Acts of Sabotage
- Acts of Terrorism and Armed Attacks
- Diesel and Hazardous Material Stockpiling
- Security and Safety Information
- Medical Emergency Information
- Technological Emergencies
- Occupational Health and Safety

A detailed plan will be submitted as a separate document by the Contractor. The Emergency Response Plan is to be approved by the Office of Disaster Preparedness and Emergency Management (ODPEM) and the Fire Department.

6.3.3 Resettlement and Relocation Plan

6.3.3.1 Introduction

As a consequence of the construction of the highway it is inevitable that communities and individuals will be affected. However, where it will be necessary to relocate persons, NROCC will involve the affected persons in the process from the start so as to make the transition a comfortable and easier one. These impacted structures were previously described in Section 5.4. Appendix 11 also outlines some Relocation Criteria.

6.3.3.2 Resettlement Criteria

All resettlement activities carried out by NROCC will be sustainable in nature by providing sufficient resources or alternatives to those who are displaced. All persons affected will be consulted and given the opportunity to participate in the planning and implementation of their own resettlement. Assistance will be provided in helping individuals to restore their standard of living or to raise it, but no individual's standard of living should be lowered as a consequence of the project. The legal tenure of affected persons will determine the type of compensation and resettlement assistance to be received. Particular attention will be given to groups such as the elderly, unemployed, those living below the poverty line, women and children and those without land tenure.

Those persons, businesses and activities to be accommodated in the Resettlement Plan will include the following:

- Dwellings, businesses and other facilities (shops, stalls) that are directly in the highway's right of way.
- Dwellings, businesses, farms lands and other facilities where the access to the properties may be affected.
- Farm lands and recreational areas are affected.
- Person who suffer temporary or permanent income loss during construction.
- Persons whose community facilities may be affected.
- Public utilities whose assets are affected (power lines, telephone lines and optical fibre lines, water distribution networks, irrigation channels etc.

Displaced persons, and owners of businesses and activities will be informed of their rights and be given options. There will be consultations with them and economically viable resettlement alternatives will be offered. Compensation will be prompt, effective and at full replacement cost for losses such as lands, structures, crops, trees, businesses and incomes lost, at present open market values.

In accordance with the size of the lot, NROCC will either acquire the total lot or compensate the owner for that portion of land and other assets that will be affected. Where access to properties is affected NROCC will seek to identify alternative access so as to ensure that there is no loss in value of the properties or impact on the businesses affected. Where no alternative access is possible then these individuals affected will be offered the same compensation packages and resettlement options provided for the dwellings and businesses located in the highway's right of way.

Stakeholder meetings will be held with the owners of the businesses and dwellings to determine what will be required to ensure their livelihood is restored. These meetings will be advertised via public media and other methods (newspaper, letters, flyers, libraries, post office, fire/police stations, town crier etc.). In addressing any farmlands and recreational areas that will be affected by the highway, NROCC will compensate the farm owners for the portion of property affected along with crops being cultivated. This compensation will be at market values determined by a third party knowledgeable in land, structures, crops and plants/trees valuation. In the instance where recreational fields (football fields, cricket pitches, walking/running tracks) are affected, NROCC will seek to rebuild these recreational facilities in close proximity to the original facility.

For individuals temporarily affected, efforts will be made to provide an alternate route to their place of business. Signage informing the general public about changes in traffic flows and routings will be erected in visible locations. As indicated, compensation will also be made for the loss of income faced during their relocation activities. For the individuals that will experience a permanent loss of income, an offer to introduce them to organisations involved with skills training or re-training will be made and financial support given to offset the associated expenses.

6.3.3.3 Resettlement Options

Recognizing the importance of the individual's right to choose and make the best decisions for themselves, the resettlement options will be explained and the person/s being relocated will be given advice in understanding the implications of each option. The two options are: Self-Relocation and Relocation by NROCC.

6.3.3.3.1 Self-Relocation

Persons can be compensated for the following; structures, lands and crops; they can then use the compensation to conduct their own relocation. These persons will also benefit from other forms of assistance such as a transportation grant, temporary rental assistance of up to six months and transitional grants to cover some transitional costs such as loss of income.

6.3.3.3.2 Relocation by NROCC

NROCC will seek to acquire houses and house lots with the intention to relocate persons who choose this mode of compensation, or because of varying reasons, such as age, gender, unemployment, and legal rights to the land, may not be able to access the open property market. Persons will be taken to visit the proposed relocation units or sites and these will be agreed with the persons prior to relocation.

6.3.3.4 Compensation Options

The following types of compensation options are listed below:

- Cash for structures and/ or crops/trees only
- Cash for structures and land
- Cash for land, structure, crops/trees
- Cash for land only
- Cash for crops/trees only
- An exchange of lands and/or buildings; NROCC purchasing house lots or houses, which by agreement with the affected person, is exchanged for possession of the lands/structures they occupy.
- Relocation Grant
- Restoration or cash compensation for restorative works to fences, adjustments to buildings or rebuilding
- Transportation assistance in relocation
- Alternative accommodation where the person wishes to be relocated.
- Temporary rental income

In most cases, compensated persons will be able to salvage all the movable objects on the land, such as all crops, buildings and fixtures, for use elsewhere. In some cases, affected persons will receive more than one type of compensation. Compensation cheques are delivered mainly through the attorneys representing vendors where the assets are registered under the Registration of Titles Act or by the Negotiators. Any and all fees to conduct land surveys, crop assessments and land assessments will be borne by NROCC.

6.3.3.4.1 Eligibility for Compensation

All compensation for lands, structures and crops will be based on the current open market values determined by the preparation of a valuation report. Valuations will be prepared by an independent company registered with the Real Estate Board of Jamaica and comprising chartered land surveyors. The valuation report for lands will assess the entire land, the area to be taken by the highway and the replacement costs of all structures. These valuations will also take account of modifications to fence and utilities if these are required.

In addition, provision exists for compensation to be made where there are losses of incomes while the replacements of structures are being undertaken and such assessments are also addressed by the valuations. NROCC also provides additional cash compensation to assist in relocation, temporary rental, transportation, etc. A separate valuation will be prepared for crops and the rates will be based on the current market rates being used by the Rural Agricultural Development Agency (RADA). Depending on the type of mature crops assessed, compensation will be made for an average period of 3-5 years.

The land acquisition strategy has been developed based on experience and reflects the various classes of ownership and title status. The following are the broad categories of classes of ownership and the options available to persons who wish to do their own relocation.

- Informal Settler/Squatter – Person in possession does not claim ownership or rights to the property. In this scenario, an independent assessment of the value of the structures based on current replacement costs is developed, as well as current market value of crops. These valuations are then agreed with the persons who are in possession of the lands.
- Informal Purchaser/Family Lands – Person in possession of the land claims to have purchased the land or have inherited the property, however, no formal receipts or title exist to confirm this. The initial treatment of this person is similar to the previous scenario with an independent market valuation and a relocation grant being paid initially to the person in possession.
- Registered Owner – Owner has a registered title in their name. Valuations of the lands and crops have been conducted. Payments made for the lands and crops in exchange for title.
- Tenants – person in possession by short term rental agreement or long-term lease. For these tenants, valuation of any structures identified to be owned by tenant as well as any crops grown by them is conducted. The valuations are then agreed with the tenant and the money paid as compensation in keeping with the previous scenarios. Similar to the previous instances these persons are also allowed to reap any crops and salvage any existing structures owned by them.

6.3.3.4.2 Documentation Required

Where ownership of lands is in dispute or unknown, this information is sent to the Commissioner of Lands who will arrange for hearings to be held and a ruling made as to who should be compensated for the lands. Certified copies of the following documents are required from persons claiming interest to lands:

- Valid Identification such as passport, driver license, national ID etc.
- Taxpayer Registration Number (TRN)
- Survey diagram (preferably prepared in affected person's name)
- Will (preferably probated)
- Registered Title or Common Law Title
- Sales Agreement and or Purchase Receipts
- Current and past Tax Receipts
- Subdivision Plans or titles to adjoining lands showing their occupation

6.3.3.4.3 Valuation of Property/Assets

The valuations will consider the following:

- Buildings only – The full replacement costs of the buildings including designs, fees, etc.
- Commercial enterprises – In addition to the facilities themselves owners will also be compensated for loss of income during the period of relocation of these facilities.
- Properties (Lands with or without Buildings) – The current market value of the property based on what similar properties are being sold for in the same vicinity. This will also include any modifications to fences and utilities which may be required.
- Crops – The current market value of the crops and trees taking into account their age and expected life.
- Farm Lands – Current value of similar lands taking into account the type of soils, costs to prepare the soil, irrigation, fencing, utility modifications and other facilities available.

In those instances, where only a portion of the lands is to be acquired depending on the size of the lot NROCC will either acquire the total lot or compensate the owner for that portion of land that will be affected. The following guidelines are applicable to determine whether the entire property will be acquired.

- Farm lands - when the remaining lands are smaller than 5 acres (20,234 sq. m) or where there is no access to the remaining lands
- Residential Lots - when the remaining lands are less than 6000 sq. ft. (557 sq. m)

Where access to properties is impossible, NROCC will seek to identify alternative access so as to ensure that there is no loss in value of the properties or impact on the businesses affected. Where there is no alternative access possible, the entire property will be acquired. These individuals will be offered the same compensation packages and resettlement options provided for the lands, dwellings and businesses located in the highway's right of way. In all instances transfer taxes, registration fees, etc. for these transactions, will be borne by NROCC.

6.3.3.5 Organizational Responsibilities

Apart from the responsibility for the acquisition of the lands needed to construct the highway and other road improvements, NROCC has the responsibility for the relocation of utilities and graves (if any) affected.

6.3.3.5.1 Utilities

Where utilities such as water and electrical infrastructures are affected as a result of the proposed highway construction, NROCC will notify the relevant authorities in charge of the affected utilities to carry out the necessary works to relocate them at NROCC's cost. Approval will also have to be sought from the utility companies, for NROCC to provide the basic physical infrastructures of road, electricity and water to any new subdivision (if any) needed to conduct resettlement activities. The respective utility companies are:

- National Water Commission – in charge of water and sewerage systems
- Jamaica Public Service – in charge of electricity
- National Works Agency and Parish Councils – in charge of main roads and parochial roads respectively
- National Irrigation Commission – in charge of the provision of irrigation channels and related infrastructures for farmlands (if applicable).
- Local Cable Companies – provides cable services

6.3.3.5.2 Graves (if any)

Special attention will be given to graves, which have sentimental, emotional and cultural values attached to them. All graves will be interred by licensed undertakers contracted by NROCC. Re-internment will be in an approved family plot or cemetery. Approval for the re-internment of graves will be sought from the St. James Municipal Corporations and Health Department.

6.3.3.6 Grievance Mechanism

Wherever individuals affected by the proposed highway are dissatisfied with any aspect of the resettlement process, these persons may address their issues. These issues can be raised orally or in writing to: NROCCs' Land Acquisition Coordinator or Manager, NROCCs' Chief Executive Office or his Designate, Commissioner of Lands, or the Court. A log will be created to keep track of these issues and to ensure that these are responded to. It is the objective of NROCC to respond to all issues raised within a reasonable timeframe.

6.3.3.7 Monitoring

Once NROCC has entered into an agreement to acquire lands and the affected persons have been relocated, there will be continued dialogue and communication. In the event where the affected persons will carry out self-relocation, NROCC will meet with each person as frequently as required to keep abreast of the progress being made to either find housing or to carry out construction activities.

Any works to be carried out by NROCC for resettlement will also be inspected weekly and a report done on the progress being made. Weekly meetings will be held to review the progress being made and to find solutions to arising issues which may originate.

Some monitoring indicators used for relocated persons' standard of living include:

- Household/land size (i.e. area and number of rooms)
- Land productivity (small farmers)
- Building materials (wood, blocks)
- Land tenure status (without legal titles/security of tenure)
- Public services (potable water, electricity, transportation, etc.)
- Social services (distance from school, health care facilities, etc.)
- Income (where possible)

6.3.4 Restoration and Rehabilitation Plan

The rehabilitation will start with the restoration of the locations of the construction campsites and other cleared areas associated with the road works. This area will be backfilled with material removed during campsite construction and supplemented with layers of topsoil also removed during clearance activities. The final slope angle of the area will be determined based on the geotechnical characteristic of the material used.

Fast growing herbs, shrubs and runners (Table 6-3) will be planted in the various pre-cleared areas. These plants will be obtained from a pre-established nursery within which the species necessary for rehabilitation will be housed.

Table 6-3 Example of plants to be used for rehabilitation currently growing within the project area

Plant Species	Common Name	Growth Form
Hyolocereus triangularis	God Okra **(endemic)**	Runner/Climber
Panicum maximum	Guinea Grass	Herb
Alternanthera ficoidea	Crab Withe	Herbs
Pluchea carolinensis	Wild Tobacco	Herb
Chromolaena odorata	Christmas Bush	Shrub
Piscidia piscipula	Dogwood	Tree
Bursera simarouba	Red Birch	Tree
Leucaena leococehphala	Lead Tree	Tree
Samanea saman	Guango	Tree
Haematoxylon campechianum	Logwood	Tree

The surface will be stabilized according to an active planting program. The establishment of a ground cover is of priority and would include planting the herbs and runners listed in Table 6-3. Their progress will be assisted with the deployment of erosion control blankets and appropriate mulch as necessary.

After the ground cover is established, hardwood trees, such as *Bursera simaruba* (Red Birch), Guango (*Samanea saman*), Logwood (*Haematoxylon campechianum*), *Piscidia piscipula (Dogwood*) and *Leucaena leococehphala* (Lead tree) can/will be planted in the final rehabilitation phase. The vegetation planted will be monitored over a minimum five-year period.

A plant nursery will be setup by the contactor to ensure that sufficient, suitable plant material is available to allow a timely re-vegetation of the site. The nursery will primarily facilitate the care of commonly occurring, native, and endemic plants currently found in the area. The locations and responsibility of this nursery will be determined by the relevant Regulatory Authorities prior to the rehabilitation.

Table 6-4 shows a list of activities and estimated time frames for the Rehabilitation Plan detailed above.

Table 6-4 Activities and estimated timeframes for Rehabilitation Plan

Activity	Estimated Timeframe
Backfilling	1 - 2 months
Levelling and Grading	2 - 3 weeks
Planting of grass, herbs, runners and shrubs and deployment of erosion control blankets and mulch	3 - 5 weeks
Planting of hardwood trees	1 – 2 weeks
Monitoring	Minimum 5 years

As part of this plan, NROCC will develop a specific Reforestation Plan with the cooperation of the Forestry Department to replant areas identified by the Forestry Department. Discussions have already started.

7.0 IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

The discussion and analysis of alternatives in Environmental Impact Assessments should consider other practicable strategies that will promote the elimination of negative environmental impacts identified. This section is a requirement of the National and Environment and Planning Agency (NEPA) and is critical in consideration of the ideal development with minimal environmental disturbance.

The project team and the consulting scientists worked together, utilizing findings of the potential project impacts to analyse possible options for the final development. In addition to examining the advantages and disadvantages of potential project alternatives over that which is proposed, the ability to meet project objectives and the feasibility (for example in terms of available technologies, budget constraints and logistics) of each were additional evaluation criteria. The following alternatives have been identified. They are discussed in further detail below:

- NO PROJECT ALTERNATIVE (“NO-BUILD”)
- SMALL IMPROVEMENTS
- IN-TOWN ALTERNATIVE
- MONTEGO BAY BYPASS ALTERNATIVES
- LONG HILL ALTERNATIVE
- PROJECT AS PROPOSED IN THE EIA

7.1 NO PROJECT ALTERNATIVE (“NO-BUILD”)

The No Build Alternative assumes that no improvements will be made in the study area and that existing conditions will remain. This alternative is often used to compare the costs and benefits of implementing proposed improvements versus the alternative of continuing to use the existing facility. For this study, the No Build Alternative would mean that the Montego Bay Perimeter Road and Long Hill Bypass would not be constructed. Further, beyond the usual maintenance activities, no other improvements or dualization would be done to Barnett Street or West Green Avenue. None of the land or existing road network in the study area is impacted under the No Build scenario.

The advantages of the No Build Alternative include:

- No right-of-way acquisitions
- Least impact to the natural environment
- No utility impacts or relocation
- No disruption to traffic during dualization of Barnett Street and West Green Avenue work
- Least costly alternative

The disadvantages of the No Build Alternative include:

- The purpose and demands of the project are not satisfied
- No improvements to traffic operations and safety
- Reduced level of service (below LOS D) and increased congestion
- No Improved access
- No Increase in reliability of the road network
- Inability to accurately predict travel times
- Fuel and Vehicle operating costs remain high
- No improved pedestrian facilities
- No employment opportunities

7.2 SMALL IMPROVEMENTS

The National Works Agency has identified several small improvements within the town (Table 7-1) that may be considered as a project alternative. It assumes that the capacity improvements will be done within the city that have limited impact on right-of-way, and utilities. This alternative is used to compare the costs and benefits of implementing the perimeter road versus the alternative of continuing to use the existing facility only. Based on a network analysis of existing conditions, these improvements will upgrade the level-of-service (LOS) to a minimum of “D” and alleviate some of the current congestion experienced in the town.

Table 7-1 Improvement Under the No-Build Alternative

Source: (Stanley Consultants Inc., 2018)

Location	Amount (JMD)
Queen's Drive/Leaders Avenue Intersection	$53,157,672.00
Barnett Street/Howard Cooke Boulevard Intersection	$9,350,797.00
Bevin Ave/River Bay Road/Howard Cooke Boulevard Intersection	$41,597,776.60
Trinity Crescent - Jarrett Terrace Overlay	$5,645,850.00
Austin Ave Overlay	$10,115,944.00
Westgate/Barnett Street Intersection	$12,821,705.00
End of Bogue Project to Barnett Street(Clock) overlay	$24,399,377.00
Howard Cooke/Catherine Hall Intersection	$10,636,645.00
Vernon Drive Overlay	$20,415,200.00
Cottage Road/Mt Salem Intersection - Austin Ave overlay	$22,588,000.00
Fish Lane - Railway Lane sidewalks and Overlay	$13,851,650.00
River Bay Road/Railway Lane - Fustic Road sidewalks and Overlay	$6,561,300.00
Church Hill Ave sidewalks and Overlay	$5,439,054.00
Roosevelt Ave/Bevin Street - Barnett Street Intersection	$7,819,644.00
Traffic Management - Mt. Alvernia Prep	$17,445,540.00
Opening up Market Street	$7,183,200.00
Urban Traffic Signal System - CDB	$100,525,000.00
Total	$369,554,354.60

The advantages of the Small Improvements alternative include:

- Limited right-of-way acquisition
- Least impact to the environment
- Least costly alternative

The disadvantages of the Small Improvements alternative include:

- The purpose and demands of the project are not satisfied
- Minimal improvements to traffic operations and safety
- Reduced level of service (below LOS D) and increased congestion
- Significant disruptions in traffic during construction
- Land acquisition will be in urban areas and require acquisition of expensive commercial properties.

7.3 IN-TOWN ALTERNATIVE

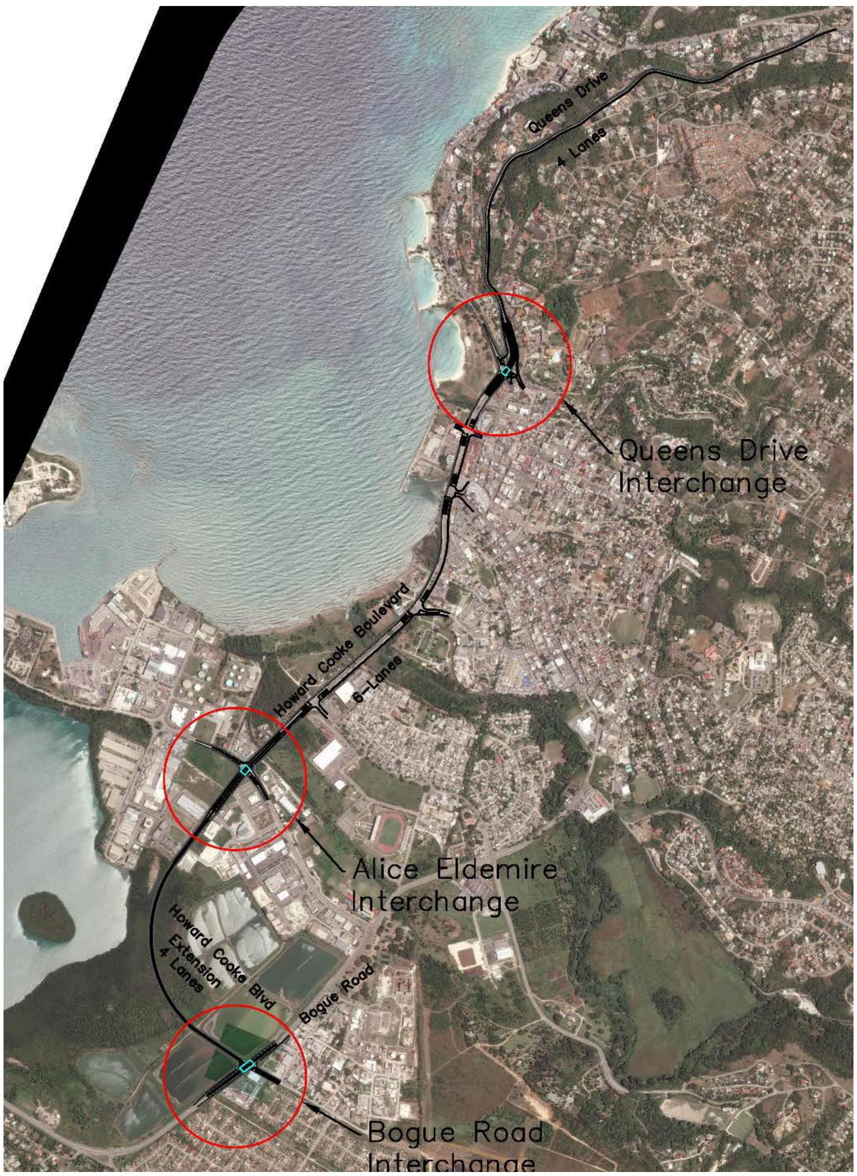
Beyond the No-Build Alternative and Small Improvements, additional improvements can be done along the existing major arterials to improve the LOS in the future scenario (Stanley Consultants Inc., 2018). Based on the growth rate and all pending and approved developments, turning volumes at the major intersections along Bogue Road, Alice Eldemire and Howard Cooke are projected to be over 500 vehicles in the AM peak. To put this volume to capacity condition in context, a typical right-turn lane at a signalized intersection has a capacity of approximately 400 vehicles per hour. These volumes would therefore require double turn lanes, especially in cases where the conflicting through volumes are also high.

Several intersection solutions were tested for the 2040 build-out including various continuous-flow intersections, and grade separations. Ultimately, in order to alleviate the congestion from the future traffic growth and build-out, grade separations are the most promising option, but with existing traffic signals spaced 300-500 m apart, it is not feasible to grade separate the intersections unless the entire corridor is an elevated road with supplemental collector-distributor lanes feeding into key interchange locations along the arterial.

For the In-town alternative, a practical solution was explored to compare an alternative through the town to a perimeter road around the town. This alternative assumed the 6-laning of Howard Cooke Boulevard, double right turn lanes at the intersections of Market Street, Barnett Street, and Lower Bevin Avenue and the extension of Howard Cooke Boulevard to Bogue Road, bypassing Alice Eldemire. Howard Cooke Boulevard would therefore be expanded from 4-lane road to 6-lane between Queens Drive and Alice Eldemire, with a 4-lane extension from Alice Eldemire to Bogue Road, making Howard Cooke Boulevard a total of 3.24 km. Additionally, grade separated interchanges are proposed at Howard Cooke Boulevard and Queens Drive, Howard Cooke Boulevard and Alice Eldemire Drive and

Howard Cooke Extension and Bogue Road. Additionally, Queens Drive would be expanded from 2 to 4 lanes.

Figure 7-1 shows the urban highway alternative to the Montego Bay Perimeter Road. This alternative is expected to have significant land impacts particularly in the vicinity of Market Street and Howard Cooke Boulevard where the right-of-way is constrained by the Baywest Shopping Centre, Sagicor shopping complex, Inland Revenue building and the downtown craft market. In order to accommodate the required 6-lane corridor with provisions for a double right-turn lane to Market Street, land would be needed on one or both sides of the road, therefore either the Baywest Shopping Centre and the craft market, or the Sagicor Centre and the tax office would need to be acquired.



Source: (Stanley Consultants Inc., 2018)

Figure 7-1 Urban Highway Alternative

In addition to the significant land impacts, utility poles along the entire length of the road would need to be relocated. The Queens Drive expansion would require the relocation of approximately 70 utility poles. The Howard Cooke Boulevard expansion would require the relocation of at least 30 utility poles. Howard Cooke Boulevard and Queens Drive also have significant potable water and sewage lines that would need protection and/or relocation. Expansion works on Howard Cooke would cause immense traffic delays during construction since there are no viable alternate routes. Expansion works on Queens Drive, would cause an increase in traffic on Gloucester Avenue which would have additional impacts on the tourism products along that road. Construction would have to be staged to provide the existing 4-lane capacity on Howard Cooke Boulevard at minimum during the peak hours. Maintenance of traffic during construction would therefore pose considerable challenges.

The total costs associated with the in-town alternative is $30,259,551.84 JMD. This does not include land and structure acquisition, which is estimated as being significant. The conceptual cost of the preferred Montego Bay Bypass perimeter road alignment was estimated at $118,306,194.88 (section 7.4). Based on the speed limit and capacity of the Montego Bay Bypass perimeter road, the travel time between Bogue and Ironshore is estimated at 15 minutes in the peak hour and includes the controlled delay at the signalized intersections at either end of the Perimeter road. Although the conceptual cost of the In-town alternative is lower ($30,259,551.84 USD), it is projected to have a travel time of 22 minutes in the peak hour and this alternative would also have significant impacts on the land uses, utilities and traffic along the corridor.

7.4 MONTEGO BAY BYPASS ALTERNATIVES

7.4.1 Summary

Using the available digital elevation model (DEM), several alignments for the perimeter road were modelled and optimized (Stanley Consultants Inc., 2018). The alignment options were segmented and further developed to generate four optimal alignments for each of three identified segments. These segments were studied to determine the environmental, socio-economic and engineering attributes and potential impacts. Comparison of the different alternatives was done through the development of evaluation criterion based on the attributes and the potential impacts that were identified. Simultaneously, an alternative was developed within the city, using the existing major arterials. Conceptual costs were developed for all alignment alternatives, including preliminary land acquisition costs.

The preferred alignment was chosen by NROCC in June 2017 based on the costs and socioeconomic impacts. This alignment would attract commuters from the southern downtown and Freeport areas, in addition to commuters west of Bogue. This alignment is especially advantageous for trips produced and attracted by the shipping port, allowing a more direct connection from shipping logistics activities in Freeport to supplementary logistics centres in the east. This alignment had the lowest conceptual cost of the alternatives that start at Howard Cooke Boulevard and Alice Eldemire Drive and was therefore the most attractive option.

7.4.2 Alternatives Development

The addition of a Montego Bay Perimeter Road will reduce the through volumes on Howard Cooke Boulevard, Alice Eldemire Drive, Queens Drive and Gloucester Avenue (Stanley Consultants Inc., 2018). These reductions will mitigate against the impact of the future growth in through volumes at all intersections along these corridors. The Perimeter road, however, may not significantly impact the turning volumes at these intersections since the demand volume into the City, reflected by these movements, is not expected to be significantly decreased. With the decreased demand for the through volume green interval (time dedicated to servicing through vehicular traffic at signalized intersections), additional time can be allocated to the protected turning movements which will improve the performance of those lane groups.

Using the digital elevation model (DEM) and key points of interest, alignments were developed to maximize the benefits of the Perimeter road while still providing access to the Perimeter road from communities on the outer bands of the City. The communities of Irwin, Porto Bello, Cornwall Courts and Salt Spring were highlighted as potential connections to the highway. Options to connect the highway in the vicinity of Ironshore in the east and Bogue in the west were explored and optimal locations chosen based on the DEM.

The design team then established alignment alternatives based on proposed connectivity, the DEM and the design criteria. As the design alternatives developed, logical segment breaks were established to compare various sub-alignment options. The sub-alignment segments are as follows:

- Segment A was developed between Bogue/West Green and Fairfield.
- Section B between Fairfield and Cornwall Courts
- Segment C between Cornwall Courts and Ironshore

7.4.2.1 Segment A – Bogue/West Green to Fairfield

Segment A begins in the vicinity of Bogue and West Green. Three main connections to the existing road network were explored:

- Howard Cooke / Industrial Road and Alice Eldemire
- Alice Eldemire and Barnet Street/Bogue Road
- Howard Cooke and West Green

In this segment, the design speed is a minimum of 65 km/h with an urban cross-section.

7.4.2.1.1 Segment A1

Segment A1 begins at the intersection of Howard Cooke Boulevard and Alice Eldemire Drive and intersects Bogue Road to end east of Granville and south of Fairfield/Tucker (Figure 7-2). This alignment would allow direct access to Howard Cooke Boulevard without having to traverse the existing congested routes. This option also offers an alternative to Alice Eldemire Drive which would alleviate some of the congestion experienced on this arterial. The A1 alignment is 3.94 km with 3.76 km being an urban cross-section.

7.4.2.1.2 Segment A2

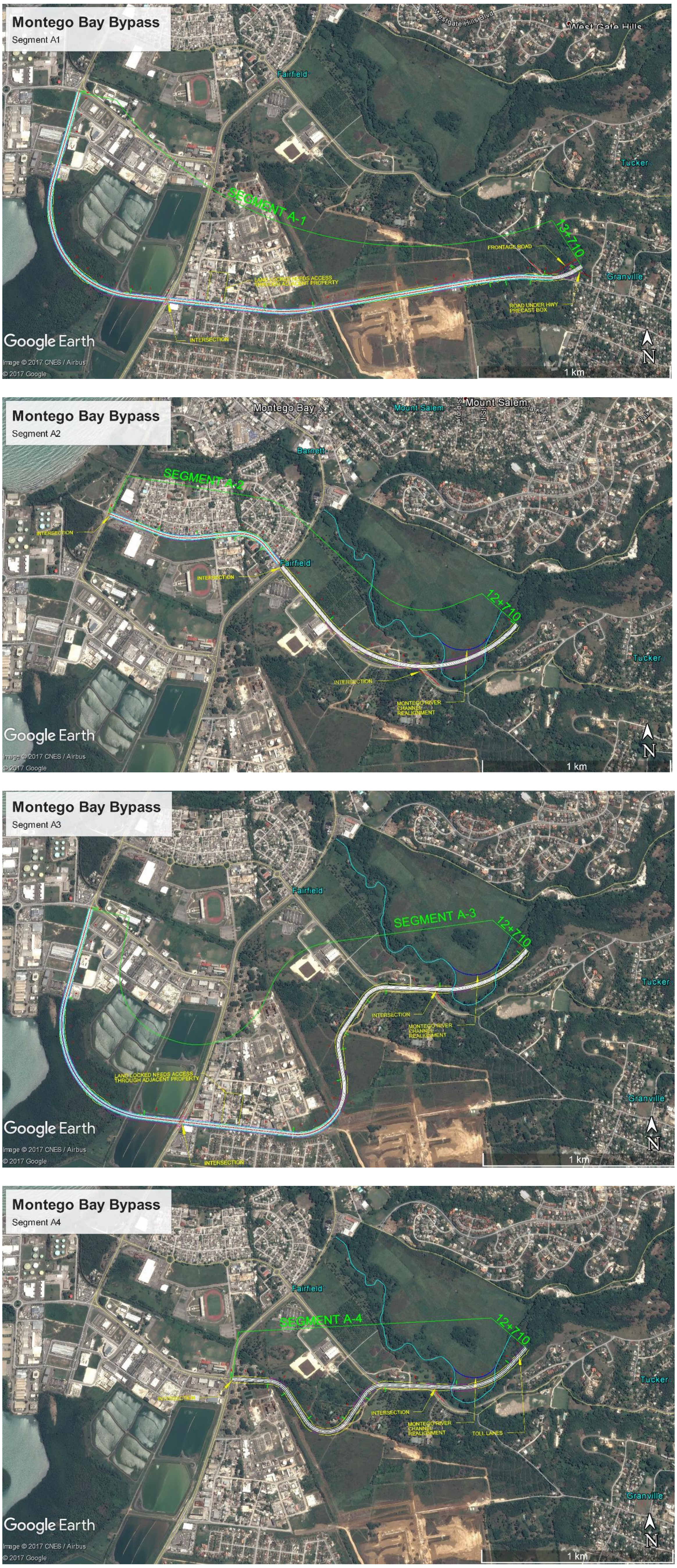
Segment A2 begins at the intersection of Howard Cooke Boulevard and West Green Road, running through West Green Road to end north of Fairfield Road. A2 is 2.7 km long with 1 km being an urban cross-section.

7.4.2.1.3 Segment A3

Segment A3 is a hybrid of A1 and A2. It begins at the intersection of Howard Cooke Boulevard and Alice Eldemire Drive, intersects Bogue Road then deviates to end north of Fairfield Road. A3 is 4.45 km long with 2.5 km being an urban cross-section.

7.4.2.1.4 Segment A4

Segment A4 begins at the intersection of Alice Eldemire Drive and Bogue Road, goes around the Barnett Tech subdivision to end north of Fairfield Road. It is 1.74 km in length with no urban cross-sections since it runs through a cemetery.



Source: (Stanley Consultants Inc., 2018)

Figure 7-2 Alignment Alternatives, Segment A1, A2, A3 and A4

7.4.2.2 Segment B –Fairfield to Cornwall Courts

Segment B begins at the end of the A segment in the vicinity of Fairfield and goes around the residential areas to the east of the Cornwall Courts residential area. Two options went south of the Irwin residential development and the other two went north of the Irwin residential development.

7.4.2.2.1 Segment B1

Segment B1 goes from Segment A1 through the community of Granville, around the south side of Irwin, east of Porto Bello to end 1 km east of Cornwall Courts. Figure 7-3 shows the alignment for B1 which is 7.74 km with only a rural cross-section. The design speed for B1 is 95 km/h.

7.4.2.2.2 Segment B2

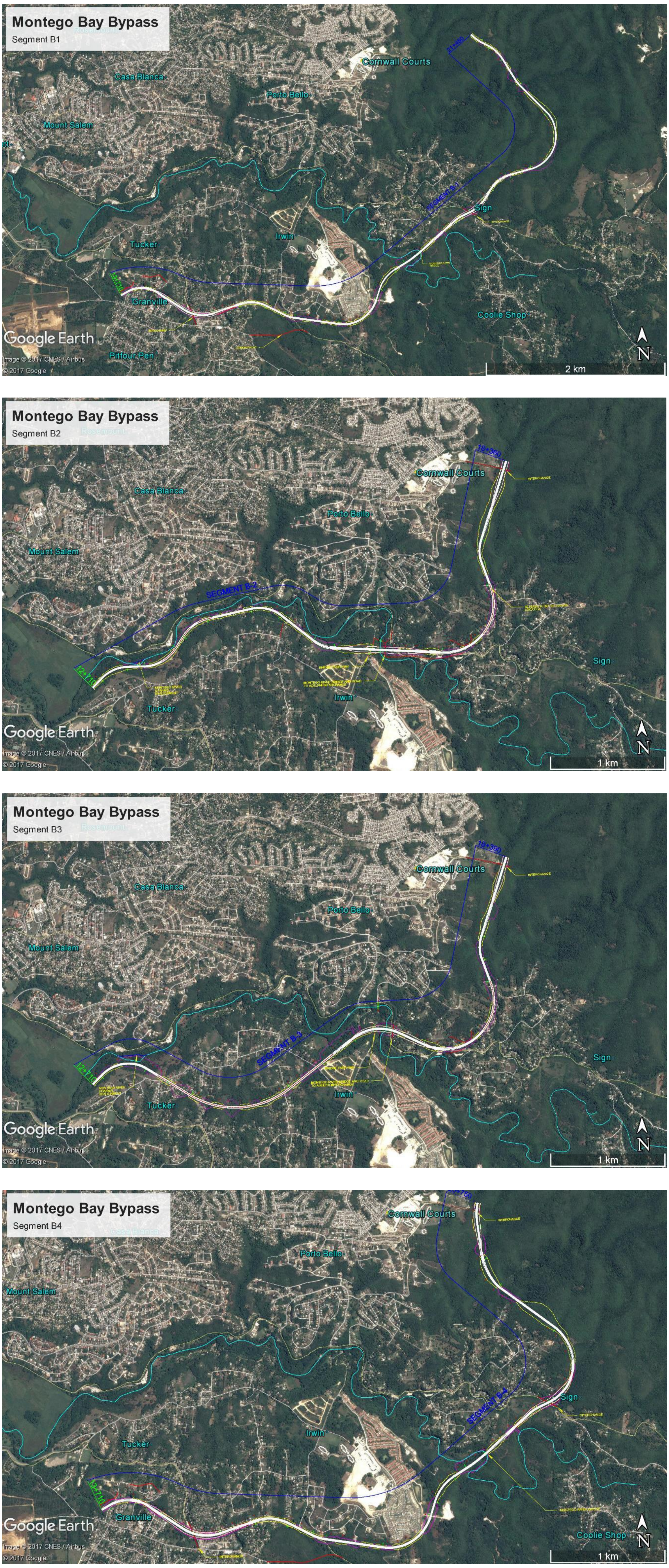
Segment B2 starts at the end of Segments A2, A3 and A4 running along the Montego River north of Tucker and Irwin. It then crosses the river and the Porto Bello main road to get to Cornwall Courts. The alignment for B2 is 5.65 km with only a rural cross-section. The design speed for B2 is 90 km/h.

7.4.2.2.3 Segment B3

Segment B3 starts at the end of Segments A2, A3 and A4 running south of the B2 alignment but still north of the Irwin community to cross the river and the Porto Bello main road to get to Cornwall Courts. Figure 7-3 shows the alignment for B3 which is 5.68 km with a rural cross-section. The design speed for B3 is 90 km/h.

7.4.2.2.4 Segment B4

Segment B4 starts at the end of A1 goes through the community of Granville, around the south side of Irwin, east of Porto Bello to end closer to Cornwall Courts than the similar alignment of B1. The alignment for B4 is 7.04 km with a rural cross-section. The design speed for B4 is 95 km/h.



Source: (Stanley Consultants Inc., 2018)

Figure 7-3 Alignment Alternatives, Segment B1, B2, B3 and B4

7.4.2.3 Segment C – Cornwall Courts to Ironshore

Segment C begins in the vicinity of Cornwall Courts and ends 340 m west of the intersection of Morgan Road and Elegant Corridor in Ironshore.

7.4.2.3.1 Segment C1

Segment C1 starts at the end of alignment B1 and goes through Salt Spring, west of Flower Hill to end on the Elegant Corridor. Figure 7-4 shows the alignment for C1 which is 5.87 km with a 435 m being an urban cross-section and a design speed of 95 km/h.

7.4.2.3.2 Segment C2

Segment C2 connects to B2, B3 and B4 and goes east of Salt Spring, through Flower Hill to end on the Elegant Corridor. Figure 7-4 shows the alignment for C2 which is 7.13 km with a 435 m is being an urban cross-section and a design speed of 95 km/h.

7.4.2.3.3 Segment C3

Segment C3 goes from alignment B2, B3 and B4 through Salt Spring, west of Flower Hill to end on the Elegant Corridor. Figure 7-4 shows the alignment for C3 which is 5.96 km with a 435 m being an urban cross-section and a design speed of 95 km/h.

7.4.2.3.4 Segment C4

Segment C4 connects to B2, B3 and B4 and goes east of Salt Spring, through Flower Hill to end on the Elegant Corridor. Figure 7-4 shows the alignment for C4 which is 5.87 km with a 435 m being an urban cross-section and a design speed of 65 km/h.

Source: (Stanley Consultants Inc., 2018)

Figure 7-4 Alignment Alternatives, Segment C1, C2, C3 and C4

7.4.3 Evaluation Criteria and Matrix

Stanley Consultants in conjunction with the NROCC identified 21 evaluation criteria that would be used to evaluate each alignment alternative (Stanley Consultants Inc., 2018). The alignment evaluation criteria were grouped in four sections: Engineering, Socio-Economic, Environmental and Cost. Selected stakeholders established the weighting for each evaluation criterion by comparing each criterion against each other and noting which was more important in this one-on-one comparison. These stakeholders were as follows:

- National Road Operating and Constructing Company (NROCC)
- National Works Agency (NWA)
- Stanley Consultants Inc (SCI)
- National Environment and Planning Agency (NEPA)
- St. James Municipal Corporation
- Planning Institute of Jamaica (PIOJ)

A matrix was developed to determine the weighting for each of the evaluation criteria to assess the alignment alternatives in an objective manner. Each major stakeholder was asked to fill out the matrix to determine which priority has the most importance to them and which has the least importance. Each evaluation criterion was compared to all the other evaluation criteria using an interactive excel spreadsheet that was developed for this purpose. The matrix returned by each participating stakeholder was combined to produce a total score for each evaluation criterion (Table 7-2). Ten points, the maximum weight, were assigned to the criterion with the highest score. The remaining evaluation criteria were assigned a weight that was equal to 10 times the score for that criterion divided by the highest score. This procedure provided the weights in the above table, which were then applied in the evaluation matrices for each alignment alternative.

The preferred alignment alternative is a combination of the highest scoring segments together. Based on the segments developed for the Montego Bay Perimeter Road, 22 possible iterations of the alignment could be explored. To understand the magnitude of the project and to populate the evaluation matrix cost criteria, conceptual level cost estimates were made based on major quantities and unit cost data relevant to the project.

The results of the Alignment Study were presented to NROCC on June 26, 2017. The preferred alignment based on the matrix scores was A4-B3-C4, however this alignment contained environmental and traffic issues that were not accounted for in the evaluation matrix. Upon evaluation of the highest-ranking alignments, NROCC chose A3-B2-C3 as the preferred alignment based on the concept of the highway beginning at Howard Cooke Boulevard and Alice Eldemire Drive and the ability for eastbound traffic to enter the highway from the intersection at Temple Gallery and Bogue Road, which would save commuters the extra travel time to enter closer to the City. The chosen preferred alignment would attract commuters from the southern downtown and Freeport areas, in addition to commuters west of Bogue. This alignment is especially advantageous for trips produced and attracted by the shipping port, allowing a more direct connection from shipping logistics activities in Freeport to supplementary logistics centres in the east. Alignment A3-B2-A3 had the lowest conceptual cost of the alternatives that start at Howard Cooke Boulevard and Alice Eldemire Drive and was therefore the most attractive option.

Table 7-2 Evaluation Criteria Ranking

Source: (Stanley Consultants Inc., 2018)

Rank	Criteria	Score	Weight
1	Flooding & Storm Surge Impacts	187	10.0
2	Impact to Wells, Springs, Aquifers	182	8.3
3	Roadway Costs	155	8.0
4	Potential for Development	154	7.9
5	Right-of-Way Costs	135	6.8
6	Average Travel Time	133	6.6
7	Wetland Impacts	124	6.4
8	Biological & Wildlife Habitat Impacts	124	6.2
9	Cost of Road Maintenance	120	6.2
10	Business & Commercial Impacts	114	6.0
11	Number of Residential Relocations	113	5.7
12	Archeological Impacts	107	5.5
13	Level of Service	106	5.0
14	Access Management	100	4.8
15	Maintenance of Traffic Impacts	91	4.6
16	Agricultural Impacts	87	4.5
17	Design Speed Variance	77	4.5
18	Number of Parcels Impacted	72	4.1
19	Noise Impacts	55	3.7
20	Underground Utilities	54	3.5
21	Utility Poles	29	2.0

7.5 LONG HILL ALTERNATIVE

One alternative to the Long Hill alignment was developed and this is illustrated in Figure 7-5.

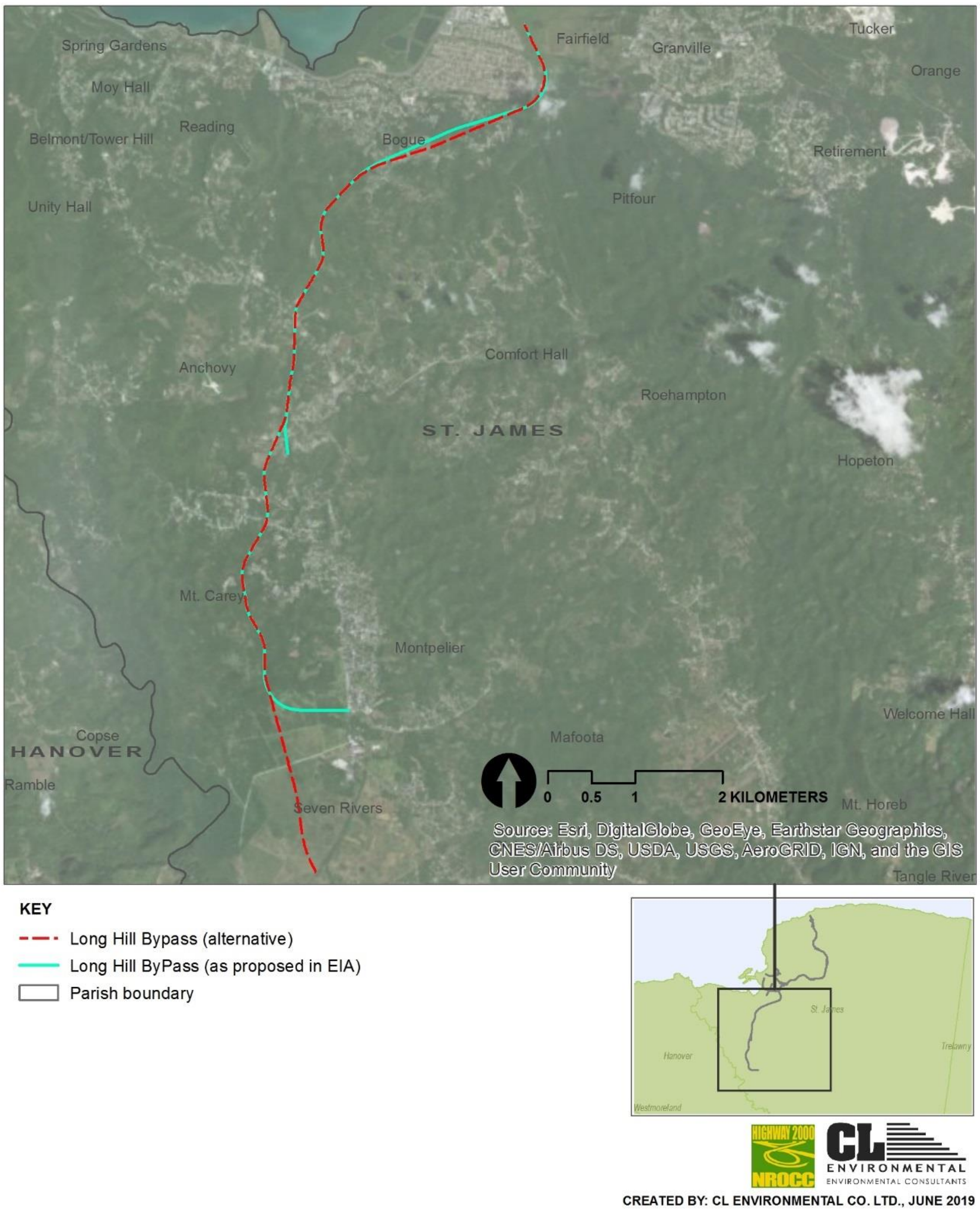


Figure 7-5 Long Hill Bypass alternative

7.6 PROJECT AS PROPOSED IN THE EIA

The biological, physical and socioeconomic impacts and mitigation measures for the project as proposed (see section 2.0) are discussed in detail throughout this report.

The following positive impacts are anticipated:

- The purpose and demands of the project are satisfied, i.e. improvements to traffic operations, reliability, access and safety
- Improved pedestrian facilities
- Reduced maintenance and fuel costs associated with better quality roads
- Employment opportunities will be created during the construction phase as well as the post-construction phase.

The following negative impacts are possible:

- Degradation of natural habitats that support ecologically important species
- Right-of-way acquisitions and relocation of residents and businesses whose properties fall within the alignment and the associated project limits
- Utility impacts and relocation
- Potential adverse impacts on noise, air quality and water quality

7.7 PREFERRED ALTERNATIVE

Of the alternatives presented in previous sections, the development as proposed in the EIA is the most economical option that will result in the provision of the urgently needed improvements to traffic operations, reliability, access and safety in and around Montego Bay. Indeed, the adverse potential impacts must be mitigated, and the various management and monitoring programmes adhered to during all project phases.

8.0 PUBLIC SENSITIZATION

8.1 PURPOSE OF THIS SECTION

The National Environment and Planning Agency (NEPA) recognizes the critical role played by the public, including civil society, community-based and non-governmental organizations (CBO's and NGO's). The process of public sensitization is designed to enhance the awareness of stakeholders and/or the general public in an open sphere. This helps to ensure that persons who are likely to be impacted are knowledgeable and therefore able to implement precautionary measures to safeguard their interest. It also seeks to facilitate stakeholder participation in the monitoring and enforcement of the conditions under which approvals are being granted.

This section outlines the results of the stakeholder consultation programme for this project and summarizes the key stakeholder issues arising to date.

8.2 STAKEHOLDER CONSULTATION PROGRAMME

Stakeholder consultation included the following mechanisms.

1. **Perception Survey**
   A survey was conducted within communities two (2) kilometres of the proposed site during the period March 29, 30, 31 and April 1, 2 and 3, 2019. The Perception Survey questionnaire (Appendix 9) administered addressed the following major issues:
   - General acceptability of the proposed project by community-based stakeholders.
   - Fears and expectations about the specific project, including any anticipated social conflict and crime.
   - Perceptions and attitudes of the community.
   - General health, safety and environmental concerns related to the project.

2. **Consultation with Stakeholders**
   i) Montego Bay Chamber of Commerce
   ii) Montego Bay Marine Park
   iii) National Water Commission
   iv) Jamaica Public Service Company Limited
   v) Flow
   vi) Digicel
   vii) Office of Disaster Preparedness and Emergency Management (ODPEM)
   viii) St James Parish Council
   ix) Fire Department

x) University of the West indies
xi) Water Resources Authority

3. **Community Meetings**
   a. Catherine Hall
   b. Salt Spring

   See Appendix 6 for attendance sheets.

4. **Public Presentation**
   a. A public presentation outlining the project, environmental impacts, and proposed mitigations main findings of the EIA will be held at a community-based meeting. The meeting will be held in conformance with the NEPA Guidelines for Conducting Public Presentations. The key points are:
      i. The Public Meeting shall not be held less than 21 days after the EIA is made available for public review; and
      ii. The public has one (1) month after the public meeting to submit written responses/comments.
   b. The continued availability of all EIA documentation for public review until a decision is made in respect of the development application. This includes:
      i. The approved Terms of Reference (appended in the EIA),
      ii. The EIA inclusive of all supporting technical appendices; and
      iii. The verbatim minutes of the Public Meeting (including the register of attendance).

8.3 ISSUES RAISED

8.3.1 Community Stakeholders

8.3.1.1 Catherine Hall Community Meeting

- Concern was raised for the children that traverse West Green Avenue and the question of whether or not an overhead bridge will be provided was asked.
- How will the overhead from temple Gallery Road to Bogue be accessed?
- Will pedestrian crossings be provided?
- Concern was raised about the impending overwhelming traffic that will be on Temple Galley Road
- Concern was raised about the noise, dust and vibration that will be caused by movements of heavy units and proximity to structures. How will the effects of vibrations be accounted for and the possible adverse effects on the structures?
- A suggestion was made to move the project from West Green Avenue to behind the Megamart

- Mention was made that the topography of the area allows for water to flow towards the sea and it settles by the Howard Cooke Boulevard as such concern was raised that raising the road will cause flooding.
- The question of what sections of the roadway will be tolled was asked.
- What will prevent vehicles from running off the road and damaging structures?
- It was suggested that the project be removed to the commercial areas and improvements be made to the residential roads
- Where will residents park their vehicles?
- What plans are there to improve drainage in the Catherine Hall area
- Special attention needs to be paid to the drains in the vicinity of the police station and the community college. Suggestion made to make the drains higher and wider
- Concern was made about the possible type of construction material to be used; mention was made that marl should not be used.
- Query as to how long after the close of the project can someone make a claim due to damages
- Will there be compensation for the removal of temporary structures?
- Where should concerns/queries/comments/complaints be lodged?
- With regards to the existing drainage in the Temple Gallery Road area, the question of forthcoming plans to improve the drainage was asked also the involvement of NWC to help resolve the sewage issues in the area was asked
- Will the road make accommodations for persons with disabilities?
- Are there any plans for NROCC to adopt a project to improve the community? A suggestion was made that the primary schools and early childhood institutions could benefit from the project.

8.3.1.2 Salt Spring Community Meeting

- Will graves be relocated and what is the process of relocation?
- What is the process for persons who do not have legal tenure or have common-law-titles and those who have not paid property taxes for years on the land?
- Currently the area is experiencing water issues and a section of the road is not repaired.
- What plans are there for persons who own lands that do not live on the land and may have migrated or are deceased?
- How will lands be addressed in situations where property taxes are not up-to-date, and it is determined that the cumulative property tax is less than the value of the land?
- How will matters of informal settling be addressed?
- When will construction begin and what is the duration?
- What is the turnaround time for compensation?
- The process of receiving a title through LAMP is long and may not be coincide with the timeframe of the duration of the project, how will such situations be addressed?
- In situations where the road severs land, how will such matters be addressed?
- A mango tree appears to be within the alignment, what will happen to the mango tree?

8.3.1.3 Salt Spring Community Development Committee

- Access to the highway from the Salt Spring community
- Help from NROCC/GOJ to access titles for land
- Will NROCC participate in local community initiatives to "uplift" the community?
- Will local community road be upgraded during construction of the Montego Bay Bypass?

8.3.2 Other Stakeholders

8.3.2.1 University of the West indies

A meeting was held on 14 April 2019 to discuss the impact of the project implementation on the proposed UWI Mona Western Campus. The following issues were raised following the presentation by members of the UWI team:

- The impact of traffic from the highway on the proposed UWI campus.
- What mechanisms will be incorporate into the design of the highway to mitigate:
    - noise impact
    - Air quality impacts
    - Potential drainage impacts
- Will noise wall be incorporated into the designs of the highway in the vicinity of the campus.
- Construction start up time:
    - NROCC's project 1st Quarter 2020
    - UWI (1200 or 250 residential rooms) 6 months starting time
- NROCC will make provision for suitable access from the highway to the UWI campus at the signalized intersection.

Queries regarding the mangroves to be removed by the road were also raised.

8.3.2.2 Water Resources Authority

- Flooding of the North Gully during intense rainfall due to additional flow from the road surface.
- Increased runoff towards the Montego bay river at lower elevations
- Detailed hydraulic and hydraulic assessment for the Long Hill Bypass section to determine potential of communities.

The Water Resources Authority (WRA) prepared two documents in relation to the proposed project, namely:

- *Assessment of the St. James November 2017 Flooding*, prepared by Johanna Richards, Water Resources Engineer and dated January 29, 2018, and
- *Preliminary Hydrological and Flood Risk Report for the Montego Bay Bypass Alignment*, prepared by Michael R. A. Wilson, Deputy Managing Director.

Information from these documents are incorporated and referenced accordingly in the EIA and the following subsections clearly outline the major findings and recommendations.

8.3.2.2.1 Assessment of the St. James November 2017 Flooding

Severe localized flooding occurred in the parish of St. James on November 22, 2017, specifically in the areas of Ironshore, Green Pond and the Montego Bay City centre. Flooding in these areas has occurred several times in the past and in an attempt to assess the cause and severity of the flooding in these areas, a team from the Water Resources Authority of Jamaica (WRA) made a field visit in November 2017 to several of the impacted areas.

There are three main watercourses whose flows contributed to the flooding: Salt Spring Gully, North Gully and South Gully. All three gullies are at the mouth of large ephemeral watercourses. Substantial floodplain encroachment has taken place for all three watercourses, and so any infrastructure in the immediate vicinity of these watercourses is at risk of flooding, especially during high-intensity rainfall events. The severity of the flooding highlights several points:

- The drains do not have the capacity to handle large storm events as they were all overtopped during this November event.
- Uncontrolled developments in the upper watersheds provide increased sediment load to drains and culverts, creating blockage. Of note was a new development near the Cornwall Courts area, in which the topsoil (consisting of marl) was exposed. This development sits at the top of the catchment contributing to the North Gully, and it is likely that sediment from this development contributed to the deposition seen in the gully. Any development in the upper areas of the catchments needs to be properly planned, and any exposed sediment properly managed.
- There has been severe encroachment on the floodplains of the gullies.

In light of this flood assessment, the following recommendations need to be considered:

- The drains need to be cleaned immediately after any large storm event;
- Any future developments in the watersheds need to be at an appropriate setback distance from the watercourses; and
- Measures are to be put in place to mitigate the erosion, sedimentation and debris flows from the upper watershed areas.

All incidences of flooding presented in this report were exacerbated by inadequate drainage infrastructure. It is therefore recommended that hydrologic and hydraulic assessments be carried out to determine the necessary infrastructural improvements. These assessments should also be used to determine the appropriate setbacks from watercourses/drainage infrastructure. This would contribute substantially to appropriate land use planning practices in the future.

8.3.2.2.2 Preliminary Hydrological and Flood Risk Report for the Montego Bay Bypass Alignment

The establishment of the Montego Bay bypass can have a positive or negative impact on the communities along its corroder on Water Resources or Flooding. Though this may see the movement of goods, services and people going faster from one point to another, it may also see communities suffering from it.

The proposed Montego Bay bypass is located in the Great River Watershed and Hydrologic basin for this report the study area is divided into three (3) sections.

SECTION 1

This section of the proposed highway begins at Ironshore near the Blue Diamond shopping centre in a South Easterly direction towards Green Pond. The road follows the Salt spring gut channel from 50m to some 200m contour at Green Pond. At the start of the proposed highway approximately 600 m towards the North East is the Ironshore Estate well, which was drilled in 1949 at a depth of 29m. The rest water level was 19m below ground level (BGL).

Approximately 752 m west of the proposed highway are the green pond well which is 33.53m deep and a rest water level of 22.56 m BGL. This well was drilled in December1968. The Casa Montego Hotel well is located some 5.5km north west of Green Pond, its depth is 25.9m and had a rest water level of 1.83m, the well was completed in September 1960. From all indications there should not be any negative impact on these wells.

The Highway alignment is expected to traverse along the salt spring gut channel from elevations of 50m and rising to some 200 m. In the WRA Flood assessment report of the November 2017, it was noted that gully contributed significantly to the flooding of the Rui Montego Bay Hotel. The report also mentioned the flooding of the Montego Bay City centre, which started as far up in the watershed as Green Pond high school.

Several recommendations were made by the WRA but most notable is a hydrologic and hydraulic assessments, the highway may exacerbate flooding associated with intense rain fall resulting from increased runoff.

SECTION 2

This section of the proposed highway begins just below Green Pond at Porto Bello going in a south westerly direction towards Fairfield, Bogue and the free Port area. There is also the section south of the proposed highway from Bellfield, through Salt spring Mountain and to Anchovy.

There are six production wells north of the proposed highway five are owned by the National Water Commission (NWC) and one by the Jamaica Public Service company (JPS. Co.). They are Irwindale, Irwin Exp III, Bouge and Catherine Mount 1 & 2, which are used for domestic water supply and the Bouge Plant well, which is used for industrial purposes. Based on the proposed alignment the impacts on these wells should be negligible in terms water levels, the wells are in the limestone aquifer with depths exceeding 40m.

The WRA operates a Stream gauging station (Montego River @ Montego Bay) on the Montego River located at West gate, this station was established in 1965, the proposed realignment of the River channel near Fairfield is not expected to impact data collection or the rating curves. It must be noted that the highway will result in increased runoff toward the river at a lower elevation, the chances of flooding within communities situated along the northern section of that corridor should be investigated.

The section south of the proposed highway from Bellfield through Salt Spring Mountain and Anchovy has several production wells within two Kilometre along the proposed alignment. These wells are all owned by the NWC namely Fairfield, Bellfield, Granville Exp.II and Pitfour, they are all for domestic water supply.

This section from Bellfield has an elevation of 12 m and increases to 91m toward Salt Spring Mountain and then to approximately 75m at Anchovy. The section of Salt Spring Mountain, Wales Pond and Comfort Hill communities are known to have flooding issues. There is a proliferation of natural depressions in these communities and during intense rainfall, the depressions becomes overwhelm and overflows flooding roadway, houses and running to the lower sections. This ultimately sees Anchovy and surrounding communities being impacted with streams of water from runoff flowing along the roadways towards Long Hill.

The proposed highway with paved surfaces may increase runoff resulting in the flooding incidents being exacerbated. This section has an underlying geology which is Montpelier Limestone and is classified as Limestone Aquiclude. The limestone aquiclude in its intrinsic properties has a very low primary permeability. This property allows the formation to pond water. However, faulting has served to generate zones of increased permeability. This formation may yield water to wells and springs, but generally in association with these zones of increased permeability. From the geological mapping this formation may extend up to 457.2metres (1500feet) in thickness in some areas. It is recommended that hydrologic and hydraulic assessments should be carried out.

SECTION 3

This section of the proposed highway begins just below Anchovy going southerly to Montpelier. This section has several depressions through which the proposed highway is to pass, there are three production well located at Montpelier of which only one is in production and is operated by the NWC for domestic water supply.

The alignment of the proposed highway is not expected to have an impact on ground water, the Montpelier Blue hole is located 3.2 km east of the highway or approximately 2.2 km north east of Montpelier NWC production well, this too should not have any negative impacts from the proposed highway.

The WRA, however notes that the Great River crosses the proposed highway this is not expected to have a negative impact on the two stream gauging stations operated by the WRA (Sevens River and Great River at Lethe). There are also two large development that the WRA commented on namely

Montpelier block 1 and Montpelier Shettlewood, a hydrologic and hydraulic assessments should be done to analyse the impact on same.

8.3.2.3 National Water Commission

On examination of the plans for both legs of the proposed highway routes, National Water Commission reported that the proposed alignments will intercept the NWC's infrastructure in several areas. These are broadly outlined below referenced to the road chainage as much as possible as mentioned in NROCC's report.

1. Alice Eldemire to Bogue Road
    a) At Chainage 10 + 000 southward along the existing commercial subdivision road – Existing 150mm water distribution pipelines.
    b) Chainage 11 + 600 along the sewage pond road – if the road is maintained at the same grade access around the ponds will be severed. Impact on the 750mm water transmission main running north/south on pond road.
    c) Intersection with Bogue Road - several water and sewage pipeline as well as sewer pumps station infrastructure will be impacted.
    d) Along Temple Gallery road – water and sewer pipelines will be impacted.
    e) Danger posed to the structure of the ponds based on the road construction method.
    f) Danger posed to the treatment efficiency of the ponds due to an imposing road structure. The ponds' treatment efficiency depends on the wind and sunlight. An imposing road could affect the ability of the ponds to utilise the sunlight and wind to efficiently treat sewage.

2. Fairfield to Adelphi Main Road
    a) Chainage 13 + 400 crossing Fairfield main road – 300mm water pipeline will impacted.
    b) Chainage 15 + 900 water distribution network in this area 100mm will be impacted.
    c) chainage 17 + 000 water distribution network along Adelphi main road will be impacted.

3. Adelphi Main Road to Salt Spring
    a) Chainage 17 + 600 water distribution network and possibly relift pump station will be impacted.
    b) Chainage 20 + 650 & 21 + 400 water distribution network will be impacted.

4. Salt Spring to Ironshore/North Coast Highway
    a) Chainage 24 + 900 water transmission and distribution network will be impacted.

5. Fairfield Intersection to Barnett Street & West Green
    a) From Fairfield intersection to Barnett Street - water transmission, distribution and sewer network will be impacted.
    b) Fairfield to Howard Cook through West Green - water transmission, distribution and sewer network will be impacted.

6. Ramble Hill to Bogue Hill

a) Crossing at Ramble Hill road – water transmission and distribution network will be impacted.
b) At Bogue Hill - water distribution network and relift pump station will be impacted.

7. Anchovy to Montpelier

a) In Anchovy and Mount Carey – water distribution network will be impacted.
b) Mount Carey to Montpelier – water distribution network will be impacted.
c) Road construction through the watershed could severely affect the quality and quantity of the water supply into the Great River as well as the Reading Spring along with the Catherine Mount #1 and #2 wells.

The detailed solutions for the impacts identified will require dialogue with the design/implementation road project team(s) along with more finalized details before presentation.

8.3.2.4 St James Municipal Corporation

- Howard Cooke boulevard and Barnett Street improvement
- Long Hill bypass proposed route
- Potential impact of urban road improvement on traffic in Montego Bay
- Proposed drainage improvement for the greater Montego bay Area.
- Resettlement issues for persons to be impacted by highway implementation. Low income housing (New Ramble area, Estuary housing site
- Implementing "social media town hall"

8.3.2.5 Jamaica Relief Mission

- Impact of highway on main entrance to the property
- Compensation for building that will be impacted by the highway.
- Possibility of relocating the main entrance to the premises.

8.3.2.6 Abundant Life Church

- Possibility of shifting the alignment to avoid the destruction of the church

8.3.2.7 Fairfield Great House

- Limiting the impact of the highway alignment on the old Fairfield hotel.
- Will the highway prevent access to the residential property?
- Possible impact of noise during construction and operation on the two major residents adjacent to the alignment.

8.3.2.8 Bogue Village Citizen Association

- Limited to the access (No right turn into Bogue Village) from Temple Gallery Road.

- Flooding concerns for phase 2 section of Bogue Village due to poorly maintained that rubs parallel to the community and Temple Gallery Road.
- Traffic issues during construction at the supermarket adjacent to Bogue Village.
- Noise during and after construction
- Air quality

8.3.2.9 Forestry Department

- Two areas of "disturbed broadleaf forest" will be impacted:
    - Irwin Forest Management Area
    - Montpelier Forest Management Area
- NROCC to identify/confirm areas in the highway footprint to be impacted and rehabilitated:
    - 32.5 hectares (Montego Bay)
    - 34.86 hectares Long Hill

8.4 INDEX OF TECHNICAL RESPONSES TO STAKEHOLDER ISSUES

Public input was incorporated into the proposed project design, the EIA; and environmental management systems. Responses to some of the issues are outlined in Table 8-1.

Table 8-1 Inventory of responses to stakeholder issues

Stakeholder/ Meeting	Issue/ question	Response
Catherine Hall Community Meeting	Concern was raised for the children that traverse West Green Avenue and the question of whether or not an overhead bridge will be provided was asked.	No bridge will be built along West Green Avenue
	How will the overhead from temple Gallery Road to Bogue be accessed?	See Section 2.3.1.2.3 - Bogue Road and Temple Gallery intersection is proposed to be grade separated. The grade separation can be accomplished with a tight diamond interchange that accommodates two right turn lanes on the northbound off-ramp and double right-turn lanes from the westbound Temple Gallery leg.
	Will pedestrian crossings be provided?	There will be pedestrian crossings at the intersections along West Green Avenue.
	Concern was raised about the impending overwhelming traffic that will be on Temple Galley Road	Traffic signals will be used to regulate the flow of traffic along Temple Gallery Road. The implementation of the "no right turn" will help to reduce congestion
	Concern was raised about the noise, dust and vibration that will be caused by movements of heavy units and proximity to structures. How will the effects of vibrations be accounted for and the possible adverse effects on the structures.	Noise – See Sections 5.2.1.5 and 5.3.1.3 Vibration - See Sections 5.2.1.7 and 5.3.1.5 Dust – See Sections 5.2.1.6 and 5.3.1.4
	A suggestion was made to move the project from West Green Avenue to behind the Megamart.	West Green Avenue is an upgrade as a Component of the Wider project. This is intended to be a benefit to the community when additional capacity is added to this corridor and by extension help to reduce congestion.
	Mention was made that the topography of the area allows for water to flow towards the sea and it settles by the Howard Cooke Boulevard as such concern was raised that raising the road will cause flooding.	See Section 5.3.1.2 – Drainage and Stormwater
	The question of what sections of the roadway will be tolled was asked.	See Section 2.3.1.3 - Toll plazas have not been included in the design plans or estimate; however, areas have been identified where toll plazas can be located.
	What will prevent vehicles from running off the road and damaging structures?	See Section 5.3.3.4 – Health and Emergency

Stakeholder/ Meeting	Issue/ question	Response
	It was suggested that the project be removed to the commercial areas and improvements be made to the residential roads	Improvement of the residential roads still would not stem the issue of traffic congestion in Montego Bay.
	Where will residents park their vehicles?	Residences that do not lie within the project footprint will not have their properties affected. Those that lie within the impact area will undergo process according to the Land Acquisition Act and the Resettlement and Relocation Plan (section 6.3.3).
	What plans are there to improve drainage in the Catherine Hall area	Drainage Assessments were conducted for all section of new road works. With the new roadworks will come upgraded drainage facilities
	Special attention needs to be paid to the drains in the vicinity of the police station and the community college. Suggestion made to make the drains higher and wider	Drainage Assessments were conducted for all section of new road works. With the new roadworks will come upgraded drainage facilities
	Concern was made about the possible type of construction material to be used; mention was made that marl should not be used.	Limestone is the most abundant and cost-effective material for road fill in Jamaica.
	Query as to how long after the close of the project can someone make a claim due to damages	Issues should be brought to NROCC at any time during the course of the project. Wherever individuals affected by the proposed highway are dissatisfied with any aspect of the resettlement process, these persons may address their issues. These issues can be raised orally or in writing to: NROCCs' Land Acquisition Coordinator or Manager, NROCCs' Chief Executive Office or his Designate, Commissioner of Lands, or the Court. A log will be created to keep track of these issues and to ensure that these are responded to. It is the objective of NROCC to respond to all issues raised within a reasonable timeframe.
	Will there be compensation for the removal of temporary structures?	Compensatory exercises will be conducted according to the Resettlement and Relocation Plan (Section 6.3.3).
	Where should concerns/queries/comments/complaints be lodged?	National Road Operating and Constructing Company (NROCC), 4th Floor DBJ Building – 11A Oxford Road, Kingston 5, Jamaica, (876) 926-7830

Stakeholder/ Meeting	Issue/ question	Response
	With regards to the existing drainage in the Temple Gallery Road area, the question of forthcoming plans to improve the drainage was asked also the involvement of NWC to help resolve the sewage issues in the area was asked	Drainage Assessments were conducted for all section of new road works. With the new roadworks will come upgraded drainage facilities. NWC is responsible for all sewage/sewerage related matters
	Will the road make accommodations for persons with disabilities?	To be looked at after the start-up date of the project.
	Are there any plans for NROCC to adopt a project to improve the community? A suggestion was made that the primary schools and early childhood institutions could benefit from the project.	To be looked at after the start-up date of the project.
Salt Spring Community Meeting	Will graves be relocated and what is the process of relocation?	See Section 6.3.3.5.2 - Special attention will be given to graves, which have sentimental, emotional and cultural values attached to them. All graves will be interred by licensed undertakers contracted by NROCC. Re-internment will be in an approved family plot or cemetery. Approval for the re-internment of graves will be sought from the St. James Municipal Corporations and Health Department.
	What is the process for persons who do not have legal tenure or have common-law-titles and those who have not paid property taxes for years on the land?	NROCC's Land Acquisition team will personally discuss these details with those persons who are within alignment footprint and impact area.
	Currently the area is experiencing water issues and a section of the road is not repaired.	Water related matters are handled by the NWC. Road repair is handled by NWA.
	What plans are there for persons who own lands that do not live on the land and may have migrated or are deceased?	NROCC's Land Acquisition team will personally discuss these details with those persons who are within alignment footprint and impact area.
	How will lands be addressed in situations where property taxes are not up-to-date, and it is determined that the cumulative property tax is less than the value of the land?	NROCC's Land Acquisition team will personally discuss these details with those persons who are within alignment footprint and impact area.
	How will matters of informal settling be addressed?	In this scenario, an independent assessment of the value of the structures based on current replacement costs is developed, as well as current market value of crops. These valuations are then agreed with the persons who are in possession of the lands. Please see section 6.3.3 for the Resettlement and Relocation Plan.

Stakeholder/ Meeting	Issue/ question	Response
	When will construction begin and what is the duration?	It is anticipated that the project will commence in the year 2020. Design Phase – 9 months; Construction Phase – 26 months.
	What is the turnaround time for compensation?	This is based on the different types of negotiation and compensation involved. Please see section 6.3.3 for the Resettlement and Relocation Plan.
	The process of receiving a title through LAMP is long and may not be coincide with the timeframe of the duration of the project, how will such situations be addressed?	NROCC's Land Acquisition team will personally discuss these details with those persons who are within alignment footprint and impact area.
	In situations where the road severs land, how will such matters be addressed?	NROCC's Land Acquisition team will personally discuss these details with those persons who are within alignment footprint and impact area. Please see section 6.3.3 for the Resettlement and Relocation Plan.
	A mango tree appears to be within the alignment, what will happen to the mango tree?	If it lies on someone's personal property, that person will be compensated for it. Please see section 6.3.3 for the Resettlement and Relocation Plan.
UWI	The impact of traffic from the highway on the proposed UWI campus.	Traffic during construction phase is expected. Mitigatory measures for these are discussed in Section 5.2.3.7
	What mechanisms will be incorporated into the design of the highway to mitigate: ○ noise impact ○ Air quality impacts ○ Potential drainage impacts	Noise – See Sections 5.2.1.5 and 5.3.1.3 Air Quality – See Sections 5.2.1.6 and 5.3.1.4 Drainage – See Sections 5.2.1.3 and 5.3.1.2
	Will noise wall be incorporated into the designs of the highway in the vicinity of the campus.	Yes. See Section 5.3.1.3.4
	Will NROCC make provision for suitable access from the highway to the UWI campus at the signalized intersection.	The preliminary alignment made provision for an exclusive access to UWI proposed campus.
	Queries regarding the mangroves to be removed by the road were also raised.	See Section 5.2.2.4 – Mangrove Community

Stakeholder/ Meeting	Issue/ question	Response
WRA	In light of flood assessment undertaken, the following recommendations need to be considered: • The drains need to be cleaned immediately after any large storm event; • Any future developments in the watersheds need to be at an appropriate setback distance from the watercourses; and • Measures are to be put in place to mitigate the erosion, sedimentation and debris flows from the upper watershed areas. Recommended that hydrologic and hydraulic assessments be carried out to determine the necessary infrastructural improvements. These assessments should also be used to determine the appropriate setbacks from watercourses/drainage infrastructure. This would contribute substantially to appropriate land use planning practices in the future.	Acknowledged – Incorporated into Mitigation
NWC	On examination of the plans for both legs of the proposed highway routes, National Water Commission reported that the proposed alignment will intercept the NWC's infrastructure in several areas. The detailed solutions for the impacts identified will require dialogue with the design/implementation road project team(s) along with more finalized details before presentation.	Acknowledged. Incorporated into Mitigation Section 5.2.3.4.1
Jamaica Relief Mission	Impact of highway on main entrance to property	Properties that lie within the impact area will undergo process according to the Land Acquisition Act and the Resettlement and Relocation Plan in Section 6.3.3
	Compensation for building that will be impacted by the highway.	Compensatory exercises will be conducted according to the Resettlement and Relocation Plan in Section 6.3.3
	Possibility of relocating the main entrance to the premises.	Only if it does not affect the alignment
Abundant Life Church	Possibility of shifting the alignment to avoid the destruction of the church	NROCC will make adjustments in the alignment to avoid the destruction of the church

Stakeholder/ Meeting	Issue/ question	Response
Fairfield Great House	Limiting the impact of the highway alignment on the old Fairfield hotel.	See Section 5.2.1.7.2 Vibration Impacts - The Fairfield Great House is the closest historical/cultural structure to the proposed alignments and lies at a distance of 41 metres from the cut and fill area of the alignment. Apart from pile driving and blasting, the vibratory roller has the highest vibration emission of the equipment listed. From a building standpoint, the vibratory roller should have no effect on the Fairfield Great House at this distance. If pile driving is to be conducted, there would be minimal risk for damage to weak or sensitive structures. However, if any blasting is to be conducted, there would be some risk of architectural damage to any ancient monuments and ruins.
	Will the highway prevent access to the residential property?	No
	Possible impact of noise during construction and operation on the two major residents adjacent to the alignment.	Noise – See Sections 5.2.1.5 and 5.3.1.3
Bogue Village Citizens Association	Flooding concerns for phase 2 section of Bogue Village due to poorly maintained that runs parallel to the community and Temple Gallery Road.	Drainage Assessments were conducted for all section of new road works. With the new roadworks will come upgraded drainage facilities.
	Traffic issues during construction at the supermarket adjacent to Bogue Village.	Traffic during construction phase is expected. Mitigatory measures for these are discussed in Section 5.2.3.7
	Noise and air quality issues	Noise – See Sections 5.2.1.5 and 5.3.1.3 Air Quality – See Sections 5.2.1.6 and 5.3.1.4
Forestry Department	• Two areas of "disturbed broadleaf forest" will be impacted (Irwin Forest Management Area, Montpelier Forest Management Area) • NROCC to identify/confirm areas in the highway footprint to be impacted and rehabilitated.	NROCC will develop a Reforestation Plan with the cooperation of the Forestry Department to replant areas identified by the Forestry Department. Discussions have already started.

8.5 PERCEPTION SURVEY

8.5.1 Introduction

During the period March 29, 30, 31 and April 1, 2 and 3, 2019, 429 community questionnaires (Appendix 9) were administered within a two-kilometre buffer of the proposed road alignment (Figure 8-1). Respondents were from twenty-eight main communities (Table 8-2) with just over fifty-five percent (55.3%) of being male and 44.7% female. Age cohort distribution was as follows: 11.3% were 18-25 years of age, 16.1% were 26-33 years, 20.8% were age 34-41 years, 22.2% were age 42-50 years, 17.5% were age 51-60 years and 12.1% were older than sixty years of age.

Table 8-2 Percentage of perception survey respondents by community

	Community	No. of respondents	%
1	Anchovy	32	7.46%
2	Reading	22	5.13%
3	Mt Carey Village	15	3.50%
4	Mt Carey	32	7.46%
5	Montpelier	27	6.29%
6	Granville	25	5.83%
7	Tucker	20	4.66%
8	Glendevon	1	0.23%
9	West Village	1	0.23%
10	Norwood	5	1.17%
11	Rosemount	3	0.70%
12	Rose Heights	4	0.93%
13	Irwin	23	5.36%
14	West Green	18	4.20%
15	Bogue Heights	14	3.26%
16	Bogue Hill	23	5.36%
17	Bogue Village	12	2.80%
18	Catherine Hall	23	5.36%
19	Downtown Mobay	10	2.33%
20	Porto Bello	10	2.33%
21	Farm Heights	11	2.56%
22	Mount Salem	16	3.73%
23	York Bush	25	5.83%
24	Cornwall Courts	8	1.86%
25	Montego Hill	3	0.70%
26	Salt Spring	16	3.73%
27	Orange	14	3.26%
28	John's Hall	16	3.73%
	TOTAL:	**429**	**100.00%**

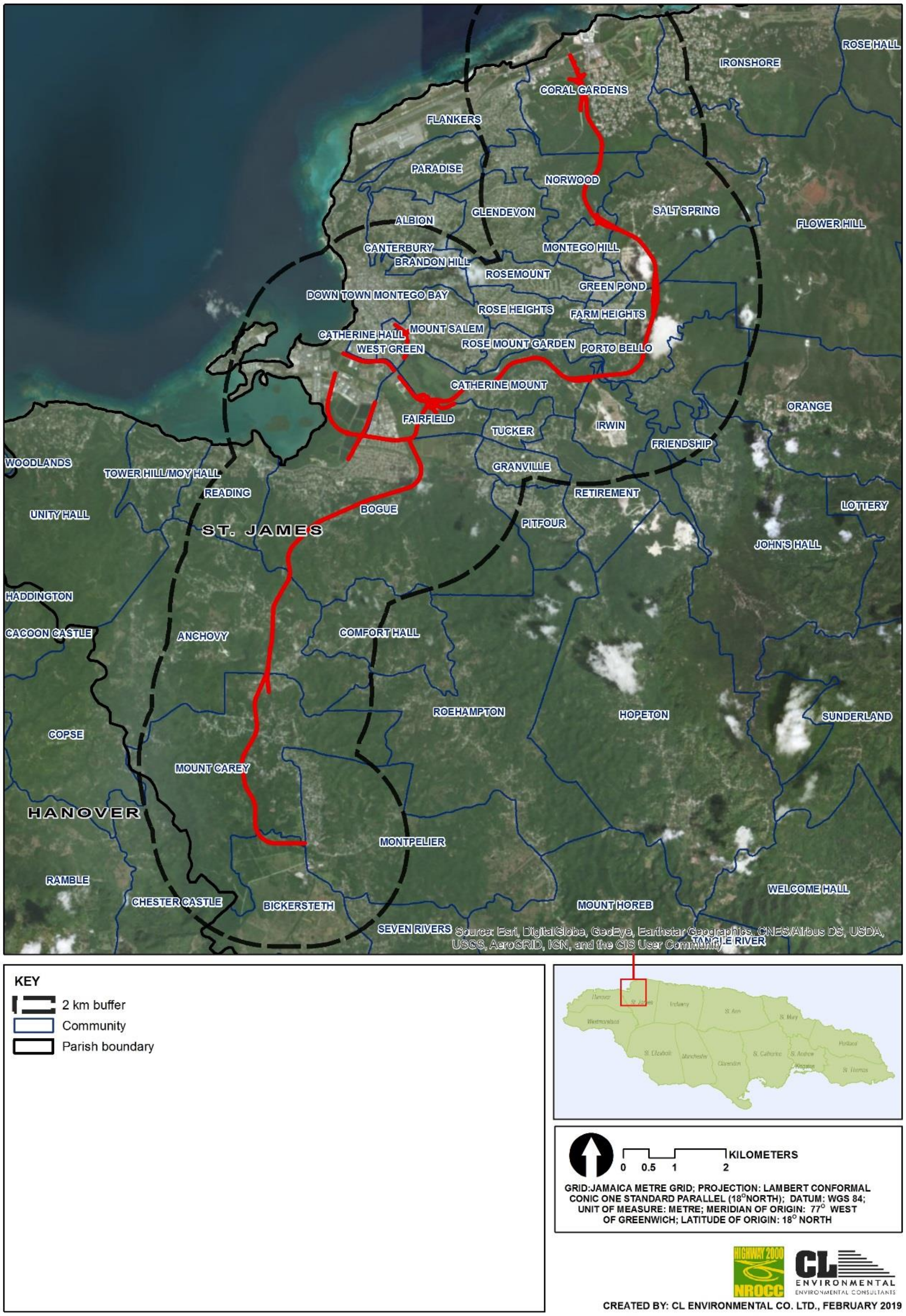


Figure 8-1 Questionnaire survey area (2km buffer)

It should be noted that some respondents were interviewed outside their community of residence or via telephone due to:

- The team being denied access to enter gated communities e.g. West Village and the Meadows of Irwin
- Recent shootings/murders and unrest in some communities e.g. Rose Heights and adjoining communities.

While limited responses were received from these communities and may not be representative of the community, they have been incorporated in the overall analysis. Additionally, some communities in close proximity have been merged and discussed together. Percentages presented are for the total number of persons offering responses; in instances where respondents did not offer an answer to a question, they were not considered part of the analyses.

8.5.2 Results and Findings

8.5.2.1 Respondents' Background

8.5.2.1.1 Employment

Of those persons interviewed who offered a response, 72.2% indicated that they were employed, 20.8% stated they were unemployed while 7.0% of individuals were retired. Of the 72.2% indicating they were employed, just over sixty percent (60.2%) of interviewees stated that they worked in the St James/Montego Bay area, while 35.5% stated that they worked within their respective communities of residence. In addition, 2.3% stated that they worked island wide, 1.6% indicated that they were employed overseas while persons indicated that they worked in Trelawny (0.3%), Hanover (1.3%) and Westmoreland (1.0%). It should be noted that in some instances, respondents worked both within and outside their community of residence, therefore percentages exceeded one hundred.

8.5.2.1.2 Housing

Regarding the number of persons residing in households, just over sixteen percent (16.2%) of households had one occupant while 17.1% had two occupants, 20.6% had three occupants while 17.6% had four persons living in the household. Just over eleven percent (11.2%) had five persons living in the household and 17.3% of households had more than five persons residing.

In general, interviewees resided in their communities over the long term. Approximately forty-five percent (44.8%) of individuals resided in their communities for all their life, and 21.4% resided in their community in excess of fifteen years. Approximately nine percent (8.7%) stated they lived in their community for between ten and fifteen years; 11.3% resided for between five and ten years. Just over seven percent (7.5%) resided in their community for between three and five years and 6.3% for under two years.

8.5.2.1.3 Healthcare

On the issue of where healthcare was mostly obtained, 24.0% stated the public clinic, 66.0% stated the public hospital, 40.6% stated that healthcare needs were mostly sourced through the private doctor while 2.3% stated the private hospital. It should be noted that in some instances, respondents offered multiple responses regarding where they mainly went for healthcare, therefore percentages exceeded one hundred. As it pertained to the specific healthcare provider, the public hospital most referenced was the Cornwall Regional Hospital. Hospiten, G-West, Mobay Hope and Fairfield were named as private medical facilities. As it pertained the public clinic, it was realised that respondents attended the public clinic within their community where one was present or visited the clinic closest to their community, the same was realised for the private doctor. It was also realised that some respondents left their community and had their healthcare needs met in Montego bay whether through a public and/or private entity.

As it related to whether respondents suffered from specific medical conditions, 17.2% of interviewees indicated that they were asthmatic, 21.2% indicated that they suffered from sinusitis, 4.0% confirmed coughing as an ailment, while 3.0% indicated that they suffered from congestion/bronchial problems. Just over three percent (3.3%) indicated that they suffered from chest pains while 0.7% confirmed frequent bouts of diarrhoea. Fifty-five percent of those interviewed indicated that they did not suffer from any of the specific conditions named. It should be noted that in some instances, respondents suffered from more than one of the listed ailments, therefore percentages exceeded one hundred.

8.5.2.1.4 Income

Respondents in general, expressed some reluctance to disclose information pertaining to income. Of those interviewed 38.9% of respondents refused to offer a response relating to their personal weekly income. Just over eighteen percent (18.5%) of persons indicated that they did not have a weekly income, while 3.2% indicated that their weekly income was under the national minimum wage of $6,200.00 per week. Approximately four percent (4.1%) of interviewees indicated that their weekly income was $6,200.00 per week; 13.6% stated that their weekly income was between $6,201.00-$10,000.00, while 16.1% stated a weekly income ranging between $10,001.00 and $20,000.00. Approximately six percent (5.6%) indicated that their weekly income was in excess of twenty thousand dollars ($20,000.00).

8.5.2.1.5 Education

Regarding the highest level of education completed, 98.6% of those interviewed offered a response. Of this number less than one percent (0.5%) indicated that they did not attend school; 19.4% stated they completed primary/all age school, 12.8% stated that they did not complete high school, 41.8% completed high school, 10.2% college, 4.0% university and 11.3% HEART/Vocational Training Institution.

As it pertained to education, 51.8% of interviewees indicated someone in the household was attending school. Of this number, 99.5% provided information on the actual number of persons attending school. Approximately forty three percent (42.7%) of respondents indicated that one person from their household was attending school while 31.4% indicated two persons and 14.5% indicated three persons. Additionally, 5.9% stated that four persons within their household were attending school, 2.7% indicated five persons while 2.7% also stated more than five persons. As it related to the school being attended 38.0% stated that the school being attended was infant/basic, 51.1% stated primary/all age, 48.4% stated high school, 5.0% college 1.8% university and 8.1% HEART/Vocational Training Institute. It should be noted that percentages will exceed one hundred as multiple persons from households attend school.

8.5.2.1.6 Transportation

On the issue of whether respondents depended on the proposed traffic corridor/roadway for any type of business, 81.9% of interviewees indicated that they did not depend on the area while 18.1% indicated that they depended on the proposed corridor. Those indicating that they depended on the proposed traffic corridor stated that they depended on the area for:

- For business to include customers/patrons and conducting business
- Travelling to work and church
- Travelling to Montego Bay
- Distributing goods (delivery and collection)
- Lands on which personal business/ place of employment/homes are located
- Tour business (associated with tourism)
- To bypass the Montego Bay town centre

As it regarded the mode of transportation to attend school, ten percent (10.0%) stated that the student(s) walked, 18.1% indicated the public bus while 56.1% stated that the public taxi was the mode of transportation. Approximately twenty percent (19.9%) indicated that students travelled to school by personal vehicle and 8.6% travelled by private bus/taxi. It should be noted that percentages will exceed one hundred as multiple persons from households attend school.

Regarding the weekly transportation cost per student, nineteen percent (19.0%) of respondents indicated that there was no cost associated with travelling to school. Approximately one percent (0.9%) indicated that weekly transportation per student was in excess of $5,000.00, 2.8% indicated a weekly cost of $4,001.00-$5,000.00 while 2.3% stated $3,001.00-$4,000.00 and 10.2% stated $2,001.00-$3,000.00. Approximately forty-five percent (44.9%) of interviewees stated that the weekly transportation cost ranged between $1,001.00 and $2,000.00 while 19.9% indicated that weekly transportation per student was less than one thousand dollars.

8.5.2.2 Awareness of Project

On the issue of respondents' awareness of the National Road Operating and Construction Company (NROCC), all (100.0%) interviewees offered a response. Approximately nineteen percent (19.1%) of interviewees stated that they had heard of the National Road Operating and Construction Company (NROCC), while 80.9% stated that they had not heard of NROCC. Of the interviewees stating that they had heard of NROCC 23.2% stated they were made aware via newspaper, 49.3% indicated awareness was via television, 28.0% stated radio, 8.5% indicated community meeting and 28.0% indicated that they heard of NROCC through word of mouth while 1.2% of interviewees stated "other" and further indicated that their awareness of NROCC was via the internet. It should be noted that percentages will exceed one hundred as some interviewees were made aware via multiple media. Regarding what was specifically known/heard about NROCC, 72.0% stated that NROCC built highways, 3.7% stated NROCC built Highway 2000, 1.2% indicated that NROCC is the company building the Long Hill Bypass while 3.7% indicated that the company was Chinese based and 1.2% indicated that the company was an overseas contracting company. Just over eight percent (8.5%) stated that NROCC was the company building the highway from Savanna-la-mar to Montego Bay.

Regarding respondents' awareness of the Montego Bay Perimeter Road Project, all (100%) respondents offered a response. Of these individuals, 28.9% of individuals stated that they had heard of the Montego Bay Perimeter Road Project while 71.1% stated that they had never heard of the project. Of the 28.9% of respondents who heard of the project, 16.1% indicated that awareness was via the newspaper, 19.4% indicated television, 21.8% stated radio, while 6.5% stated they were made aware via community meeting and 40.3% indicated word of mouth. It should be noted that percentages will exceed one hundred as some interviewees were made aware via multiple media. Regarding what was specifically known/heard about the Montego Bay Perimeter Road Project, 66.9% stated that a highway is to be built, 17.7% stated that existing roads will be upgraded, 1.6% indicated that the perimeter road will pass through the Bogue Village community while 0.8% indicated that the highway is to be built from Bogue to Coral Gardens. Some respondents (12.1%) while indicating awareness did not offer specific information.

In response to whether respondents knew that it was proposed that sections of the perimeter road be tolled, all (100%) respondents offered a response. Of those who responded 19.6% indicated that they knew that sections of the road would be a toll road while 80.4% stated that they did not know that sections of the road would be a toll road.

Regarding respondents' awareness of the Long Hill Bypass Road Project, 99.5% of respondents offered a response. Of these individuals, 46.1% of individuals stated that they had heard of the Long Hill Bypass Road Project while 53.9% stated that they had never heard of the project. Of the 46.1% of respondents who heard of the project, 4.6% indicated that awareness was via the newspaper, 15.7% indicated television, 10.7% stated radio, while 4.1% stated they were made aware via community meeting and 65.0% indicated word of mouth; 0.5% indicated "other" and stipulated that awareness was via a "town cry" . It should be noted that percentages will exceed one hundred as some interviewees were made aware via multiple media. Regarding what was specifically known/heard about the Long Hill Bypass Road Project, 68.5% stated that a bypass/new road is to be built on Long Hill, 16.2% stated that existing Long Hill road will be fixed/upgraded (to include widening and removing existing corners), 2.0% indicated that the bypass will be for trucks only while 1.5% indicated that the existing road will be abandoned. Three percent (3.0%) of interviewees stated that the Long Hill Bypass was being built to reduce traffic congestion while 0.5% indicated that the existing road would see a reduction in traffic volume. Some respondents (8.1%) did not offer specific information.

Regarding respondents' awareness of the Barnett Street Road Upgrade, all (100.0%) of respondents offered a response. Of these individuals, 12.8% of individuals stated that they had heard of the Barnett Street Road Upgrade while 87.2% stated that they had never heard of the project. Of the 12.8% of respondents who heard of the project, 7.3% indicated that awareness was via the newspaper, 7.3% indicated television, 9.1% stated radio, while 7.3% stated they were made aware via community meeting and 60.0% indicated word of mouth. The remaining respondents (9.1%) while indicating awareness did not state the medium by which they were made aware. Regarding what was specifically known/heard about the Barnett Street Road Upgrade, 76.4% stated that the existing road (Barnett Street) will be upgraded/expanded, 3.6% stated a new road will be built while 1.8% of interviewees stated that cameras and traffic lights will be installed on Barnett Street. Some respondents (18.2%) did not offer specific information.

As it pertained to respondents' awareness of the West Green Avenue Road Upgrade, all (100.0%) of respondents offered a response. Of these individuals, 10.3% of individuals stated that they had heard of the West Green Avenue Road Upgrade while 89.7% stated that they had never heard of the project. Of the 10.3% of respondents who heard of the project, 9.1% indicated that awareness was via the newspaper, 4.5% indicated television, 11.4% stated radio, while 4.5% stated they were made aware via community meeting and 40.5% indicated word of mouth.

On the issue of interviewees being aware that NROCC was the company to implement the project, all (100.0%) interviewees offered a response. Of these respondents 93.7% of individuals interviewed indicated that they did not know NROCC was the company to implement the project, while 6.3% of those interviewed stated that they were aware.

8.5.2.3 Willingness to Pay

On the issue of willingness to pay a toll, 31.8% of interviewees stated that they were uncertain while 36.2% stated that they would be willing to pay a toll and 32.0% indicated that they would not be willing to pay a toll. Of the 36.2% of respondent who indicated that they would be willing to pay a toll, respondents indicated that they would be willing to pay $100.00 (21.9%), $150.00 (11.1%), $200.00 (21.9%), $250.00 (1.9%), $300.00 (8.4%), $350.00 (0.6%), $400.00 (6.5%), $500.00 (11.0%), $700.00 (1.3%) and $900.00 and over (5.2%). Some respondents (10.3%) while indicating a willingness to pay a toll did not stipulate a dollar value.

8.5.2.4 Concerns

Regarding whether respondents had any concerns about the project, 98.8% of interviewees offered responses. Of these persons, 30.2% indicated that they had concerns about the project while 69.8% stated that they did not have any concern. Concerns expressed pertained to:

- Whether property would be affected and the need for relocation (25.8%)
- The delay in starting the project (12.5%)
- The structural integrity of the roadway once built (1.6%)
- The potential for flooding (2.3%)

- The impact on the present/current traffic situation (10.2%)
- The impact on school (0.8%)
- The potential loss of business (7.0%)
- Whether job opportunities would be created (3.1%)
- The new traffic corridor resulting in an influx of criminal elements (3.1%)
- Whether public consultations would be held prior to the start of the project (0.8%).
- The duration of the project (4.7%)
- Noise and dust pollution (24.2%)
- Whether tax payers would be financially burdened to cover costs associated with the project (7.8%)
- Reckless road use (2.3%)
- Whether long term job opportunities would be created (2.3%).

It should be noted that percentages will exceed one hundred as some respondents offered multiple responses.

8.5.2.5 Perceived Impacts

On the issue of how respondents thought the project would affect their life, 18.0% of respondents indicated that the project would not affect their life in any way, while 26.2% anticipated a positive impact and 8.7% anticipated a negative impact. Approximately forty-seven percent (47.1%) were not sure if the project would affect their life.

Regarding the 8.7% of individuals anticipating a negative impact, they anticipated:

- they would need to relocate or would be displaced (residence or business) (21.6%)
- there would be increased crime in their community (5.4%)
- possible flooding (2.7%)
- Increased traffic volume (8.1%)
- Increased travel cost (8.1%)
- A reduction in the number of customers/patrons for their businesses (10.8%)
- Noise and dust pollution (24.3%)
- Traffic delays during construction (10.8%)
- Not being compensated for losses (2.7%)

The remaining 5.5% of respondents while indicating that they expected to be negatively impacted by the project did not supply any detail of exact impact.

As it pertained to the 26.2% of interviewees who indicated that they thought the project would affect their lives positively, anticipated that:

- Commuting would be easier (33.0%)

- Job opportunities would be created (14.3%)
- Commuting would be faster/quicker (35.7%)
- Traffic congestion would be reduced (9.8%)
- There would be an increase in business (6.3%)
- There would be alternate route created for travel (1.8%)

In response to how individuals travelled into Montego Bay less than one percent (0.7%) of respondents indicated that they walked to Montego Bay, 14.0% stated that they travelled by public bus while 58.7% stated that they travelled by public taxi. Approximately thirty percent (29.8%) indicated that they travelled by personal vehicle while 1.9% stated that they travelled to Montego Bay by private bus/taxi. It should be noted that percentages will exceed one hundred as some respondents travel to Montego Bay via multiples modes of transportation.

On the issue of how interviewees thought construction of a perimeter road around the central business district of Montego Bay could impact their commute, 97.9% of those interviewed offered a response. Of these, 55.2% indicated that were unsure about how their commute would be affected while 6.7% indicated that their commute would not be affected. Thirty-five percent (35.0%) indicated that construction of the perimeter road would make their commute easier while 3.1% indicated that their commute would be made more difficult.

For those expecting an easier commute (35.0%), it was expressed that the construction of the perimeter road would result in:

- Less traffic congestion (38.1%)
- Better traffic flow/ faster commuting (38.1%)
- Increased personal efficiency (1.4%)
- Easier access (6.1%)
- Improved road conditions (9.5%)

The remaining 6.8% of interviewees offered no specific response.

For those expecting a more difficult commute (3.1%), it was expressed that the construction of the perimeter road would result in:

- Increased traffic congestion during the construction phase of the project (46.2%)
- Increased Traffic (53.8%)

8.5.2.6 Thoughts on Flooding and Fires

When asked about flooding 16.2% of respondents indicated that their community was affected by flooding while 83.8% stated that flooding did not affect their community. Those indicating that their community was affected stated that flooding occurred only during times of heavy rain (59.4%), each time there was a rainfall event (5.8%) and during hurricanes (4.3%) while 1.4% of interviewees stated that flooding occurred at other times and specified that flooding would occur as a result of run-off from rainfall events outside the community flowing into the community. Affected areas named were:

- Anchovy down Long Hill
- Anchovy Post Office to Anchovy High School
- Long Hill
- Mount Carey
- Montpelier to include the community, roadway, orange groves,
- Montpelier Blue Hole Community
- York bush to include the gully, playground, the spring
- John's Hall main road
- Tucker Square in the vicinity of the Moravian Church
- Main Street Tucker
- June Plum Avenue Catherine Hall
- Fairfield Avenue
- Irwin Road
- Irwin Crossing Tucker
- Catherine Hall Primary and Clinic
- Gully Bus Stop in Downtown Montego Bay
- Lower Union Street
- Cornwall Courts in the vicinity of the Apartment Complex
- Cornwall Courts Shopping Centre
- Bogue Heights
- Bogue Village
- Bogue Hill Primary School

Regarding the height to which water levels rose 85.5% of those confirming that flooding occurred offered a response. Of these respondents, 8.5% of those indicating that flooding occurred in their community stated that water levels were less than 0.3 metre, 49.1% stated that during times of flooding water levels rose to between 0.3 and 1.5 metres while 42.4% advised that water levels exceeded 1.5 metres.

Regarding whether the proposed corridor for the perimeter road was affected by flooding, 68.9% of interviewees, stated that the proposed corridor was not affected by flooding, while 22.1% stated that they did not know if the area was affected. Of the 9.0% of those stating that the proposed corridor was affected by flooding, 5.3% stated that flooding occurred each time there was a rainfall event, 39.5% stated only in times of heavy rains and 2.6% stated flooding occurred during hurricanes. Some respondents (52.6%) offered no specific response. Specific areas named were:

- Bogue to include Bogue Road, Bogue Shopping Village
- Fairview to include the Shopping Centre

- Long Hill
- Reading (in the vicinity of D&G Depot)
- Montego Bay town centre to include Barnett Street and King Street
- Alice Eldemire Drive
- Howard Cooke Highway (in the vicinity of the Police Station and Fisherman's Beach)
- Howard Cooke Highway
- Tucker Road
- Gully Bus Stop – Downtown Montego Bay
- Anchovy

On the issue of how high water levels rose, only 68.4% of those indicating that the proposed traffic corridor was affected by flooding offered a response. Of this number 23.1% indicated that water levels were less than 0.3 metres while 53.8% stated that water levels rose to between 0.3 and 1.5 metres and 23.1% indicated that water levels exceeded 1.5 metres.

On the issue of whether there are problems with frequent fires along the proposed traffic corridor, 68.3% of respondents indicated that the proposed corridor was not affected by frequent fires while 31.7% stated that they did not know if the corridor was affected. None of the respondents indicated that the proposed corridor was affected by fire.

8.5.2.7 Knowledge of Protected Areas

Regarding whether there was any site or area along the proposed traffic corridor considered to be a protected area, historic area or area of national, historic or environmental importance, 33.3% of interviewees stated they did not know of any such area or site, 64.3% stated that no such area was located along the proposed stretch while 2.3% indicated that there was an area/site which was considered to be a protected area or area of historic, national or environmental importance.

Places named were:

- Cotton Tree and the Anglican Church in Montpelier
- The Great House/ Carl Jarrett Great House at Carter Rock in Granville
- Rasta Town/Village in Irwin
- Jamaica Relief Ministries Orphanage
- Wales Pond (approx. 3 miles from Gordon Crossing Postal Agency) in Bogue Hill

9.0 CONCLUSION

9.1 SUMMARY OF FINDINGS

The safety and functional deficiencies that exists, plus overall capacity needs within Montego Bay, are prohibiting growth and development in the second city. Further, as the only city in the western region of Jamaica, Montego Bay provides major governmental services to the neighbouring parishes. The demand for a perimeter road therefore includes demands for improved road infrastructure and network linkages, as well as social and economic demands. The proposed road works outlined within this report will certainly provide the desirable capacity to the road network in and around the city of Montego Bay, as well as offer the possibility of opening up new areas to development along the newly created corridors (Montego Bay Bypass and Long Hill). Specifically, the following project objectives are fulfilled by the proposed project:

- Provide alternative route around the central business district (CBD) in Montego Bay
- Reduce congestion in the city
- Spur economic benefit
- Provide additional capacity on the road network and access to areas that previously were inaccessible or have limited access

From an economic feasibility standpoint, the base case with Gloucester Avenue being restricted is almost feasible, with an EIRR of 11.6%, NPV of -3.0 million US dollars, and a high FYRR of 14.6%; therefore the project should not be delayed.

On the contrary, the degradation of natural habitats that support ecologically important species; costly and disruptive right-of-way acquisitions, relocation of residents, businesses and utilities; and the adverse effects on noise, air quality and water resources are potential negative impacts of the project. These concerns are highlighted though the stakeholder involvement and public interviews conducted for the purposes of this EIA. The implementation of mitigation measures as well as the various management and monitoring programmes should assist in reducing these effects.

9.2 LIMITATIONS AND ASSUMPTIONS

- Domestic water consumption calculations were based on the assumption that water usage is 227.12 litres/capita/day and sewage generation at 80% of water consumption. Water consumption for workers in Jamaica is calculated at 19 litres/capita/day and sewage generation at 100% water consumption.
- For the hydrologic and hydraulic analysis, design discharges were computed on the assumption that saturated conditions exist at the start of the storm event. To account for the potential impact of climate change, a surcharge of 10% was added to the peak discharges to arrive at the design discharge (in keeping with the recommendations of the NWA).

- The results of the vegetation survey are reflective of areas surveyed. Unfortunately, no contiguous woodlands were accessible in the lands along Mount Carey and contiguous stands of limestone forest or woodland were difficult to locate at Bogue Village, Fairfield and Irwin.
- The invertebrate fauna was likely improvised due to sampling during the dry season.
- Geospatial data utilised throughout the EIA were either acquired from relevant authorities and institutions or collected as primary data for the purposes of the EIA. In the case of the former, it must be stressed that if any positional or thematic inaccuracies exist within these datasets, any mapped outputs or spatial queries and analyses undertaken utilising this data would likely also reflect these inaccuracies. Where possible, acquired GIS data were verified in the field to reduce any possible inaccuracies; such instances are stated in the report.
- For noise modelling, the model used was the General Prediction model, therefore wind speed and wind direction were not considered. Road elevation was derived from a DEM, created by spotlights. Buildings were not placed in the model; therefore the effect of shielding and diffraction was not accounted for. The ISO 9613-2 was used, which assumes that wind blows from each source to each receiver, which was not the case. The noise wall calculations used the present elevations not the final built elevations needed for the design.
- Regarding viewshed analysis: Some observer points are situated in relatively complex terrain and as such a single point may not always represent the view from all areas in the area. Further, engineered road heights were not used 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.

10.0 INDEX

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Jamaica 1:50,000, (Series Montego Bay, Sheet 2, 1991

Arc View GIS 3.2

Google Earth

Ikonos Imagery

Taino Site Maps

Barnett View Gardens

Mount Salem

Fairfield

Salt Spring

Hartfield

Estate maps of St. James

St. James 58-Flawson, G.M. (Hon)- Porto Bello Estate

St. James-63 –John Tharp, Green Pond

St. James 68A- Israel Clarke

St. James 72-Glendevon

St. James 99 Green Pond

St. James 107- Irwin

St. James 170 Irwin, V. Kirkpatrick Hall Estate

St. James 180- Anchovy Bottom

St. James 200- Bellfield

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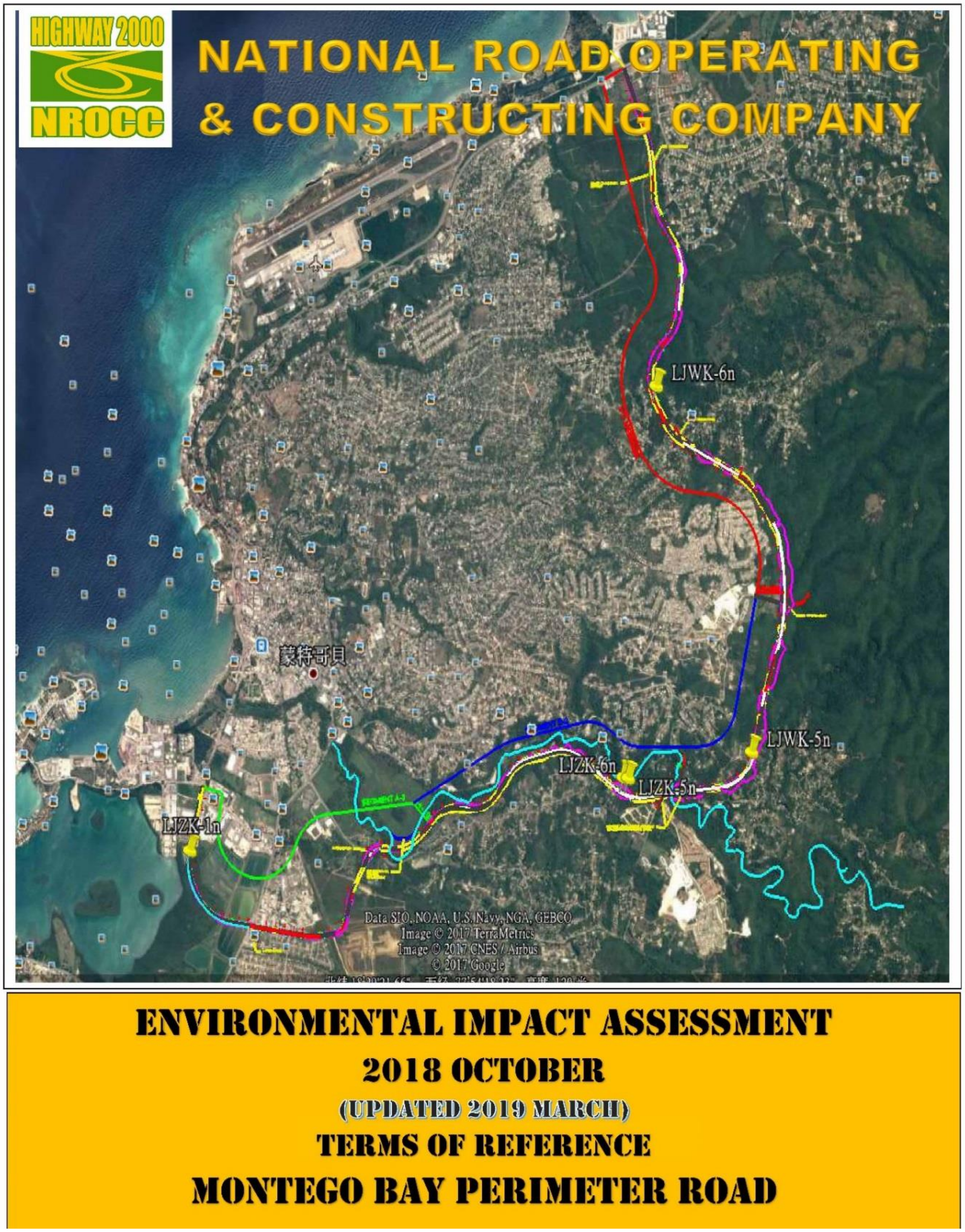
12.0 APPENDICES

Appendix 1 – Draft Terms of Reference



NATIONAL ROAD OPERATING & CONSTRUCTING COMPANY

ENVIRONMENTAL IMPACT ASSESSMENT
2018 OCTOBER
(UPDATED 2019 MARCH)
TERMS OF REFERENCE
MONTEGO BAY PERIMETER ROAD

CONTENTS

I. PROJECT BACKGROUND:

1. Overview:

The National Road Operating and Constructing Company Limited (NROCC), working through the Ministry of economic Growth and Job Creation, has acquired funding for the development of an alternative route around the central business district (CBD) in Montego Bay to reduce congestion in the city and to spur economic benefit.

The proposed Montego Bay Bypass will provide additional capacity to the road network as well as offer the possibility of opening up new areas to development along the corridor. As the only city in the western region of Jamaica, Montego Bay provides major governmental services to the neighboring parishes. The demand for a bypass road therefore includes demands for improved road infrastructure and network linkages, as well as social and economic demands.

Figure 1: Geographical Location of Montego Bay Bypass Project

Montego Bay is Jamaica's second largest City and has a population of approximately 110,000 citizens (STATIN). It is Jamaica's premier tourist destination with possibly the largest concentration of tourist destinations on the island. It is also the home of Jamaica's busiest airport and welcomes cruise ships to its port 2 days per week. Montego Bay therefore, has a significant impact on the economy of Jamaica since tourism accounts for 15% of the gross domestic product (GDP).

The Jamaica Tourist Board's (JTB) Annual Travel Statistics Report for 2015 estimated an average annual growth rate of approximately 3.8% for the tourism sector. Growth in the tourism sector will result in additional traffic being generated by the Airport and Sea Port, as well as additional traffic through the City to access different attractions in and around Montego Bay; this includes traffic intending to bypass the City of Montego Bay.

2. Tourism Demand

Montego Bay, referred to as the tourism capital of Jamaica, has the largest and busiest airport in Jamaica due to the movement of tourist in and out of the country. There is also a high concentration of hotels and tourist destinations in and around the city centre. With the tourism sector expected to grow at 3.8% per annum (Annual Travel Statistics Report for 2015, Jamaica Tourist Board), there is also expected to be a continued growing demand on the transportation infrastructure. Growth in the tourism sector will result in additional traffic being generated by the Airport and Sea Port. This This increase in traffic due to the increasing arrivals at the airport and the sea port will result in (1) additional traffic through the City as the visitors try to access different attractions in and around Montego Bay and (2) increase in traffic intending to bypass the City of Montego Bay as visitors seek to access attractions in other tourist destinations such as Negril and Ocho Rios.

3. Access and Transportation

The commercial centre, with all its amenities, lies at the heart of the city with its main thoroughfare along the coast. This coastal corridor carries over 30,000 vehicles per day but operates as a major urban arterial with closely spaced signalized intersections to provide access to the city centre. Along the North Coast Highway (Elegant Corridor) traffic signals are spaced every 1 km while Howard Cooke Boulevard and Alice Eldemire Drive traffic signals are spaced 300m – 500m apart. The closely spaced signals on Howard Cooke Boulevard in particularly have serious capacity constraints with high turning volumes headed into the city centre. Even with modest traffic projects around the City, the main coastal roads have existing capacity constraints and limited right-of-way for expansion. Currently, the coastal roads must provide access to the city, as well as provide access through the city with limited viable alternatives.

4. Project Rationale

Historically, it is well documented that in developing countries investment in transportation infrastructure generates economic benefits by reducing transportation costs for existing activities, providing access to new areas with economic development potential and creating investment activities. This proposed highway will meet international standards and requirements of projects of this nature and will alleviate the current traffic problems in the poorly built and insufficient roads infrastructure in Montego Bay and its environs.

The following are examples of the generalized benefits/justification of the project which are given in Vision 2030:

→ Reduce traffic
→ Reduce travel time
→ Reduce accident potential for both vehicular and pedestrian traffic
→ Stimulate economic growth
→ Create jobs

The construction of Montego Bay Bypass will provide significant benefits to the travelling public to include:

→ Travel time savings (possible increase productivity and lower transportation costs)
→ Vehicle operating cost savings
→ Public safety savings (reduced accident costs)
→ Rehabilitation and maintenance cost savings on the existing highway network, and;
→ Savings related to other externalities (primarily air pollution related).

5. Scope of Works

a. The construction of approximately 15 kilometers of 4-lane, divided arterial toll road circling Montego Bay city business district; in keeping with the Concept Design.

b. The construction of approximately 10.5 kilometers of 2-lane, rural arterial highway with climbing lanes and escape ramps where required, in accordance with AASTHO Standards, leading from Montpelier intersection of B8 Road and B6 Road to Temple Gallery Road (Long Hill Bypass); in keeping with the Concept Design.

c. Upgrading of approximately 1.7km of urban road and construction of an additional 2-lane bridge across the Montego River.

d. The construction of one (1) Toll Plaza consisting of toll lanes, canopy, admin building, storage and fencings. The toll plaza shall be similar to the existing at May Pen on the main line (East-West Corridor). Total area of building to be 900 square meters. Details to be finalized during the design process.

I. Montego Bay Perimeter:

The Montego Bay Perimeter road alignment will have grade separated intersections at Bogue Road (K11+600), Fairfield Road (K13+400), Riverside drive (K15+900), Irwin road (K17+000), Adelphi Road (K17+170), Cornwall courts (K19+400), Cottage road (K20+660) and Salt Spring road (K21+400). The alignment will have a round-about at Quebec road and Ironshore subdivision Road (K24+400).

II. Long Hill Bypass:

The Long Hill bypass will begin at the intersection of the proposed Montego bay Bypass and the Temple Gallery/Clarence Nelson Drive, in the vicinity of the Bogue Village and Montego Bay West Village Housing Estates as an urban Intersection with "at-grade" crossing. The alignment will proceed in a general southerly direction through scrub land towards Bogue Hill crossing the Ramble Hill road with a grade separated overpass. The grades for this section will range from approximately 2% to 8%. The Long Hill Bypass will have grade separated intersections at Whales Pond Road, Bogue Hill Drive and Anchovy Main Road. The alignment will have a round-about in the vicinity of Montpelier.

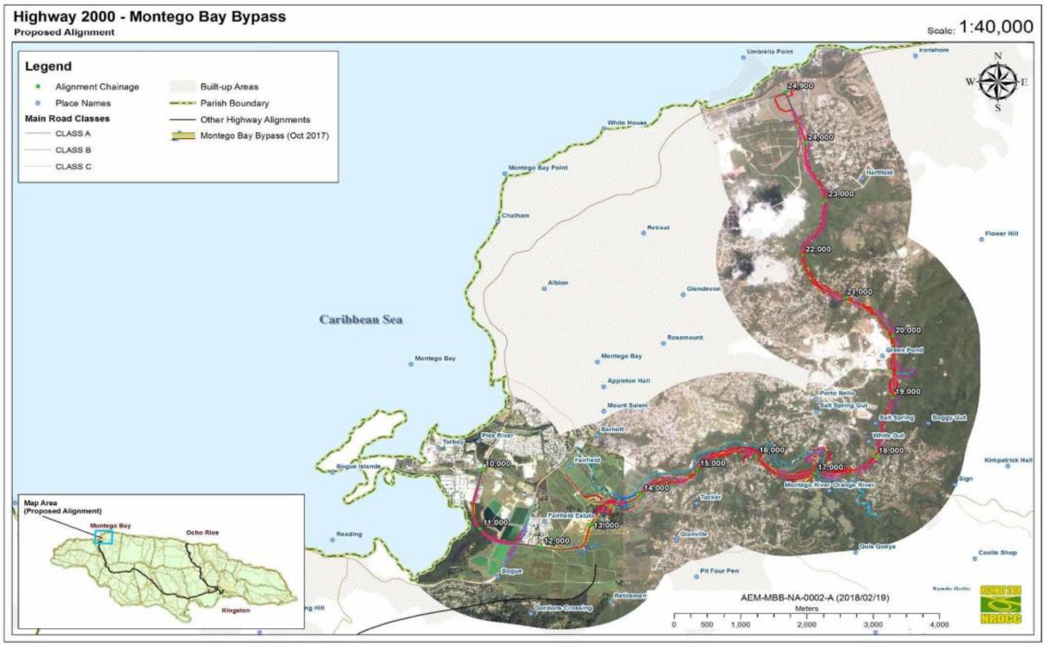
III. Barnett Street Dualization:

Barnett Street improvement is the dualization of 1.06 km of the existing two-lane road section from the intersection of West Green and Fairfield road in a northerly direction and ending at Cottage road. The proposed works will involve the construction of an additional two-lane bridge over the Montego Bay River in the vicinity of the West gate Shopping Center. The implementation of this section of road is designed to complement the Montego Bay Bypass by moving approximately 27,000 VPD in and out of the Central Business district.

IV. West Green Avenue to Fairfield Road Dualization:

West Green Avenue improvement is the dualization of the .82 km existing link road between Howard Cooke Boulevard and the Bogue Road at the Fairfield Road intersection. The construction will result in the removal of the existing round-a-bouts and the creation of signalized intersections, construction of sidewalks, concrete median barrier and drainage improvement. The aim is to improve the capacity to convey traffic between these two busy corridors and by extension the proposed Montego Bay Bypass and reduce travel time. The length of the roadway is .82 km

Figure 2: Schematic Diagram of the proposed Montego Bay Bypass Road



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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.

Executive Summary

Task 1: Description of the Project

Provide a comprehensive description of the project area, noting areas to be reserved for construction and verges and all adjacent properties that may be directly or indirectly impacted by the development. The description of the project is to illustrate 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 a toll plaza.

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:

→ The impact that the construction of the road will have on the adjacent road network.
→ Methods and location of construction surplus material disposal
→ Any changes to associated water diversion management system

→ Management of modifications, vehicular traffic, equipment and waste
→ The proposed off-site facilities such as construction camps and infrastructure service
→ Proposed decommissioning and abandonment of works and/or facilities
→ 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.
→ Public Health and Safety.
→ Workers Health and Welfare

Task #2: Description of the Environment:

Baseline data will be generated to give an overall evaluation of the existing environmental conditions, values and functions of the area, as follows:

→ Physical environment
→ Biological environment
→ Socio-economic environment
→ Archaeological environment

Baseline data will include:

2.1 Physical

→ 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 on, or in close proximity to the site.
→ Identification of old landslides on or active landslides and any other existing scars and areas of potential landslides in close proximity to the highway route.
→ Detailed hydrological assessment to be conducted

→ Reference will be made to future development of lands. Special emphasis should be placed on storm water run-off and drainage patterns and any slope stability issues that could arise will be thoroughly explored.

→ Water quality and quantity of any existing rivers, ponds, or streams in the vicinity of the highway, and particularly to be crossed by the highway.
→ Quality Indicators should include but not necessarily be limited to suspended solids, turbidity, oil and grease.
→ 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,
→ Noise levels of undeveloped site and the ambient noise in the area of influence.
→ Obvious sources of pollution existing and extent of contamination
→ Availability of solid waste management facilities.
→ Availability of public sanitary facilities (rest stops) along the corridor
→ 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.
→ Outline methods to assess the potential impact on the air quality during construction and operation to include baseline air quality information
→ Outline methods to assess the potential residual air quality impact.
→ A section will be included called "Issues of Natural Hazard and Geotechnical Stability".
→ Proximity of Raw material to haulage route and stockpile area
→ Proximity of the corridor to established residential settlements

2.2 Watershed Management Issues

Assessment of the sub-watershed areas/catchment areas within Long Hill and its environs.

There should be a detail inventory of the different forest types inclusive of structure and composition within the sub-watershed areas. An assessment of endemism and value should also be determined. A valuation of the forest resources to be impacted is required to be done.

2.3 Drainage and Storm Water Issues:

i) Identify and clearly map locations of natural and manmade drainage features within the project area. These are to include sinkholes, underground aquifers, rivers, gullies and drainage infrastructure. The presence of drainage features is to be verified by the Water Resources Authority

ii) The EIA Report will cover but not be limited to:

iii) Temporary drainage for the site during construction to include mitigation for erosion and sediment control.

iv) Permanent drainage solution for the site/s during operation, to include mitigation for erosion and sediment control.

v) 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.

vi) Assessment of the impact of draining the sites 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.

vii) Assessment of drainage channels for debris flow associated with up gradient land use as well as impacts related to climate change.

viii) Assess the use of detention ponds to regulate peak flow.

ix) Identify and clearly map locations of sinkholes based on the Water Resources Authority data base, to ensure that where necessary, these are not traversed by the highway alignment. Ensure that where possible the associated vegetation remains intact.

x) Identify other effects of storm water such as the input of oil and grease into the aquatic environment.

xi) EIA to include detailed drainage maintenance Plan for all drainage installation related to the project

2.3.1 Realignment of a section of Montego River

i) Assess the hydrological issues that are likely to be associated with the 800 meters realignment of the Montego River at Km 13+600 – 14+400 downstream facilities vis-à-vis, Barnett Street Road Bridge, West Gate Shopping Center, West Green Housing Scheme and the Charles Gordon Market.

ii) Assessment the likely impacts of the realignment viz-a-viz, potential increased flow velocities on downstream scour etc.

iii) Asses any impacts on any upstream water channel (Irwin and Tucker Gullies)

2.3.2 Highway Impact on a section of the Bogue Wetland.

i) Describe the area of wetland to be impacted by the road construction and the mangrove species that will be destroyed.

ii) Asses the possible impact of wetland modification activities on surrounding areas.

iii) Assess the likely impacts of raising the area 2-3 meters above existing ground viz-a-viz, potential land flooding.

iv) Provide options that are suitable to compensate for the unavoidable loss of wetland resources and the likely changes in biodiversity that are likely to occur.

v) Provide recommendations mitigation measures that can be implemented as part of the proposed highway works. This may include option for replanting or compensation.

vi) Discuss possible alternative to this alignment that could lead to the prevention of loss of the mangroves as well as the Bogue lagoons.

2.4 Conduct Hazard Vulnerability Assessment

2.5 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 should 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.

The various types of forest must be treated as a singular entity and the types emphasized for assessment and protection. These include mangrove and other existing swamp forest, riparian forest, broad-leaf forest and limestone forest.

A description will be given of:

i) The general flora and fauna of the terrestrial areas that are impacted by the road construction.

ii) Provided a detailed inventory of migratory species that utilize the mangrove wetland and other areas close to the proposed highway project.

iii) Indicate the types of waterfowls that are likely to be found in this area and the possible impact of the project.

iv) Different ecosystem types including cave and sinkholes and their species, if present

v) 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.

vi) Biological diversity importance of the area

vii) Invasive and economically important species

viii) Mitigation measures to avoid or minimize negative impacts on wildlife, wildlife habitat, and vegetation communities/ecosystems.

2.4 Socio-economic and 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, compensation and development of resettlement action plan, 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.

2.4.1 Archaeological Environment

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 should 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).

2.4.1.2 Archaeological Impact Assessment (AIA)

i) The aims of the AIA are to document in a concise manner the significant cultural issues to include historical documentation, maps, plans, estate accounts, published or unpublished narratives, data and photographs.

ii) Examine the major and possible impacts of project on these resources and recommend where necessary, mitigation actions.

iii) Prepare a "stand alone" report of the AIA based on the requirements of the Jamaica National Heritage Trust (JNHT).

2.4.3 Survey of Impacted Structures:

The aim of the Impacted Structure Profile study is to identify and characterize the structures to be impacted by the construction of the proposed Highway link. The specific objectives are as follows:

i) Create a geospatial database inclusive of impacted structures and associated attribute information such as building type, materials and condition; number of occupants and building and lot use.

ii) Acquire photographs of each impacted structure. An important aspect of the field survey is the collection of social and economic information for each impacted structure. Information such as household size, weekly income, attendance at educational institutions, building and lot use, material types and building conditions are examples of the type of information that were required. Further, the interviewee's awareness of the proposed project and willingness to relocate were also considered vital essential pieces of information.

iii) Prepare an analytical report showcasing statistical analyses and spatial mapping.

2.4.4 Community Perception Surveys

Consultations to be conducted in various communities and with various interest groups on the perception of the highway development. The following communities are to be given due consideration based on their proximity to the proposed alignment.

i) Salt Spring,

ii) Cornwall Courts

iii) Meadows of Irwin

iv) Porto Bello

v) Bogue Village

vi) Granville/Tucker

vii) Catherine Hall

viii) Montego Bay West Village

ix) Bogue Hill/Heights

x) Anchovy

xi) Mount Carey (York Bush, Mt. Carey Village)

xii) Mount Pelier

2.5 Economic Activity and Livelihood Issues in the Montego Bay Area

i) Assess the likely economic benefits of the road project on the various communities and stakeholders and how they are likely to be distributed among the zones are key considerations.

ii) The following will also be identified:

→ Private land acquisition concerns and related issues

→ Local economic benefits and cost overall on an individual community basis

→ 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

→ Correlation between the roadway construction and possible traffic issues for the adjoining communities

→ 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)

→ 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.

→ Social rights of ways and pedestrian crossings

→ Security and safety issues that may impact construction activities as work is carried out in volatile areas such as Salt Spring, Green Pond and Granville.

TASK #3: LEGAL AND REGULATORY CONSIDERATIONS

i) 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.

ii) The examination of the legislation should include at minimum, legislation such as the NRCA Act, the Public Health Act, the Forestry Act, the Town and Country Planning Act, the Toll Roads Act, the Main Roads Act, St, James Parish Development Order 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:

→ Flooding potential and changes in drainage pattern

→ Blasting/blast vibrations and other such activities on human settlements adjacent to the highway corridor.

→ landscape impacts of excavation and construction

→ loss of and damage to geological and paleontological features

→ landscape impacts of excavation and construction

→ slope stability

→ loss of species and natural features

→ Impact on migratory birds

→ habitat loss and/or fragmentation and creation of access to forested areas

→ biodiversity/ecosystem functions

→ pollution of potable, surface or ground water

→ air pollution

→ socio-economic and cultural impacts

→ maintenance of any alternative routes identified

→ impact on private and commercial property owners and recreational facilities

→ impact of flooding, loss of natural features, excavation and construction on the historic landscape, architecture and archaeology of the site

→ risk assessment and hazard management (slope stability, flooding, debris torrents and seismic activity.

→ Impact on downstream communities from runoff and realignment of a short section of the Montego River.

→ Impact on ecosystem service/function of the Bogue wetlands

→ Spoil site management

→ Climate change impact on coastal areas

→ Siltation and sediment loading

→ technological hazards, noise, solid waste disposal

→ soil and change in land use

→ National Water Commission infrastructure (potable water supply – Great River catchment, Bogue sewage treatment plant and the sewerage network within the sphere of impact of the project)

→ Other utilities and the related infrastructure within the project area

→ Assessment of the potential impacts of the project on coastal areas inclusive of marine park (Montego Bay Marine Park) and Special Fishery Conservation Area

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) 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.

viii) 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

ix) 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.

x) 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.

xi) Characterize the extent and quality of the available data, explaining significant information deficiencies and any uncertainties associated with the predictions of impacts.

xii) 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 Program

(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 program and report should include:

i) Introduction outlining the need for a monitoring program 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

vi) The Monitoring report should also include, at minimum:

→ Raw data collected. Tables and graphs are to be used where appropriate

→ Discussion of results with respect to the development in progress, highlighting any parameter(s) which exceeds the expected standard(s).

→ Recommendations

→ Appendices of data and photographs if necessary. Consideration will be given to the development of a Resettlement Action Plan.

vii) During construction and occupation/operation of the highway, health impact assessment on the toll booth operators for the effect of emission

viii) A system to be developed to address public complaint

TASK #7 PROJECT ALTERNATIVES

i) 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.

ii) Alternatives should be identified in relation to the disturbance of the Bogue Wetlands and realignment of the Montego River and possible changes in the alignment to reduce impact on forested areas along the Long Hill bypass corridor. Where realignment can reduce environmental impacts, those measures should be included as alternatives.

TASK #8 PUBLIC PARTICIPATION

8.1 Stakeholder Consultation:

Consultation will take place in several communities along the proposed alignment to garner feedback on their perception of the highway alignment. The communities are listed in the section 2.4.4 above.

8.2 Utility Companies

Consultations will take place with utility companies to document their concerns and

8.3 Public Presentation of EIA findings:

i) 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, two consultations are recommended.

ii) 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.

iii) Ten (10) 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.

iv) 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.

TASK #9 CONCLUSION

Provide information that, in the opinion of the Consultant and based on the findings, indicate the possible impact of the proposed project on the environment. Highlight, whether these are positive, negative, reversable/irreversible or neutral.

TASK #10 LIST OF APPENDICES AND REFERENCES

The appendices should include but not be limited to the following documents:

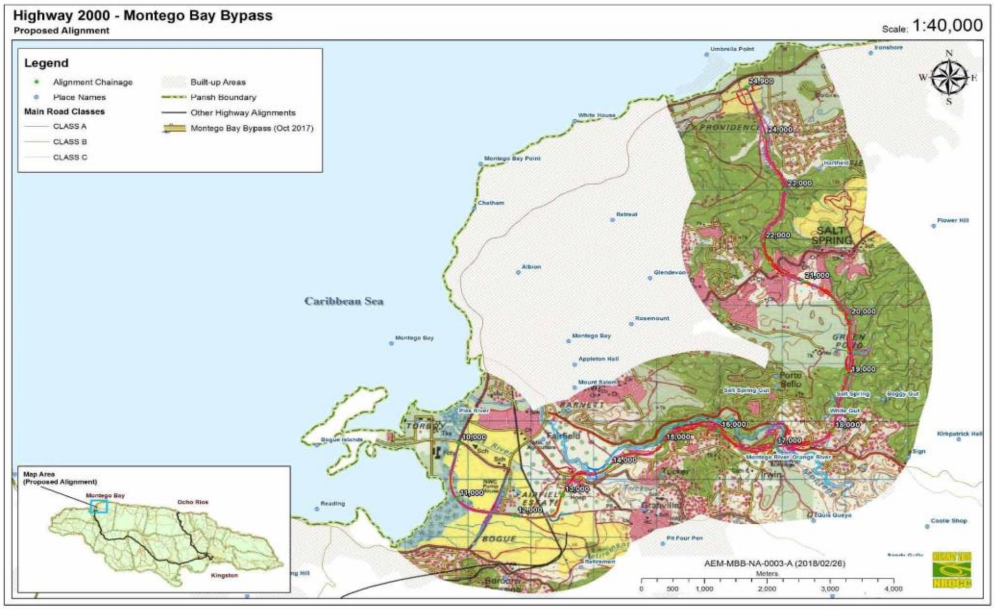
i. Reference documents
ii. Photographs/ maps
iii. Data Tables
iv. Glossary of Technical Terms used
v. Final Terms of Reference
vi. Profile of the project proponent and implementing organization
vii. Composition of the consulting team, team that undertook the study/assessment, including name, qualification and roles of team members
viii. Notes of Public Consultation sessions
ix. Instruments used in community surveys

All findings must be presented in the EIA report and must reflect the headings in the body of the TORs, as well as, references. GIS references should be provided where applicable. One hard copy and an electronic copy must be submitted to NEPA for review after which the Agency will indicate the number of hard copies along with an electronic copy of the report to be submitted. One copy of the document should be perfect bound.

The report should include appendices with items such as maps, site plans, proposed streetscapes (that will demonstrate the preservation of the windows to the sea concept from the roadway), the study team and their individual qualifications, photographs, and other relevant information. All of the foregoing should be properly sourced and credited. The EIA should consult and include the documents listed below:

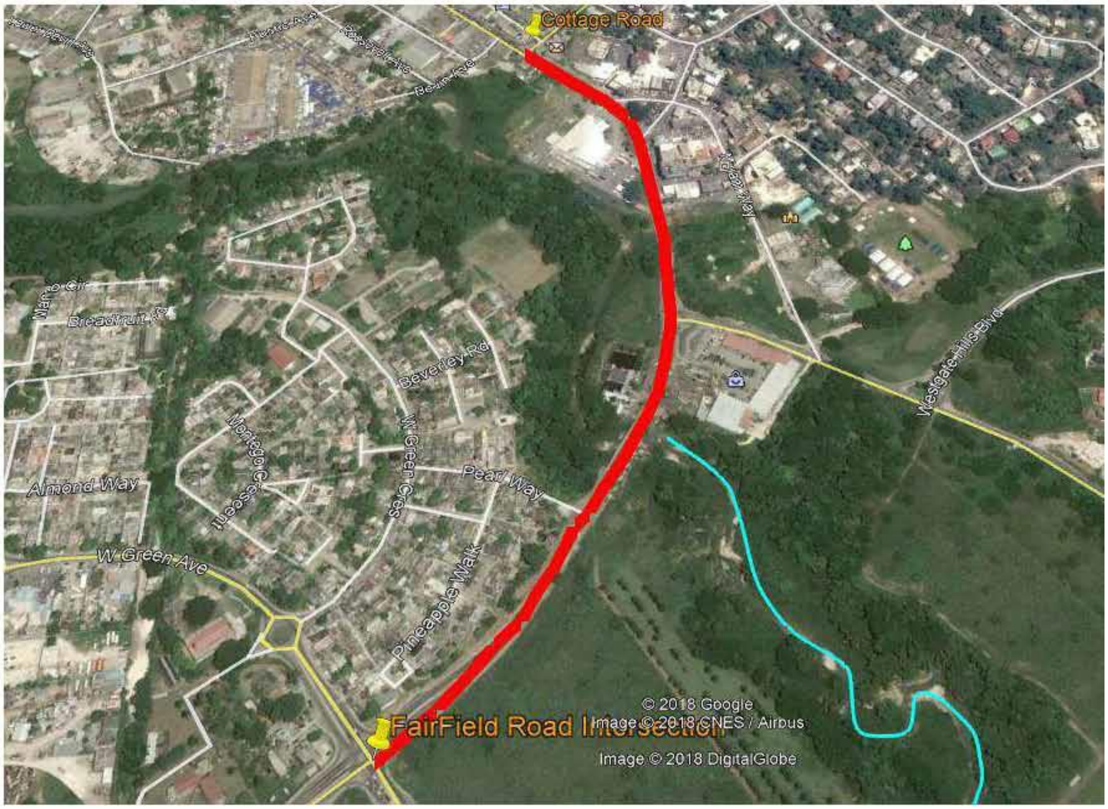
Reference Documents to Support Development of the EIA:	Source
i) Hillside Development Manual 2014	Mines and Geology Division (MGD)
ii) Development and Investment Manual 2007	-
iii) Resettlement Strategy for Jamaica	Squatter Management Unit (MJCEG)
iv) Probabilistic Seismic Hazard Assessment for Jamaica	ODPEM

APPENDIX 1: MONTEGO BAY BYPASS ALIGNMENT



APPENDIX 2: LONG HILL BYPASS

APPENDIX 3: BARNETT STREET



APPENDIX 4: WEST GREEN AVENUE

Appendix 2 – Study Team

- **CL Environmental Co. Ltd.:**
  - Carlton Campbell, Ph.D., CIEC (Noise, Noise Modelling)
  - Matthew Lee, M.Sc. (Air Quality, Climate, Vibration)
  - Rachel D'Silva, B.Sc. (Benthic Assessment, Structure Survey)
  - Karen McIntyre, M.Sc. (Legislation, Socioeconomics, Viewshed Analysis and GIS)
  - Glen Patrick (Field Technician – Air Quality and Noise)
  - Alec Silvera, B.Sc. (Water Quality, Structure Survey)

- **CEAC Solutions Co. Ltd..:**
  - Christopher Burgess, P.E. (Climate Impact, Hydraulic/Hydrology Assessment)
  - Carlnenus Johnson, P.E. (Traffic Impact Assessment)
  - Kristifer Freeman, P.E. (Hydrology and Hydrogeology Assessment)
  - Marc Henry, BSc. - Draughtsman
  - Odaine Perry - (Hydraulic/Hydrology Assessment)

- **Associate Consultants:**
  - Marc Rammelaere, M.Phil (Geology, Soils, Geomorphology)
  - Eric Garraway, Ph.D. (Faunal Survey)
  - Damion Whyte, M. Phil (Faunal Survey)
  - Philip Rose, Ph.D. (Vegetation Survey)
  - Camilo Trench, M.Sc. (Mangrove Survey)
  - Jannette Manning, M.Sc. (Perception Survey)
  - Audene Brooks (Heritage and Cultural, Archaeological Impact Assessment)

Appendix 3 – Hydrolab DS-5 Water Quality Multiprobe Meter Calibration Certificate

DATE: 10-2-12	DOCUMENT #: 19005-00-Tech_Series5_Instruc
PAGE: 1 OF 2	REVISION: 1

OTT Hydromet

Section A: **Series 5, and 5x Sonde Functional Test Data Sheet**

Service Request # WO-00241207	Customer CL ENVIRONMENTAL	Date Started 12-7-18
Housing Serial # 048757	Embedded Serial# 48757	Additional Driver Firmware:
Technician RO	Model: **Datasonde** ✓ 5 ✓ **Minisonde** 5x	LDO 2.98 TURB 2.12 PAR 1.02 DEP 100 2.13

Customer Display Information

I/D NA	DOM 012110	Baud Rate 19200	Security 2	SDI NA	TTY
Parameter	TIME	TEMP	PH	SPCond	ORP
Units		C	UNITS	mS/cm	mV
Parameter	DEP 100	PAR	TURB	LDO%	LDO
Units	METERS	uE/s/m	NTU	SAT	mg/L

For Sonde with Depth – Coefficients

A: -740.292	B: 2610.112	C: 15.69118	D: -3056.038
E: -.005767	F: -3.57118	G: 1187.84	H: 9.512107E-05
I: .002114	J: 1.793437	SER: 0.0	

FLUOROMETER OFFSETS

1ST NA	X10:	X1:
2ND	X10:	X1:

For Sonde with TDG or PAR – Coefficients

A: NA	**B:**	**C:**	**D:**
Local:	Ref:		

Performance, Test and Evaluation

Current MPL Rev-- 5.44 Upgrade to MPL Rev--	pH Electrolyte & Teflon Junction Replaced- Yes ✓ No NA	DO membrane Replaced Yes No NA ✓
Sensors cleaned –Yes ✓	RTC Battery Replaced Yes ✓ No	Desiccant Replaced –Yes ✓ No

Section B:

	Submission 1 Day 1	Submission Day
Customer Observations Verified / Customer Request	Y ✓ N N/A PT&E Upgrade	Y N N/A PT&E Upgrade
Set Time and Date	Yes ✓	Yes
Verified all hardware updates as current	Yes ✓	Yes
Total current draw. (Check all that apply) MPL PCB 40mA ✓ SC Turbidity 20mA ✓ LDO 80mA ✓ 4Beam Turbidity 10mA Flourometers: 1st 30mA 2nd 30mA 3rd 30mA PAR 10mA ✓ (Optimal Values not to exceed +20mA overall.)	170mA	
Current draw of circulator. (20 mA max. beyond previous values.)	NA	
Operation of self-cleaning motor verified—	P ✓ F NA	P F NA
Audio functions correctly	P ✓ F	P F
RTC sleep/wake-up test.	P ✓ F	P F

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Rev 1

Additional Notes

DATE: 10-2-12	DOCUMENT #: 19005-00-Tech_Series5_Instruc
PAGE: 2 OF 2	REVISION: 1

Temp probe test at room temperature. 20.00 ° C (+/- 0.1)	Sonde Temp : 19.97 ° C	Sonde Temp : ° C
DO 100% sat integrity window verified at +50 mmHg over current bp. (Clark Cell only)	P F NA ✓	P F NA
DO 100% saturation calibration verified - local BP (+/- 0.2 mg/L Clark Cell) (+/- 0.1mg/L LDO)	Temp : 21.17 BP : 636.4 mg/L : 7.41 Drift +/- :	Temp : BP : mg/L : Drift +/- :
Scale Factor (0.7 -- 1.3) LDO Only	1.093	
Conductivity zero (air) calibration verified - (+/-.005mS)	.000	
Conductivity calibration verified – 1.412 mS/cm (± .04 mS) ✓ 12.856 mS/cm (± .2 mS) 47.6 mS/cm (± .2 mS)	12.86	
Conductivity linearity verified – .100 mS/cm (± .005 mS) ✓ .500 mS/cm (± .025 mS)	.505	
pH 7 buffer calibration verified– (+/- .2 pH)	7.00	
pH slope calibration verified at 10 units.	10.00	
ORP calibration verified at 21.45 ° C (+/- 20 mV)	436	
Turbidity - Calibration accepted & verified with DI Water (0.0 +/- 0.7 NTU)	.5	
Turbidity - Calibration accepted & verified at (100.0 +/- 1 NTU) with Hach StablCal	100	
Turbidity - Linearity verified with 40 NTU Hach StablCal – (+/- 4 NTU)	39.7	
Depth zero calibration verified – (.02 meters)	.00	
Depth Check verified – (+/- 0.03 meters) Tank depth: .50	.50	

Specific Ion NA Low C High C mV mV	Specific Ion NA Low C High C mV mV	Specific Ion NA Low C High C mV mV

N03- calibration verified	P F NA ✓	P F NA
NH4+ calibration verified	P F NA ✓	P F NA
Cl- calibration verified	P F NA ✓	P F NA
Chlorophyll 'a' calibration verified	P F NA ✓	P F NA
Rhodamine 'wt' calibration verified	P F NA ✓	P F NA
Blue-green Algae calibration verified	P F NA ✓	P F NA
PAR calibration verified	P ✓ F NA	P F NA
TDG calibration verified (+/- 2 mmHg)	P F NA ✓	P F NA
Logging/Sensor Stability Test	P ✓ F	P F
pH linearity verified at 4 units. (+/- 0.20 units)	4.02	
Battery pack setup and checked	P ✓ F NA	P F NA
Display, Baud Rate, Communications mode settings returned as received.	Yes ✓ No	

Calibrated Test Equipment Used – Description	**X-number**
Power Supply	X- 8011
Fluke 1524 -- Reference Thermometer	X- 8244
DVM Digital Multimeter	X- 7240

Section C. Final Check-off Prior to Submitting for Estimate

Exterior is clean ✓ **Clear** pH 4 Buffer in storage cup ✓	Hach Business System updated ✓ Date Completed 12-8-18

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Appendix 4 – Noise Meter Calibration Certificates

Brüel & Kjær
North America Inc.

The Bruel and Kjaer Calibration Laboratory
3079 Premiere Parkway Suite 120
Duluth, GA 30097
Telephone: 770-209-6907
Fax: 770-447-4033
Web site address: http://www.bksv.com

A2LA ACCREDITED
Calibration Certificate # 1568.01

CERTIFICATE OF CALIBRATION No.: CAS-339049-C8X1P1-801 Page 1 of 2

CALIBRATION OF:

Calibrator: Brüel & Kjær Type 4231 IEC Class: 1 Serial No.: 3008614

CUSTOMER:

C.L. Environmental Company Ltd.
20 Windsor Avenue
Kingston 10 Jamaica

CALIBRATION CONDITIONS:

Environment conditions:	Air temperature:	23	°C
	Air pressure:	98.29	kPa
	Relative Humidity:	43	%RH

SPECIFICATIONS:

This document certifies that the acoustic calibrator as listed under "Type" has been calibrated and unless otherwise indicated under "Final Data", meets acceptance criteria as prescribed by the referenced Procedure. Statements of compliance, where applicable, are based on calibration results falling within specified criteria with no reduction by the uncertainty of the measurements. The calibration of the listed transducer was accomplished using a test system which conforms to the requirements of ISO/IEC 17025, ANSI/NCSL Z540-1, and guidelines of ISO 10012-1. /For "as received" and "final" data, see the attached page(s). Items marked with one asterisk (*) are not covered by the scope of the current A2LA accreditation. This Certificate and attached data pages shall not be reproduced, except in full, without written approval of the Bruel and Kjaer Calibration Laboratory-Duluth, GA. Results relate only to the items tested. The transducer has been calibrated using Measurement Standards with values traceable to the National Institute of Standards and Technology, National Measurement Institutes or derived from natural physical constants. The acoustic calibrator has been calibrated in accordance with the requirements as specified in IEC60942.

PROCEDURE:

The measurements have been performed with the assistance of Brüel & Kjær acoustic calibrator calibration application Software version 2.3.4 Type 7794 using calibration procedure 4231 Complete

RESULTS:

[X] "As Received" Data: Within Acceptance Criteria
[X] "Final" Data : Within Acceptance Criteria
[ ] "As Received" Data: Outside Acceptance Criteria
[ ] "Final" Data : Outside Acceptance Criteria

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with EA-4/02from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the calibrator under calibration.

Date of Calibration: 31 October, 2018

Certificate issued: 31 October, 2018

Debra Wilson
Calibration Technician

Quality Representative

Brüel & Kjær
North America Inc.

CERTIFICATE OF CALIBRATION

No.: CAS-339049-C8X1P1-801

Type: 4231 Serial No.: 3008614 Page 2 of 2

Sound Pressure Levels

All stated values are valid at environmental reference conditions

Nominal Level [dB]	Accept Limit Lower [dB]	Accept Limit Upper [dB]	Measured Level [dB]	Measurement Uncertainty [dB]
94	93.80	94.20	94.00	0.12
114	113.80	114.20	113.97	0.12

Frequency

Nominal Frequency [Hz]	Accept Limit Lower [Hz]	Accept Limit Upper [Hz]	Measured Frequency [Hz]	Measurement Uncertainty [Hz]
1000	999.00	1001.00	999.98	0.10

Total Distortion*

Distortion mode: [X] TD* [ ] THD*

Calibration Level [dB]*	Accept Limit [%]*	Measured Distortion [%]*	Measurement Uncertainty [%]*
94	1.00	0.40	0.13
114	1.00	0.11	0.13

Environmental Reference Conditions:

Pressure: 101.3 kPa, Temperature: 23 °C, Relative Humidity: 50%

Instrument List

Type	Description	Serial no	Cal. date	Due date	Calibrated by	Trace number
3560	PULSE Analyzer	2723320	2018-10-22	2019-10-31	KC	CAS-335103-K3P9T8-301
9545	Transfer Microphone	3	2017-11-30	2018-11-30	WS	CAS-266536-L2C3Q6-701
4228	Reference Sound Source	2970961	2017-04-08	2019-04-08	William Shipman	CAS-212121-C8J1D8-708

During the calibration the calibrator has been loaded by the load volume of the Transfer Microphone. The load volumes for a number of different types of Transfer Microphones are listed in the table below.
For Brüel & Kjær Pistonphones types 4220 and 4228 the result of the SPL calibration has been corrected to be valid for a load volume of 1333 mm^3 . For all other types the result is valid with the actual load volume.

Transfer Microphone Type	Fulfils standard IEC 61094-1 LS	Fulfils standard IEC 61094-4 WS	Load Volume 1" (1/2" mic including DP-0776)	Load Volume 1/2"
4180	yes	yes	1126 mm^3	43 mm^3
4192	-	yes	1273 mm^3	190 mm^3
9545	-	-	1333 mm^3	-

Condition "As Received":

GOOD

Comments

Page 1 of 2

TSI INCORPORATED – OCONOMOWOC
1060 Corporate Center Drive, Oconomowoc, WI 53066 USA
tel 651 490 2811 + toll free 800 245 0779 + web www.tsi.com

Certificate of Calibration

Certificate No: 764862 0QI0110126

Submitted By: CL ENVIRONMENTAL CO
20 WINDSOR AVENUE
KINGSTON 5, JAMAICA

Serial Number:	0QI0110126	Date Received:	12/14/2018
Customer ID:		Date Issued:	12/17/2018
Model:	QC-10 CALIBRATOR	Valid Until:	12/17/2019

Test Conditions:

Temperature: 18°C to 29°C
Humidity: 20% to 80%
Barometric Pressure: 890 mbar to 1050 mbar

Model Conditions:

As Found: OUT OF TOLERANCE
As Left: IN TOLERANCE

SubAssemblies:

Description: **Serial Number:**

Calibration Procedure: 56V981

Reference Standard(s):

I.D. Number	Device	Last Calibration Date	Calibration Due
ET000176	FLUKE 45 MULTIMETER	2/22/2017	2/22/2019
ET0000556	B&K ENSEMBLE	6/23/2018	10/31/2019

Measurement Uncertainty:

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

Calibrated By: James Cullinane III — JAMES CULLINANE III, Service Technician — 12/17/2018

Reviewed/Approved By: Paul M. Wegman — Technical Manager/Deputy — 12/17/2018

This report certifies that all calibration equipment used in the test is traceable to NIST or other NMI, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of 3M Detection Solutions.

098-393 Rev. B

An ISO 9001 Registered Company
ISO 17025 Accredited Calibration Laboratory

A2LA ACCREDITED Calibration Laboratory CERT# 1326.01

TSI INCORPORATED — OCONOMOWOC
1060 Corporate Center Drive, Oconomowoc, WI 53066 USA
tel 651 490 2811 + toll free 800 245 0779 + web www.tsi.com

Certificate of Calibration

Certificate No: 764862 0QI0110126

(A) indicates out of tolerance condition

Test Type	Nominal	Tolerance-	Tolerance+		As Found	As Left	Unit
AC OUT/1kHz	1.000	0.950	1.050		1.008	1.000	VAC
Calibration	114.0	113.7	114.3	A	113.6	114.0	dB
Frequency	1000	980	1020		1003	1003	Hz

* indicates non accredited

098-393 Rev. B

An ISO 9001 Registered Company
ISO 17025 Accredited Calibration Laboratory

A2LA ACCREDITED Calibration Laboratory CERT# 1326.01

Appendix 5 – AirMetrics Air Sampler Calibration Certificate

NIST Traceable Transfer Standard Calibration

Calibration Date:	06/21/2018	Orifice #	MNF1829-	By:	
Ambient Temp, ºK:	297.8	Pri Std #	LFE786620		
Amb Press, mmHg:	757.0	Manometer #	DIG1829	Chk:	

Std ΔH (inH_2O)	Manometer ΔH (inH_2O)	Actual Flow (alpm)	Calc Flow (alpm)	Difference* (%diff)
4.68	4.64	7.905	7.932	-0.34
3.82	3.78	7.141	7.146	-0.08
3.02	2.99	6.371	6.341	0.46
2.35	2.32	5.592	5.570	0.39
1.76	1.73	4.808	4.792	0.33
1.42	1.40	4.282	4.298	-0.37
1.09	1.08	3.754	3.759	-0.12
0.82	0.81	3.223	3.237	-0.45

Manometer ΔH vs Act Flow Linear Regression Results:

m_{flo} =	**5.9690**
b_{flo} =	**-0.1317**
r^2 =	**0.9999**

* all points must be within ± 2%

The MiniFlo calibration is performed with an NIST-traceable standard. Each unit has a unique pair of calibration constants derived from the calibration which are used to calculate the actual air flow rate at all ambient conditions. The unit's calibration should be recertified annually.

The actual flow rate is a function of the pressure drop across the device, the ambient temperature, and the ambient pressure. The relationship of these variables and the unique calibration constants ("m" and "b") for each device is presented in the following equation (Eq.A):

$$Q_{act} = m_{flo} \times \sqrt{\frac{\Delta H \times T_{act}}{P_{act}}} + b_{flo}$$

Q_{act} = actual flowrate, liters per min
ΔH = manometer reading, inches of water
T_{act} = ambient temperature, ºK
P_{act} = ambient pressure, millimeters of mercury

CAUTION: The weather service, most airports, etc, reduce the atmospheric pressure to a common reference (sea level). The equation above requires the atmospheric pressure at the location where the MiniFlo is being used.

The equation below may be used to estimate the ambient atmospheric pressure at any elevation if the sea level pressure is known.

$$P_{act} = P_{sea} \times \left(1 - \frac{E}{145300}\right)^{5.25}$$

P_{act} = Ambient Atmospheric Pressure
P_{sea} = Sea Level Atmospheric Pressure
E = Site elevation, feet

Airmetrics
1940 Don St., Suite 300
Springfield, OR 97477
(541) 683-5420

Appendix 6 – Flora Species

Endemic flora highlighted in yellow; species of national importance highlighted in green.

DAFOR occurrence rank: usually a subjective scale of specie occurrence within an area of study. The acronym refers to, Dominant, Abundant, Frequent, Occasional, Rare.

FAIRFIELD

Scientific name	Common name	Growth form	Central Fairfield	Upper Fairfield/ Irwin	Lower Fairfield (Bogue + Theatre)
Abrus precatorius	Red Bead Vine	Climber/Twiner	O	O	
Adenanthera pavonina	Red Bead Tree	Tree		F-A	
Adiantum pyramidatum	Maiden-Hair Fern	Herb	O-F	F	
Alophylus cominia		Tree	P		
Alternanthera ficoide	Crab With	Herb		O-F	
Andropogon citratus	Fever Grass	Herb			R-O
Antigonon leptopus	Coalita	Climber/Twiner	O-F		
Artocarpus altilis	Breadfruit	Tree			O
Asystasia gangetica		Herb		O	
Bambusa vulgaris	Common Bamboo	Arborescent			O
Bidens pilosa	Spanish Needle	Herb		F	F
Blighia sapida	Ackee	Tree	F	O	
Bromelia pinguin	Ping Wing	Shrub			R
Bunchosia media		Shrub	R		
Bursera simaruba	Red Birch	Tree	D	R	
Capparis flexuosa	Bottle-Cod Root	Shrub	O		
Casearia hirsuta	Cloven Berries	Shrub	F	F-A	
Cecropia peltata	Trumpet Tree	Tree	O	R	
Chiococca alba	David's Root	Climber/Twiner	F		
Chromolaena odorata	Christmas Bush	Shrub	F		O
Chrysophyllum cainito	Star Apple	Tree		R-O	
Cieba pentandra	Silk Cotton Tree	Tree	O		
Cissus sicyoides	Pudding With	Climber/Twiner		R-O	
Citrus sp.		Tree			R
Cocos nucifera	Coconut	Tree			O-F
Comocladia pinnatifolia	Maiden Plum	Tree	O	O	
Cordia alba	Duppy Cherry	Tree		O	
Cordia brownei	Black Sage	Shrub		O-F	
Cordia bullata		Shrub			O
Cordia collococca	Clammy Cherry	Tree	O	R	
Cordia gerascanthus	Spanish Elm	Tree		R	
Cordia globbosa		Shrub		R-O	
Croton humilis	Pepper Rod	Shrub		O	
Delonix regia	Poinciana	Tree	O		O
Desmodium canum		Herb		R-O	
Enterolobium cyclocarpum	Elephant Ear	Tree			R-O
Euphorbia hispida		Herb			A

Scientific name	Common name	Growth form	Central Fairfield	Upper Fairfield/ Irwin	Lower Fairfield (Bogue + Theatre)
Fagara martinicensis	Prickly Yellow	Tree	O-F		
Ficus sp.		Tree	R-O		
Guazuma ulmifolia	Bastard Cedar	Tree		R	R
Haematoxylon campechianum	Logwood	Tree		O	O
Heliotropium angiospermum	Dog's Tail	Herb	R		
Ipomoea tiliacea	Wild Potato	Climber/Twiner			O
Jatropha gossypiifolia	Belly-Ache Bush	Shrub		O	
Juniperus sp.		Tree			R
Lagerstroemia indica	June Rose	Shrub			R
Lagerstroemia speciosa	Queen's Flower tree	Tree			R
Lantana camara	Wild Sage	Shrubby Herb	O-F		
Lasiacis divaricata	Bamboo Grass	Herb	O-F		
Leucaena leucocephala	Lead Tree	Tree	F		
Malpighia punicifolia	Barbados Cherry	Shrub		R	
Malvaviscus arboreus	Mahoe Rose	Shrub	R		
Manilkara zapota	Naesberry	Tree	R		
Melicoccuus bijugatus	Guinep	Tree	O		
Melochia nodiflora		Shrub		O	
Miconia laevigata		Shrub		O	
Mimosa pudica	Shame Weed	Herb		F	
Morinda royoc	Strong Back	Shrub		R	
Muntinga calabura	Jamaican Cherry	Shrub	O		
Murraya paniculata	Mock Orange	Tree	O		
Musa sapientum	Banana	Herb			O
Nectandra sp.		Tree	R		
Oxandra lanceolata	Black Lancewood	Tree	R		
Panicum maximum	Guinea Grass	Herb	F	D	O
Paspalum sp.		Herb		F	
Passiflora rubra	Bat Wing	Climber/Twiner	O	R	
Pennisetum purpureum	Elephant Grass	Herb	A		A
Pimenta dioca	Pimento	Tree		R	
Piper amalago var. amalago		Shrub	R		
Piscidia piscipula	Dogwood	Tree	F		
Pisonea aculeata	Cockspur	Shrub	R	R	
Psophocarpus palustrus	Wing Bean	Climber/Twiner			O
Psychotria sp.		Shrub		R	
Rhaphidophora aurea	Ornamental Wicker Vine	Climber/Twiner	O		
Ricinus Communis	Castor Oil Plant	Shrub	O		F

Scientific name	Common name	Growth form	Central Fairfield	Upper Fairfield/ Irwin	Lower Fairfield (Bogue + Theatre)
Roystonea altissima	Mountain Cabbage	Tree	R-O	O	F
Samanea saman	Guango	Tree	F	O	O
Sansevieria trifasciata	Tiger Cat	Herb	F		
Selenicereus grandiflorus	Queen-of-the-Night	Climber/Twiner	R-O		
Smilax balbisiana	Briar Withe	Climber/Twiner	F		
Solanum erianthum	Wild Susumber	Shrub		O	
Solanum torvum	Susumber	Shrub	O		
Sorghum halepense	Johnson Grass	Herb			D
Syngonium auritum	Five Finger	Climber/Twiner	R-O		
Terminalia catappa	W.I. Almond	Tree			O
Themeda arguens	Piano Grass	Herb		O	
Tillandsia sp.		Epiphyte	R		
Tournefortia maculata		Climber/Twiner	O		
Tournefortia volubilis	Chigger Nut	Climber/Twiner	O	R	
Triumfetta triloba	Bur Weed	Shrub	O	R	
Turnera ulmifolia	Ram-Goad Dashalong	Herb		O	
Zamia sp.		Shrub			R

QUEBEC

Scientific name	Common name	Growth form	Upper Quebec	Lower Quebec
Acacia macracantha	Park Nut	Tree		F
Andropogon pertusus	Seymour Grass	Herb		F
Bumelia salicifolia	White Bullet	Tree	O	
Bunchosia media		Shrub	O	
Bursera simaruba	Red Birch	Tree	O	
Calyptranthes sp.		Tree	A	
Capparis ferruginea	Mustard Shrub	Shrub	O	O
Capparis flexuosa	Bottle-Cod Root	Shrub		O
Casearia hirsuta	Cloven Berries	Shrub		O
Chiococca alba	David's Root	Climber/Twiner	O	
Chrysophyllum cainito	Star Apple	Tree	O	
Coccoloba sp.		Tree	O	
Comocladia pinnatifolia	Maiden Plum	Tree		O
Cordia alba	Duppy Cherry	Tree		A
Cordia bullata		Shrub	F	
Cordia gerascanthus	Spanish Elm	Tree		O
Cordia globbosa		Shrub		O
Cpraria biflora	Goatweed	Herb		O
Crescentia cujete	Calabash Tree	Tree		O
Croton humilis	Pepper Rod	Shrub		O
Croton linearis	Rosemary	Shrub	O	
Cupania glabra	Wild Ackee	Tree	O	

Scientific name	Common name	Growth form	Upper Quebec	Lower Quebec
Diospyros tetrasperma	Clamberry	Tree		O
Eugenia amplifolia		Tree		O
Fagara martinicensis	Prickly Yellow	Tree	O	F
Galactia pendula		Climber/Twiner	R	
Guazuma ulmifolia	Bastard Cedar	Tree		O
Haematoxylon campechianum	Logwood	Tree	F	D
Hypelate trifoliata	Ketto	Shrub	O	
Ipomoea tiliacea	Wild Potato	Climber/Twiner		O
Jasminum fluminense	Azores Jasmine	Climber/Twiner		O
Jatropha gossypiifolia	Belly-Ache Bush	Shrub		O
Lantana camara	Wild Sage	Shrubby Herb	O	O
Lasiacis divaricata	Bamboo Grass	Herb	O	
Leucaena leucocephala	Lead Tree	Tree		O
Lisianthius longifolius	Jamaican Fuchsia	Shrub	O	
Malpighia glabra	Wild Cherry	Shrub		A
Metopium brownii	Burn Wood	Tree	A	
Muntinga calabura	Jamaican Cherry	Shrub		O
Ocotea sp.		Tree		O
Oeceoclades maculata	Monk Orchid	Herb	O	
Oxandra lanceolata	Black Lancewood	Tree	O	
Panicum maximum	Guinea Grass	Herb		O
Paullinia barbadensis	Supple Jack	Climber/Twiner		O
Piscidia piscipula	Dogwood	Tree	D	
Pisonea aculeata	Cockspur	Shrub		O
Pithecellobium unguis-cati	Privet	Tree		O
Rhoeo spathacea	Oyster Plant	Tree	O	
Scleria lithosperma		Herb	O	
Simaruba glauca	Bitter Damson	Tree	R	
Smilax balbisiana	Briar Withe	Climber/Twiner	F	
Solanum erianthum	Wild Susumber	Shrub		O
Spathodea campanulata	African Tulip Tree	Tree		O
Stachytarpheta jamaicensis	Porter Weed	Herb		O
Stigmaphyllon emarginatum		Tree		O
Tabernaemontana divaricata	Coffee Rose	Tree	R	
Tabernaemontana laurifolia		Shrub		O
Thespedia populnea	Seaside mahoe	Tree		O
Thrinax parvifolora	Broom Thatch	Tree	O	
Tournefortia volubilis	Chigger Nut	Climber/Twiner		O
Zoysia tenuifolia	Carpet Grass	Herb		F

GREEN POND

Scientific name	Common name	Growth form	DAFOR
Adenanthera pavonina	Red Bead Tree	Tree	O-F
Adiantum pyramidatum	Maiden-Hair Fern	Herb	O
Andropogon pertusus	Seymour Grass	Herb	A
Bauhinia divaricata	Bull Hoof	Tree	R
Bidens pilosa	Spanish Needle	Herb	O
Blighia sapida	Ackee	Tree	O
Bursera simaruba	Red Birch	Tree	D

Scientific name	Common name	Growth form	DAFOR
Cecropia peltata	Trumpet Tree	Tree	R
Centrosema pubescens		Climber/Twiner	O
Chromolaena odorata	Christmas Bush	Shrub	O
Cordia bullata		Shrub	O
Cordia gerascanthus	Spanish Elm	Tree	O
Cupania glabra	Wild Ackee	Tree	O
Eugenia amplifolia		Tree	O
Fagara martinicensis	Prickly Yellow	Tree	F
Guazuma ulmifolia	Bastard Cedar	Tree	F
Haematoxylon campechianum	Logwood	Tree	A
Hohenbergia sp.		Epiphyte	R
Hylocereus triangularis	God Okra	Epiphyte	O
Ipomoea sp.		Climber/Twiner	O-F
Ipomoea tiliacea	Wild Potato	Climber/Twiner	O
Lantana camara	Wild Sage	Shrubby Herb	O
Lasiacis divaricata	Bamboo Grass	Herb	O
Malpighia glabra	Wild Cherry	Shrub	O
Mangifera indica	Mango	Tree	O
Melochia nodiflora		Shrub	O
Metopium brownii	Burn Wood	Tree	R
Morinda royoc	Strong Back	Shrub	O
Nectandra sp.		Tree	F
Paullinia barbadensis	Supple Jack	Climber/Twiner	O
Piper amalago var. amalago		Shrub	O
Piscidia piscipula	Dogwood	Tree	O
Pisonea aculeata	Cockspur	Shrub	O
Polypodium polypodioides	Resurrection Fern	Epiphyte	O
Psophocarpus palustrus	Wing Bean	Climber/Twiner	O
Rhipsalis baccifera	Mistletoe	Epiphyte	O
Samanea saman	Guango	Tree	O
Scleria lithosperma		Herb	O-F
Sida acuta	Broomweed	Shrubby Herb	O
Themeda arguens	Piano Grass	Herb	O-F
Tillandsia juncea		Epiphyte	R
Trichostigma octandrum	Hoop Withe	Herb	O
Triumfetta triloba	Bur Weed	Shrub	O

MONTEGO HILLS

Scientific name	Common name	Growth form	DAFOR
Andrographis paniculata	Rice Bitters	Herb	O
Bidens pilosa	Spanish Needle	Herb	O
Blighia sapida	Ackee	Tree	F
Bunchosia media		Shrub	R
Chromolaena odorata	Christmas Bush	Shrub	R-O
Fagara martinicensis	Prickly Yellow	Tree	O
Manilkara zapota	Naesberry	Tree	O
Metopium brownii	Burn Wood	Tree	R
Pimenta dioca	Pimento	Tree	A
Ruellia tuberosa	Duppy Gun	Herb	R

Scientific name	Common name	Growth form	DAFOR
Sabal jamaicensis	Bull Thatch	Tree	R
Swietenia mahagoni	W.I. Mahogany	Tree	P
Tragia volubilis	Twining Cowitch	Climber/Twiner	R

MONTPELIER

Scientific name	Common name	Growth form	Grasslands Adjacent Woods of Montpelier	Abandoned Alignment Adjacent Montpelier	Woods of Montpelier
Achyranthes aspera		Herb			R
Adenanthera pavonina	Red Bead Tree	Tree			O-F
Adiantum pyramidatum	Maiden-Hair Fern	Herb			F
Alocasia macrorrhizos	Giant Taro	Herb			R
Alophylus cominia		Tree			R
Alternanthera ficoide	Crab With	Herb			F
Andropogon pertusus	Seymour Grass	Herb	A		
Bidens pilosa	Spanish Needle	Herb	F		
Cananga odorata	Ylang Ylang	Tree			O
Carica papaya	Papaw	Tree			R
Castilla elastica	Panama rubber tree	Tree			R
Cecropia peltata	Trumpet Tree	Tree		O	
Cedrella odorata	West Indian Cedar	Tree			O
Centrosema pubescens		Climber/Twiner	O		
Chiococca alba	David's Root	Climber/Twiner			F
Chromolaena odorata	Christmas Bush	Shrub	O-F		
Cissus sicyoides	Pudding With	Climber/Twiner			R
Citrus sp.		Tree		F	F
Commelina sp.		Herb			R
Cordia bifurcata		Shrub	R-O		O
Cordia globbosa		Shrub			O
Crescentia cujete	Calabash Tree	Tree			R
Cupania glabra	Wild Ackee	Tree			O
Cyperus sp.		Herb			O
Desmodium canum		Herb	R		
Diffenbachia seguine	Dumb Cane	Herb			O
Fagara elephantiasis	Yellow Sanders	Tree			O
Guazuma ulmifolia	Bastard Cedar	Tree			R-O
Guzmania sp.		Epiphyte	R-O	R	F
Haematoxylon campechianum	Logwood	Tree			O
Heterotrichum umbellatum	American Gooseberry	Shrub		R	
Hyptis capitata	Ironwort	Herb	R-O		
Ipomoea tiliacea	Wild Potato	Climber/Twiner	F		
Lantana camara	Wild Sage	Shrubby Herb	F		
Mangifera indica	Mango	Tree		R	
Melicoccuus bijugatus	Guinep	Tree	R-O		
Melochia nodiflora		Shrub			R-O
Miconia impetiolaris		Shrub			F
Mikania micrantha	Guaco	Climber/Twiner	O		
Mimosa pudica	Shame Weed	Herb	O		

Scientific name	Common name	Growth form	Grasslands Adjacent Woods of Montpelier	Abandoned Alignment Adjacent Montpelier	Woods of Montpelier
Moghania strobilifera	Wild Hops	Shrub			R
Nectandra antillana	Yellow Sweetwood	Tree	O		F
Nephrolepis sp.		Herb			O
Panicum maximum	Guinea Grass	Herb		A	
Pavonia spicata var. spicata	Smaller Mahoe	Shrub	R		
Peltophorum linnaei	Braziletto	Tree		R	O
Pennisetum purpureum	Elephant Grass	Herb	A	D	
Pisonea aculeata	Cockspur	Shrub			R
Polypodium polypodioides	Resurrection Fern	Epiphyte		F	F
Psychotria daphnoides		Tree			R
Ribes uva-crispa	Gooseberry	Shrub			R
Rivinia humilis	Bloodberry	Herb			R
Roystonea altissima	Mountain Cabbage	Tree			R
Saccharum officinarum	Sugar Cane	Herb		D	
Serjania laevigata		Climber/Twiner			R
Sorghum halepense	Johnson Grass	Herb	A		
Spathodea campanulata	African Tulip Tree	Tree	F		D
Syngonium auritum	Five Finger	Climber/Twiner			O
Terminalia catappa	W.I. Almond	Tree			R-O
Thelypteris sp.		Herb			O
Themeda arguens	Piano Grass	Herb		A	
Tillandsia juncea		Epiphyte		O	F
Trophis racemosa	Ramoon	Tree			R
Wedelia trilobata	Creeping Ox-eye	Herb	O		
Xanthosoma sagittifolium	Coco	Herb			R-O

MOUNT CAREY

Scientific name	Common name	Growth form	DAFOR
Adiantum pyramidatum	Maiden-Hair Fern	Herb	O
Albizzia lebbeck	Woman's Tongue Tree	Tree	O
Amaranthus dubius	Spanish Calalu	Herb	F
Antigonon leptopus	Coalita	Climber/Twiner	R
Artocarpus altilis	Breadfruit	Tree	R-O
Bambusa vulgaris	Common Bamboo	Arborescent	F
Bidens pilosa	Spanish Needle	Herb	A
Blechum pyramidatum		Herb	F
Blighia sapida	Ackee	Tree	O
Cassia ligustrina		Shrubby Herb	F
Cecropia peltata	Trumpet Tree	Tree	F
Cedrella odorata	West Indian Cedar	Tree	R
Chromolaena odorata	Christmas Bush	Shrub	F
Cieba pentandra	Silk Cotton Tree	Tree	R
Cocos nucifera	Coconut	Tree	O
Corchorus siliquosus	Slippery Bur	Herb	F
Cupania glabra	Wild Ackee	Tree	R
Ephorbia pulcherrima	Poinsettia	Shrub	R

Scientific name	Common name	Growth form	DAFOR
Eupatorium triste	Old Woman's Bitter Bush	Shrub	O
Ficus maxima		Tree	R
Guazuma ulmifolia	Bastard Cedar	Tree	O
Haematoxylon campechianum	Logwood	Tree	O
Ipomoea sp.		Climber/Twiner	F
Ipomoea tiliacea	Wild Potato	Climber/Twiner	F
Lantana camara	Wild Sage	Shrubby Herb	O-F
Leucaena leucocephala	Lead Tree	Tree	O
Mangifera indica	Mango	Tree	O-F
Manilkara zapota	Naesberry	Tree	R
Melochia nodiflora		Shrub	R
Mikania micrantha	Guaco	Climber/Twiner	F
Mimosa pudica	Shame Weed	Herb	O
Musa sapientum	Banana	Herb	O
Nectandra antillana	Yellow Sweetwood	Tree	O
Nectandra sp.		Tree	R
Nephrolepis sp.		Herb	F-A
Pandanus utilis	Screw Pine	Tree	O
Panicum maximum	Guinea Grass	Herb	A
Paullinia barbadensis	Supple Jack	Climber/Twiner	F
Pennisetum purpureum	Elephant Grass	Herb	A
Persea americanum	Avocado Pear	Tree	O
Pilea nummulariifolia		Climber/Twiner	F
Pimenta dioca	Pimento	Tree	R
Piper hispidum		Shrub	O
Pisonea aculeata	Cockspur	Shrub	O
Psophocarpus palustrus	Wing Bean	Climber/Twiner	F-A
Psychotria daphnoides		Tree	R
Rhaphidophora aurea	Ornamental Wicker Vine	Climber/Twiner	O
Roystonea altissima	Mountain Cabbage	Tree	R
Saccharum officinarum	Sugar Cane	Herb	R
Samanea saman	Guango	Tree	R-O
Solanum erianthum	Wild Susumber	Shrub	O-F
Spathodea campanulata	African Tulip Tree	Tree	O
Stachytarpheta jamaicensis	Porter Weed	Herb	F
Syngonium auritum	Five Finger	Climber/Twiner	O
Terminalia catappa	W.I. Almond	Tree	R-O
Thelypteris sp.		Herb	O
Themeda arguens	Piano Grass	Herb	A
Theobroma cacao	Cocoa	Tree	R
Triumfetta triloba	Bur Weed	Shrub	F
Urechites lutea	Nightshade	Climber/Twiner	R-O
Wedelia trilobata	Creeping Ox-eye	Herb	O

ANCHOVY TO BOGUE HILLS

Scientific name	Common name	Growth form	DAFOR
Adiantum sp.		Herb	O
Alophylus cominia		Tree	F
Andira inermis	Cabbage Bark Tree	Tree	F
Bauhinia divaricata	Bull Hoof	Tree	R-O
Bixa orellana	Anatto	Tree	O

Scientific name	Common name	Growth form	DAFOR
Blighia sapida	Ackee	Tree	F
Bocconia frutescens	John Crow Bush	Tree	R
Borreria laevis	Button Weed	Herb	F-A
Bryophyllum pinnatum	Leaf-of-Life	Herb	F
Bursera simaruba	Red Birch	Tree	O
Casearia guianensis	Wild Coffee	Tree	F-A
Casearia hirsuta	Cloven Berries	Shrub	R
Cecropia peltata	Trumpet Tree	Tree	F
Cieba pentandra	Silk Cotton Tree	Tree	R
Clethra occidentalis	Soapwood	Tree	O
Comocladia pinnatifolia	Maiden Plum	Tree	O-F
Cupania glabra	Wild Ackee	Tree	F
Dendropanax arboreus	Angelica Tree	Tree	R
Dioscorea sp.	Yam	Climber/Twiner	O
Eugenia amplifolia		Tree	O-F
Fagara elephantiasis	Yellow Sanders	Tree	O
Ficus aurea		Tree	R
Ficus maxima		Tree	O
Guazuma ulmifolia	Bastard Cedar	Tree	F
Haematoxylon campechianum	Logwood	Tree	F-A
Hibiscus elatus	Blue Mahoe	Tree	O
Hohenbergia sp.		Epiphyte	O
Hylocereus triangularis	God Okra	Epiphyte	R
Ipomoea sp.		Climber/Twiner	O
Ipomoea tiliacea	Wild Potato	Climber/Twiner	O
Mangifera indica	Mango	Tree	O
Marchantia sp.		Bryophyte	O-F
Miconia impetiolaris		Shrub	F
Moghania strobilifera	Wild Hops	Shrub	O
Muntinga calabura	Jamaican Cherry	Shrub	R
Nectandra antillana	Yellow Sweetwood	Tree	O
Nephrolepis sp.		Herb	D
Ocotea sp.		Tree	R
Oeceoclades maculata	Monk Orchid	Herb	O
Pavonia spicata var. spicata	Smaller Mahoe	Shrub	R-O
Pennisetum purpureum	Elephant Grass	Herb	F
Peperomia sp.		Herb	O-F
Picramnea antidesma	Macary Bitter	Shrub	R-O
Pilea nummulariifolia		Climber/Twiner	R
Piper amalago var. amalago		Shrub	O-F
Piper amalago var. nigrinodum	Black Jointer	Tree	R-O
Piper hispidum		Shrub	O
Pithecellobium unguis-cati	Privet	Tree	R
Pluchea carolinensis	Wild Tobacco	Herb	O
Polypodium polypodioides	Resurrection Fern	Epiphyte	O-F
Pseudelephantopus spicatus	Dog's Tongue	Herb	O-F
Rytidophyllum tomentosum	Search-me-Heart	Herb	R
Sapindus saponaria	Soap Berry Tree	Tree	O-F
Simaruba glauca	Bitter Damson	Tree	R-O
Solanum ciliatum	Cockroach Poison	Herb	R-O
Spathodea campanulata	African Tulip Tree	Tree	F
Stachytarpheta jamaicensis	Porter Weed	Herb	F

Scientific name	Common name	Growth form	DAFOR
Syngonium auritum	Five Finger	Climber/Twiner	R
Terminalia catappa	W.I. Almond	Tree	R
Tragia volubilis	Twining Cowitch	Climber/Twiner	R
Trophis racemosa	Ramoon	Tree	O
Turnera ulmifolia	Ram-Goad Dashalong	Herb	O

RESIDENTIAL SPECIES

Scientific name	Common name	Growth form	Residential
Antigonon leptopus	Coalita	Climber/Twiner	F
Artocarpus altilis	Breadfruit	Tree	F-A
Blighia sapida	Ackee	Tree	F-A
Cedrella odorata	West Indian Cedar	Tree	R
Cieba pentandra	Silk Cotton Tree	Tree	R
Guazuma ulmifolia	Bastard Cedar	Tree	R
Ipomoea tiliacea	Wild Potato	Climber/Twiner	O
Mangifera indica	Mango	Tree	F
Manilkara zapota	Naesberry	Tree	O
Musa sapientum	Banana	Herb	F
Panicum maximum	Guinea Grass	Herb	F-A
Rhaphidophora aurea	Ornamental Wicker Vine	Climber/Twiner	O
Roystonea regia	Cuban Royal Palm	Tree	R-O
Saccharum officinarum	Sugar Cane	Herb	O
Samanea saman	Guango	Tree	O
Solanum erianthum	Wild Susumber	Shrub	R
Terminalia catappa	W.I. Almond	Tree	F

WEST GREEN AVE

Scientific name	Common name	Growth form	Occurrence (DAFOR)
Cissus sicyoides	Pudding Withe	Climbers/Twiners	O-F
Ipomoea tiliacea	Wild Potato		A
Passiflora edulis	Passion Fruit		R
Passiflora foetida	Sweet Cup		R-O
Phaseolus atropurpureus			R-O
Pseudocalymma alliaceum	Garlic Vine		R
Rhaphidophora aurea	Ornamental Wicker Vine		O-F
Amaranthus dubius	Spanish Calalu	Herbs	F
Bidens pilosa	Spanish Needle		A
Callisia fragrans	Basket Plant		R-O
Commelina sp.			R
Heliconia sp.			F
Kallstroemia maxima	Police Macca		O-F
Lablab purpureus	Bonavist Bean		R
Lippia alba	Colon Mint		F
Musa sapientum	Banana		O
Nephrolepis sp.			R

Scientific name	Common name	Growth form	Occurrence (DAFOR)
Panicum maximum	Guinea Grass		A
Parthenium hysterophorus	Santa Maria		O
Pennisetum purpureum	Elephant Grass		R-O
Ruellia brittoniana	Mexican Bluebell		O-F
Ruellia paniculata			O
Spilanthes urens	Pigeon Coop		O
Sporobolus sp.			D
Trichostigma octandrum	Hoop Withe		R-O
Tridax procumbens			F-A
Bougainvilia sp.		Shrubs	F
Cajanus cajan	Pigeon Pea		R
Chromolaena odorata	Christmas Bush		R
Codiaeum variegatum	Garden Croton		O
Cordyline sp.			O
Dracaena rubra	Song of India		O
Duranta erecta	Duranta Gold		O-F
Euphorbia millii	Crown-of-Thorns		R-O
Hibiscus rosa-sinensis	Shoe Black		F
Hibiscus tiliaceus var. variegata	Seaside Mahoe		O
Ixora sp.			O
Leucophyllum frutescens	Texas Sage		F
Muntinga calabura	Jamaican Cherry		R
Nerium oleander	Oleander		O
Polyscias sp.	Aralia		R-O
Ricinus Communis	Castor Oil Plant		R
Yucca aloifolia	Spanish Bayonet		O
Agave americana	Sentry Plant	Shrubby Herbs	O
Agave confusa			O
Lantana camara	Wild Sage		F
Acacia macracantha	Park Nut	Trees	R
Adonidia merrillii	Christmas Palm		O
Annona reticulata	Custard Apple		O
Annona squamosa	Sweet Sop		O
Artocarpus altilis	Breadfruit		O
Bauhinia purpurea	Poor-Man's Orchid		O
Blighia sapida	Ackee		F
Carica papaya	Papaw		R
Casuarina equisetifolia	Willow		F-A
Cecropia peltata	Trumpet Tree		R
Chamaedorea elegans	Parlour Palm		O
Citrus sp.			R
Cocos nucifera	Coconut		O
Conocarpus erectus var. sericeus	Silver Buttonwood		O
Delonix regia	Poinciana		O-F
Ficus benjamina	Ornamental Fig		O
Mangifera indica	Mango		A
Melicoccuus bijugatus	Guinep		R-O
Moringa oleifera	Moringa		O
Plumeria sp.	Frangipani		O
Ptychosperma elegans	Solitaire Palm		R
Rhoeo spathacea	Oyster Plant		O
Roystonea regia	Cuban Royal Palm		R

Scientific name	Common name	Growth form	Occurrence (DAFOR)
Samanea saman	Guango		F-A
Spathodea campanulata	African Tulip Tree		R
Spondias dulcis	June Plum		O
Tabebuia rosea	Pink Poui		F
Tabebuia rufescens	Yellow Poui		F
Terminalia catappa	W.I. Almond		F

BARNETT STREET

Scientific name	Common name	Growth form	DAFOR
Bambusa vulgaris	Common Bamboo	Arborescent Herb	R
Cucurbita pepo	Field Pumpkin	Climbers/Twiners	R
Ipomoea sp.			O-F
Momordica charantia	Ccerasee		R-O
Achyranthes indica	Devil's Horsewhip	Shrubs	O
Amaranthus dubius	Spanish Calalu		F
Andropogon pertusus	Seymour Grass		D
Arundo donax	Wild cane		O-F
Barleria prionitis	Porcupine Flower		R
Bidens pilosa	Spanish Needle		O
Boerhavia diffusa	Hog Weed		F-A
Cenchrus echinatus	Sandbur		O
Eleusine indica	Yard Grass		F
Euphorbia heterophylla	Painted Leaf		R-O
Euphorbia hirta	Asthma Plant		O
Kallstroemia maxima	Police Macca		O
Malvastrum sp.			O
Manihot esculenta	Cassava		R
Melochia pyramidale			R-O
Musa sapientum	Banana		O
Panicum maximum	Guinea Grass		A
Pennisetum purpureum	Elephant Grass		R
Ruellia paniculata			O
Sorghum halepense	Johnson Grass		O-F
Sporobolus sp.			A
Tridax procumbens			A
Bougainvilia sp.			O
Cajanus cajan	Pigeon Pea		R
Capparis sp.			R
Sida acuta	Broomweed	Shrubby Herb	O
Annona reticulata	Custard Apple	Trees	R
Blighia sapida	Ackee		O
Carica papaya	Papaw		R
Ceiba pentandra	Silk Cotton Tree		R
Cordia collococca	Clammy Cherry		R-O
Cordia sebestena	Geiger Tree		O
Ficus benjamina	Ornamental Fig		R
Gliricidia sepium	Quick Stick		R
Leucaena leucocephala	Lead Tree		R

Scientific name	Common name	Growth form	DAFOR
Livistona sp.			O
Morinda citrifolia	Hog Apple		R
Moringa oleifera	Moringa		R
Phoenix roebelenii			O
Roystonea regia	Cuban Royal Palm		O
Samanea saman	Guango		O
Spathodea campanulata	African Tulip Tree		F
Syzygium malaccense	Otaheite apple		R
Tamarindus indica	Tamarind		R
Washingtonia sp.			O

Appendix 7 – NEPA Guidelines for Public Participation

SECTION 2

PUBLIC CONSULTATIONS GUIDELINES
FOR
ENVIRONMENTAL IMPACT ASSESSMENTS

SECTION 2 - TABLE OF CONTENTS

CHAPTER 1: GENERAL GUIDELINES

1.0 Introduction

There are two levels of public consultation involved in the Environmental Impact Assessment (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 takes place after the EIA report is prepared in the form of a public meeting and the submission and review of comments on the EIA report. This occurs after the applicant has provided the information needed for adequate review by the public.

1.1 Purpose

These guidelines are prepared in relation to the second level of consultation outlined above for the use of the applicant and the public.

CHAPTER 2: SPECIFIC GUIDELINES FOR PUBLIC MEETING FOR ENVIRONMENTAL IMPACT ASSESSMENTS (EIAS)

2.1 Requirements

Arrangements for the public consultation, in particular the public meeting, must be made in discussion with NEPA in respect of date, time, venue, chairperson, specially invited participants and length of time for the submission of comments.

A permanent record of the meeting is required hence, the applicant must submit to NEPA a copy of the verbatim report of the public meeting within seven (7) days of the date of the meeting.

2.2 Public Notification

The public must be notified at least three (3) weeks before the date of the public meeting. The applicant must seek to ensure that in addition to specific invitation letters, at least **three (3)** notices are placed in the most widely circulated newspapers advertising the event; one (1) notice per week. A copy of the notice shall be forwarded to NEPA for approval prior to publication in the newspapers. The NEPA will also post a copy of the Notice on its Website once it has been approved. To ensure that the Notice is distributed as widely as possible, at least two (2) other methods of notification such as community notice boards, flyers, town criers etc. shall be utilized. In addition, specific notice to relevant local NGOs and community groups should be made by the applicants. Evidence of the two (2) additional methods of notification and specific notices must be submitted to the NEPA.

The notices should indicate that:-

-the EIA has been submitted to NEPA;
- the purpose of the meeting;
- how to access the EIA report for review;
- the date, time and venue of the public presentation;
- contact information (NEPA/NRCA/TCPA and the APPLICANT).

The public meeting should be conducted no less than 3 weeks after the EIA has been accepted for posting and has been made available to the public and no less than 3 weeks after the first notice announcing public meeting has been published by the applicant. ***(A typical notice is in***

Appendix 1).

2. 3 Responsibility of Applicant

The applicant is responsible for distribution of copies of the EIA Report to make them available to the public at least three (3) weeks before the public meeting. Copies should be placed in the Local Parish Library and the Parish Council Office as well as the NEPA Documentation Centre, NEPA Regional Office nearest to the project site and other community locations as agreed upon. A summary of the project components and the findings of the EIA in non-technical language should also be prepared for distribution at the public meeting.

2.4 Conduct of the Meeting

With respect to the conduct of the meeting, the chairperson should be independently selected so as to ensure his/her neutrality. NEPA should be consulted regarding the selection of a chairperson. The role and responsibilities of the chairperson are outlined in ***Appendix 3***.

2.5 The Presentation

The technical presentation by the applicant should be simple, concise and comprehensive. The main findings of the EIA including adverse and beneficial impacts identified and analyzed should be presented. **(A typical agenda for a meeting is given in Appendix 2)**

Mitigation measures and costs associated with these measures should be presented. The meeting should inform the public on how they will get access to monitoring results during the construction and operational phases of the project, as it seeks to facilitate their participation in the monitoring and enforcement of the conditions under which approvals may being granted. Graphic and pictorial representations 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 a minimum of 30 minutes for questions. ***(A typical outline of a Project presentation is given in Appendix 4)***

2.6 Submission of Verbatim Report

The applicant will submit to NEPA a copy of the verbatim report of the public meeting within seven (7) days of the date of the meeting.

2.7 Submission of Public Comments

Please note that the public will be given a period of twenty-one (21) days after the public meeting to submit written comments to NEPA.

CHAPTER 3: CONDUCTING SUBSEQUENT PUBLIC CONSULTATIONS

The applicant is required to conduct other public consultations once the scope and size of the project has changed significantly; once deemed necessary by the Authority. The additional consultation may be required whether or not a permit has already been granted and issued for the development.

3.1 Requirements

Arrangements for the public meeting must be made in consultation with NEPA in respect of date, time, venue, chairperson and participants.

A permanent record of the meeting is required hence, the project proponent/consultant will submit to NEPA a copy of the verbatim report of the public meeting within seven (7) days of the date of the meeting.

3.2 Public Notification

The public must be notified at least one (**1) week** before the date of the public presentation. The developer/consultants must seek to ensure that in addition to specific invitation letters; at least **one (1) notice** is placed in one of the most widely circulated newspapers advertising the event. The notice shall also be forwarded to NEPA for posting on its website. To ensure that the notice is distributed as widely as possible, other methods of notification such as community notice board, flyers, town criers etc. shall be utilized as appropriate. In addition, specific notice to relevant local NGOs and community groups should be made by the developer/consultants.

The notice should indicate that:-

- the purpose of the meeting
- changes have been made to original proposal for which the EIA has been submitted to NEPA;
- how to access the EIA report for review;
- the date, time and venue of the public meeting;
- contact information.

The public meeting should be conducted no less than **one (1) week** after the document outlining the changes and any supporting technical information have been made available to the public and no less than **one (1) week** after the notice announcing public meeting has been published by the applicant. ***(A typical notice is in Appendix 5).***

3.3 Responsibility of Applicant

The applicant is responsible for distribution of the document outlining the changes and any supporting technical information to the public at least **one (1) week** before the public meeting. The document outlining the changes and any supporting technical information should be placed in the Local Parish Library and the Parish Council Office, NEPA Documentation Centre as well as at the NEPA Regional Office nearest to the site and any other community locations as agreed upon.

A summary of the project components, highlighting the changes in non-technical language should also be prepared for distribution at the public meeting.

3.4 Conduct of the Meeting

With respect to the conduct of the meeting, the chairperson should be independently selected so as to ensure his/her neutrality. NEPA should be consulted regarding the selection of a chairperson. The role and responsibilities of the chairperson are outlined in ***Appendix 3***.

3.5 The Presentation

The technical presentation by the applicant should be simple, concise and comprehensive. The changes to the proposal and any supporting technical information should be presented as well as any adverse and beneficial impacts identified and analyzed. **(A typical agenda for a meeting is given in Appendix 7)**

Mitigation measures and costs associated with these measures should be presented. The meeting should inform the public on the ways in which monitoring results may be accessed during the construction and operational phases of the project, bearing in mind that the public and non-governmental groups are expected to be involved in post-approval monitoring. Graphic and pictorial documentation may 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 a minimum of 30 minutes for questions. ***(A typical outline of a Project presentation is given in Appendix 6)***

3.6 Submission of Verbatim Report

The applicant will submit to NEPA a copy of the verbatim report of the public meeting within **seven (7) days** of the date of the meeting.

3.7 Submission of Public Comments

Please note that the public will be given **ten (10) days** after the public meeting to submit written comments to NEPA.

APPENDICES

APPENDIX 1

NOTIFICATION OF PUBLIC MEETING

THERE WILL BE A PUBLIC CONSULTATION ON THE ENVIRONMENT IMPACT ASSESSMENT REPORT

OF:

VENUE:

DATE:

TIME:

THE PUBLIC IS INVITED TO PARTICIPATE IN THE CONSULTATION BY WAY OF ASKING QUESTIONS RELATING TO THE PROPOSED PROJECT.

A COPY OF THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT MAY BE CONSULTED AT THE
____________________ PARISH LIBRARY
____________________ PARISH COUNCIL OFFICE
NEPA'S Documentation Centre at 11 Caledonia Avenue, Kingston 5
____________________ NEPA Website: www.nepa.gov.jm
For further information contact:

APPENDIX 2

AGENDA

1. WELCOME AND INTRODUCTION

2. STATEMENT BY THE NATIONAL ENVIRONMENT & PLANNING AGENCY

3. PRESENTATION OF EIA FINDINGS AND MEASURES TO MINIMIZE IMPACTS

4. QUESTION AND ANSWER SESSION

5. CLOSING REMARKS

APPENDIX 3

ROLE AND RESPONSIBLITIES OF THE CHAIRPERSON

The chairperson has the main role of guiding the conduct of the meeting and seeing to it that the concerns of the public are adequately aired and addressed by the proponent/consultants.

The responsibilities of the chairperson include explaining the NEPA approval process, that is, the steps involved and the role of the NEPA at these public presentations. In other words, the chairperson should explain the context within which the meeting is taking place.

The chairperson should ensure that adequate time is allowed for questions and answers, and must understand clearly and communicate the purpose of the meeting to the audience. The chairperson is responsible for introducing the presenters.

The chairperson should contribute to but not monopolize the meeting.

APPENDIX 4

STRUCTURE OF PRESENTATION

1. DETAILED DESCRIPTION OF PROJECT PROPOSAL

2. DETAILS OF IMPACTS IDENTIFIED

3. DESCRIPTION OF PROPOSED MITIGATION MEASURES

4. RESPONSE TO ANY ISSUES RAISED PRIOR TO PUBLIC CONSULTATION (MEDIA, WRITTEN QUERY ETC.)

APPENDIX 5

NOTIFICATION OF PUBLIC MEETING - CONDUCTING SUBSEQUENT PUBLIC CONSULTATIONS

FURTHER TO THE ENVIRONMENTAL IMPACT ASSESSMENT (titled) dated prepared by XXXX permit# (WHERE RELEVANT). The (name of applicant) INVITES YOU TO A PUBLIC MEETING FOR name of project and brief description of change to proposal of (location)

THE PUBLIC IS INVITED TO PARTICIPATE IN THE MEETING BY WAY OF ASKING QUESTIONS RELATING TO THE PROPOSED AMENDMENT TO THE PROJECT PROPOSAL.

VENUE:
DATE:
TIME:

A COPY OF THE (LIST DOCUMENTS TO BE CONSULTED) MAY BE CONSULTED AT THE:

For further information contact: applications@nepa.gov.jm

APPENDIX 6

STRUCTURE OF PRESENTATION - CONDUCTING SUBSEQUENT PUBLIC CONSULTATIONS

1. DETAILED DESCRIPTION OF PROJECT ORIGINALLY PROPOSED/APPROVED (IF PERMIT GRANTED)
2. CHANGES TO THE PROPOSAL
3. DETAILS OF IMPACTS IDENTIFIED BASED ON THE CHANGES
4. DESCRIPTION OF PROPOSED MITIGATION MEASURES
5. RESPONSE TO ANY ISSUES RAISED PRIOR TO PUBLIC CONSULTATION (MEDIA, WRITTEN QUERY ETC.)

APPENDIX 7

AGENDA - CONDUCTING SUBSEQUENT PUBLIC CONSULTATIONS

1. WELCOME AND INTRODUCTION
2. STATEMENT BY THE NATIONAL ENVIRONMENT & PLANNING AGENCY
3. PRESENTATION OF TECHNICAL DOCUMENTS RELATED TO THE CHANGE IN THE PROPOSAL AND MEASURES TO MINIMIZE IMPACTS
4. QUESTION AND ANSWER SESSION
5. CLOSING REMARKS

Appendix 8 – Community Meeting Attendance Sheets

Catherine Hall

National Road Operating & Constructing Company

Montego Bay Perimeter Road

HIGHWAY 2000 NROCC

COMMUNITY MEETING – Catherine Hall

Howard Cooke Primary School, Wednesday 2019 February 27

ATTENDANCE REGISTER

Nº	NAME	ORGANIZATION/ COMMUNITY	SIGNATURE
1	Meava Henry	West Green	[illegible]
2	Hubert William	Catherine Hall	[illegible]
3	Lincoln Robinson	Catherine Hall	[illegible]
4	Christopher Thomas	The Gleaner	[illegible]
5	Anthony Dillon	West Green	[illegible]
6	PRESTON DEMETRIUS	Preston Demetrious & Associates	[illegible]
7	Floyd V. Hitchner	Cornwall Cont Citizens Assoc.	[illegible]
8	Oliver Wilson	Catherine Hall	[illegible]
9	Tindy Ann Fletcher	Catherine Hall	[illegible]
10	Hyacinth Grey	Catherine Hall	[illegible]
11	Paulette Heron	Catherine Hall	
12	Gregory Brissett	Catherine Hall	[illegible]
13	Hector Simons	Catherine Hall	[illegible]
14	Edna Delaney	West Green	[illegible]
15	Angela Malcolm	Catherine Hall	[illegible]
16	Winston Chambers	H.O.P.A.C. [illegible]	[illegible]
17	Deaney Simpson Francis	516 Catherine Hall	[illegible]
18	Deloris Mullings	529	[illegible]
19	Marsha Ricketts	474	
20	Yvonne Campbell	350	[illegible]

National Road Operating & Constructing Company

Montego Bay Perimeter Road

HIGHWAY 2000 NROCC

COMMUNITY MEETING – Catherine Hall

Howard Cooke Primary School, Wednesday 2019 February 27

ATTENDANCE REGISTER

N°	NAME	ORGANIZATION/ COMMUNITY	SIGNATURE
1	Eathle Bernard	Catherine Hall	[illegible]
2	Carlos Williams	West green	[illegible]
3	Emsley Williams	West green	[illegible]
4	Utoni Tapping	[illegible]	Catherine Hall
5	Carrol McFarlane	[illegible] Catherine Hall	[illegible]
6	Trevor Sukhrai	Bogue Village	[illegible]
7	Christopher Smith	Bogue Village	[illegible]
8	Lucinda Clark-Sterling	Catherine Hall	L. Clarke-Sterling
9	Winston East	Cathrin Hall	W. East
10	Richard Barry	Catherine Hall	R. B.
11	DAVE SCOTT	Howard Cooke Primary	Dave Scott
12	Claudel Robinson	Irwin CDC	[illegible]
13	Phillip Myers	NROCC	Phillips
14	Antoinette Bernard	Catherine Hall	[illegible]
15	Sonia Wint	Catherin Hall	[illegible]
16	Faylene James	Catherine Hall	
17	Ann Maureen Campbell	Catherine Hall	A Campbell
18	Elaine Tobisse	Cathrin Hall	[illegible]
19	Rosemarie Brown	Cathrin Hall	R Brown
20	Ryan Doharney	CATHERINE HALL	R. Doharney

National Road Operating & Constructing Company
Montego Bay Perimeter Road

HIGHWAY 2000 NROCC

COMMUNITY MEETING – Catherine Hall

Howard Cooke Primary School, Wednesday 2019 February 27

ATTENDANCE REGISTER

Nº	NAME	ORGANIZATION/ COMMUNITY	SIGNATURE
1	Samuel Heron	Catherine Hall	[signature]
2	Vilma Clark	Westgreen	[signature]
3	Terence Williams	Catherine Hall	[signature]
4	Phyllis Reid	Catherine Hall	P Reid
5	Robert Blake	Catherine Hall	R Blake
6.	Troy Wheelan	✓	[signature]
7	Brenton Bernard	Catherine Hall	
8	Marlinda Earle	Catherine Hall	
9	Fitzroy Floyd	Catherine Hall	
10	Maurice Gillett	Catherine Hall	
11	Vern Briscoe	Catherine Hall	
12	Ewl Mortley	NROCC	[signature]
13			
14			
15			
16			
17			
18			
19			
20			

Salt Spring

Salt Spring Baptist Church Feb 23, 2019.

National Road Operating & Constructing Company

Montego Bay Perimeter Road

HIGHWAY 2000 NROCC

COMMUNITY MEETING – Catherine Hall

Howard Cooke Primary School, Wednesday 2019 February 27

ATTENDANCE REGISTER

Nº	NAME	ORGANIZATION/ COMMUNITY	SIGNATURE
1	Annmarie Norris	Salt Spring P.O.	C Morris
2	Aldeth Broomfield	" "	A Broomfield
3	Phyllis Spence	Flower Hill	P Spence
4	Carmen Robinson	Flower Hill	C Robinson
5	Carl Burgher		
6	Earl Clark	Salt Spring	E C
7	Coril Calvery	Salt Spring	C. Calvert.
8	MARCIA Hurge	Salt Spring	M Hurge
9	ALDITH McLeod	SALT SPRING	A. McLeod
10	Claudia Robinson	Salt Spring	C Robinson
11	Noudette Rhodes	Salt Spring Cottage	N. Rhodes
12	Hyacinth Grey	Salt Spring Cottage	H. Grey
13	Normalyn Grey	Cottage	N Grey
14	Sonja Rhodes	Cottage	S Rhodes
15	Sylvia Morris	"	S. Morris
16	Sanika Calvert	"	S Calvert
17	Tancia Goulbourne	"	Goulbourne
18	Clover Spence Morris	Cottage	C S Morris
19	Cleveland Moore		
20	Vincent Cunningham	Cottage Rd.	[illegible]

National Road Operating & Constructing Company

Montego Bay Perimeter Road

HIGHWAY 2000 NROCC

COMMUNITY MEETING – Catherine Hall

Howard Cooke Primary School, Wednesday 2019 February 27

ATTENDANCE REGISTER

N°	NAME	ORGANIZATION/ COMMUNITY	SIGNATURE
	E. BRYAN		
1	A Stern	Cottage.	
2	A Stern	Cottage	
3	Evelyn Bennett	Salt Spring	
4	Ann marie Douglas	Salt Spring	
5	Althea Burrell	Salt Spring	AB
6	Audley Mills	Salt Spring.	
7	Maureen Allen	Salt Spring Cottage	
8	Dianna Allen	salt spring cottage	
9	Cormeta Morris	Salt spring cottage	
10	Beverly Robinson	Salt Spring Hall Lane	
11	Angella Dascota	Salt Spring	
12	Whitley Myrie	Salt Spring	
13	Henry Lawrence	Salt Spring	
14	Janette Day Allen	Salt Spring Cottage	[signature]
15	Novlette Ricketts	Salt Spring cottage	N Ricketts
16	Malissa Haynes	MEGJC	Mg
17	Richard Cargill	MEGJC	[signature]
18	Phillip Mayers	NROCC	Phillip
19	ERROL MORTLEY	NROCC	[signature]
20			

Appendix 9 – Perception Survey Instrument

MONTEGO BAY PERIMETER ROAD PROJECT
COMMUNITY QUESTIONNAIRE

DATE:___________________ **INTERVIEWER:_______________**

The National Road Operating and Construction Company (NROCC), working through the Ministry of Economic Growth and Job Creation has acquired funding for the development of an alternative route around the central business district in Montego Bay to reduce congestion in the city. The proposed Montego Bay Perimeter Road will provide additional capacity to the road network as well as offer the possibility of opening up new areas to development along the corridor. The length of the road corridor is approximately 15.4 kilometers starting at Alice Eldemire Drive and Howard Cooke Highway with the end point at the Intersection with the A1North Coast Highway at Ironshore. The overall project as initially proposed comprises seven segments – Segment 1 Alice Eldemire to Bogue Road, Segment 2 – Bogue Road to Fairfield, Segment 3 Fairfield to Porto Bello/Irwin, Segment 4 Porto Bello/Irwin to Cornwall Courts, Segment 5 Cornwall Courts to Salt Spring, Segment 6 Salt Spring to Ironshore and Segment 7 Ironshore to North Coast Highway. While not finalized at this time, sections of the road will be tolled. The construction phase of the project is expected to be twenty-five months. It is further proposed that a Long Hill Bypass approximately 10.5 kilometers will be constructed. This road once complete will connect to the Montego Bay Perimeter Road. Also, as part of the project will be the improvement of Barnett Street which will result in the dualization of 1.06 kilometers of the existing two-lane road section from the intersection of West Green and Fairfield Road in a northerly direction ending at Cottage Road. It is also proposed that West Green Avenue will also be improved. This will see the dualization of the 0.82 kilometers existing link road between Howard Cooke Boulevard and the Bogue Road at the Fairfield Road intersection. This construction will result in the removal of the existing round-a-bouts and the creation of signalized intersections.
NB: Use map to show location of proposed project

COHORT DESCRIPTION

1. What is the name of this/your community? ___________________________
2. (i) Male (ii) Female
3. Age group (i) 18- 25 yrs (ii) 26-33 yrs (iii) 34-41 yrs (iv) 42 – 50 yrs (v) 51 – 60 yrs (vi) older than 60 yrs
4. What is your current employment status? (i) employed (ii) unemployed (iii) retired
   a. If employed in which city/town do you work? _____________________________
5. Including yourself, how many people live in your household? ____ (i) # of adults ____ (ii) # of children under 18 yrs ____
6. How long have you lived in your community? (i) <2 yrs (ii) 3-5 yrs (iii) 5- 10 yrs (iv)10-15 yrs (v) > 15 yrs (vi) all your life
7. In the event of illness, where do you mainly obtain health care?(i) Public Clinic_____________________ (ii) Public Hospital __________________(iii) Private Doctor ___________________ (iv) Private Hospital __________________
8. Do you suffer from any of the following conditions? (i). Asthma (ii). Sinusitis (iii) coughing (iv) congestion/bronchial problems (v) chest pains (vi) bouts of diarrhoea
9. What is your average weekly income? (i) no income (ii) under $6,200 per week (iii) $6,200 per week (iv) $6,201 - $10,000 per week (v) $10,001 - $20,000 per week (vi) over $20,000 per week (vii) refuse to answer
10. Do you depend on the proposed traffic corridor/roadway for any type of business? (i) yes (ii) no
    a. If yes what do you depend on it for? ____
11. What is the highest level of education you completed? (Which was the last school you attended) (i) None (ii) Primary/All Age (iii) Some High School (iv) High School (v) College (vi) University (vii) HEART/Vocational training institute
12. Is there anyone in your household attending school at this time? (i) yes (ii) no
    a. If yes how many persons/children? (i) 1 (ii) 2 (iii) 3 (iv) 4 (v) 5 (vi) more than 5
    b. What school(s) do they attend (i) infant/basic (ii) primary/all age (iii) high school (iv) college (v) University (vi) HEART/ Vocational Training Institute
13. How does the child/children/student travel to school? (i) walk (ii) public bus (iii) public taxi (iv) personal vehicle (v) private bus/taxi (vi) other _______________________
14. What is the average weekly transportation cost per child/student? (i) less than $1000 (ii) $1001-$2000 (iii) $2001-$3000 (iv) $3001-$4000 (v) $4001-$5000 (vi) more than $5000 (vii) no cost for transportation

PERCEPTION

15. Have you ever heard of the National Road Operating and Construction Company (NROCC)? (i) yes; (ii) no
    a. If yes, what have you heard? ____
    b. If yes, how were you made aware? (i) Newspaper (ii) Television (iii) Radio (iv) Community meeting (v) Word of mouth (vi) Other -----------------------------
16. Have you ever heard of the Montego Bay Perimeter Road Project? (i) yes; (ii) no
    a. If yes, what have you heard? ____
    b. If yes, how were you made aware? (i) Newspaper (ii) Television (iii) Radio (iv) Community meeting (v) Word of mouth (vi) Other -----------------------------

March 2019

17. Did you know that it is proposed that sections of the perimeter road will be tolled (a toll road)? (i) yes; (ii) no
18. Would you be willing to pay a toll to travel on this road (i) yes (ii) no (iii) not sure
    a. If yes how much would you be willing to pay for one-way travel? _____________
19. Have you ever heard of the Long Hill Bypass Road Project? (i) yes; (ii) no
    a. If yes, what have you heard? ____
    b. If yes, how were you made aware? (i) Newspaper (ii) Television (iii) Radio (iv) Community meeting (v) Word of mouth (vi) Other ------------------------------
20. Have you ever heard of the Barnett Street road upgrade? (i) yes; (ii) no
    a. If yes, what have you heard? ____
    b. If yes, how were you made aware? (i) Newspaper (ii) Television (iii) Radio (iv) Community meeting (v) Word of mouth (vi) Other _____________________________
21. Have you ever heard of the West Green Avenue road upgrade project? (i) yes; (ii) no
    a. If yes, what have you heard? ____
    b. If yes, how were you made aware? (i) Newspaper (ii) Television (iii) Radio (iv) Community meeting (v) Word of mouth (vi) Other _______________________
22. Did you know that the National Road Operating and Construction Company (NROCC) the company to implement this project? (i) yes; (ii) no
23. Do you have any concerns about the project as proposed? (i) yes; (ii) no
    a. If yes, what are they? ____
    ____
24. Do you think this project will affect your life (i) positively or (ii) negatively? (iii) not at all (iv) not sure
    a. If positive how so? ____
    b. If negative how so?____
25. How do you travel into Montego Bay? (i) walk (ii) public bus (iii) public taxi (iv) personal vehicle (v) private bus/taxi (vi) other ____________________
26. Do you think that the construction of a perimeter road around the central business district in Montego Bay will make commuting (i) easier for you (ii) more difficult for you (iii) will not affect your commute (iv) not sure
    a. If easier how so? ____
    b. If more difficult how so? ____
27. Are there problems with frequent flooding in your community? (i) Yes (ii) No
    a. If yes how frequently (i) each time it rains (ii) only times of heavy rains (iii) during hurricanes (iv) other
28. Where are the affected areas? ____

    How high does the water level rise? (i) less than 1 foot (ii) 1-5 ft (iii) more than 5 ft
29. Are there problems with frequent flooding along the area proposed for the perimeter road construction (Alice Eldemire Drive/Howard Cooke Highway to the A1North Coast Highway at Ironshore).? (i) Yes (ii) No (iii) don't know
    a. If yes how frequently (i) each time it rains (ii) only times of heavy rains (iii) during hurricanes (iv) other
30. Where are the affected areas? ____

    How high does the water level rise? (i) less than 1 foot (ii) 1-5 ft (iii) more than 5 ft
31. Are there problems with frequent fires along the area proposed for the perimeter road construction (Alice Eldemire Drive/Howard Cooke Highway to the A1North Coast Highway at Ironshore? (i) Yes (ii) No (iii) don't know
32. Do you know of any site or area proposed for the perimeter road construction considered to be (i) a protected area (ii) historic area (ii) or other area of national, historic or environmental importance? (i) Yes (ii) No (iii) don't know

    If yes please give us as much detail as you can on this area ____
    ____

Signature of Interviewer: ....

Thank You for your time.

March 2019

Appendix 10 – Generalised Guidelines for the Treatment of Sinkholes

General Subject: Treatment of Sinkholes

Design Considerations.

The following design considerations will be followed during the design and construction of the North South Highway in areas where sinkholes are present:

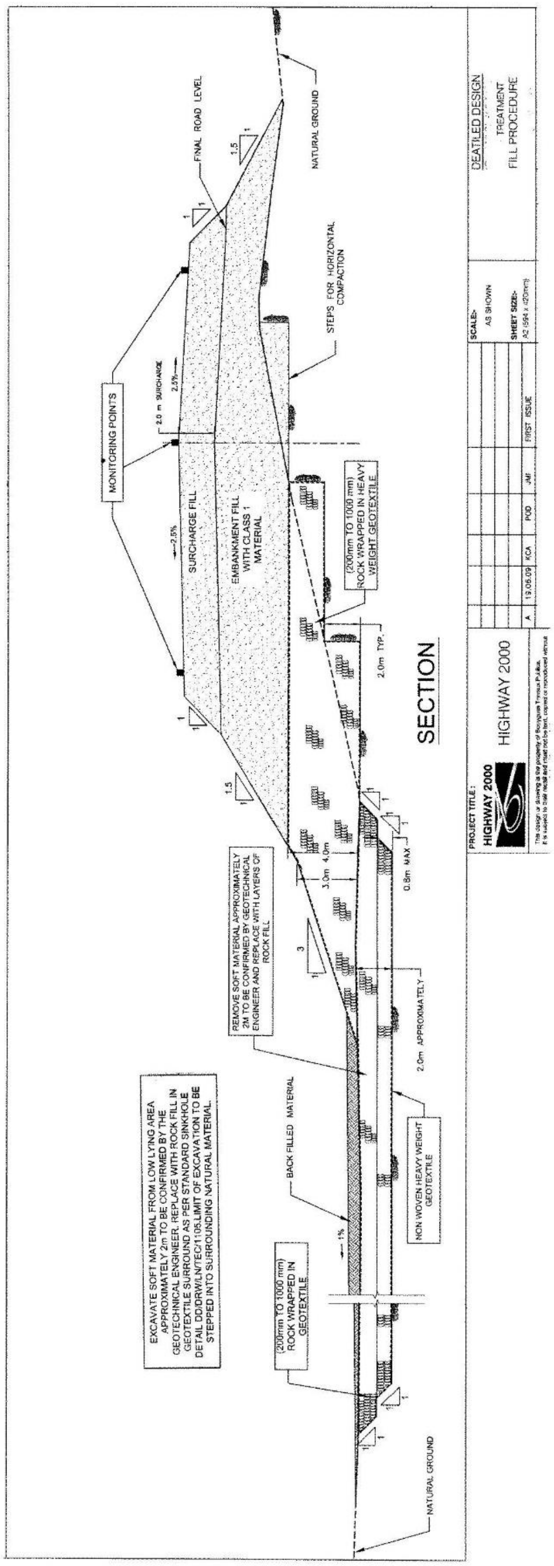
- Avoidance. Determine if there are any feasible alternatives that would avoid construction in the area of the sinkhole. Where the sinkhole is the natural outfall for the stormwater runoff from the roadway area, determine if the stormwater runoff can be diverted away from the sinkhole to an adequate surface water channel.
- Minimization of Impacts from Direct Discharges. If avoidance is not possible, drainage outfalls from the highway should include natural buffer zones between the outlet of the highway drainage structure and the sinkhole in order to provide for a natural filtering process and to improve runoff water quality by filtration and absorption of contaminants.

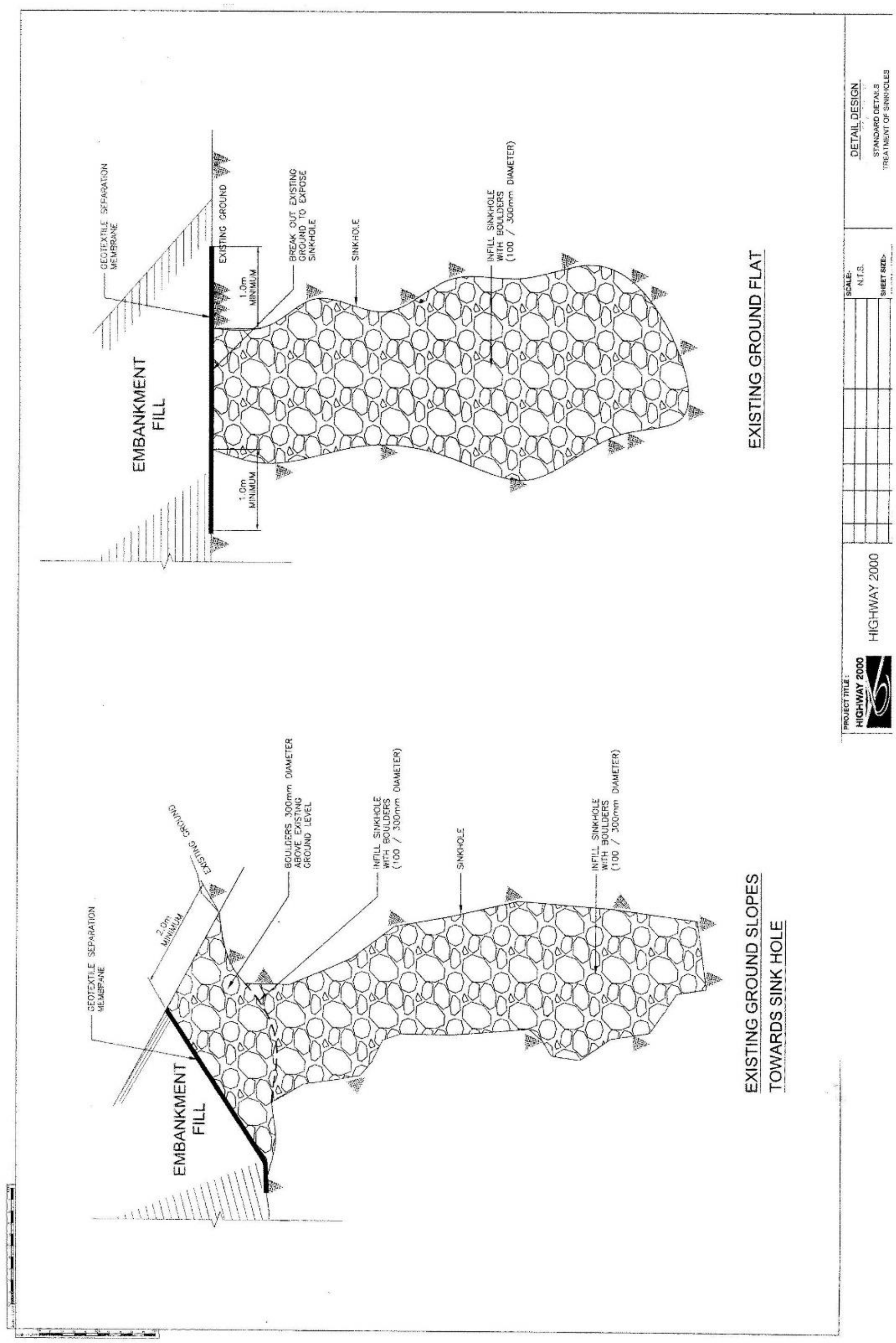
  If stormwater runoff from the highway project is directed to the sinkhole, the drainage design for the project should reflect how the sinkhole is anticipated to function after completion of the construction activities. The project should be designed to avoid any flood damages resulting from potential blockage and ponding in the sinkhole area.

General Treatment of Sinkholes.

The mitigation and treatment of any sinkhole affected by the construction of the highway will be in general terms as follows (see Figures 1 and 2 attached):

1. Excavation of soft material to a depth specified by the geotechnical engineer. Enlarge the sinkhole, as necessary, to allow for installation of the filter material.
2. Placement of non-woven geotextile at the bottom of excavated material and placement of boulders (100/300 mm rip-rap).
3. Specific detail design information will be developed during the design of the project.


SECTION
MONITORING POINTS
SURCHARGE FILL
EMBANKMENT FILL WITH CLASS 1 MATERIAL
2.0 m SURCHARGE
FINAL ROAD LEVEL
NATURAL GROUND
STEPS FOR HORIZONTAL COMPACTION
(200mm TO 1000 mm) ROCK WRAPPED IN HEAVY WEIGHT GEOTEXTILE
2.0m TYP.
REMOVE SOFT MATERIAL APPROXIMATELY 2M TO BE CONFIRMED BY GEOTECHNICAL ENGINEER AND REPLACE WITH LAYERS OF ROCK FILL
EXCAVATE SOFT MATERIAL FROM LOW LYING AREA APPROXIMATELY 2m TO BE CONFIRMED BY THE GEOTECHNICAL ENGINEER. REPLACE WITH ROCK FILL IN GEOTEXTILE SURROUND AS PER STANDARD SINKHOLE DETAIL DD/DRW/LN/TEC/1105.LIMIT OF EXCAVATION TO BE STEPPED INTO SURROUNDING NATURAL MATERIAL.
BACK FILLED MATERIAL
(200mm TO 1000 mm) ROCK WRAPPED IN GEOTEXTILE
NON WOVEN HEAVY WEIGHT GEOTEXTILE
2.0m APPROXIMATELY
0.6m MAX
3.0m
4.0m
PROJECT TITLE:
HIGHWAY 2000
DEATILED DESIGN
TREATMENT
FILL PROCEDURE
SCALE:
AS SHOWN
SHEET SIZE:
FIRST ISSUE


EMBANKMENT FILL
GEOTEXTILE SEPARATION MEMBRANE
EXISTING GROUND
1.0m MINIMUM
BREAK OUT EXISTING GROUND TO EXPOSE SINKHOLE
SINKHOLE
INFILL SINKHOLE WITH BOULDERS (100 / 300mm DIAMETER)
EXISTING GROUND FLAT
2.0m MINIMUM
BOULDERS 300mm DIAMETER ABOVE EXISTING GROUND LEVEL
EXISTING GROUND SLOPES TOWARDS SINK HOLE
DETAIL DESIGN
STANDARD DETAILS
TREATMENT OF SINKHOLES
SCALE: N.T.S.
SHEET SIZE:
PROJECT TITLE:
HIGHWAY 2000

Appendix 11 – General Drainage Guidelines (Rev 4)

NORTH SOUTH HIGHWAY (CAYMANAS TO OCHO RIOS) PROJECT

GENERAL DRAINAGE GUILINES

1. INTRODUCTION

1.1 PURPOSE

The purpose of this document is to provide general guidance on drainage for the implementation of drainage designs. It is intended that the drainage studies, plans, design reports, construction drawings etc. are prepared in accordance with sound engineering and best management practices to meet the requirements of the local governing regulations and the Concession Agreement. These guidelines are intended to reduce or eliminate any negative impacts resulting from the proposed development, to improve existing drainage conditions where possible and to enhance public safety.

1.2 DISCLAIMER

NROCC and NWA will review the drainage reports and plans for construction for conformance with drainage regulations. This notwithstanding, NROCC assume no liability for insufficient design or improper construction. Review and approval does not absolve the developer, design engineer, or contractor of liability for inadequate design or poor construction. The Developer's design engineer has the responsibility to design drainage facilities that meet standards of practice for the industry and promote public safety.

2. DRAINAGE PLANNING

2.1 PURPOSE

The purpose of proper Drainage Planning is to encourage thoughtful and careful consideration of drainage issues when preparing to impose change on a natural system by the proposed highway facility to benefit upstream, downstream, and adjacent properties. The purpose for applying proper drainage planning is to minimize or eliminate adverse impacts and to achieve the many benefits, including the following:

1. Minimum disturbance to the existing conditions.
2. Increased public safety.
3. Reduced costs, including the cost to repair property damaged by flooding, erosion and deposition of sediment, and the cost of drainage infrastructure and maintenance.
4. Continuity of stormwater flow through the site to maintain existing conditions to minimize and to prevent impacting adjacent, upstream, and downstream properties.
5. Improved stormwater quality.

6. Reduce the loss of groundwater recharge resulting from development.

2.2 DRAINAGE PLANNING PHILOSOPY

Planning of drainage facilities should be based upon incorporating natural waterways, artificial channels, storm drains, and other drainage works into the development of the proposed North South highway. Preserving natural channel systems and floodplains is the preferred alternative and should be the focus of the planning effort. Defining the need for constructed channels and storm drains should be based on minimizing the impact to the preserved natural system while meeting the safety, stormwater quality and aesthetic criteria that govern the need for such facilities.

Drainage should be considered on the basis of two design phases. The first is the preliminary phase where conceptual drainage plans are developed. The second is the final design phase, which encompasses detailed engineering using the first phase as the basis for the final design. The first phase is a more global view, and results in the conceptualization of an overall drainage solution. The second phase is an extension of the first where the engineering details for the localized issues are worked out.

2.3 DRAINAGE PLANS

Conceptual drainage plans deal with the broad assessment of existing drainage conditions and development of conceptual alternatives to accommodate drainage. Final drainage plans provide detailed analysis of preferred conceptual solutions, and/or documentation of engineered solutions and details to support the final design of a project. This section describes the two types of plans and their respective component phases.

1. **Drainage Master Plan and Preliminary Drainage Design Report**: A Drainage Master Plan is a conceptual plan that establishes the drainage approach and system to be used for the entire highway.

   The first step in preparing a Drainage Master Plan is studying the hydrology of the watersheds that contribute stormwater runoff to the master plan study area, and the hydrology of the onsite area.

   The second step is definition of existing 100-year floodplains and base flood elevations for watercourses within the proposed development.

   The third step is definition and evaluation of drainage system alternatives, and recommendation of a drainage scheme. The key to preparing the Drainage Master Plan is developing an approach to intercept offsite flow and identifying a workable means of conveying the flow through the project. The method for discharging to the downstream drainage network (whether natural or man-made) is established in a manner that returns the flow to its historical flow path without changing the pre-development flow characteristics.

The Preliminary Drainage Design Report is a conceptual drainage plan of the proposed highway Outline. It implements the drainage system recommended in the Drainage Master Plan to the specific proposed development in question. Adjustments are made to the Drainage Master Plan hydrology and hydraulics, if necessary, and alternatives for drainage facilities specific to the proposed development are defined that meet the guidelines defined in the Drainage Master Plan.

2. **Final Drainage Design Report**: A Final Drainage Design Report constitutes a final drainage plan component. Final drainage construction drawings provide engineered solutions and details to implement the final drainage design of the highway. The Final Drainage Design Report documents the supporting calculations and design assumptions the construction drawings are based on. The hydrology and hydraulics of the selected approach from the Drainage Master Plan and Preliminary Drainage Design Report is further refined and documented to apply to the specifics of the chosen drainage.

2.4 DRAINAGE PLANNING PLOCESS

2.4.1 PLAN DEVELOPMENT

The drainage planning process requires the collection and assimilation of existing information. Consideration must be given to regulations, environmental impacts, regional hydrology, flood hazards, safety, and cost.

2.4.2 REGULATIONS, POLICIES AND STANDARDS

All drainage plans and construction drawings shall meet the required and local regulations.

2.4.3 DESIGN HYDROLOGY AND HYDRAULICS

The Developer/Contractor should determine if there is existing hydrologic and hydraulic information available for the upstream watershed and project site that is suitable for use in design of the project improvements. This includes researching for existing drainage information to complement the required drainage design. In the event there is insufficient hydrology or hydraulic information available, then the Developer's drainage engineer will have to generate new information. Source of climate/rainfall data to be from Metrological Office and previous studies on Jamaica's hydrology (sources include: WRA, NWA). At the drainage plan level, the Developer's drainage engineer should concentrate on quantifying off-site flows that may impact the project, and determine the means for conveying that flow through the project site. A reasonable estimate of the design peak discharge is necessary to approximate the channel or drainage structure capacity and size. Again, the improvements presented in a drainage plan shall not adversely impact adjacent properties.

2.4.4 OTHER HAZARD CONSIDERATIONS

Drainage plans need to focus on more than flood levels derived from open channel hydraulic analyses. Aggradation of channel beds and overbanks via sedimentation and degradation of channels from erosive processes are threats to the performance of drainage systems that should be considered. In addition, ponding areas up gradient of elevated roads, railroads, and irrigation canals must be considered during the development of the drainage plan to assess finished floor elevations, outfall hydraulics, and compensation for volume displacement.

2.4.5 SAFETY

A basic tenet of any capital improvement project is the promotion of public safety. Public safety must be a consideration taken throughout the development of a drainage plan. Excessive stormwater depth, velocity, erosion, sedimentation, and/or poor stormwater quality pose a threat to safety and public health.

2.5 FINAL DESIGN CONSIDERATIONS

The drainage plan serves as the framework for final design. A thorough drainage plan streamlines the final design process.

It is during final design that roadway drainage is analyzed and catch basins/storm drains are designed. The specifics and supporting analysis for open channels including culverts and bridges, and the influences of sedimentation and scour, are developed during final design. It is here that stormwater storage facility details, including pump stations if appropriate, are enumerated to permit review by the relevant agencies and subsequent construction. During final design, the design engineer applies the drainage policies and standards to minimize capital cost and long term maintenance of the drainage improvements while accommodating safety and health concerns.

3 DRAINAGE DESIGN GUIDELINES

3.1 INTRODUCTION

These hydrology and hydraulics general design guidelines contain the minimum standards for applying the technical concepts. The Developer shall comply with all local agencies and standards required and used in Jamaica on projects of this magnitude and established in the Concession Agreement.

There are many computer programs available to help in the design of drainage systems. These programs may use different methods of analysis. Therefore, the Developer's designer of the drainage system should check with the governing agency before using a particular software packages to apply the corresponding standards.

3.2 PUBLIC SAFETY

Designs for hydraulic structures must address the issue of safety. The main purpose shall be to minimize the disturbances to natural watercourses. The design of hydraulic structures must also address the protection of the natural environment. The proposed drainage structures shall provide conveyance through the highway during major flooding events (such as 100-year storm), and maintaining existing drainage patterns.

3.2.1 **Protection Related to Depth and Velocity.** The designer shall carefully consider public safety where standing water depths, and water flow depths and velocities pose a hazard. This should be done for design of all drainage facilities, including stormwater storage facilities, channels, storm drains and roadway systems.

3.2.2 **Channel Drop Structure Height.** For all channel drop structures, the maximum vertical height from invert crest to invert toe shall be 0.5 m. Larger drops may be allowed if access and safety issues are addressed to the satisfaction of the Reviewer. Protection for the effects of scour and erosion shall be provided. Drop structures constructed of concrete or pneumatically placed concrete shall have a roughened surface to discourage inappropriate recreational use.

3.2.3 **Trash-racks and Access Barriers.** Trash-racks may be required on the entrances and access barriers on outlets to conduits or other hydraulic structures. Where such barriers are required, they shall be placed on both the inlet and outlet ends. They are required in areas where debris potential and/or public safety indicate they are necessary, such as in developed areas or where a person could likely be injured or trapped.

3.3 HYDROLOGY

3.3.1 DESIGN STORM DURATION CRITERIA

The design storm duration specified for the type of structure under consideration in combination with the size of the contributing drainage area, varies depending on the risk to public safety. The following minimum standards shall be applied for the differing applications.

Table 3.1 Design Storm Duration Criteria

Purpose/Method	Criteria
Analysis for undisturbed drainageways and design of engineered channels, bridges, and culverts:	
Drainage Area: 0 to 160 acres (Rational Method or Unit Hydrograph Method)	If only design peak charges are needed, then the Rational Method is acceptable.
Drainage area: 160 acres to 20 square miles (Unit Hydrograph Method)	6-hour local storm. Engineering judgment may dictate use of a 24-hour storm depending on soil conditions, or other hydrologic parameters or criteria. NROCC/NWA may require analysis of both the 6-hour and 24-hour storms, and require that the larger peak discharge be utilized.
Drainage area: 20 to 100 square miles (Unit Hydrograph Method)	Either a critically centered 6-hour local storm, or a 24-hour general storm. NROCC/NWA will require analysis of both the 6-hour local storm and the 24-hour general storm, and requires that the larger peak discharge and runoff volume be utilized.
Drainage area.100 to 500 square miles (Unit Hydrograph Method)	24-hour general storm.

3.4 HYDROLOGIC AND HYDRAULIC DESIGN

3.4.1 MINUMUM DESIGN CRITERIA. The following peak discharge and storm frequency related design criteria are to be applied for the listed drainage features.

Table 3.4.1 Minimum Drainage Design Criteria

Drainage Feature	Peak Frequencies	
	2-year through 50-year	100-year
For all storm frequencies up to and including the 100-year: 1. Channel and/or storm drain systems installed as needed to meet roadway drainage criteria. 2. Historic drainage divides should be retained. Flows within existing streets should follow historic drainage paths.		
Adjacent Roads	10-year: One 3.6 m dry driving lane maintained in each direction, and flow depths not to exceed curb height.	d_{max} vehicular travel lane = 150 mm
Highway	10-year: One 3.6 m dry driving lane maintained in each direction, and flow depths not to exceed curb height.	d_{max} vehicular travel lane = 150 mm

Table 3.4.2 Minimum Drainage Design Criteria

Drainage Feature	Peak Frequencies	
	2-year through 50-year	100-year
Criteria for Street without Curb and Gutter (longitudinal flow)	For all storm frequencies up to and including the 100-year: 1. Historic drainage divides should be retained. Flows within existing roadways should follow historic drainage paths. 2. Runoff to be contained 0.30 m below the finished floor of adjacent buildings.	
	Runoff conveyed by channel with maximum water surface no greater than the lowest adjacent road subgrade or alternative design approved by relevant agencies for the storm frequency listed below by street classification. Culvert outlet V_{max} = 4.6 m/s	Runoff to be conveyed by channel with maximum flow depth in vehicular travel lane as specified below by street classification.
Channel adjacent to Highway	10-year frequency	d_{max} shoulder = 150 mm
Channel adjacent to local streets	10-year frequency	d_{max} vehicular travel lane = 150 mm

Table 3.4.3 Minimum Drainage Design Criteria

Drainage Feature	Peak Frequencies	
	2-year through 50-year	100-year
CULVERTS AND BRIDGES		
Criteria for Cross Road Culverts Common to all Street Classifications	Runoff to be conveyed by culvert with maximum water surface no greater than the lowest adjacent road subgrade or alternative design approved by Reviewer, for the storm frequency listed below by street classification. Culvert outlet V_{max} = 4.6 m/s	Runoff to be conveyed by culvert with maximum depth in vehicular travel lane as specified below by street classification. Culvert outlet V_{max} = 4.6 m/s Where flow weirs over road, suitable erosion protection shall be provided.
Highway	10-year frequency	
Local Roads	10-year frequency	

Culverts.

The following guidelines are specific to culverts.

- All culverts shall be hydraulically designed.
- Site information shall consider topographic features, channel characteristics, aquatic life, high-water information, existing structures, soil and water chemical characteristics, abrasion potential and other related site specific information.
- Culvert location in both plan and profile shall be investigated to avoid sediment buildup in culvert barrels.
- Culverts shall be designed to accommodate debris or proper provisions shall be made for debris maintenance.
- Material selection shall include consideration of service life. The expected service life is dependant on numerous variables such as; soil characteristics, water chemistry, bedload, groundwater levels, and use of various protective coatings. The design service life of a drainage facility is defined as the expected maintenance free service life of each installation.
- Culverts shall be located and designed to minimize hazards to traffic and people.
- All pipes shall be installed with bedding and backfill materials suitable for the particular pipe material used.
- No asphalt coatings may be used on pipes within stream systems as the coating may abrade and enter the stream environment.
- All pipe outfalls shall be protected from scour.
- Culvert installations shall be designed, to the extent practicable, to maintain stream stability
- Equal consideration in the selection of pipe materials is required where alternate products are judged to be of satisfactory quality and equally acceptable on the basis of engineering and economic analysis.
- Hydraulic design procedures for culverts are based on the publications and

software of the Federal Highway Administration.

A. Allowable Headwater

The maximum allowable headwater shall:

- Not encroach upon upstream property improvements,
- Be below the outside edge of the shoulder for the design flood frequency,
- Be below the edge of shoulder of the low point in the road grade,
- Not divert flow into adjacent watersheds.

B. Location

- Culvert length and slope shall be chosen to approximate existing topography, and to the degree practicable: the culvert invert should be aligned with the channel bottom and the skew angle of the stream, and the culvert entrance should match the geometry of the roadway embankment.
- Culvert skew shall not exceed 45 degrees as measured from a line perpendicular to the roadway centerline.

C. End Treatment

All culvert ends shall be protected. Consideration shall also be given to safety since some end treatments can be hazardous to errant vehicles. If the culvert cannot be extended to the clear zone, the use of end grates may be required as per AASHTO Roadside Design Guide. Unless specified, culvert end treatment visible from the roadway shall be oriented parallel to the roadway; otherwise place perpendicular to the pipe.

- Headwalls
  - Are used to anchor pipes to prevent uplift,
  - Must extend beyond the clear zone or be protected,
  - May be beveled, as appropriate, to increase the hydraulic performance of the culvert (inlet control).
  - Improved inlets such as side-tapered and slope-tapered inlets can increase the hydraulic performance of the culvert, but may also add to the total culvert cost. Therefore, they should only be used if practicable.
- Wingwalls
  - Are use to contain roadway fill for culverts ≥ 1,220 mm rise.
  - Are used where the side slopes of the channel are unstable.
  - Are used where the culvert is skewed to the normal channel flow.
  - Can affect hydraulic efficiency if the flare angle is $< 30°$ or $> 60°$.

E. Outfall Protection

- Outfalls shall be protected from erosion.
- Outlet velocity shall be calculated and at a minimum, outfall protection be provided for the same design storm as the culvert. Where conditions indicate that greater outfall velocity may occur at a lesser storm event, provide protection for that event.

- Riprap outfalls may be used when the outlet Froude number (Fr) is less than or equal to 2.5. In general, riprap aprons prove economical for transitions from culverts to overland sheet flow at terminal outlets, but may also be used for transitions from culvert sections to stable channel sections. Stability of the surface at the termination of the apron shall be considered.
- Energy dissipators may be designed according to HEC-14, *Hydraulic Design of Energy Dissipators for Culverts and Channels* or using the Energy Dissipator subroutine included in HY-8 or other acceptable hydraulic calculation methods.
- Evaluate downstream channel stability and provide appropriate erosion protection.

4 GENERAL CONSTRUCTION DRAWING REQUIREMENTS

Preparation by Licensed Professional Engineer. All plans for engineered drainage improvements shall be prepared under the direction of a licensed Civil Engineer.

Plan Requirements for Q100 < 1.4 m^3/s Engineered drainage improvements designed for flows less than 1.4 m^3/s may be shown in plan view with spot elevations, flow direction arrows, and typical sections. The plan shall show the horizontal alignment and dimensions as well as the type and extent of the proposed work.

Plan Requirements for Q100 ≥ 1.4 m^3/s

1. All drainage improvement plans may be required to contain a plan and profile as well as adequate cross sections to describe geometry.

3. The profile, if required, shall show the following: proposed invert, estimated water surface profile, energy grade line, hydraulic jump location and length, original ground at channel center line, top of slope, all utilities and structure crossings, and if necessary, top of proposed embankment and fill including freeboard as required.

Requirements for Q100 ≥ 14.2 m^3/s
The following are general requirements for drainage improvement plans:

1. Information to determine drainage patterns.

2. Information to determine that an adjacent property drainage pattern will not be adversely affected.

3. A HEC-RAS (or other accepted hydraulic software) analysis for designed channels and existing washes shall be provided. The model characteristics and results shall be submitted in plan and profile. The plan view shall show existing and proposed ground contours, depict the exact location of the beginning and end point locations of each cross section, the left and right bank station alignments, the limits of defined reaches, and 100-year floodplain limits. Profiles shall include the existing ground, design water surface, and the energy gradeline. This information is to be provided with the design data sheet(s) from the hydrology/hydraulics report.

4. Profiles of storm drains and catch basins and connector pipes shall be provided. These profiles shall show gutter elevation, top of curb elevation, catch basin type, depth, size and cross-section, connector pipe invert at the catch basin and at the inlet to the main line storm drain (as well as any grade breaks), connector pipe size and slope in m/m, and the location and size of existing and proposed utilities along the profile and in the vicinity of the catch basin. Each catch basin profile shall be labeled by road centerline station or main storm drain stationing if different. Profiles shall also include:

   A. The finished roadway elevation over the storm drain pipe.
   B. The pipe profile and size.
   C. The design peak discharge (m^3/s) in each storm drain pipe segment.
   D. The velocity (m/s) in each storm drain pipe segment.
   E. Appropriate stationing.

5. On the storm drain plan sheets, the engineer should show the rim and invert elevations at all existing sanitary sewer manholes.

6. In plan and profile, existing and proposed underground utilities shall be labeled according to size and type. Corresponding alphanumeric labels shall be shown for each utility and depicted in the legend. If the utility is an underground conduit, give all the details such as number of ducts and whether or not the conduit is encased in concrete. Any utilities to be constructed prior to the project shall be shown and so indicated. Conflicts between existing utilities and proposed construction are to be identified. Utilities that are abandoned or to be abandoned shall be indicated as well as those designated to be relocated or removed. The engineer shall contact the appropriate utility if any questions arise about types or locations of underground facilities. Existing and proposed underground tanks shall also be shown.

7. The minimum vertical clearance between a proposed storm drain and all existing utilities shall be 0.4 m unless otherwise required by the given utility.

8. Below ground utilities shall be dimensioned from the road center or monument line.

9. Above ground utilities such as power poles, light poles, guys and anchors, irrigation structures, utility pedestals, transformers, switching cabinets, gas regulators, waterline back-flow prevention units, and other features shall be called out including size and pad elevation, and shown in plan, and stationed relative to the adjacent road monument line or centerline from the street side face of the utility (e.g. 12+330 R 14m).

10. When below ground appurtenances (utilities, monuments, tanks, valve boxes, and other features) depicted on As-Built or "Record" drawings cannot be field located, they shall be shown and labeled as "not found".

11. The following items shall be shown on storm drain plan and profile sheets:

   A. New storm drain pipe
   B. Manholes/Junction structures
   C. Catch basins
   D. Connector pipe
   E. Pipe collars
   F. Prefabricated pipe fittings
   G. Other drainage appurtenances (headwalls, trash racks, drop inlets, hand rails, pipe supports, etc.).

5 REVISION AND APPROVAL PROCESS

The review and approval process will be done by NROCC and NWA. It will be phased in three stages (as per Concession Agreement):

1. Drainage Master Design (Outline Design),
2. For Approval Design, and
3. Final Design.

6 SCOUR AND EROSION CONTROL

a) Provide scour protection to mitigate downstream erosion at all culvert outlets and stream crossings based on a case-by-case analysis to determine outlet velocities.

b) Design scour and erosion control. For velocities greater than 1.2 m/s but less than 4.5 m/s, provide loose riprap. For velocities greater than 4.5 m/s, provide an energy dissipater. Use Standard Details where possible.

REFERENCES:

1. AASHTO A Policy on Geometric Design of Highways and Streets, 5th Edition (Green Book), 2004;
2. AASHTO Roadside Design Guide, 3rd Edition, 2002;
3. FHA Highway Hydrology, 2nd Edition, October 2002;
4. FHA Urban Drainage Design Manual, 3rd Edition, September 2009;
5. FHA Hydraulic Design of Highway Culverts, 3rd Edition, Revised May 2005;
6. Concession Agreement (National Road Operating and Construction Company and Jamaica North South Highway Company Limited), June 21, 2012.

Appendix 12 – Storm Water Management Statement

1

CONTRACTOR	CHINA HARBOUR ENGINEERING COMPANY		
(A) PROJECT	NORTH-SOUTH LINK OF HIGHWAY 2000		
(B) METHOD STATEMENT #	SWM003		
(C) ENVIRONMENTAL ASPECT	SRORM WATER MANAGEMENT		
(D) METHOD STATEMENT	MEASURES TO BE USED TO MANAGE STORM WATER RUN-OFF DURING THE CONSTRUCTION AND OPERATION OF HIGHWAY.		
Prepared by :	China Harbour Engineering Company	Reviewed by:	23/1/2013
Approved by:	25/1/2013		
Presented to:	National Road Operation and Construction Company (NROCC)		

JANUARY 2013

METHOD STATEMENT FOR THE MANAGEMENT OF STORM WATER RUN-OFF DURING THE CONSTRUCTION AND OPERATION OF HIGHWAY.

APPROACH AND METHODOLOGY

1. The road design drawings and the EIA will be carefully perused.
2. All flood prone areas will be mapped. Special attention will be given to these areas during construction.
3. Drains will be constructed according to approved drainage plan.
4. Bridges, culverts and drainage will be designed to accommodate a 100 year flood event.
5. Runoff from the hydrophobic surfaces of the high way will be concentrated in roadside swales, channels, and ditches. These drainage systems will empty concentrated flow into natural drains.
6. All natural watercourses/drains will be preserved, and if needs be, will be improved, to match the proposed increase flow rate of storm water-runoff.
7. Flow direction of all natural drains will be preserved.
8. Natural water courses will not be impeded.
9. Where needs be, check dams; filter rocks; and/or fabric checks will be used to reduce velocity of run-off in drain ways, swales, ditches, and channels.
10. For sheet flows over slopes, filter rocks will be used to reduce run-off velocity and increase infiltration.
11. All sinkholes in proximity to the road foot print will be carefully managed according to proposed Sinkhole Management Method Statement. EVERY EFFORT WILL BE MADE TO PRESERVE ALL SINKHOLES.
12. Where road traverses drain with high flow volume, box culvert will be constructed; for smaller flow volume, pipe culvert will be used. It will be ensured that all culverts have the appropriate size hydraulic inlet, as per drainage plan.

13. It will be ensured that drains and culverts are maintained, during construction and operating of the highway, to mitigate flooding.
14. Drain and culvert inlet will be protected from scouring using riprap.
15. Dirt drains will be armoured to reduce the velocity of storm water flow.
16. Gabion works, retaining wall etc. will be used to stabilize embankments of watercourses where earthworks have caused embankments to be prone to erosion.
17. Catch basins will be protected from blockage using appropriate inlet protection.
18. For channels with extreme flow, gabions and gabion mattresses will be used to dissipate the high energy of storm water run-off.
19. It will be ensured that drainage onto and between any wetland area adjacent to the road construction activities is established and maintained, using appropriately sized culverts to maintain existing water flow regimes.
20. Slopes will be revegetated to reduce the flow velocity of storm water run-off, and hence erosion. As for steep slopes, diversions, using swales will be used to shorten slope and minimize run-off down the slope and/or stones will be used to construct barriers along contour of slope to convert concentrated flow to sheet flow.
21. Slope drains will be used as follows: on slopes before permanent storm water drainage structure are installed, where diversion measures are being used to concentrate flow, and where storm water from uphill areas/down slope runs straight into receiving streams or rivers. Slope drains will be designed to carry peak discharge from storm water event.
22. Impact and mitigation monitoring will be done by CHEC's Environmental Engineer, assigned to the project.
23. CHEC will be obliged to modify this mitigation approach to satisfy the concerns and recommendations articulated, at any time, by the National Environmental and Planning Agency (NEPA).

PERSONNEL AND MATERIALS

To deal with storm water management during the construction and operation of the highway, the following personnel, materials and equipment will be made available at site, at all times.

Personnel

a. Environmental Engineer
b. Site Engineer
c. Surveyors
d. Site Supervisor
e. Labourers

MATERIALS AND EQUIPMENT

a. EIA documents
b. Environmental and Mitigation Plan
c. Map of flood prone areas
d. Design drawing of drainage plan
e. Construction materials for construction of storm water drains, riprap, slope drains, ditches, swales, bridges, culverts et al.
f. Construction equipment.

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f. Construction equipment.

Appendix 13 - Resettlement Criteria

Eligibility for Assistance and Compensation

The land acquisition strategy has been developed based on experience and reflects the various classes of ownership and title status. The following are the broad categories of classes of ownership and the options available to persons who wish to do their own relocation:

a. Informal Settler/Squatter – Person in Possession does not claim ownership or rights to the property.

In this scenario an independent assessment of the value of the structures based on current replacement costs is developed, as well as current market value of crops.. These valuations are then agreed with the persons who are in possession of the lands.

Persons will have the following options:

1. To relocate to another portion of the said lands where this is possible, both legally and physically.
2. To relocate to other lands identified by the individual, these could be lands owned by family members/relatives within the community or lands where the individual has worked out some form of arrangement to utilize.
3. To relocate to other lands identified by NROCC, which are either government owned or are being purchased as part of the acquisition/relocation exercise.

Persons may also benefit from temporary rental assistance, transportation assistance as well as assistance in the preparation of new roadway access to the properties identified.

b. Informal Purchaser/Family Lands – Person in possession of the land claims to have purchased the land or have inherited the property, however, no formal receipts or title exist to confirm this position.

The initial treatment of this person is similar to the previous scenario with an independent market valuation and a relocation grant being paid initially to the person in possession.

The options available for relocation are similar to the foregoing:

1. To relocate to another portion of the said lands where this is possible.
2. To relocate to other lands identified by the individual, these could be lands owned by family members/relatives within the community or lands where the individual has worked out some form of arrangement to utilize.

3. To relocate to other lands identified by NROCC, which are either government owned or are being purchased as part of the acquisition/relocation exercise.

In addition to the foregoing assistance can also be provided to help the person to document his ownership in the property. Once the person is able to establish ownership of the land itself, payment is made for the lands.

Similar to the previous scenario persons may also benefit from temporary rental assistance, transportation assistance as well as assistance in the preparation of new roadway access to the properties identified.

c. Registered Owner – Owner has a registered title in their name.

Valuations of the lands and crops carried out. Payments made for the lands and crops in exchange for title in the name of NROCC. Persons may also benefit from temporary rental assistance and, transportation assistance to carry out their relocation.

d. Tenants/ Tenant Framers – person in possession by short term rental agreement or long term lease.

For these tenants valuation of any structures identified to be owned by tenant framers as well as any crops grown by them is carried out. The valuations are then agreed with the tenant farmers and the monies paid as compensation in keeping with the previous scenarios. Similar to the previous instances these persons are also allowed to reap any crops and salvage any existing structures owned by them.

The options available for relocation are similar to the foregoing:

1. To relocate to another portion of the said lands where this is possible.

2. To relocate to other lands identified by the individual, these could be lands owned by family members/relatives within the community or lands where the individual has worked out some form of arrangement to utilize.

3. To relocate to other lands identified by NROCC, which are either government owned or are being purchased as part of the acquisition/relocation exercise.

The property owner will be instructed to give their tenants official notice and a date agreed with the tenants, by when they must give up complete possession of property. Temporary rental assistance may also be provided to the tenants.

The options for people affected by the ROW of the highway are summarised below in the entitlement matrix.

Table 5: Showing the Entitlement Matrix

Persons affected	Option 1	Option 2	Transitional Costs	Notes
Non-resident owners of farmlands and/or houses	Full replacement value for the land that is affected	A house and house plot of at least equivalent value to the one affected. This could be an existing house or could be constructed by NROCC	Exemption from taxes and stamp duty in accordance with the Land Acquisition Act. The owners will be compensated for permanent and standing crops and will be allowed to harvest the crops wherever possible	The owner will be compensated for the entire property if it is classified as "fully affected"
Resident owners of houses and house plots that are affected	Full replacement value for the land and all structures	A house and house plot of at least equivalent value to the one affected. This could be an existing house or could be constructed by NROCC	Exemption from taxes and stamp duty in accordance with the Land Acquisition Act. Owners will be paid an amount equivalent up to 6 months' rent If necessary NROCC will provide transport to move the family's personal effects to another site Owners will be compensated for any permanent	The owner will be compensated for the entire property if it is classified as "fully affected"

Persons affected	Option 1	Option 2	Transitional Costs	Notes
			or standing crops and will be allowed to harvest the crops wherever possible.	
Affected residents with no claims to the land they are living on (squatters)	Full replacement value for all improvements (houses, other buildings, permanent and other crops)	Relocation in a house that is better than their existing house either (i) in the same land, if this is legally feasible, (ii) on another plot, belonging to relatives or where the person has another arrangement, (iii) on government land or (iv) on a remaining area or other land acquired by NROCC	Exemption from taxes and stamp duty in accordance with the Land Acquisition Act. An amount equivalent to up to 6 months' rent If necessary NROCC will provide transport to move the family's personal effects to another site They will be compensated for any crops and will be allowed to harvest them Owners are allowed to salvage structures for which they have received compensated	Squatters will only be compensated for any improvements they made to the land.

Persons affected	Option 1	Option 2	Transitional Costs	Notes
Resident owners with irregular titles (informal contracts or on "family lands")	Full replacement value for all improvements (houses, other buildings, permanent and other crops) NROCC will help the affected person to acquire full title to the land and will compensate him/her for the land once the title has been regularized	Relocation in a house that is better than their existing house either (i) in the same land, if these is legally feasible, (ii) on another plot, belonging to relatives or where the person has another arrangement, (iii) on government land or (iv) on a remaining area or other land acquired by NROCC	Exemption from taxes and stamp duty in accordance with the Land Acquisition Act. Owners will be paid an amount equivalent of up to 6 months' rent If necessary NROCC will provide transport to move the family's personal effects to another site Owners will be compensated for any crops and will be allowed to harvest them Owners are allowed to salvage structures for which they have received compensated.	
Tenants working land belonging to others or living in houses belonging to others	Full replacement value for any assets belonging to the tenant and support to find a secure tenancy in another place	Alternative measures for restoration of livelihoods (for people who depend on the land they are renting for their livelihood)	accordance with the Land Acquisition Act. Owners will be paid an amount equivalent to 6 months' rent If necessary NROCC will	Wherever possible tenant farmers will be offered the alternative of another plot of land that is equal to or better than the land that is affected.

Persons affected	Option 1	Option 2	Transitional Costs	Notes
			provide transport to move the family's personal effects to another site Owners will be compensated for any crops and will be allowed to harvest them	
Affected businesses	Compensation at full replacement value for all land and/or buildings belonging to the business that have to be acquired, and Compensation for loss of earnings during the relocation process		Exemption from taxes and stamp duty in accordance with the Land Acquisition Act NROCC will pay for or provide transport to move the business and its equipment to a new site Owners are allowed to salvage structures for which they have received compensated	NROCC will provide vending facilities for some vendors where it's feasible to have a 'Rest Stop' along the highway.