Environmental and Social Impact Assessments for the Rehabilitation of the George Price Highway from Miles 47.9 - 79.4

Final Report on the Environmental and Social Impact Study

Ministry of Works and Transport
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(T-B) Roaring Creek Bridge, Z-Curve leading to Cayo, and Monitoring noise at Belmopan – Roaring Creek junction.

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ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ADI	Area of direct environmental and social influence
AMSL	Above Mean Sea Level
BVDC	Benque Viejo del Carmen
BECOL	Belize Electric Company Limited
BET	Belize Environmental Technologies
BRM&CZ	Belize River Mouth & Coastal Zone
Bze	Belize
Cat.	Category
CBD	Convention on Biodiversity, 1992
CRFP	Community Relations Focal Point
CITES	Convention on the International Trade in Endangered Species of Wild Flora and Fauna, 1975
CLC	The 1992 Civil Liability Convention
CLO	Community Liaison Officer
CPS	Child Protective Services
dB	decibels
DEMO	District Emergency Management Organization
DDF	Depth-Duration-Frequency
DOE	Department of Environment
ECP	Environmental Compliance Plan
EIA	Environmental Impact assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Act
EPP	Emergency Preparedness Plan
ESBA	Environmental Social Based Assessment
ESIA	Environmental and Social Impact assessment
FGD	Face Group Discussion
GBRB	Greater Belize River Basin
GIS	Geographical Information System
GOB	Government of Belize
GPH	George Price Highway

H.	Hurricane
HH	Household
IDB	Inter-American Development Bank
IPCC	*Intergovernmental Panel on Climate Change*
iRAP	International Road Assessment Programme
km^2	Square kilometer
LIC	Land Information Center
L/min.	Litres per minute
MARPOL	International Convention for the Prevention of Pollution from Ships and the 1978 Protocol
MEAs	Multilateral environmental agreements
MBRS	Meso-American Barrier Reef System
µs/cm	microsiemens per centimeter
mg/L	milligrams per litre
MHD	Mnistry of Human Development
mls	miles
m	meters
m^3/s	cubic meters per second
mm	millimeter
MNRA	Ministry of Natural Resources and Agriculture
MOWT	Ministry of Works and Transport
MPH	miles per hour
NEAC	National Environmental Appraisal Committee
NEMO	National Emergency Management Organization
NTU	Nephelometric Turbidity Units
OPRC	International Convention on Oil Pollution Preparedness, Response and Co-operation
PAPs	Project Affected Persons
PIC	Prior Informed Consent
PMF	Probable Maximum Flood
POPS	Persistent Organic Pollutants
ppm	parts per million
ppt	parts per thousand
PSWGIA	Philip S W Goldson International Airport

Ramsar	Convention on Wetlands of International Importance Especially as Waterfowl Habitat, 1971 (Ramsar)
RC	Roman Catholic
ROW	Right of Way
RRD	Roaring River Drive
RTA	Road Traffic Accidents
SES	Socio-Economic Survey
S.I.	Statutory Instrument
SIB	Statistical Institute of belize
SRTM	NASA Shuttle Radar Topographic Mission
TD	Tropical Depression
TDS	Total dissolved solids
ToR	Terms of Reference
TPI	topographic position index
TS	Tropical Storm
UNCCD	United Nations Convention to Combat Desertification and Drought
UNFCCC	United Nations Framework Convention on Climate Change
VR	Valued Receptors
WD	Women’s Department
WHO	World Health Organization
WMO	World Meteorological Organization

Executive Summary

CHAPTER 1: PROJECT DESCRIPTION

The Government of Belize (GOB) through the Ministry of Works and Transport (MOWT) is seeking funding from the Inter-American Development Bank (IDB) for a road construction Project to rehabilitate the George Price Highway (GPH) between the junction of the George Price and Hummingbird Highways at Belmopan and the western border with Guatemala at mile 79.4 near the town of Benque Viejo del Carmen; and to refurbish or relocate the Roaring Creek Bridge at mile 48 near Belmopan.

This section of the George Price Highway is critically important to the country's social and economic fabric, as it links three western towns (San Ignacio, Santa Elena and Benque Viejo) and surrounding villages to the administrative capital in Belmopan and to the country's commercial center in Belize City. The areas serviced by this section of the highway are critical to the country's agricultural sector in the West, in which is located some of the country's most important agricultural lands, farms, businesses and industries. It also services the economically important tourism sector in the West, boasting many inland tourism resorts and some of the more prominent archaeological sites.

Of equal importance is the fact that this section of the highway is a part of the Pan American Highway, linking the rest of Central America and Mexico with Belize. As an international highway then, the George Price Highway, including this section, must be constructed to international standards. The rehabilitation of this section of the GPH is proposed to be done in accordance with AASHTO standards. The George Price Highway [GPH] includes a total of approximately 127.8 km of two lane surfaced (chip seal) road which was originally built in the 1930s.

This Project has become necessary, as the George Price Highway, particularly in this proposed Project area, has significantly deteriorated, with the last rehabilitation having been undertaken in the mid-1980s. Consequently, this section of the George Price Highway has contributed its fair share in earning Belize the unenviable distinction of having the highest incidence of road traffic fatalities in Central America and the Caribbean, with its pavement being in poor condition, non-existent or unpaved shoulders, extremely limited pedestrian facilities in villages and towns, and limited markings and signage.

Additionally, parts of the highway in the Project Area are prone to flooding. Floodwaters have also washed over the Roaring Creek Bridge at least twice in the last ten years, possibly undermining its structural integrity. This is of serious concern, as the Roaring Creek Bridge is a crucial link in the evacuation route from east to west during the hurricane season and a crucial link in the commercial and tourism route in conducting trade with Guatemala and providing access to archaeological, cultural and adventure sites in the western part of the country. The Belize National Evacuation Plan identifies these issues associated with the GPH as critical and in need of urgent attention.

Study Area

The Study Area for the GPH ESIA Project is defined as 4 kilometers on either side of the center line of the GPH, beginning at the junction of the George Price and Hummingbird Highways at mile 47.9 and ending at the western border at mile 79.4 near the town of Benque Viejo del Carmen. This 29.5-mile segment of the Western Corridor is partitioned into three sections for the purposes of this ESIA:

1. Section I is 8.1 miles in length, running from mile 47.9 at the junction of the George Price and Hummingbird Highways, to Mile 56 at the junction of the Iguana Creek and Spanish Lookout Roads. This Road Section is the most densely populated with five established villages along the existing ROW. These villages are Roaring Creek, Camalote, Teakettle, Ontario and Blackman Eddy.

2. Road Section II is a little longer at 9 miles in length, running from mile 56 at the junction of the Iguana Creek and Spanish Lookout Roads to mile 65 at the Red Creek Bridge in Santa Elena Town. Along this stretch of the GPH is the Central Farm agriculture, education and research community and three established villages, namely Unitedville, Georgeville, and Esperanza.
3. Road Section III is the longest at 12.4 miles. This section spans the length of the GPH from Buena Vista Street, San Ignacio Town at mile 67 to the western border at mile 79.4 near Benque Viejo del Carmen Town.

Expected Project Outputs

The Project has five main outputs that are expected to address several critical issues as outlined below:

1. Improve the vertical and horizontal alignment of the road system including areas of serious concerns such as the horizontal curve at the existing Roaring Creek Bridge and the "Z" curve in Road Section 1.

2. Improve the drainage system considering the effects of climate change, with design allowance for a 20-year flood event for the road system and a 100-year flood for the Roaring Creek Bridge.

3. Upgrade the existing road system to new profile standards approved by the Ministry of Works and Transport [MOWT] including 3.5m (11.5 feet) wide lanes, 1.5m surfaced shoulders and a design life of 20 years.

4. Conduct new designs for major intersections, particularly the Iguana Creek Road and GPH intersections and the entrance to the town of Benque Viejo del Carmen.

5. Improve road safety features primarily through villages and other communities.

CHAPTER 2: ROAD AND INFRASTRUCTURE CONDITIONS

Road Pavement Assessment

This assessment is conducted to determine the extent of deterioration and failure that have occurred to the various segments of the road with the ultimate goal of quantifying the various levels of remedial measures necessary to meet the design life of 20 years. The assessment included visual surveys, geotechnical evaluations and a road roughness survey.

Section 1

The visual survey indicated that Section I is the most deteriorated, with pavement structure defects along most of its length. The most common defects include edge cracking and shoulder drop-off along the entire length of this section. Additionally, there are many instances of medium to high severity patching throughout. While some areas in this section have recently been upgraded, including areas in Camalote and Ontario; the overall quality of this section is poor.

Section 2

Road Section II, like Road Section I, has high levels of deterioration in many areas, including edge cracking and lane drop-offs evident along most of its length. These defects for the most part include patching, depressions, weathering and ravelling.

Section 3

Road Section III is the least deteriorated portion of the highway. The overall quality of this section is fair to good, with minimal defects such as patching, ravelling, edge cracking and small pot holes between miles 75.8 to 75.9.

The geotechnical survey was conducted along the project route to evaluate the structural, mechanical and physical properties of the sub-soil, and identified and developed soil profiles along the route of the highway. This survey revealed strong evidence of pavement deterioration and base failure as a result of relatively weak and inadequate base and sub-base layers.

While the results of the road roughness assessment were still being analysed, the overall results of current assessments indicated that the general condition of the Project route is poor to fair with only Road Section III confirmed as being engineered. Many areas include a range of different pavement defects for long lengths of the highway.

Assessment of Bridges

There are a total of five (5) bridges along the route of the GPH in the Project Area: one main bridge at the beginning of Road Section I [bridge No. 1]; three relatively minor bridges within Road Section II [bridges No. 2, 3 and 4]; and one bridge within Road Section 3 [bridge No. 5] at the entrance to the town of Benque Viejo del Carmen.

1. Bridge No.1: Roaring Creek Bridge

The Roaring Creek Bridge is an old structure, reportedly built in the 1940s, and its condition today reflects this fact to some extent. While the bridge is in a *prima facie*, good structural condition, there are issues obtaining, making its retention for the Project unacceptable. These issues include:

- the level of the structural upgrade that would be required to bring it up to Project standard;
- the current alignment of the bridge and the roadway which includes a significantly dangerous horizontal curve;
- its existing relatively low elevation, including that of the carriageway, where flood waters rise above its deck to the top of the rails of the bridge; and
- its inadequate carriageway width to meet the Project standards of some 42 feet [13.1m] including sidewalks and shoulders, and 33 feet [10m] where sidewalks are not included.

2. Bridge No. 2: Barton Creek Bridge

The Barton Creek Bridge is in very good condition with no signs of structural distress. However, the geometry of the bridge and roadway in the area presents a problem, as the western exit of the bridge leads into a horizontal curve with very limited sight distance. This situation has resulted in a number of accidents.

3. Bridge No. 3: Garbutt Creek Bridge

The Garbutt Creek Bridge and the adjacent roadway have no alignment issues as it is located along a straight segment of road at the bottom of a valley. There is, however, a hydraulic issue as recent floods caused water to flow across the bridge. This further caused significant damage to the adjacent road and to one of the bridge abutments, which was recently repaired. The bridge has sufficient width to accommodate the Project standard carriageway and shoulders but not the sidewalks. With the exception of the abutment issue, the bridge exhibits no signs of structural concern.

4. Bridge No. 4: Red Creek Bridge

The assessment of the Red Creek Bridge shows this bridge to include a reinforced concrete base. The abutments of this bridge showed signs of erosion and would need to be stabilized. In synthesis, the assessment indicated the bridge to be in fairly good structural condition, with no signs of significant deterioration. The bridge spans a very short distance at around 30 feet and is expected to be able to sustain the design loads for the project. The main issue for the Red Creek Bridge, much like the Garbutt Creek Bridge, is the fact that it is located in a valley which has seen floods overflowing the bridge deck.

5. **Bridge No. 5: Benque Viejo Bridge**

The assessment of this bridge indicates that the current hydraulic radius and deck elevation of the Benque Viejo Bridge is inadequate. The location of the bridge is in the convergence of several major drains and the area is susceptible to flooding. The bridge is in a fair condition but the quality of the concrete seems to be less than optimal. Additionally, there are some signs of deterioration.

Drainage Assessment

There are various areas prone to flooding along the GPH in the Project Area. These include the Roaring Creek Bridge, Camalote at mile 50, Teakettle Village at mile 53, Blackman Eddy at 58, Georgeville at 62 and 63, Central Farm at mile 64, San Ignacio at mile 67, Succotz at mile 71 and Benque Viejo at mile 73. In addition to these main problem sites, a more detail inventory of the flood prone areas is provided in Annex I, which is also intended to be addressed as part of this road rehabilitation program.

- **Roaring Creek Bridge**

It is observed that the flooding that occurs at the Roaring Creek Bridge is not so much an issue of the hydraulic capacity of the Roaring Creek Bridge, but rather is the result of the backwater effects arising from the confluence of the Roaring Creek River and the Belize River. The issue then is one of elevation, and the deck of any bridge at this location should be elevated some 1m above the existing bridge rail.

- **Camalote at Mile 50**

It is observed that water flows over the GPH at this low spot as a result of surface water run-off crossing the highway, stretching a distance of some 200m along the road way at an average depth of 300mm and taking less than an hour to recede. The two concrete pipe culverts, each with a diameter is 24" at the location, are structurally in good condition but are hydraulically undersized and are presently half filled with sediments.

- **Teakettle at Mile 53**

Like Camalote at mile 50, this area along the GPH is a low spot and water also flows over the road as a result of surface water run-off crossing the highway, stretching 100m along the road way at an average depth of 600mm and taking less than 30 minutes to recede. One corrugated steel pipe with a diameter of 36" does not appear to be affected by traffic loading (no sagging). Hydraulically however, it is undersized and is further hampered by the almost complete blocking of the inlet and outlet with vegetation.

- **Blackman Eddy at Mile 58**

This area along the GPH is once again a low area and water flows over the road as a result of surface water run-off crossing the highway, stretching 100m along the road way at an average depth of 300mm and taking less than 30mins to recede. One corrugated steel pipe with a diameter of 36" does not appear to be affected by traffic loading (no sagging). It is however, hydraulically undersized.

- **Georgeville at Mile 62**

This area along the highway floods, (water flows over the road), as a result of surface water run-off crossing the highway at this low point in the road and large volumes of water coming from the Chiquibul Road, stretching 20 m along the road way at an average depth of 50-100 mm and taking less than 30 minutes to recede. One concrete pipe culvert with a diameter of 36" and two concrete pipe culverts with diameters of 24 inches each do not appear to be affected by traffic loading (no sagging). They are however, hydraulically undersized.

- **Georgeville at Mile 63**

It is observed that this section of the GPH in the Project Area, with quite deep embankments in excess of 10 feet, is a major point of flooding across the highway. At its worst, the flood levels have been observed to be 600mm to 900mm above the road, and taking longer than 1 hour to recede. There are four steel culverts at this point: two (2) 36" and two (2) 24" .The two 36" culverts appear structurally sound; however, both 24" culverts are in poor condition. Hydraulically, this system of culverts is inadequate, particularly in length, with no proper end structures.

- **Central Farm at Mile 64**

Excessive rains at this point of the GPH in the Project Area, in the vicinity of the bridge, have caused overtopping of the roadway by flood waters; but the hydraulic capacity of the creek in the vicinity of the bridge has not been ascertained to provide for possible solutions.

- **Red Creek at Mile 67**

Like Central Farm at mile 64, excessive rains at this point of the GPH in the Project Area, in the vicinity of the bridge, have caused overtopping of the roadway by flood waters; but the hydraulic capacity of the creek in the vicinity of the bridge has not been ascertained to provide for possible solutions.

- **Succotz at Mile 71 and Benque at Mile 73**

The 2008 TD 16 flood (a 30-year flood event) caused approximately 800m of the GPH in the Project Area to be flooded along the road in Succotz and about 200m at the entrance to Benque. The estimated peak stage at the Benque hydrological monitoring site for the 2008 flood event was 6.11m, resulting with a peak flood water level of 5 feet above the GPH at some spots in Succotz, and 4 feet at the entrance of Benque Viejo. The effects of climate change on future peak floods, frequency and intensity are yet to be determined.

- **Road Safety**

Belize roads and highways have continually experienced a high incidence of fatal traffic accidents. According to the World Health Organization's Global Status Report on Road Safety (2009), Belize recorded the highest fatality rate of the Caribbean Development Bank's borrowing member countries for which data was available.

In 2011, there were 5 fatal traffic accidents reported within the Project Area. These accidents occurred between miles 69 and 70, mile 53 and 54, miles 72 and 73, miles 61 and 62 and at Central Farm. This indicates that 7% of all traffic fatalities within Belize occurred within the Project Area. In 2012, traffic fatalities in the Project Area were 3. These were in Teakettle Village between miles 53 and 54, in Ontario Village at mile 56, and between miles 67 and 68. These traffic fatalities represent 5% of the total throughout the country.

Countermeasures proposed by a 2012 International Road Assessment Programme (iRAP) Belize Final Technical Report for making Belize's roads safer include shoulder widening, roadside safety barriers, delineation, pedestrian crossings, traffic calming, road surface upgrades, pedestrian footpath, signalized intersection, delineated intersection, road side safety hazard removal, bicycle facilities, and lane widening.

CHAPTER 3: POLICY AND LEGAL FRAMEWORK

In ensuring that the rehabilitation of the GPH in the Project Area is undertaken within the legal and regulatory framework in Belize, there are several national legislations and accompanying regulations which the Chief Engineer and his contractors must adhere to. Foremost among these legislations is the Environmental Protection Act and its Regulations. There are also national advisory policy documents which must be considered as well to ensure that the activities of the proposed road project are aligned with GOB's national sustainable development goals. Furthermore, there are several important operational policies of the IDB that must be taken into account as well as a few Multilateral Environmental Agreements.

The ESIA is also prepared to address IADB's Environmental and Social Safeguard Compliance Policy, Disaster Risk Management Policy, Involuntary Resettlement Policy Gender Equality in Development Policy and Access to Information Policy.

CHAPTER 4: ENVIRONMENTAL SETTINGS

This chapter provides the baseline information of the Study Area and includes additional background environmental information collected by the ESIA team from the various rapid assessments that included the following:

- A rapid survey of the flora and fauna of the project area
- a geological assessment of the area,
- hydrological and water quality assessments of the Belize, Mopan and Macal Rivers and its major tributaries inclusive of a natural spring located in the Village of Ontario and
- a rapid assessment of the environmental quality of the project area as it relates to air quality and noise.

The information is presented by providing a general background of the Cayo District, then narrowing the information to the general study area and finally focussing on the three project sections.

CHAPTER 5: SOCIO-ECONOMIC SETTINGS

This Chapter of the Environmental and Social Setting Section provides a description of the existing social environment and is underpinned by an analysis of key demographic characteristics, social infrastructure, social values and lifestyles using established indicators. The baseline provides the platform from which to identify any social impacts the community may face, or changes that may occur to the existing social environment, by the introduction of the proposed Road Rehabilitation Project; and enables the identification of effective strategies to help mitigate the negative impacts associated with the Project, while maximizing the positive.

Multiple sources using various methods provided the baseline information in this subsection, which was disaggregated by the three (3) defined Road Sections along the existing ROW in its presentation.

- Focus Group Discussions (FGD) and Key Informant Interviews with Village chairpersons and educators, women and youth from the target communities as well as other frequent road users, viz. cyclists, bus drivers and taxi operators were conducted over the period June-July 2014 by BET.
- A Socio-Economic Survey (SES) was conducted during the month of June by BET targeting two principal audiences within the Study Area. A random sample of households drawn from the communities along the existing ROW based on sample size of 232 Household (HH), confidence level of 95% and limits of 7% with overall response rate of 97%; and a purposeful sample of HH in close proximity/within the 100 feet wide corridor.
- With support from the Statistical Institute of Belize, the 2000 and 2010 Census databases were mined; and relevant information on target communities along the ROW was obtained and used to inform the SES design and supplement its findings as per this Report.
- Properties/Structures within the existing ROW/100 ft. corridor were identified for special consideration.

This Chapter also addresses social issues related to Cultural Heritage in accordance with the Belize Environmental Compliance Protocols and the National Institute of Culture and History Act Chapter 331 where a complete archaeological assessment was conducted within the Study Area. The archaeological assessment identified the total extent of archaeological remains within the project area, focusing on locating and recording all structures, sites and cultural features within the area that would be impacted by the road rehabilitation project.

For purposes of the Archaeological Assessment, the GPH corridor was divided into three road sections with specific attention to areas where archaeological materials have been recorded. In addition GIS analyses of Light Detection and Ranging (LiDAR) data was utilized where available, to identify possible archaeological features.

All settlement data was inputted into a Geographical Information System (GIS) database for further insight into geographical relationships and patterning. Finally, site and structure locations and their attributes were inputted and plotted on the base map.

Identified archaeological areas of interest in Road Section I includes areas in Camalote, Teakettle, Ontario and Blackman Eddy which have scattered mounds and plazuelas within the existing carriageway buffer zone or road corridor as stated in the Archeological Impact Assessment. Areas in Road Section II includes areas at Lower Dover, Floral Park, Baking Pot and Esperanza which show signs of mounds, plazuelas and patios that are of archeological interest, located within the road corridor or study area. In Road Section III, sites are located at Cahal Pech, Buenavista, Nohoch Ek, Actuncan and Xunantunich which are partially within the road buffer zone.

Furthermore, a rapid inspection of the quarries in the Teakettle, Georgeville, and the Western Sanitary Pit indicated no surface archaeological features. However, developers must be cognizant of subsurface features especially around the Western Sanitary Pit where the minor center of Nohoch Ek is located. Any horizontal expansion of these existing quarries will require a more systematic survey of the area prior to any mechanized material extraction.

There is also the presence of two cemeteries in close proximity to the existing ROW in the villages of Roaring Creek and Blackman Eddy that have been identified in the wider baseline assessment, although these may not necessarily be disrupted by the road rehabilitation Project.

CHAPTER 6: ASSESSMENT OF ALTERNATIVES

As part of the EIA requirement, there is the need to assess alternatives to a proposed development and its associated activities.

The evaluation of alternatives may encompass a wide range of economic, social, and environmental considerations associated with the various available options. This section focuses on the evaluation of alternatives to the overall proposed development, inclusive of the ‘No Action Alternative’. It focuses on the options that are most practical for the proposed Project Area.

Preliminary baseline information indicates that the major issues associated with the rehabilitation of the GPH are those primarily associated with the:

- need to resurface almost the entire length of the road section within the Study Area;
- rehabilitation or replacement of the Roaring Creek Bridge and associated low lying road sections;
- Z Curve, because of the danger it poses to motorists and the precarious nature of this embankment and the instability of the steep adjoining hill side;
- low-lying entrance to Succotz and Benque Viejo and its proposed roundabout.

In addition, baseline information was specifically obtained on a number of alternatives being considered to address these most critical issues, while planning for projected climate change impacts and disaster risk management. This chapter presents an assessment of alternatives and the recommended options.

The **'No Action Alternative'** although discussed and required to be considered, often represents an option in these types of projects, that is not always the least impacting and in the best interest of the general public, or proponent, from an environmental, economic and social point of view. In these instances, both the proponent and regulatory agency need to consider the economic and social opportunities a project of this nature presents in the development of the area.

The project provides a good opportunity for the area to improve its road infrastructure essential in maintaining the economic activities of the Cayo District and further enhance its tourism, and agricultural activities. Hence, the no-action alternative is not an economically viable option. This option would result in the loss of economic opportunities, such as the generation of employment, revenue, foreign exchange, etc. It would also result in the loss opportunity to address issues of flooding, proper drainage, and improved road safety. Moreover, the potential impacts to the environment and resources of the area are for the most part amenable to mitigation, while offering an opportunity for significant benefits to be derived from its implementation.

Hence, the **"No Action Alternative"** is primarily being used as a baseline mark from which to assess the impacts of the proposed implementation of the project.

1. Road Resurfacing

A road surface assessment of the Project Area indicated that almost its entire length would need resurfacing and that only Road Section III appeared to have some engineering design considerations. The evaluation for road surfacing looked at the following three alternatives:

- Alternative 1: rehabilitation of the road pavement using a flexible double chip seal surfacing;
- Alternative 2: rehabilitation of the road pavement using a semi-structural flexible hot mix asphalt road surfacing; and
- Alternative 3: rehabilitation of the road pavement using a rigid (concrete) pavement.

The assessment indicated that Alternative 1could achieve the 'Design life of 20 years' if it is supported by timely routine and periodic maintenance. The advantage of this option is that it has a relatively short period of disturbance during construction and MOWT and local contractors are most familiar with this alternative. This alternative also allows for greater employment opportunities and injection of resources into the local economy(multiplier effect). More comfortable ride, greater traction and higher visibility of pavement markings relative to concrete for improved road safet. It also had the lowest capital cost ($\$58/m^2$), but higher maintenance cost. This option provides for low initial capital investment and with a robust maintenance program, may be the most economically viable in consideration of the projected traffic volume.

Recommended Option: In consideration of the environmental, social and economic factors, Alternative 1 would be the preferred option since $1 invested would go 47% further than Alternative 2 and 72% further than Alternative 3 in mileage.

2. Roaring River Crossing

An essential component of the George Price Highway Rehabilitation consists in determining the most feasible option for crossing the Roaring River near the George Price and Hummingbird Highway junction. Currently, vehicular and pedestrian traffic cross over this section of the creek via the Roaring Creek Bridge. However, over the past years, the inefficiency of this infrastructure has been evident, particularly during flooding in the area. Flood waters constantly rise in the area, and in a few instances, covered the deck of the bridge. Furthermore, there is little indication of significant maintenance measures and the bridge itself is narrow and out of alignment (Anthony Thurton and Associates). There are four alternatives discussed, inclusive of the no-action alternative.

- **Alternative 1: Keep Existing Bridge**

This option is not viable as the deck of the bridge cannot be raised above flood levels. In addition the current bridge alignment and narrow deck pose a traffic risk to motorists and pedestrians. The bridge also does not meet the standards adopted by the Project which will see major bridges having a width of 43 feet [13.1m] including sidewalks and shoulders and 33 feet [10m] where sidewalks are not included.

- **Alternative 2: Realign and Raise Roadway and Construct New Bridge Adjacent to the Existing One**

This alternative would require that a small narrow section of the Agriculture and Trade Show grounds be acquired as well as two narrow strips of private property on the other side of the bridge to allow for realignment of the highway at the Roaring Creek crossing. The new bridge is proposed to be constructed 1m above the high water level and would be of the required width of 43 feet including sidewalks (1 in 100 year flood). This alternative would also allow for maintaining the old Roaring Creek Bridge as a by-pass during construction and as a tourist attraction and historical landmark, and as a pedestrian and cycle crossing after construction. It would also allow for the relocation of the Guanacaste Park entrance allowing for safer access and egress and the beautification of the remaining open space area.

- **Alternative 3: Detour**

This option would provide an alternative route across the Roaring River, as a disaster risk management response, in the event of a calamity occurring at the GPH/Roaring Creek crossing, cutting off that section of the country from the rest of Belize. This proposed alternative is outside the current flood zone and thereby mitigates against flood issues in this area. The proposed detour is located within the limits of Belmopan City and Roaring Creek Village. This option would require acquisition of land, paving of approximately 2.5 kilometres of road and a bridge. While this option is outside the scope of the current project it is recommended to be considered by Government in its inclusion for future plans as an important Disaster Risk Management option.

Recommended Option: The recommended option is Alternative 2; to realign the road section and construct a new, elevated bridge meeting international standards with crossing adjacent to existing Roaring Creek Bridge. The new elevated bridge would mitigate against impacts of flooding and allow for year round access during disasters. Construction would minimally, adversely impact the Roaring River environment. It would also improve access to Guanacaste National Park, reducing traffic risks to visitors due to the current entrance location. The new bridge will come at a higher cost, but allows for maintaining the old bridge as a tourist attraction increasing the tourism/economic value of area.

3. Z-Curve

The Z-Curve at mile 56 and is another critical area in the proposed rehabilitation of the GPH. It consists of a sharp "Z" curve around a steep rock hill with a prominent drop towards the Belize River on the outside. The area is considered a safety risk because of the danger it poses to motorists, the precarious nature of this embankment and the instability of the steep adjoining hill side. Four alternatives are discussed in this assessment: widen road by shaving hillside to stabilize hill and re-contouring the curve; cut through hill allowing for realignment of road; split the road to allow for 2 single lanes in opposite direction around the hill and the no-action alternative.

- **Alternative 1: Widen Road by Shaving Hillside to Stabilize Hill and Re-contouring of Curve**

This alternative proposes to widen the road by shaving the hillside while at the same time providing for its stabilization. In addition, it would involve the re-countering of the road to allow for the appropriate banking and placement of speed reducers and additional traffic signs. An old road that goes around the hill is proposed to be used as temporary bypass while this activity is taking place..

- **Alternative 2: Cutting Through Hill for Realignment of Road**

Alternative 2 involves cutting through the hill such that the horizontal curve is no longer an issue. Again, the old road that goes around the hill is proposed to be used as temporary bypass while this activity is taking place. This option will require a significant amount of cutting and earth moving activities, to allow for the 100 feet ROW and the proper sloping and stabilization on both sides of the cut, with a minimum gradient of 1.5 to 1 ratio. This alternative would also have the potential to negatively impact the howler monkeys who are frequent visitors to the area; and the potential for siltation and sedimentation of the Belize River if appropriate mitigation measures are not put in place. From a social point of view, the impacts can be considered as moderate since it will require the acquisition of the right of way and a prolonged period of traffic disruption while the hill is being cut.

- **Alternative 3: Split the Road to Allow for 2 Single Lanes in Opposite Directions around the Hill**

This alternative proposes to use an old road that goes around the Z-Curve area, which is also proposed in Alternatives 1 and 2, to be utilized as a temporary bypass during construction. The old road would be upgraded to provide for a permanent detour allowing for the flow of traffic in opposite directions around the hill. This option would require the acquisition of considerable amounts of land for the approximately 1,283m length of ROW. This also has the potential for having the highest biodiversity impact of all the alternatives, as it would cut through one of the few remaining forested areas within the Project Area. In addition, this option also has the potential to adversely impact the hydrology of the area if the appropriate mitigation measures are not implemented.

Recommended Option: The recommended option is Alternative 2: Cutting through the hill for realignment of the road. This option significantly reduces the risks to Belize River from chemical spills. It however presents significant potential environmental impacts (siltation and sedimentation to BZ River) during construction if not properly mitigated; and moderate impacts to wildlife. Its social impacts include prolonged disturbances during construction and high occupational and safety hazard from significant cutting and blasting. Accident risk to public will however, be significantly reduced due to the realignment. Finally, this option presents moderate to high capital costs due to significant earth moving activities but the materials obtained from cutting the hill may reduce the construction costs of material supplies.

4. Entrances of Succotz and Benque Viejo

These two areas are interrelated and are located in the village of Succotz and the entrance to Benque. Both areas have major natural drains discharging into the Mopan River and draining the upland areas within which these two communities are located. Exacerbating the problem is the fact that these two areas also lie at a point where the Mopan River takes a sharp turn, accelerating the flow of water (energy) at these points where the natural drains discharge.

In order to mitigate against flooding in these areas, it would require elevating the low lying areas of the road to a height that is technically viable without significant adverse impacts to adjacent properties. It is also proposed that the road be widened to allow for safer flow of traffic and implementation of international standards proposed for the rehabilitation of this section in the Project Area.

The following four alternatives are discussed: elevating the road to adjust for a 20 yr. flood; a simple link between the highway and the existing road network located in the higher areas in Succotz that would bypass the area for which two alternatives are discussed; and the no-action alternative.

- **Alternative 1: Elevating the Low-lying Areas to Accommodate a 20 Year Flood**

This option would require the construction of a retaining wall along these low areas and the minimal widening of the highway. In addition, there would be the need for the replacement of the culverts crossing the highway for the 2 main natural drains emptying into the river. This would then mean that the bridge at the entrance to Benque would have to be replaced. Elevating the highway would also require that a side road be built to reduce the steep approach to the ferry. These activities, with proper mitigation measures, would have minimal impact to the river bank and the river itself. However it would require the temporary displacement of the kiosks vendors situated near the entrance of the ferry.

- **Alternative 2: Succotz Bypass Option 1**

This option provides a simple link between the highway and the existing road network located in the higher areas in Succotz that would bypass the flood prone areas of the GPH. It starts at the old Negroman Road and extends for 741.6m south where it converges with the streets behind Succotz. This option would require the acquisition of land for the ROW and the construction of a bridge. It would also require that the existing streets be paved to allow for climate proofing and the all-weather use of these roads during flood events on the GPH. It would also require mitigation for two archaeological points of interest identified in the area of the proposed ROW. It is recommended that this bypass be designed and constructed to allow for easy and safe access in line with MOWT Street Standards as opposed to international highway specifications.

- **Alternative 3: Succotz Bypass Option 2**

Alternative 3 is somewhat similar to alternative 2 and also starts at the old Negroman road and extends to the south in the form of an arc to the point of convergence with the streets behind Succotz. This route measures 910m in length and would require the construction of a bridge but would allow for the avoidance of existing buildings and archaeological points of interest. This option would however require the acquisition of more land in comparison to the Succotz Bypass Option 1; but would also require that the road be paved. It is recommended that this bypass be designed and constructed to allow for easy and safe access in line with MOWT Street Standards as opposed to international highway specifications. **The recommended option is a combination of Alternatives 1 and 2, to elevate the low-lying areas to accommodate a 20 year flood and**

CHAPTER 7: ASSESSMENT OF ENVIRONMENTAL AND SOCIAL IMPACTS

This Chapter of the ESIA presents the assessment of the potential environmental and social impacts associated with the proposed road rehabilitation project. For each relevant environmental and social parameter, the potential impacts are discussed. The evaluation of potential environmental and social effects during the ESIA aims to be as accurate and objective as possible, whilst providing as much detail as is available according to the proposed design. Many of the potential impacts have also been taken into account during design of the project through iterative discussions with the design engineers and MOWT. The information is presented in three main blocks:

- Assessment of the potential Environmental Impacts;
- Disaster Risk Management and climate change impacts; and
- Assessment of the potential social impacts which also includes the assessment of the potential impacts on the archaeology of the project area.

Summary of Environmental and Social Impacts

While the proposed rehabilitation project is projected to have significant positive social and economic benefits it has the potential to affect the surrounding air and water quality; exacerbate soil erosion and soil stability, and the hydrology and drainage of the area as well as nearby or adjacent ecosystems within the project area during the construction phase. However, because the project involves the rehabilitation of an existing road, these issue are relatively less significant in scope that had it been the construction of a new road.

In addition, to these environmental issues, the activities of the proposed road rehabilitation activities will temporarily, negatively impact the lives of residents of communities along the ROW and road users. It will require the acquisition of small strips of private properties in at least three areas of road alignment and temporarily displace a few roadside vendors and their source of livelihoods. These potential social impacts are discussed in more detail in the subsequent sections. However, at the end of the road rehabilitation project there will be significant net positive social benefits and an improved quality of life of the members of these communities and remaining Belizean populace.

The assessment provides abatement measures that are tailored to reduce these potential adverse impacts to the point where the impacts are insignificant or within acceptable limits, either through effective design and best practices or through sound Environmental Management System (EMS) of the road rehabilitation activities.

In addition, the report provides three different types of impact matrix summarizing the potential environmental impacts associated with the road rehabilitation activities, the general road activities, and the critical areas of concerns and major accompanying activities. The first matrix assesses the direction, duration, location, magnitude, extent and significance of the projected impacts. The other Matrix look at the road activities and provides a quantitative assessment of the impacts on the various environmental elements of concern relative to each other.

The analysis of the matrices indicated that most impacts were classified as either minimal to medium, very localized and of short duration. The activities with the highest impacts are those associated with the: Construction of Round About at Benque; Realignment of the road section at the Z-Curve; Upgrading of the temporary by-pass for the Z –Curve; Elevation of road section at Succotz; and Elevation of the road section at Benque. At the end of each issue assessed, the evaluation team also identified a series of recommended mitigation measures.

Climate Change Impacts and Disaster Risk Management

This subsection looks at the hazards, whether natural or man-induced that could impact the project or which the road rehabilitation activities and plans must take into consideration. These include high winds, storm surges, torrential rains, flash floods/inundations, and tornadoes. It then goes on to provide an assessment of the risk. The study indicated that most of the communities on the GPH ROW are vulnerable to both natural and man-made hazards.

The assessment examined the impacts that Climate and climate change related effects have had and will continue to have direct and indirect impacts on the GPH and provides a number of recommendations to mitigate against its predicted negative impacts which included mainstreaming risk reduction during highway upgrade and maintenance.

Dam Break Risk

The information indicates that there are sections of the upgraded GPH that are at high risk to a dam break flood event. Although the probability of such an event is small throughout the projected 50-year lifespan of the Chalillo dam, the possibility of such an event still hangs over the head of all communities and interests downstream of the dam. Mitigation measures to reduce the impacts a dam break flood on the western corridor of the GPH are limited to the durability and water-resistance of the road surfacing material used during re-construction, and firmness of the road foundation.

Social Impacts

The social impact assessment is designed to ensure that the Project's potential impacts on individuals and groups of people are understood, so that positive impacts can be enhanced by Project design while negative ones are mitigated, without compromising the economic efficiency of the MOWT Road Project and its benefits for project affected persons (PAPs). Ideally, this should be achieved without negative impacts.

The assessment indicates that in both construction and operational phases of the Project, there is an opportunity for maximizing positive impacts on local employment through involving unskilled (and where possible skilled) labour from all Project communities. However, although the generation of employment opportunities resulting from Project activities are expected as a positive impact, there is a risk that conflicts could arise between local residents and new comers or outsiders over such employment opportunities. Furthermore, there is high risk that, unless Project employment and contractors are managed appropriately, the recruitment procedure could be less than transparent, meaning that people without connections would not get access to Project opportunities – namely employment and other livelihood benefits.

Potential Archaeological Impact

The Road Project has the potential to positively impact established sites though increased volume of visitors and enhancement as tourist destinations for increased opportunities of livelihoods and overall added economic benefits/development of the wider area. In similar fashion, the Project also has the potential to negatively impact archaeological mounds within extreme close proximity to the ROW as well as identified graveyards if the necessary precautions are not taken.

Archaeological points of significance are mostly located in the wider Study Area, with few instances of mounds within close proximity to the existing ROW. As identified by the archaeological assessment, the particular areas of interest within the three road sections as are as follows:
Road Section 1: Camalote, Teakettle, Ontrario and Blackman Eddy have scattered mounds and plazuelas within the existing carriageway buffer zone or road corridor;
Road Section 2: Lower Dover, Floral Park, Baking Pot and Esperanza also show signs of mounds, plazuelas and patios that are of archaeological interest; again, these are located within the road corridor ; and
Road Section 3: The sites of Cahal Pech, Buenavista, Nohoch Ek, Actuncan and Xunantunich are well established sites that are partially within the road buffer zone.

Mitigation measures suitable to conserve and preserve existing mounds is paramount and as such the Project will employ the following:

- The proposed road works will be limited to the existing track and road width;
- Safety barriers will be erected to protect the existing mounds, plazuelas and patios that are within the buffer zone;
- GPS readings were taken to register the locations that the road works would need to consider;
- Preferred alternate routes were chosen to avoid direct impact to archaeological mounds and plazuelas as indicated in the Archaeological Assessment and Road Alternative Identification.

CHAPTER 8: ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

Chapter 8 focuses on the development of a social and environmental management plan to reduce potential adverse impacts to the point where the impacts are insignificant or negligible; either through effective design, the use of green technologies and best practices, or through sound operational management of the Road Rehabilitation Project and its accompanying activities. The management plan proposed for the rehabilitation of the GPH involves the close integration of an Environmental Impact Mitigation Plan, which aims to prevent adverse impacts from occurring and keeps those that do occur within an acceptable level; and an Environmental Monitoring Program which provides information that can enable more-accurate prediction of the associated impacts and the necessary feed-back mechanism essential in adjusting the ESMP. The ESMP has as its objectives, finding better alternatives and ways of doing things; enhancing the environmental and social benefits of the road rehabilitation project; avoiding, minimizing or remedying adverse impacts; and ensuring that residual adverse impacts are kept within acceptable levels.

An important activity of the ESMP is the identification of appropriate mitigation measure for an identified impact, which must take into consideration its cost- effectiveness, as this has the potential for significant financial implications. Its implementation however, must effectively address the impact with little or no residual repercussion to the environment. Consequently, continuous mitigation measures will be implemented throughout the Project's cycle to protect and conserve the environment and social setting of the study area as best as possible.

Chapter 8 then provides a summary of the Environmental Mangement Plan, in tabular form, of the proposed mitigation measures aimed at ameliorating the negative impacts of the environmental issues identified in the impact assessment section of the ESIA, as in the following example: Activity – earth movement while constructing abutments at RC Bridge; Environmental Effects – siltation; Mitigation measures – use of wing dams made of sand bags or use of silt curtains; Monitoring Indicators – visual inspections; Monitoring and Reporting Frequency – monitor during construction activities; and Party(ies) Responsible – contractor, PEU, DOE.

A monitoring program is next developed in Chpater 8 with the intention of providing information necessary to ensure that the recommended mitigation measures set out in the design of the rehabilitated road works are implemented in accordance with the requirements of existing legislations and recommended mitigation measures. The parameters chosen for the monitoring program are those that have been identified primarily for the construction phase of the project, since upon completion, the impacts during operation would be minimal and with net positive environmental and social impacts. These parameters include water quality to effectively identify potential water pollution problems associated with road construction, the cause of the problems and the mechanisms to manage any identified issues; and ambient air monitoring to address the control of fugitive and airborne dust emissions as well as vehicular exhausts emissions and vehicular noise generation above normal. The Environmental Management Plan ends with a guide for assessing the costs associated with monitoring environmental impacts and reporting these activties to the DOE and PEU.

The second part of Chapter 8 treats with the Social Management Plan. The Social Management Plan (SMP) describes the overall management and monitoring of these mitigation measures. It specifies the responsibilities, timings, institutional structures, human resources and estimated annual costs required to effectively implement MOWT's social management plan.

It goes on to outline management measures that have been developed in order to minimize or avoid negative Project impacts and maximize Project benefits. This includes Social Impact Mangement Measures which outlines specific mitigation and management measures for each impact identified in the SIA, with a description of the social performance targets that MOWT and its Contractors will strive to meet, measured using specified Key Performance Indicators (KPIs); and the Management of Social Risks which will be managed through mitigation and a Participatory Public Participation Process, inclusive of a Grievance Mechanism, and developing good relationship with stakeholders and PAPs through effectively managing impacts.

The Mangement of Social and Mitigation Measures are then outlined in tabular form as in the following example:

- Impacts – in-migration could disrupt local culture and the in- migration of single male workers could cause social problems and affect social cohesion;
- Key Performance Indicators – % of workers hired from local PAPs communities, number of grievances about workers'conduct and number of sexual exploitation/harassment cases investigated and substantiated;
- Target – at a minimum 30% of workers sourced locally, no unresolved grievances related to workers' conduct, 100% of sexual exploitation/harassment cases investigated in line with Zero Tolerance Policy;
- Mode of Verification – employee records, grievance database, Human Services/Police Administrative reports;
- Responsibility – MOWT and PEU;
- Mitigation Management Measure – MOWT to require contractors to develop policies for workers induction and a socio-culturally appropriate code of conduct for interacting in communities inclusive of training on gender related issues inclusive of sexual harassment of adult females, sexual exploitation of adolescent girls and HIV and AIDS training. The latter could be arranged through the Ministry of Human Development, Women's Department/independent social worker; source local labour force insofar as requisite skills allow with special quota for women to balance the population structure imbalance; training for workers and the communities on the mandatory child abuse reporting law should be required; and
- Cost – measures to be built into contracts and cost of a one off training inclusive of fees and logistical support is $1,500.

Chapter 8 ends by outlining a MOWT Grievance Mechanism and a Consolidated Social and Environmental Management Plan.

CHAPTER 9: PUBLIC PARTICIPATION PROCESS

Chapter 9 sums up the ESIA Study Report by detailing the process of community engagement and consultations followed during the ESIA preparation as well as offering broader guidance during the construction and operational phases of the Road Project for continued engagement with the communities within the Study Area. Recognizing the benefits associated with effective public participation and on the flipside, the inherent risks to the successful implementation of the proposed Road Project, public participation is not merely seen as a statutory requirement but a very important process through which effective social and environmental management and mitigation measures may be established and implemented.

To this end, the overall Public Participation Process is guided by the EIA as well as other national advisory and international policy safeguards and designed to: ensure that interested and affected parties are well informed about the proposed Project; provide a wide range of interested and affected parties sufficient opportunity to engage and provide input and suggestions on the proposed Project; verify that interested and affected parties' issues have been accurately recorded, considered and/or addressed; draw on local knowledge in the process of identifying environmental and social issues associated with the proposed Project; and to involve interested and affected parties in identifying ways in which these can be addressed; provide opportunities for clearing up misunderstanding about technical issues, resolving disputes and reconciling conflicting interests; contributing towards transparent and accountable decision making and maintaining a healthy, vibrant democracy while complying with all legal requirements across the life-cycle of the Project.

In the pre-feasibility phase of the Road Project, BET engaged with the communities along the existing right of way from the onset through key informant interviews, focus group discussions, probability and purposeful surveys, community meetings and the required public consultation as per the EIA regulations. These communities were carefully studied so as to ensure the use of the most socio-culturally appropriate participatory approaches during the various consultations.

Information generated from the various community consultations identified overwhelming support for the proposed Road Project with anticipated positive local economic development benefits as a result of the road rehabilitation and directly through local employment. In addition, high on the list, were anticipated positive benefits from improved design and road safety measures especially for pedestrians (school children) and relief from long standing flooding due to poor/non-existent drainage/culverts. Also identified as issues of concerns, were the narrowness and potholes on the GPH making it even more unsafe to users. Notwithstanding the perceived positive benefits, residents were also concerned about the potential increase in reckless driving, traffic flow, speeding and noise pollution as a result of improved road conditions; and the potential disruption to community cohesion through influx of workers. A critical concern among educators and women had to do with the predominantly male workforce associated with road projects and thee high risk of sexual exploitation of adolescent girls and sexual harassment of women in the communities.

To address these matters, residents identified the need to ensure implementation of appropriate pedestrian crossings, signage, bus stops, lighting, and traffic calming measures inclusive of highway police patrols as well as the need to have contractors hire locals, with special consideration for women and youth in the communities. Additionally, the need for adequate drains and culverts were duly identified. The concerns and recommendations were well triangulated across the various consultation methods and groups during the overall process in the pre-feasibility phase conducted by BET.

Furthermore, tt is recommended that the MOWT through its PEU implement key social management mechanisms to ensure continued engagement during the construction and operational phases of the Road Project and to build on the successes of early positive experiences to date. These mechanisms include but are not limited to: (i) A Grievance Mechanism, which provides the structure to respond either where the social impact mitigation measures are not functioning as envisaged, or when unanticipated social impacts arise for which mitigation measures have not been developed; and (ii) Establishment of part-time Community Liaison Officers, one for each Road Section for the construction phase and at least one year into the operational phase of the Project life cycle. These mechanisms underpin the management of environmental and social risks associated with the Project by ensuring effective relationships and a feedback loop with Project stakeholders and project affected persons.

CHAPTER 1: PROJECT DESCRIPTION

1.1 Introduction

The Government of Belize (GOB) through the Ministry of Works and Transport (MOWT) is seeking funding from the Inter-American Development Bank (IDB) for a road construction Project to rehabilitate the George Price Highway (GPH) between the junction of the George Price and Hummingbird Highways at Belmopan and the western border with Guatemala at mile 79.4 near the town of Benque Viejo del Carmen; and to refurbish or relocate the Roaring Creek Bridge at mile 48 near Belmopan.

This section of the George Price Highway is critically important to the country's social and economic fabric, as it links three western towns (San Ignacio, Santa Elena and Benque Viejo) and surrounding villages to the administrative capital in Belmopan and to the country's commercial center in Belize City. The areas serviced by this section of the highway are critical to the country's agricultural sector in the West in which is located some of the country's most important agricultural lands, farms, businesses and industries. It also services the economically important tourism sector in the West, boasting many inland tourism resorts and some of the more prominent archeological sites.

Of equal importance is the fact that this section of the highway is a part of the Pan American Highway, linking the rest of Central America and Mexico with Belize. As an international highway then, the George Price Highway, including this section, must be constructed to international standards. The rehabilitation of this section of the GPH is proposed to be done in accordance with AASHTO standards. The George Price Highway [GPH] includes a total of approximately 127.8 km of two lane surfaced (chip seal) road which was originally built in the 1930's.

This Project has become necessary, as the George Price Highway, particularly in this proposed Project area, has significantly deteriorated, with the last rehabilitation having been undertaken in the mid-1980s. Consequently, this section of the George Price Highway has contributed its fair share in earning Belize the unenviable distinction of having the highest incidence of road traffic fatalities in Central America and the Caribbean; with its pavement being in poor condition, non-existent or unpaved shoulders, extremely limited pedestrian facilities in villages and towns, and limited markings and signage.

Additionally, parts of the highway in the Project Area are prone to flooding. Floodwaters have also washed over the Roaring Creek Bridge at least twice in the last ten years, possibly undermining its structural integrity. This is of serious concern, as the Roaring Creek Bridge is a crucial link in the evacuation route from east to west during the hurricane season and a crucial link in the commercial and tourism route in conducting trade with Guatemala and providing access to archeological, cultural and adventure sites in the western part of the country. The Belize National Evacuation Plan identifies these issues associated with the GPH as critical and in need of urgent attention.

1.2 George Price Highway Study Area

The Study Area for the GPH ESIA Project is defined as 4 kilometers on either side of the center line of the GPH, beginning at the junction of the George Price and Hummingbird Highways at mile 47.9 and ending at the western border at mile 79.4 near the town of Benque Viejo del Carmen. This 29.5 mile segment of the Western Corridor is partitioned into 3 sections for the purposes of this ESIA, as shown in Figure 1.1.

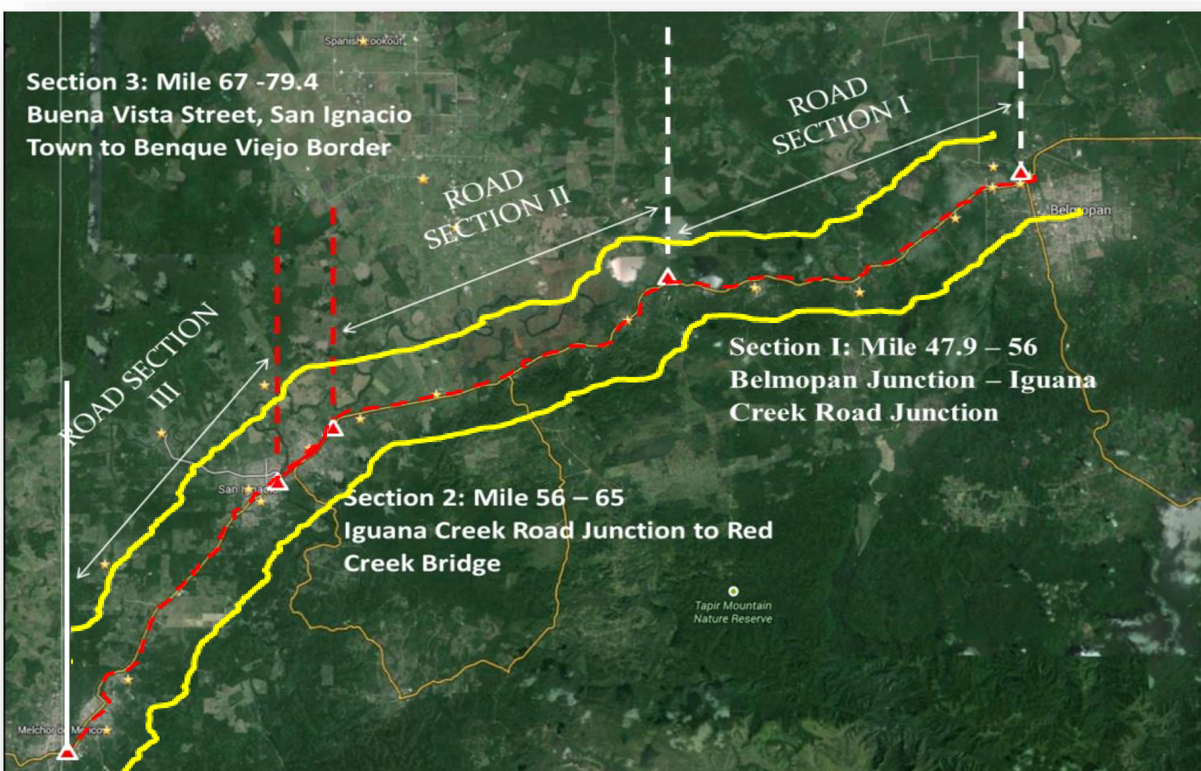


Figure 1.1: Map of Study Area

Road Section I is 8.1 miles in length, running from mile 47.9 at the junction of the George Price and Hummingbird Highways to Mile 56 at the junction of the Iguana Creek and Spanish Lookout Roads. This Road Section is the most densely populated with five established villages along the existing ROW. These villages are Roaring Creek, Camalote, Teakettle, Ontario and Blackman Eddy.

Road Section II is a little longer at 9 miles in length, running from mile 56 at the junction of the Iguana Creek and Spanish Lookout Roads to mile 65 at the Red Creek Bridge in Santa Elena Town. Along this stretch of the GPH is the Central Farm agriculture, education and research community and three established villages, namely Unitedville, Georgeville, and Esperanza.

Road Section III is the longest at 12.4 miles. This section spans the length of the GPH from Buena Vista Street, San Ignacio Town at mile 67 to the western border at mile 79.4 near Benque Viejo del Carmen Town.

This 29.5 miles section of GPH runs almost parallel with the southern bank of the middle and upper Belize River channel, crossing Roaring Creek via the narrow Roaring Creek Bridge and the Macal River at the Hawksworth Bridge at San Ignacio-Santa Elena. The GPH straddles the bank of the Belize River at the Z-curve (Mile 54) at about 300 - 350 meters above the normal water level, about 100 - 150 meters of the bank at Blackman Eddy (Mile 58), and within 3 - 6 meters from the bank of the Mopan River in some sections of the highway from San Jose Succotz Village to the entrance of Benque Viejo Town.

Figure 1.2 is a map of the central and western corridor of the Greater Belize River Basin (GBRB) and the GPH Highway (orange line), showing the location of capital Belmopan, the main district towns of San Ignacio/Santa Elena and Benque Viejo del Carmen, and villages in the proposed GPH rehabilitation zone. The map also shows the extensive agriculture land use in the basin, and the northwestern sector of the Mountain Pine Ridge.

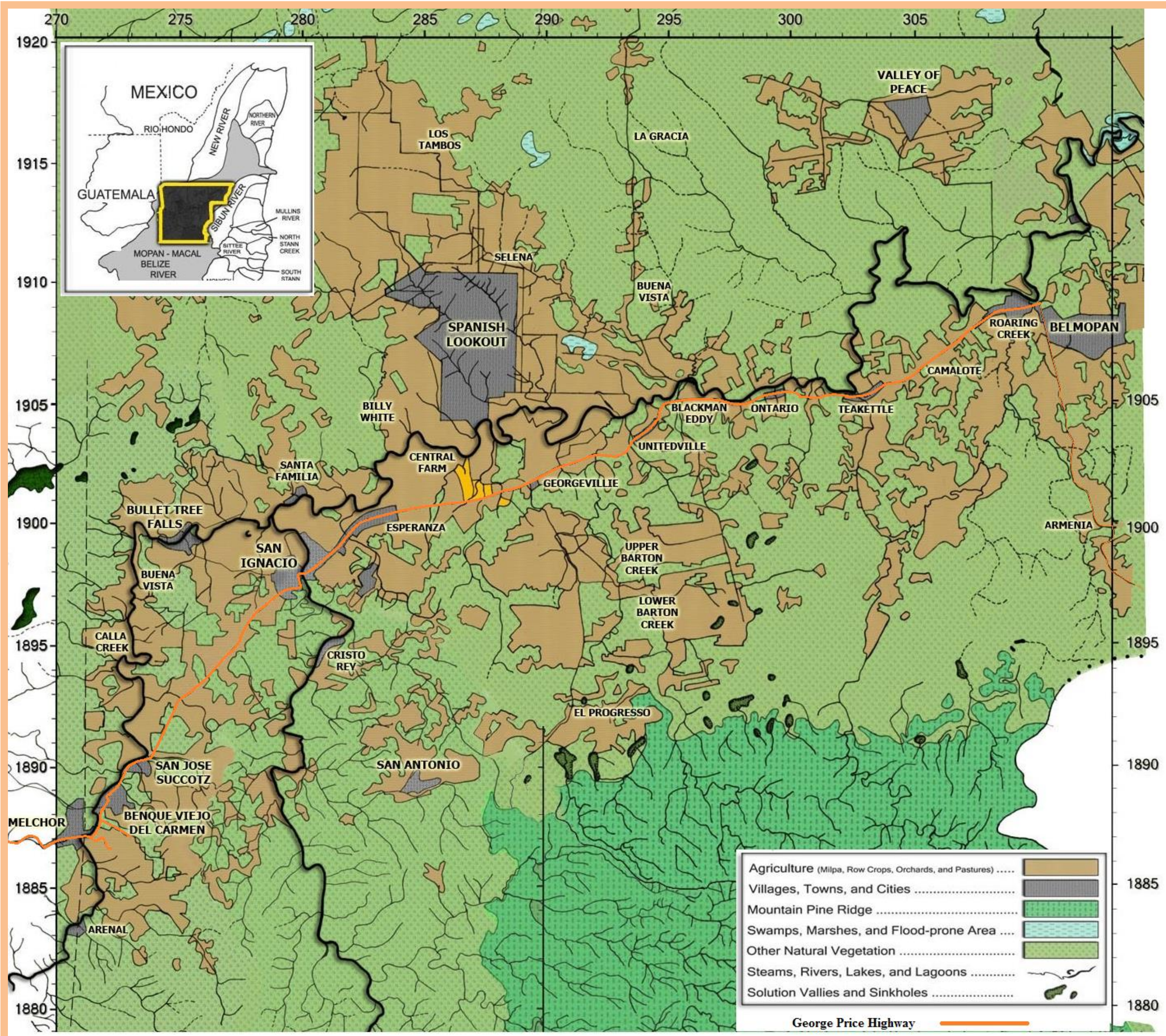


Figure 1.2: Upper Belize River Basin and GPH, Cayo District, Belize.

1.3 Expected Project Outputs

The Project has five main outputs that are expected to address several critical issues as outlined below:

1. Improve the vertical and horizontal alignment of the road system including areas of serious concerns such as the horizontal curve at the existing Roaring Creek Bridge and the "Z" curve in Road Section 1.

2. Improve the drainage system considering the effects of climate change with design allowance for a 20 year flood event for the road system and 100 year flood for the Roaring Creek Bridge.

3. Upgrade the existing road system to new profile standards approved by the Ministry of Works and Transport [MOWT] including 3.5m (11.5 feet) wide lanes, 1.5m surfaced shoulders and a design life of 20 years.

4. Conduct new designs for major intersections particularly the Iguana Creek Road and GPH intersections and the entrance to the town of Benque Viejo del Carmen.

5. Improve road safety features primarily through villages and other communities.

CHAPTER 2: ROAD AND INFRASTRUCTURE CONDITIONS

2.1 Introduction

The following information contained in this section of the report has been synthesized from the various assessments (road pavement, culvert, Bridges and Traffic) conducted by Anthony Thurton and Associates Limited in preparation for the anticipated road rehabilitation program, the assessment of alternatives and their economic analysis. In addition, information on road safety is also been provided based on the statistics and data contained in the iRAP Belize Final Technical Report of 2012 and MOWT Road Safety Management Capacity Review Final Report of March 2012.

2.2 Road Pavement Assessment

This assessment is conducted to determine the extent of deterioration and failure that have occurred to the various segments of the road with the ultimate goal of quantifying the various levels of remedial measures necessary to meet the design life of 20 years. The assessment included visual surveys, geotechnical evaluations and a road roughness survey.

The visual survey indicated that Section I is the most deteriorated, with pavement structure defects along most of its length. The most common defects include edge cracking and shoulder drop-off along the entire length of this section. Additionally, there are many instances of medium to high severity patching throughout. While some areas in this section have recently been upgraded, including areas in Camalote and Ontario; the overall quality of this section is poor.

Road Section II, like Road Section I, has high levels of deterioration in many areas, including edge cracking and lane drop-offs evident along most of its length. These defects for the most part include patching, depressions, weathering and ravelling.

Road Section III is the least deteriorated portion of the highway. The overall quality of this section is fair to good, with minimal defects such as patching, ravelling, edge cracking and small pot holes between miles 75.8 to 75.9.

The geotechnical survey was conducted along the project route to evaluate the structural, mechanical and physical properties of the sub-soil, and identified and developed soil profiles along the route of the highway. This survey revealed strong evidence of pavement deterioration and base failure as a result of relatively weak and inadequate base and sub-base layers.

While the results of the road roughness assessment were still being analysed, the overall results of current assessments indicated that the general condition of the Project route is poor to fair with only Road Section III confirmed as being engineered. Many areas include a range of different pavement defects for long lengths of the highway.

While some efforts were made to rehabilitate some of the worst affected areas over the years, those attempts were sparse and only fairly improved the overall quality of this portion of the GPH, which the proposed Project intends to address. Common defects of the GPH in the Project Area include edge cracking and lane drop-offs, which highlight the necessity to include well-designed shoulders that merge adequately with the existing terrain.

2.3 Assessment of Bridges

There are a total of five (5) bridges along the route of the GPH in the Project Area: one main bridge at the beginning of Road Section I [bridge No. 1]; three relatively minor bridges within Road Section II [bridges No. 2, 3 and 4]; and one bridge within Road Section 3 [bridge No. 5] at the entrance to the town of Benque Viejo del Carmen.

2.3.1 Bridge No.1: Roaring Creek Bridge

The Roaring Creek Bridge is an old structure, reportedly built in the 1940s, and its condition today reflects this fact to some extent. The concrete utilized in its construction does not show a high degree of consistency, as limestone aggregates with high clay content was detected in some areas particularly the end spans. However, concrete cores taken from the deck of the structure indicate that the compressive strength of the concrete is fair for its age, even though such strength is considered low by today's standards.

Constant repairs have been done on the bridge to address substantial deterioration in some critical areas including a number of cracks in certain areas of the structure, particularly in the end spans. One column had developed horizontal cracks throughout its cross sectional area, and a second column displayed the early stages of similar cracks. Significant signs of spalling were observed in the end bays of the structure along with evidence or remedial works done to repair other defects. In another case, shear strips corroded through an entire cross section and various elements, again primarily in the end spans, seem hollow and are undergoing spalling. Less significant signs of spalling were also evident in the concrete deck.

The critical arch support structure over the long centre span shows no signs of significant deterioration for its age. The abutments of the structure appear to be in good condition and show no signs of distress. Additionally, there are no signs of stress emanating from movement, either vertical or horizontal, of the bent foundations.

While the bridge is in a *prima facie*, good structural condition, there are issues which makes its retention for the Project unacceptable. These include the level of the structural upgrade that would be required to bring it up to Project standard; the current alignment of the bridge and the roadway which includes a significantly dangerous horizontal curve; its existing relatively low elevation, including that of the carriageway, where flood waters rise above its deck to the top of the rails of the bridge; and its inadequate carriageway width to meet the Project standards of some 43 feet [13.1m] including sidewalks and shoulders, and 33 feet [10m] where sidewalks are not included.

2.3.2 Bridge No. 2: Barton Creek Bridge

The Barton Creek Bridge is in very good condition with no signs of structural distress. However, the geometry of the bridge and roadway in the area presents a problem, as the western exit of the bridge leads into a horizontal curve with very limited sight distance, a situation that has resulted in a number of accidents.

2.3.3 Bridge No. 3: Garbutt Creek Bridge

The Garbutt Creek Bridge and the adjacent roadway have no alignment issues as it is located along a straight segment of road at the bottom of a valley. There is however a hydraulic issue as recent floods caused water to flow across the bridge. This further caused significant damage to the adjacent road and one of the bridge abutments which was recently semi-permanently repaired. The bridge has sufficient width to accommodate the Project standard carriageway and shoulders but not the sidewalks. With the exception of the abutment issue, the bridge exhibits no signs of structural concern.

2.3.4 Bridge No. 4: Red Creek Bridge

The assessment of the Red Creek Bridge shows this bridge to include a reinforced concrete base. The abutments of this bridge showed signs of erosion and would need to be stabilized. In synthesis the assessment indicated the bridge to be in fairly good structural condition, with no signs of significant deterioration. The bridge spans a very short distance at around 30 feet and is expected to be able to sustain the design loads for the project. The main issue for Red Creek Bridge, much like the Garbutt Creek Bridge, is the fact that it is located in a valley which has seen floods overflowing the bridge deck.

2.3.5 Bridge No. 5: Benque Viejo Bridge

The assessment of this bridge indicates that the current hydraulic radius and deck elevation of the Benque Viejo Bridge is inadequate. The location of the bridge is in the convergence of several major drains and the area is susceptible to flooding. The bridge is in a fair condition but the quality of the concrete seems to be less than optimal. Additionally, there are some signs of deterioration.

2.4 Drainage

There are various areas prone to flooding along the GPH in the Project Area. These include the Roaring Creek Bridge, Camalote at mile 50, Teakettle Village at mile 53, Blackman Eddy at 58, Georgeville at 62 and 63, Central Farm at mile 64, San Ignacio at mile 67, Succotz at mile 71 and Benque Viejo at mile 73. In addition to these main problem sites, a more detail inventory of the flood prone areas is provided in Annex I which is also intended to be addressed as part of this road rehabilitation program.

2.4.1 Roaring Creek Bridge

It is observed that flooding that occurs at the Roaring Creek Bridge is not so much an issue of the hydraulic capacity of the Roaring Creek Bridge, but rather is the result of the backwater effects arising from the confluence of the Roaring Creek River and the Belize River. The issue then is one of elevation and the deck of any bridge at this location should be elevated some 1m above the existing bridge rail.

2.4.2 Camalote at Mile 50

It is observed that water flows over the GPH at this low spot as a result of surface water run-off crossing the highway, stretching a distance of some 200m along the road way at an average depth of 300mm and taking less than an hour to recede. The two concrete pipe culverts, each with a diameter is 24" at the location, are structurally in good condition but are hydraulically undersized and are presently half filled with sediments.

2.4.3 Teakettle at Mile 53

Like Camalote at mile 50, this area along the GPH is a low spot and also water flows over the road as a result of surface water run-off crossing the highway, stretching 100m along the road way at an average depth of 600mm and taking less than 30 minutes to recede. One corrugated steel pipe with a diameter of 36" does not appear to be affected by traffic loading (no sagging), however hydraulically it is undersized and is further hampered by the almost complete blocking of the inlet and outlet with vegetation.

2.4.4 Blackman Eddy at Mile 58

This area along the GPH is once again a low area and water flows over the road as a result of surface water run-off crossing the highway, stretching 100m along the road way at an average depth of 300mm and taking less than 30mins to recede. One corrugated steel pipe with a diameter of 36" does not appear to be affected by traffic loading (no sagging), however hydraulically it is undersized.

2.4.5 Georgeville at Mile 62

This area along the highway floods, (water flows over the road), as a result of surface water run-off crossing the highway at this low point in the road and large volumes of water coming from the Chiquibul Road, stretching 20 m along the road way at an average depth of 50-100 mm and taking less than 30 minutes to recede. One concrete pipe culvert with a diameter of 36" and two concrete pipe culverts with diameters of 24 inches each do not appear to be affected by traffic loading (no sagging), however hydraulically they are undersized.

2.4.6 Georgeville at Mile 63

It is observed that this section of the GPH in the Project Area, with quite deep embankments in excess of 10 feet, is a major point of flooding across the highway. At its worst, the flood levels have been observed to be 600mm to 900mm above the road, and taking longer than 1 hour to recede. There are four steel culverts at this point, two (2) 36” and two (2) 24” .The two 36” culverts appear structurally sound, however both 24” culverts are in poor condition. Hydraulically, this system of culverts is inadequate, in particular in length, with no proper end structures.

2.4.7 Central Farm at Mile 64

Excessive rains at this point of the GPH in the Project Area, in the vicinity of the bridge, have caused overtopping of the roadway by flood waters; but the hydraulic capacity of the creek in the vicinity of the bridge has not been ascertained to provide for possible solutions.

2.4.8 Red Creek at Mile 67

Like Central Farm at mile 64, excessive rains at this point of the GPH in the Project Area, in the vicinity of the bridge, have caused overtopping of the roadway by flood waters; but the hydraulic capacity of the creek in the vicinity of the bridge has not been ascertained to provide for possible solutions.

2.4.9 Succotz at Mile 71 and Benque at Mile 73

The 2008 TD 16 flood (a 30-year flood event) caused approximately 800m of the GPH in the Project Area to be flooded along the road in Succotz and about 200m at the entrance to Benque. The estimated peak stage at the Benque hydrological monitoring site for the 2008 flood event was 6.11 m, resulting with a peak flood water level of 5 feet above the GPH at some spots in Succotz, and 4 feet at the entrance of Benque Viejo. The effects of climate change on future peak floods, frequency and intensity are yet to be determined.

2.5 Road Safety

Belize roads and highways have continually experienced a high incidence of fatal traffic accidents. According to the World Health Organization’s Global Status Report on Road Safety (2009), Belize recorded 68 road deaths in 2006, equivalent to approximately 31.1 traffic deaths per 100,000 inhabitants and the highest fatality rate of the Caribbean Development Bank’s borrowing member countries for which data was available. In 2009, Belize experienced approximately 70 road deaths per year (WHO 2009). This equated to a rate of 23.6 deaths per 100,000 inhabitants. According to a 2012 Road Safety National Capacity Report conducted by the International Road Assessment Programme (iRAP), within the Latin American and

Caribbean Countries, Belize has the highest death rate from traffic accidents per 100,000 inhabitants.

In 2012, there were a total of 718 traffic accidents in which 649 persons were injured and 69 were killed. Of those killed, 19 were pedestrians, 12 were passengers, 22 were cyclists and 16 were drivers. In 2013, 51 fatal traffic accidents were reported.

In 2011, there were 5 fatal traffic accidents reported within the Project Area. These accidents occurred between miles 69 and 70, mile 53 and 54, miles 72 and 73, miles 61 and 62 and at Central Farm. This indicates that 7% of all traffic fatalities within Belize occurred within the Project Area. In 2012, traffic fatalities in the Project Area were 3. These were in Teakettle Village between miles 53 and 54, in Ontario Village at mile 56, and between miles 67 and 68. These traffic fatalities represent 5% of the total throughout the country.

Countermeasures proposed by a 2012 International Road Assessment Programme (iRAP) Belize Final Technical Report for making Belize's roads safer include shoulder widening, roadside safety barriers, delineation, pedestrian crossings, traffic calming, road surface upgrades, pedestrian footpath, signalized intersection, delineated intersection, road side safety hazard removal, bicycle facilities, and lane widening.

The International iRAP report further suggests however, that in order to make the road network in Belize safer, efforts that go beyond traditional engineering improvements will be necessary. This includes ensuring that road communities have the opportunity both to contribute to road design and public awareness/education programs. Additionally significant benefits could be realized through coordinated targeting of risk factors for road users (such as speeding, seat belt wearing, and alcohol consumption) and vehicles.

The views and concerns of the communities along the GPH in the Project Area in relation to the road design, safety features, etc. are documented in the Social and Environmental Setting of this ESBA Report.

CHAPTER 3: POLICY AND LEGAL FRAMEWORK

3.1 Introduction

In ensuring that the rehabilitation of the GPH in the Project Area is undertaken within the legal and regulatory framework in Belize, there are several national legislations and accompanying regulations which the Chief Engineer and his contractors must adhere to. There are national advisory policy documents which must be considered as well to ensure that the activities of the proposed road project are aligned with GOB's national sustainable development goals. Furthermore, there are several important operational policies of the IDB that must be taken into account as well as a few Multilateral Environmental Agreements.

3.2 Natural Resources and Environmental Protection Laws

Belize has in place a very expansive and detailed legal and regulatory framework for sustainable development underpinned by an integrated environmental management approach. This legal and regulatory framework includes national legislations and regulations that address issues of environmental management including pollution control and prevention, natural resource management, biodiversity conservation, protected areas management, preservation of historic and cultural resources, chemicals management and integrated water resources management. In addition, Belize has also signed on to various multilateral environmental agreements (MEAs). This chapter details the relevant environmental legislations and regulations that Blue Waters International must comply with, as well as the government departments it must interact with, in both its development and operation phases.

3.2.1 The Environmental Protection Act

The Environmental Protection Act (EPA) legislates the role of the Department of the Environment not only as the principal institution with the responsibility for the control and prevention of pollution but also as the national entity with responsibility for coordinating matters related to ensuring the prudent use and proper management of Belize's resources and the protection of the environment.

The EPA entrusts the Department of the Environment with a broad range of functions relating, but not limited to the following:

- the assessment of pollution, and the coordination of activities relating to the discharge of wastes;
- the licensing of activities that may cause pollution and the registration of sources of pollution;
- the carrying out of research and investigations as to the causes, nature and extent of pollution; and
- the enforcement of necessary prevention and control measures.

Also, the Department of the Environment has the responsibility for formulating environmental codes of practices, specifying procedures, practices or release limits for pollution control relating to works, undertakings and activities during any phase of their development and operation, including the location, design, construction, start-up, closure, dismantling and clean-up phases and any subsequent monitoring activities.

In addition to the broad regulatory authority, the Act also provides the Department of Environment with significant investigation, inspection, and enforcement authorities. In fact, the Act contains substantial penalties for violation of pollution control and EIA requirements, e.g., a fine of up to BZ$50,000, two years imprisonment, or both. Furthermore, in any conviction for an offense under the Act, the court is authorized to order the offender to take remedial action with respect to the harm caused to the environment, and any person who may suffer loss or damage as a result of an offense may bring a civil action against the offender.

The Act has been amended several times since its passage, with the most recent done in 2009. The 2009 Amendments of the Environmental Protection Act provide for greater environmental control and management of the petroleum industry, to make improved provisions for the protection of the Belize Barrier Reef System, to establish an environmental management fund, to provide for out-of-court settlement in appropriate cases, and to provide for the issue of violation tickets for pollution offences. The earlier amendments to the Environmental Protection Act also included fiscal and economic incentives for pollution control. Among other things, the amendments made it clear that the Act is binding on the Government, increased the levels of fines and sanctions (including stop orders), and authorized the Department of Environment to charge fees for permits, licenses and applications.

The main regulations made under the Act are the Environmental Impact Assessment Regulations (S.I. # 107 of 1995 and its amendment of 2007); the Environmental Protection (Effluent Limitation) Regulations (S.I. #94 of 1995) and its amendment of 2009; the Pollution Regulations (S.I. #56 of 1996) and its amendments of 2009 and the Hazardous Waste Regulations of 2009.

3.2.2 The Environmental Impact Assessment Regulations

The EIA process in Belize is comprehensive and follows internationally accepted stages: screening, scoping, EIA, reporting, public consultation, a review process and the preparation of an environmental compliance plan (ECP). Responsibility for undertaking the EIA and the preparation of EIA report lies with the project proponent, who also has to undertake public consultation, and on completion of the EIA report, publish details of where the report may be obtained so that members of the public can review the report and submit comments on the proposals.

The EIA Regulations set out the information to be included in the EIA report, which must include the establishment of an environmental baseline, description of the proposed project, identification of and prediction of potential impacts, identification of mitigation measures, evaluation of project alternatives, and selection of the preferred alternative, resource assessment and the preparation of an Environmental Management Plan (EMP) to identify any mitigating and monitoring measures to be implemented.

The EIA procedure is controlled by the DoE, which is responsible among other things for determining whether an EIA is required, reviewing and approving the ToR prepared by the project proponent, determining procedures for public consultation, and directing the evaluation and approval of the EIA report.

The EIA Report has to be submitted to the DoE for the review process. The DoE may request additional material and the EIA is not considered to be complete until the developer has supplied all the information requested. The DoE will not adjudicate on the project until this process has been completed satisfactorily. The DoE may make copies of the EIA available to interested persons, will review the EIA against the ToR, and determine whether further studies are needed and note the existence of any significant adverse effects. The DoE will advise the project proponent within 60 days of their decision, during which time the developer must not start the project.

The EIA Regulations established the National Environmental Appraisal Committee (NEAC) as the agency responsible for reviewing ElA reports, advising the DoE of the adequacy or otherwise of the EIA, and advising the DoE on the need for a public hearing. NEAC is chaired by the Chief Environmental Officer, who is also the head of the DoE, and the Committee is made up of representatives from the main environmental government agencies. During the process of evaluation of the EIA, NEAC may conduct site visits and interviews with key stakeholders as part of the consultation process.

The EIA process also calls for various levels of public consultation. This includes meetings with key stakeholders in order to get their views and inputs, local community consultations, the publishing of two notices in a local newspaper publishing the location and dates when the EIA document will be made available to the public for a period of two weeks.

Whenever the DoE determines necessary, then a formal public hearing at a community near the proposed site may be required as another form of consultation. A decision on the various levels of consultation is made by the DoE after due consideration of the local context of the project site, the pre-existing conditions, the magnitude and significance of the impacts, among other factors. During the process of evaluation of the EIA, members of the NEAC may conduct site visits and interviews with key stakeholders as part of the consultation process.

At the final stage of approval, the DoE requires the project proponent to sign an Environmental Compliance Plan, a legal document to which the developer must adhere. This document is legally binding and contains the mitigation measures, stages of development, and technology to be used during the various phases of the project. It also makes provisions for monitoring and enforcement of the conditions agreed to and provisions for failure to implement the agreement.

In the event that NEAC decides that the project should not go ahead on environmental grounds, the developer may appeal to the Minister.

The regulations divide projects or activities into three categories. Schedule 1 lists those projects that automatically require an environmental assessment based on the sensitivity of the surroundings or the nature of the undertaking. Schedule 2 lists those projects that may require an assessment to be carried out, depending on the outcome of an environmental questionnaires or statement. Schedule 3 lists activities or programs that do not require an assessment to be conducted which may not have significant impacts on the environment.

A Schedule 1 project for which a full EIA is mandatory includes under Schedule I – Infrastructure Projects:- (c) Construction of national highways and roads of more than 10 miles in length.

3.2.3 The Environmental Protection (Effluent Limitation) Regulations

These regulations were established to control and monitor discharges of effluent into any inland waters or the marine environment of Belize; prohibit the discharges of effluent from new and altered sources; implement a licensing system for the discharge of effluents; and establish and implement the requirements for the treatment of effluents. In 2009 this regulation was amended to allow for greater consistency with the Cartagena Convention and the Aruba Protocol on land-based sources of marine pollution. Where any effluent is produced in the rehabilitation of the GPH in the Project Area, arrangement will need to be made with the Department of the Environment for its proper disposal.

3.2.4 The Pollution Regulations

These Regulations address issues of air, water and soil pollution, including noise pollution. Part III – 6 (1) deals generally with the emission of contaminants into the air where no person may cause, allow or permit contaminants to be emitted or discharged either directly or indirectly into the air from any source. Regulation 31 states that no person shall pollute the land so that the condition of the land is so changed as to be capable of making the land noxious or harmful to animals. Regulation 32 provides that no person shall cause any seepage or leaching contamination of the adjacent soil, groundwater or surface water.

Regulation 33 empowers the DOE to issue directions to persons for the elimination of waste or a solid waste treatment plant and disposal system. Regulation 35 prohibits the deposition of waste in a place other than a site approved by DOE for the storage or elimination of waste or operation of a waste treatment plant or waste management system. Finally, regulation 37 prohibits any person from causing or allowing any equipment to emit unreasonable noise from any premises without attempting to abate such noise.

3.2.5 The Hazardous Waste Regulations

These regulations establish legal directions for the transportation, storage, and disposal of hazardous waste. Where the storage of any hazardous waste in connection with the rehabilitation of the GPH in the Project Area becomes necessary, it must be done in accordance with section 10 (1) of the regulations. It addresses the prevention of leaks and requires that a secondary containment be provided for the storage of hazardous materials. The regulation requires that hazardous waste is adequately labelled and there is no contact among incompatible hazardous wastes. It also requires that routine inspections are performed and the place where they are stored is secured, prominently identified as a waste storage site, is equipped with suitable equipment to handle emergency situations, is provided with trained operators, has no opening in the secondary containment, and provides no access for surface water to enter the secondary containment.

3.2.6 The National Park Systems Act

The National Park System Act establishes protected areas throughout Belize. It makes provisions for their protection including the flora and fauna, natural monuments, and other objects of cultural and natural value contained therein. Where rehabilitation work of the GPH in the project area is in close proximity to a protected area, as in the case of the Guanacaste Park, special care should be taken to ensure that such work does not disturb the functioning, including access to, or destroy the biological integrity of such protected areas.

3.2.7 Wildlife Protection Act

The provisions of the Wildlife Protection Act offers further protection of Belize's natural resources in the project area. Section 4 (1) which prohibits, in any area closed to the hunting of wildlife, any person from hunting any wildlife of any species; being found in possession of any wildlife or part thereof; or carrying any gun, spear, trap or other means for hunting wildlife. The requirements of this legislation requires attention as it pertains to construction workers in these areas.

3.3 Socio-Economic Legislation

3.3.1 The Labour Act

Labour relations between contactors and their workers will be governed by the Labour Act which makes provisions for recruiting employees, terms and conditions of employment, payment of wages, dispute resolution etc.

3.3.2 Workmen Compensation Act

The Workmen Compensation Act applies to workers who are involved with cases of accidents on the job or while being transported to the job. The Act makes provisions for the contactors' liability for compensation, amount of compensation, conditions of compensation, insurance, insolvency or bankruptcy of the contractor, etc.

3.3.3 International Labour Organization Conventions Act

The ILO Conventions Act lists the ILO Conventions ratified by Belize and which have the force of law in Belize. As such, these Conventions will govern the relation between contractors and their workers as to the particular subject matter of the Convention. These Conventions include, *inter alia,* Minimum Age, Right of Association, Minimum Wage, Freedom of Association and Protection of the Right to Organize, Abolition of Forced Labour, Radiation Protection, Paid Leave, etc.

3.3.4 Social Security Act

Workers involved with the rehabilitation of the GPH in the Project Area are assured some monetary insurance by the provisions of the Social Security Act, which requires that contractors pay social security contributions for their employees to assist them in times of sickness or injury.

3.3.5 National Occupational Safety and Health Bill

Comprehensive legislation governing workers safety and health have been introduced in the House of Representative in the form of a National Occupational Safety and Health Bill. While this is not yet law, the provisions of this Bill serves as an excellent best practice guide for ensuring the safety and good health of workers involved with the rehabilitation of the GPH in the Project Area.

3.3.6 Dangerous Goods Act

In situations where contractors may import, produce, transport, store and/or distribute dangerous goods such as explosives, petroleum products, gunpowder, dynamite, nitroglycerine, gun cotton, blasting powders, fulminate of mercury or of other metals, coloured fires, other similar substances, the Dangerous Goods Act will govern these activities.

3.3.7 Public Health Act

The health conditions of the workers camps and that of the communities in which they are located during the rehabilitation the GPH in the Project Area, is governed by the Public Health Act. In the worker's camps and communities, the Public Health Act regulates water supply, drainage, garbage collection and storage, infectious diseases, mosquito destruction, sanitation and prevention of nuisances etc. Also, the Public Health Act makes provisions for ensuring that establishments providing food services are staffed by persons in receipt of Food Handlers Certificates from the Public Health Department and that these food establishments have sanitary toilet and washing facilities.

3.3.8 National Institute of Culture and History (NICH) Act

The NICH Act protects our cultural assets during the rehabilitation of the GPH in the Project Area in particular in section 62 (1) which prohibits the willful damage, destruction or disturbance of any ancient monument, or their marking or defacing, or removal; or the removal or destruction of any antiquity. Another important provision of the NICH Act is section 63 which authorizes the Director of Archaeology to direct any … contractor … who is about to engage in any operation which in the opinion of the Director is liable to destroy, damage, interfere with or otherwise be to the detriment of any ancient monument or antiquity; not to proceed with any operation until the Director shall have had an archaeological exploration and survey carried out; and to take or to refrain or desist from taking any such action as part of the operation as the Director may decide to be fair and reasonable for the proper protection of the ancient monument or antiquity.

3.3.9 Village Council Act

Every Village Council is charged with the good governance and improvement of its village including the sanitation of the village, drainage and sewage, the suppression and abatement of nuisances, ensuring sound environmental practices by all persons in the village, etc. Genuine consultations with all the Village Councils affected by the GPH rehabilitation is therefore necessary to ensure the acceptance of the Project and its workers into the affected communities, and to afford the communities the opportunity to be a part of the Project design and execution.

3.3.10 Protection against Sexual Harassment Act

The Provisions of the Protection against Sexual Harassment Act provides for the prohibition of sexual harassment in the workplace by an employer of fellow employees so that both male and female workers will be working in a respectful and pleasing environment.

3.3.11 Families and Children Act

The Families and Children's Act protects the interest of families and children in society. Where any person legally considered a child is employed in any facet of the work in the rehabilitation of the GPH in the Project Area, the Act in section 7 ensures that such employment is not detrimental to the child's health, education, or mental, physical or moral development. Additionally, under this legislation, any member of the public who has knowledge of child abuse has a moral duty to report; while any person whose occupations involove direct contact with children have a legal obligation to do so.

3.3.12 Intoxicating Liquor Licensing Act

The peace and quiet and protection of minors in villages affected by the rehabilitation of the GPH in the project area is secured by the provisions of the Intoxicating Liquor Licensing Act, in particular section 44 of the Act which prohibits the sale of alcohol to persons under 18 years of age (and consequently their presence in such liquor establishments).

3.4 Public Roads Act

It is by authority contained in the Public Roads Act that work on the GPH in the Project Area is made legally possible. The Public Roads Act in section 3 entrusts the Chief Engineer with the responsibility, under the authority, control and direction of the Minister of Works, with the construction, alteration, maintenance and supervision of all public roads of Belize, which includes all existing highways. It is therefore with the consent and approval of the Chief Engineer, that the GPH will be rehabilitated in the Project Area.

The Chief Engineer is empowered by the Public Roads Act in relation to any work on any public road, including the work involved with rehabilitating the GPH in the Project Area, to close, divert, prohibit or manage traffic in the public interest; appropriate uncultivated lands; make arrangements for compensation, on behalf of the Government of Belize, with the owners of appropriated cultivated land; lawfully enter upon any land; take material from any cultivated or uncultivated land; erect buildings or place construction debris on any adjacent land; make temporary roads; remove any obstruction or encroachment; or construct tunnels, culverts or bridges on any adjacent land.

The Public Roads Act authorizes the Chief Engineer to acquire land on behalf of the Government of Belize if necessary for the rehabilitation of the GPH, and in section 10 (2), where the Chief Engineer and the owner cannot agree on the compensation to be made for the acquired land, proceedings are taken to take possession of the land and pay compensation in accordance with the Land Acquisition (Public Purposes) Act.

3. 5 Land Acquisition (Public Purposes) Act

The Land Acquisition (Public Purposes) Act makes provisions for compulsorily acquiring land for public purposes, assessment and compensation, etc. Section 11 (1) of the Land Acquisition (Public Purposes) Act stipulates that all claims related to the payment of compensation under the Act shall be submitted to a Board of Assessment. The Board shall comprise the Chief Justice, or other Judge of the Supreme Court nominated by the Chief Justice, who shall be the Chairman of the Board; a member appointed by the Minister; and a member nominated by the owner of the land to be acquired. An award of the Board may be enforced in the same manner as a judgment or order of the Supreme Court.

3.6 National Advisory Policies

3.6.1 National Environmental Policy

Belize National Environmental Policy and Strategy 2014 to 2024 commits to making Belize *Resilient* by committing to policies for Disaster Risk Reduction and Climate Change Adaptation. From studies done for this ESIA, the rehabilitated GPH in the Project Area will be designed and constructed to withstand known natural and technological disasters; and alternative routes where possible and feasible are suggested for those brief moments when the rehabilitated GPH in the Project Area becomes impassable.

3.6.2 National Protected Areas System Policy and Plan

The National Protected Areas System Policy and Plan recognizes that Protected Areas are an important resource base for the development and strengthening of economic activities and contribute to poverty elimination by supporting industries such as agriculture, tourism, fisheries, timber and non-timber products, research, bio-prospecting, mining, water and energy services among others. As such, and in particular in relation to tourism, a rehabilitated GPH in the Project Area helps to achieve the objectives of the Policy by affording locals and tourists easy access to adjacent tourism related Protected Areas.

3.6.3 National Culture Policy (Draft)

The Government of Belize believes that the Draft National Culture Policy will provide the framework for identity-building and cultural exchange for the purpose of creating a cohesive and improved quality of life so that people throughout the world come to recognize and appreciate Belize's way of life. An improved and resilient GPH in the Project Area will contribute greatly to this desired cohesion by allowing Belizeans of all cultures from the remainder of the Country to interact all year round with Belizeans along the GPH in the Project Area, and vice-versa.

3.6.4 National Gender Policy

The National Gender Policy aims at, *inter alia*, promoting and facilitating women's and men's equal access to, and control over productive resources, services and opportunities. The employment and service opportunities provided by the rehabilitation of the GPH in the Project

Area should therefore be available to both genders equally. BET in this ESIA therefore makes recommendations for equal participation of women in the GPH rehabilitation project.

3.6.5 Belize Horizon 2030

A key long term goal for Belize up to the year 2030 is to ensure that the Government of Belize is able to make timely investments in key economic infrastructure, especially the road network and transportation system. The rehabilitation of the GPH in the Project Area is therefore a major contributor to the investment needed in our road network.

3.6.6 National Poverty Elimination Strategy and Action Plan

The National Poverty Elimination Strategy and Action Plan recognizes that the provision of economic and social infrastructure is salient to a number of poverty reduction initiatives. Road maintenance and construction are recurrent demands on capital expenditure and contribute critically to economic development by linking poor communities to larger population centers, and providing agricultural access, the transfer of goods and the provision of services. A rehabilitated GPH in the Project Area will therefore better serve as a poverty reduction tool to the rural communities along and adjacent its path.

3.6.7 National Sustainable Tourism Master Plan for Belize 2030

The National Sustainable Tourism Master Plan identifies as a main constraint to tourism development in Belize, the poor level of accessibility on land, mainly due to a small amount of paved roads leading to the tourism assets which results in uneven distribution of tourism flow in the country, overcrowding in some sites and underutilization of others. The rehabilitation of the GPH in the Project Area will therefore continue to contribute to ready and easy access, for most of the way, to the many tourism destinations in the West.

3.6.8 Belize National Land Use Policy for Land Resource Development

A guiding principle of the Sustainable Land Use Policy is that climate change adaptation and mitigation issues must be considered and mainstreamed into land use planning. While the rehabilitation of the GPH in the Project Area will take place virtually in the footprint of the existing highway and negligible virgin land would be required for road building, the changes that are proposed in this ESIA, including a new bridge, realignments, etc., have all taken climate change adaptation and mitigation issues into consideration.

3.6.9 Government of Belize Policy on Adaptation to Climate Change

One objective of the GOB Policy on Adaptation to Climate Change is to prepare all sectors of Belize to meet the challenges of global climate change. This includes the Transportation Sector in which several of Belize's roads and bridges are vulnerable to seasonal floods. Belize's waterways also become un-navigable during certain periods. Sea level rise and changes in rainfall patterns could increase the episodes of flooding which will impact the nation's transportation. As a result, the Policy tasks the Ministry of Works and the Port Authority to undertake climate change vulnerability studies of the nation's roads, bridges and waterways and prepare adaptation options to meet these threats. The rehabilitation of the GPH in the Project Area will go some ways in achieving the goals of the Policy.

3.7 Environmental and Social Safeguard Policies of the IDB

3.7.1 Environmental and Social Safeguard Compliance Policy

The objectives of the Environmental and Social Safeguard Compliance Policy, is to enhance long-term development benefits by integrating environmental sustainability outcomes and strengthening environmental management capacities throughout the Project. In preparing this ESIA, BET is addressing issues of screening and classification, environmental assessment requirements, consultation, supervision and compliance, trans-boundary impacts, natural habitats and cultural sites, hazardous materials and pollution prevention and abatement.

3.7.2 Disaster Risk Management Policy

The objective of the Disaster Risk Management Policy is to supporting MOWT to systematically manage risks related to natural hazards by identifying these risks, reducing vulnerability and by preventing and mitigating related disasters before they occur. BET and its Disaster Risk Management Expert has identified the areas along the GPH that are prone to flooding from the hills or river, prone to traffic accidents because of bad alignment, prone to pedestrian fatalities because of few or non-existent pedestrian facilities; and is proposing mitigating measures to address these vulnerabilities.

3.7.3 Involuntary Resettlement Policy

It is not projected that there will be a need for large scale involuntary resettlement as a result of the rehabilitation of the GPH in the Project Area, largely because the rehabilitation work that will be undertaken will be almost exactly in the footprint of the existing highway. It is expected that there may be a few cases of compensation under the Land Acquisition (Public Purposes) Act however, in relation to realignment of the GPH in certain areas.

3.7.4 Gender Equality in Development Policy

The objective of the Policy is to promote gender equality and the empowerment of women. As a consequence, BET and its Social Expert will be offering recommendations for involving and protecting women in all possible areas of the rehabilitation of the GPH in the Project Area.

3.7.5 Access to Information Policy

The Access to Information Policy makes important information on the IDB's funded activities available to the Public. Such information includes EIAs and Environmental and Social Management Reports. This policy is on all-fours DOE's procedural requirements which makes EIAs available to the public.

3.8 Multilateral Environmental Agreements

Belize is a signatory to approximately thirty international conventions, treaties and agreements that deal in some way or another with the protection of the Environment. Many of these have since found their way into national legislation, particularly in the Environmental Protection Act and its Regulations. These conventions target biodiversity protection such as the Convention on Biodiversity, 1992 (CBD), the Convention on the International Trade in Endangered Species of Wild Flora and Fauna, 1975 (CITES), the Convention on Wetlands of International Importance Especially as Waterfowl Habitat, 1971 (Ramsar),and the Convention on World Heritage Sites, 1972. There are others that focus more on other environmental issues of international concern related to pollution prevention, protection of the ozone layer, climate change and chemicals management and include the UNCCD, UNFCCC, the Vienna Convention and its Montreal Protocol and amendments, Basel Convention, Rotterdam Convention on PIC, The Stockholm Convention on POPs, MARPOL, Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1972 and its 1996 London Protocol, CLC and Fund Convention, OPRC, and the Cartagena convention and its Protocols on Oils Spills and Land Base Sources of Marine Pollution.

CHAPTER 4: ENVIRONMENTAL SETTINGS

4.1 Geology of Study Area

4.1.1 General Geology

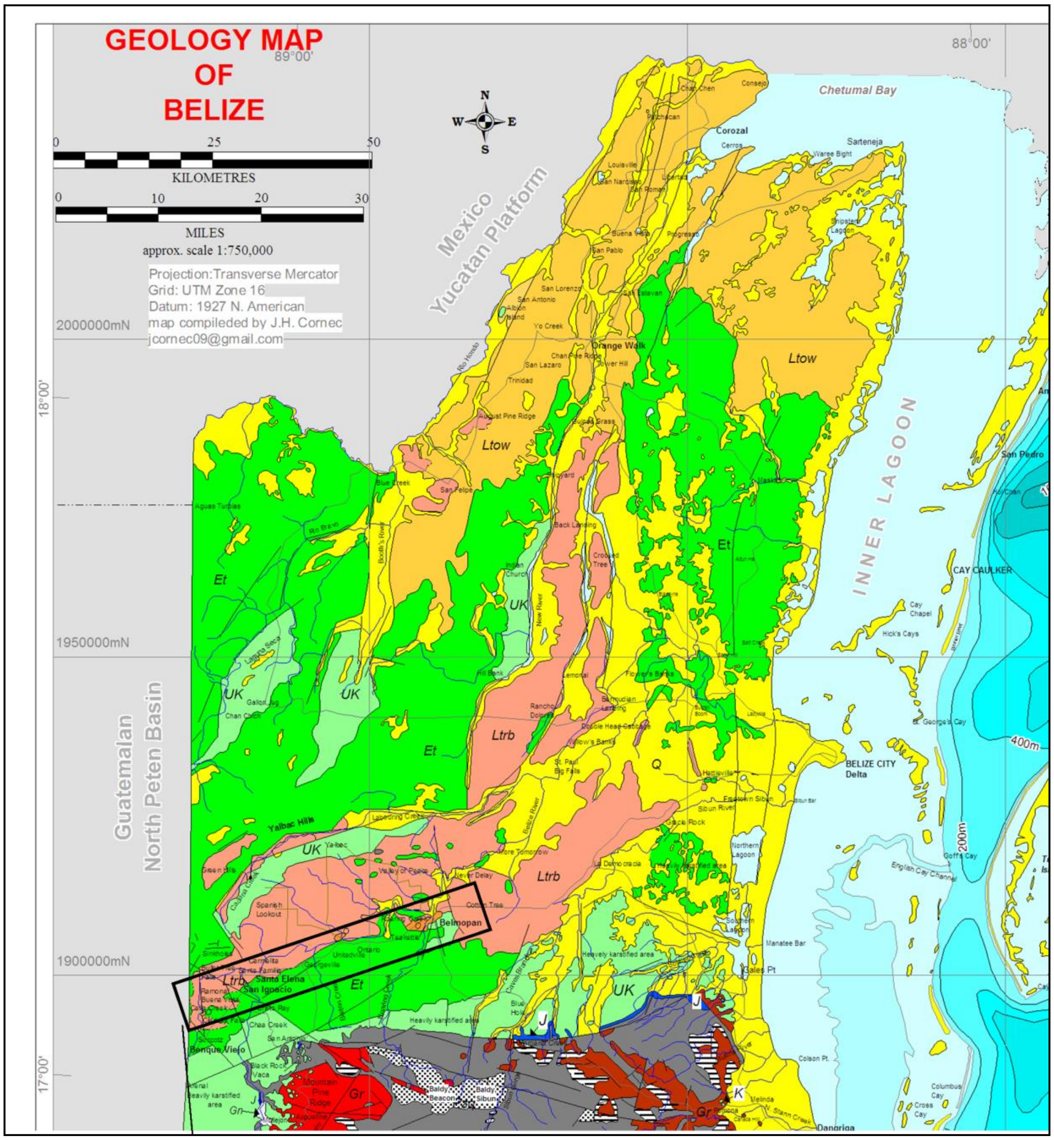
The Study area from the George Price Highway (GPH)/Hummingbird Highway (Guanacaste Junction) to the Belize/Guatemala (Benque) Border, going in a west-south westerly direction is underlain primarily by Early Tertiary sediments of the Doublon Formation/El Cayo Group. It consists of lagoonal laminated limestone and dolomitic sections, marls, numerous gypsum occurrences, bentonitic clays of volcanic origin and chert nodules, which are unconformable overlain by late Tertiary red bank Group deposits of variegated clays, generally grey to red mottled with some gypsum sands and chert deposits that would be representative of a slag deposit and some Quaternary alluvial deposits, sands, sands and gravels, Figure 4.1.

In general, the study area except for some small portions along Section I & II, are predominantly underlain by consolidated marls and limestones. These marls and limestones form a gently undulating topography and tend to be typically massive with little to no variation in composition.

The hillocks to the south of the study area, both within Section I and Section II, are primarily limestone outcrops that show bedded crystalline micritic limestones that are tan to white in color, relatively hard and consolidated material with some marl and clay inclusions.

Along Section II between the Iguana Creek Road Junction and the Georgeville junction there are numerous occurrences of clays and reports of gypsum occurrences at or near surface. The clay deposits vary in thickness and the occurrences in the lower regions of the Spanish Lookout area are overlain by chert nodule deposits of varying thicknesses.

Section III from Mile 67 GPH to the Benque Border is underlain by predominantly immature marls with limestone boulders and pebbles, tan to white in color and with some clay inclusions. There are some isolated consolidated limestone hillocks with thinly bedded limestones.



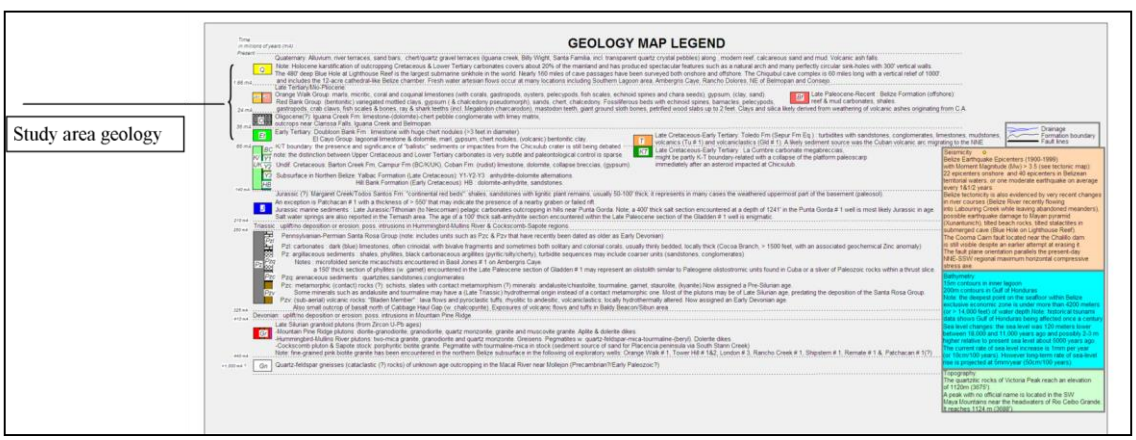
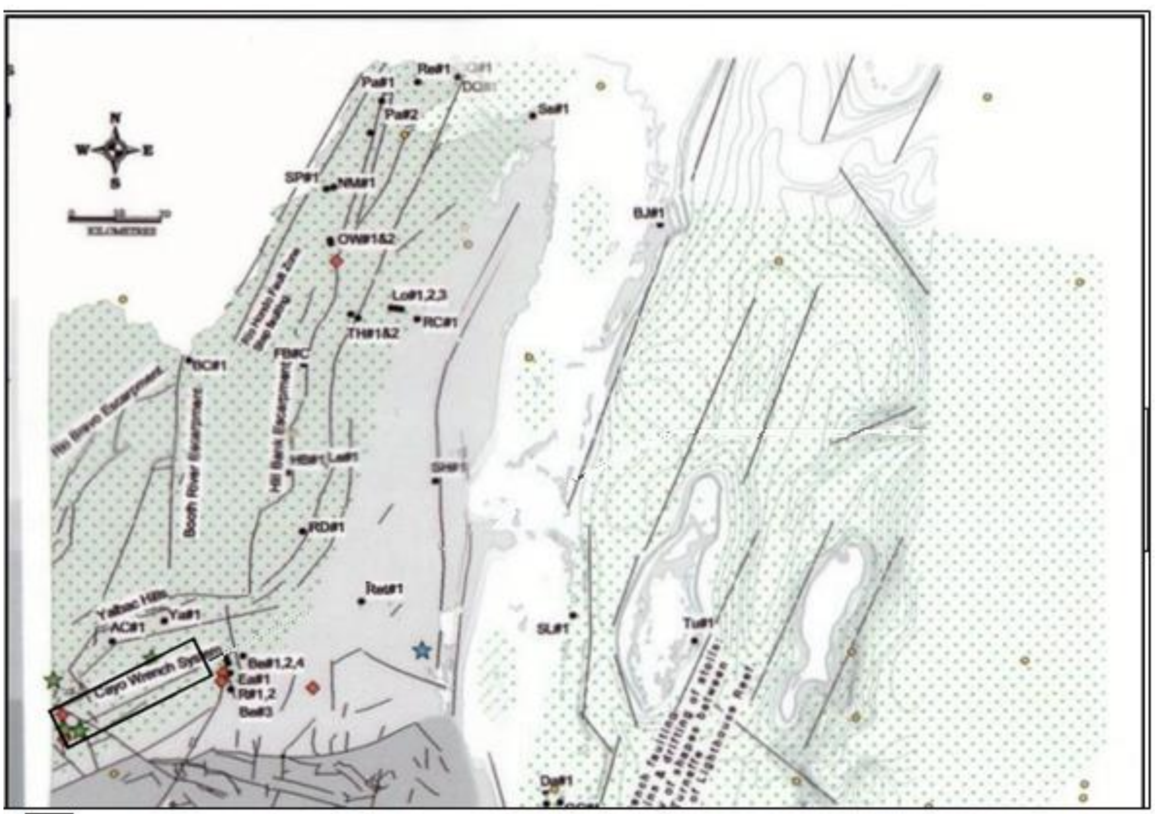


Figure 4.1: Cornec Geology Map of Belize 2010

4.1.2 Tectonics

The Study area can be considered tectonically inactive as these faults predate all recent deposits and there is no evidence of recent faulting within the study area. However, the project area is subject to the Cayo Wrench system of NE-SW lateral fault blocks, Figure 4.2. This NE-SW lateral wrench system consist of a series of isolated fault blocks and associated escapements, running near parallel to each other showing massive vertical displacement along the thrust faults.

The vertical exposure seen along the"Z Curve" with the associated near vertical drop off to the Belize River below (35+m drop, with 30m vertical hillock exposure, relative to road) exhibits this block faulted zone. To the north, the Yalbac Escarpment, an up-thrusted fault block which produced the Yalbac Hills, is also evidence of the thrust fault system. Further evidence of the ancient faulting can be seen in the extended fault control shown in the alignment of the Belize River between the villages of Onatario and Bullet Tree falls, the rapid southernly turn in the river is also controlled by the N-S trending splay fault located within the western edge of the study area.



Study Area Showing tectonic features within 4mile

Figure 4.2: Tectonic Map of Belize

4.1.3 Topography

The topography of the project zone varies from the hilly country of the immediate south and south west of San Ignacio-Santa Elena, in the direction of the western end of the project site around Benque Viejo del Carmen; to the subdued relief of the floodplains of the Macal and Belize River, down to the rolling terrain in the Banana Bank-Roaring Creek area (Halcrow,1998). The hilly country is characterized by rounded hills, reaching about 160 m in the immediate vicinity of the proposed Macal River Crossing, separated by steep, narrow valleys, farther upstream, Figure 4.3. Table 4.1 provides information on the elevations of the watersheds of the GBRB.

Table 4.1: Watersheds and Sub-catchments of the GBRB

Belize River Sub Basins	Area (km^2)	Lc (km)*	Hmax (m)**	Hmin (m)***	Mean annual flow m^3/s
Crooked Tree/Northern Lagoon (1)	**370.17**	**61.35**	**30.00**	**5.00**	
Labouring Creek (2)	**2056.79**	**161.88**	**500.00**	**10.00**	
Beaver Dam Creek (3)	**99.48**	**22.37**	**60.00**	**20.00**	
Roaring Creek (4)	**323.16**	**58.76**	**960.00**	**20.00**	
Iguana Creek (5)	**88.35**	**21.97**	**130.00**	**20.00**	
Barton Creek (6)	**115.69**	**35.41**	**740.00**	**20.00**	
Macal River (7)	**1468.98**	**126.50**	**900.00**	**60.00**	**25.7**
Chiquibul (8)	**1544.60**	**138.27**	**880.00**	**150.00**	**19.9**
Mopan (9)	**2044.18**	**174.17**	**700.00**	**60.00**	**39.16**
Belize (10)	**1632.0**	**447.11**	**700.00**	**0.0**	**97.1**

* Mean length of channel; ** Maximum elevation at source; *** Minimum elevation near mouth
(Source: National Hydrological Department, 2013; INSIVUMEH, 2005)

Downstream to the north, northwest, and southeast the land is relatively flat, falling below 60 m towards the central and eastern Belize River floodplain. Table 4.2 is a summary of the topography of the GBRB and spacial extent of plains and slopes. The greater percent (30 %) of the Basin is flat land, while steep slopes (25 – 35 degrees) and karst slopes (≥ 35 degrees) make up 20% each of the total area. Undulating plain (1 to 5 degree) make up another 20 % of the area.

Table 4.2: Topography of the Greater Belize River Basin

Slope Class	% Area
Less than 1 degree: plain	30
1 to 5 degree: undulating plain	20
5 to 25 degrees: rolling plain	5
25 to 35 degrees: local relief > 30 m hills	5
25 to 35 degrees: steep slopes	20
≥ 35 degrees: karst	20

Source: NARMAP, 1995

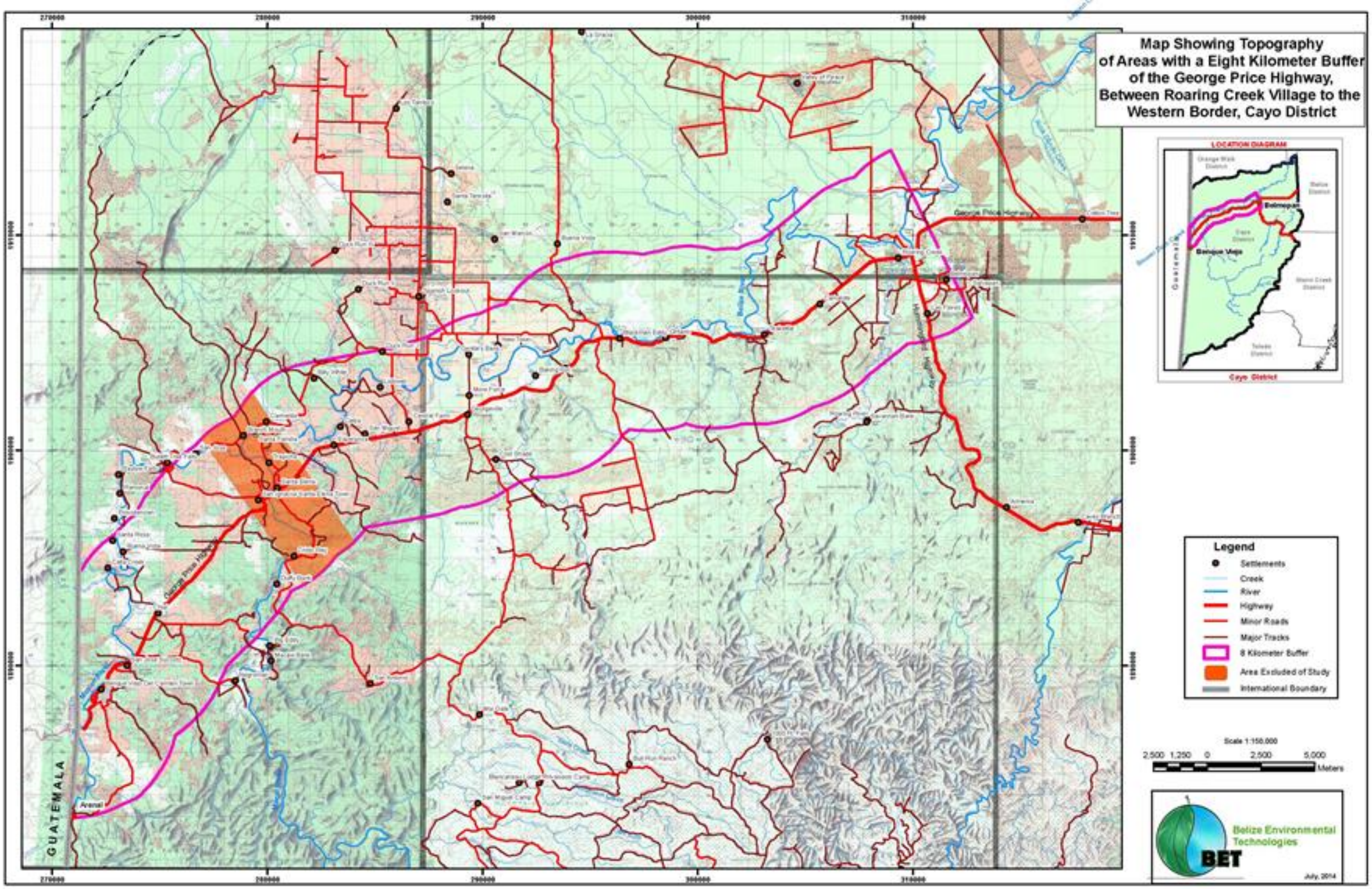


Figure 4.3: Map Showing General Topography of Study Area

4.1.4 Land Use

The land use of the study shows that a considerable portion of the Area is used for agriculture on both sides of the George Price Highway from its junction with the Hummingbird Highway to the Belize Guatemalan border. Intensive rotational crop agriculture is practiced where alluvial soils are found. These rotational crops are mainly corn and beans. Intensive agriculture is practiced in this northwest section of the George Price Highway. However, in certain areas such as east, southeast and northeast of the Spanish Lookout community and in the Iguana Creek area cattle ranching is practiced. This is because the alluvial soils of this area are loaded with gravel and stones that makes it difficult for farming machinery to operate.

The Maya Mountain foothills lie to the south and south-west of the study area. These areas have greater forest cover and the forests are in their early stages of succession. Cattle ranching is more common in the lower foothills.

The land use in the GBRB is summarized in Table 4.3, highlighting the land use area for each sub catchment. Figure 6.4 also provides a map of the major land use classification of the area. A more detail description of the land use of the three sections of the study area is provided in the section pertaining to the ecology of the Study Area.

Table 4.3: Land use in Belize River Sub-catchments

Sub-catchment	Total	Forest	Agriculture	Scrubland	Grassland Savannah	Urban
Crooked Tree	370.17	222.00	0.00	13.43	130.31	4.43
Labouring Creek	2056.79	1494.35	382.36	54.88	125.21	0.00
Beaver Dam Creek	99.48	73.15	14.07	1.91	9.78	0.57
Roaring Creek	323.16	230.22	19.44	59.21	5.41	8.88
Iguana Creek	88.35	9.77	76.64	0.34	1.59	0.00
Barton Creek	115.69	75.90	39.03	0.76	0.00	0.00
Macal River	1468.98	1276.55	71.73	114.23	1.04	5.43
Chiquibul River	1544.60	1539.15	0.00	5.46	0.00	0.00
Mopan River	2044.18	1849.20	179.49	6.56	0.00	8.93

(Source: TYPSA, 2010)

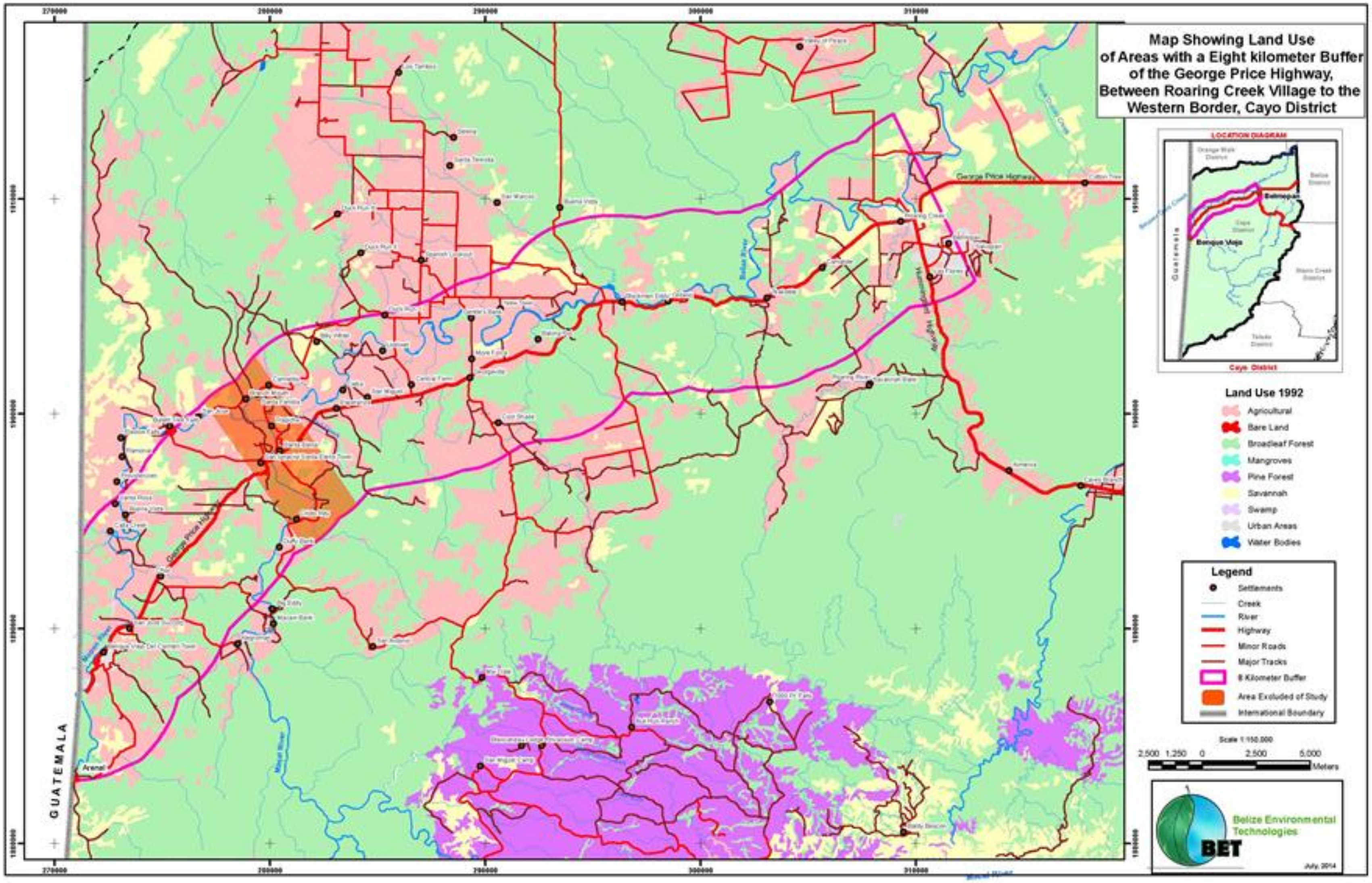


Figure 4.4: Land Use of Area of Interest

4.1.5 Soils of Project Area

Within the study area, a total of twenty (20) test pits were dug to examine material suitability and competencies as well as to identify and describe the various soil types and characteristics within the three sections of the proposed GPH upgrade, Figure 4.5. A more detailed analysis of the results of the Test Pit Survey is further discussed in the ESIA.

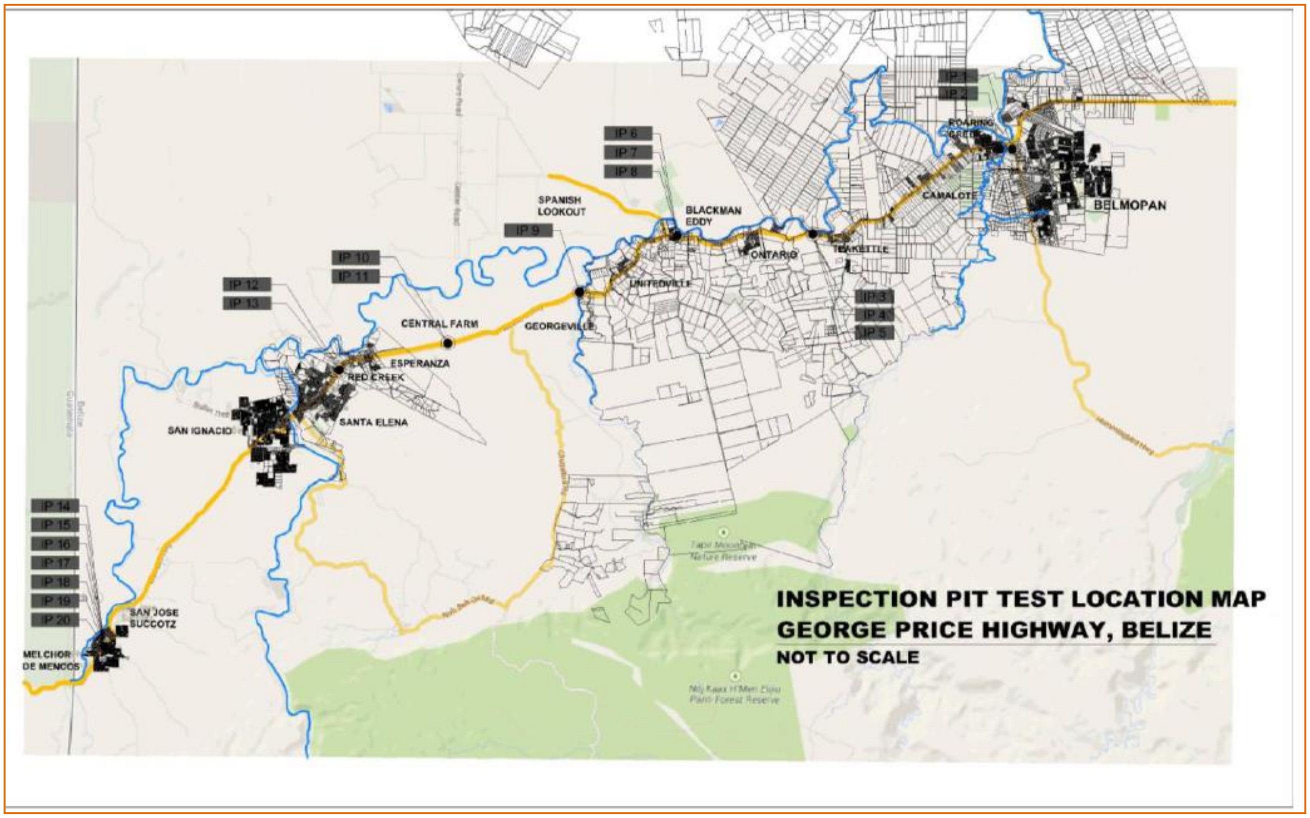


Figure 4.5: Test Pit Location Map

4.1.6 Construction Materials

The baseline survey of existing qurrries and extraction sites within or near the project area indicated that there were nineteen (19) existing localities for marl and/or limestone and marl, and twelve (12) existing localities for onland sand and gravel or gravel, Figure 4.6. This would indicate that the availability of material would not be an issue.

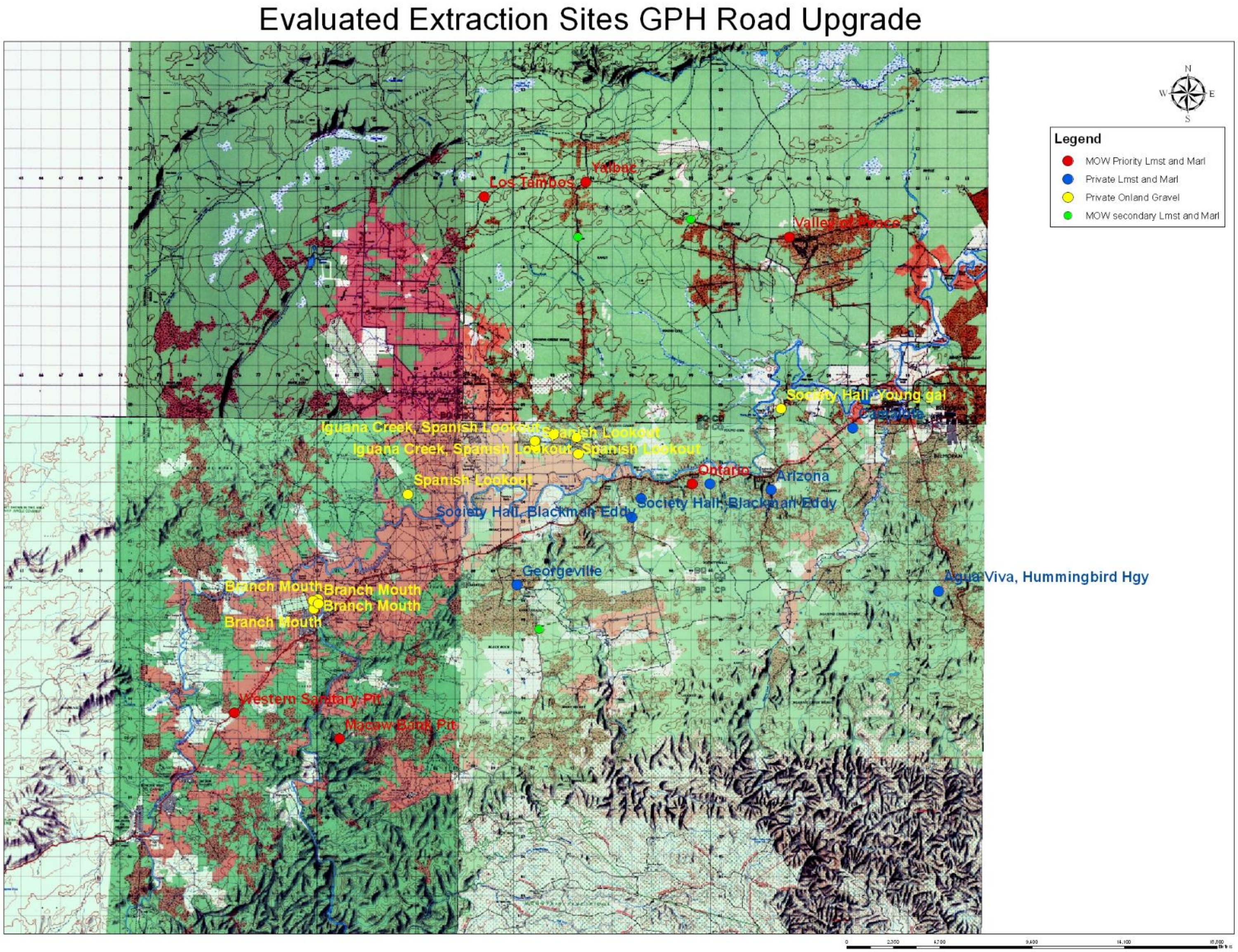


Figure 4.6: Test Pit Location Map

4.2 Overview of the Climate and Weather of Belize

In accordance with the Köppen climate classification, the climate in Belize can be described as tropical rainforest (Am - Tropical monsoon) in the higher terrain of the central mainland and southern districts, and tropical wet and dry (Aw - Tropical wet and dry) in the remainder of the country, tempered by the Caribbean Sea (WMO, 1997, FAO-SDRN, 1997). The climate also exhibits seasonal subtropical characteristic during the cool, transition period that runs from December through February.

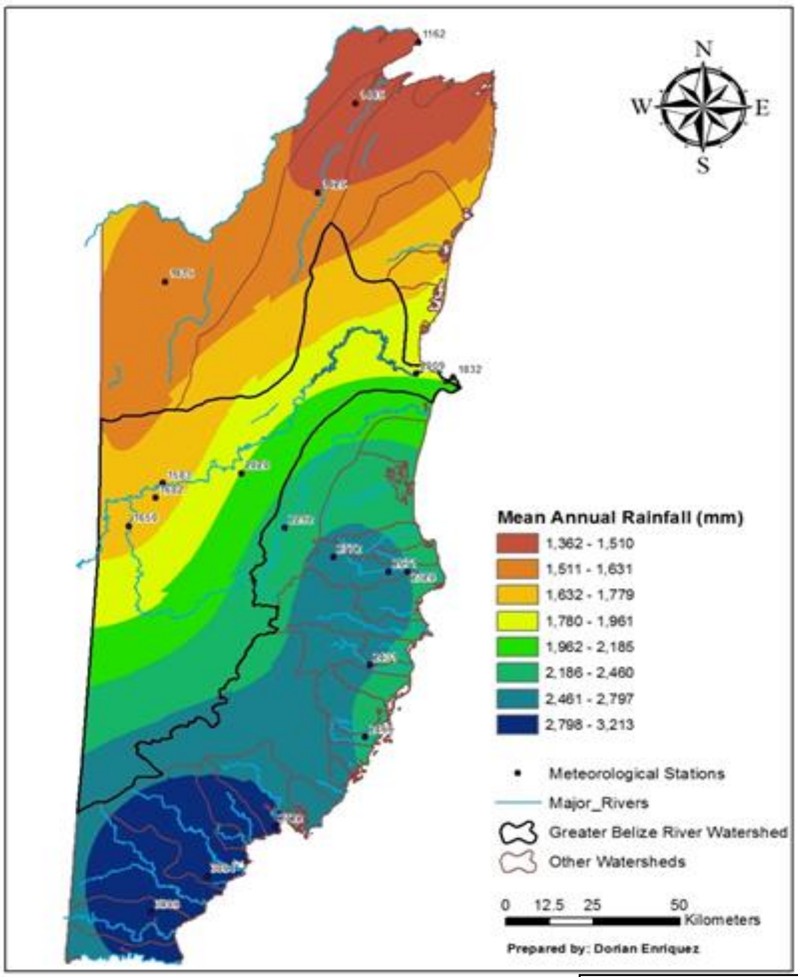


Figure 4.7 Mean Annual Rainfall over Belize

There are two distinct seasons: a wet season, which normally commences around mid-May in the south and early June in the north, and lasts until November; and a dry season, which stretches from mid-February until May. Mean annual rainfall increases from the north to the south of the country, with a mean annual of about 1,400 mm (55 inches) in the northern districts to near 3,864 mm (152 inches) in the south, around the Punta Gorda Agricultural Station at 5 Miles, Figure 4.7. Daily average temperatures in January, the coldest month of the year, vary from 24˚C along the coast to 22˚C in the interior at Central Farm, and 20˚C in the Baldy Beacon area of the Mountain Pine Ridge. In July, it ranges from 29˚Cover the coast to 28˚C inland and 25˚C in the elevated terrain inland. Extreme maximum temperatures in excess of 38˚C often occur in the exposed interior and northern districts in April and early May, the height of the dry season. The annual mean Relative Humidity is 82%, but conditions can become oppressively humid from June until September, especially over coastal regions. The hurricane season in Belize runs from June 1 until November 30.

From mid-May to November, the winds are predominantly northeasterly to easterly. These trade winds or tropical easterlies have moderate to deep moist layers that feed perturbations or disturbances in the easterlies, which generate the tropic rain showers events of the wet season. Winds during the cool, transition period are mainly northerly to north-easterly and are generally drier. Squally weather often accompany the passage of cold fronts during the cooler months, which may produce turbulent and dangerous sea conditions. The dry season winds are generally from the southeast and east and are characteristically gusty and dry.

4.2.1 Climatic Conditions in the Greater Belize River Basin

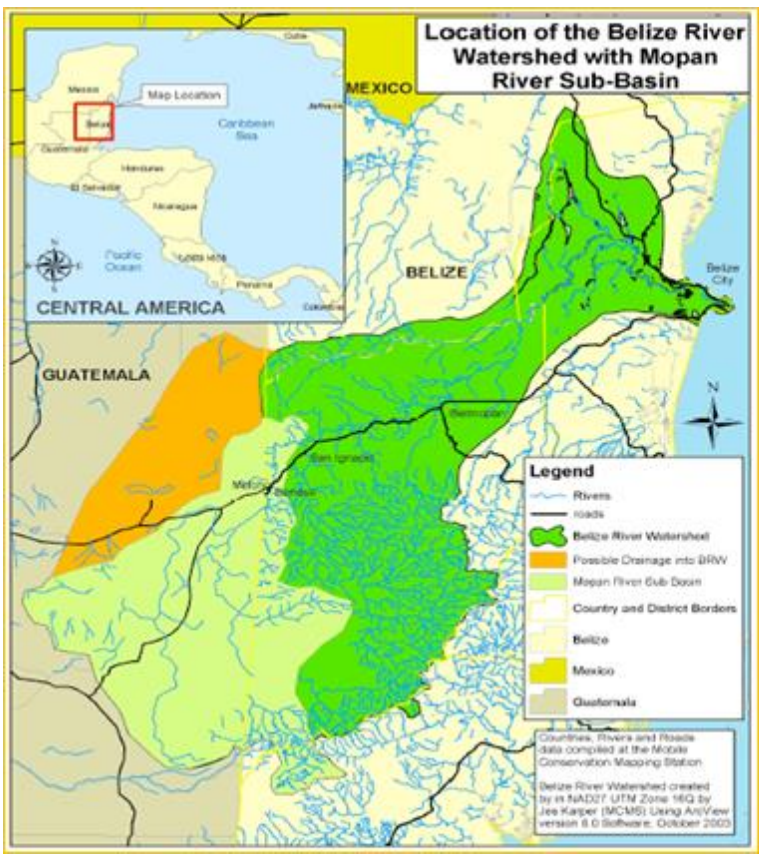


Figure 4.8: The Greater Belize River Basin

The Greater Belize River Basin is a trans-boundary catchment system comprising of ten sub-basins. Two of these, the Mopan and Chiquibul are shared with Guatemala, while the remainder is in Belize. Figure 4.8 is a map of the GBRB and portions of the main roads that traverse the basin in Belize and Peten, Guatemala. More on the surface hydrology of the GBRB is presented in the Hydrology Section. Figure 4.9 (a) and (b) are climate charts for Central Farm and Belmopan. The mean annual rainfall range from about 2000 to 2800 mm in the southern Cayo District to around 1600 - 2000 mm in the northern and north-western border. Peak maximum rainfall occurs in July and October at Central Farm and in June and September at Belmopan. Rainfall surplus is evident from June until January. The mean maximum temperature varies from 29°C to near 35°C in Belmopan and from 28 – 35 at Central Farm.

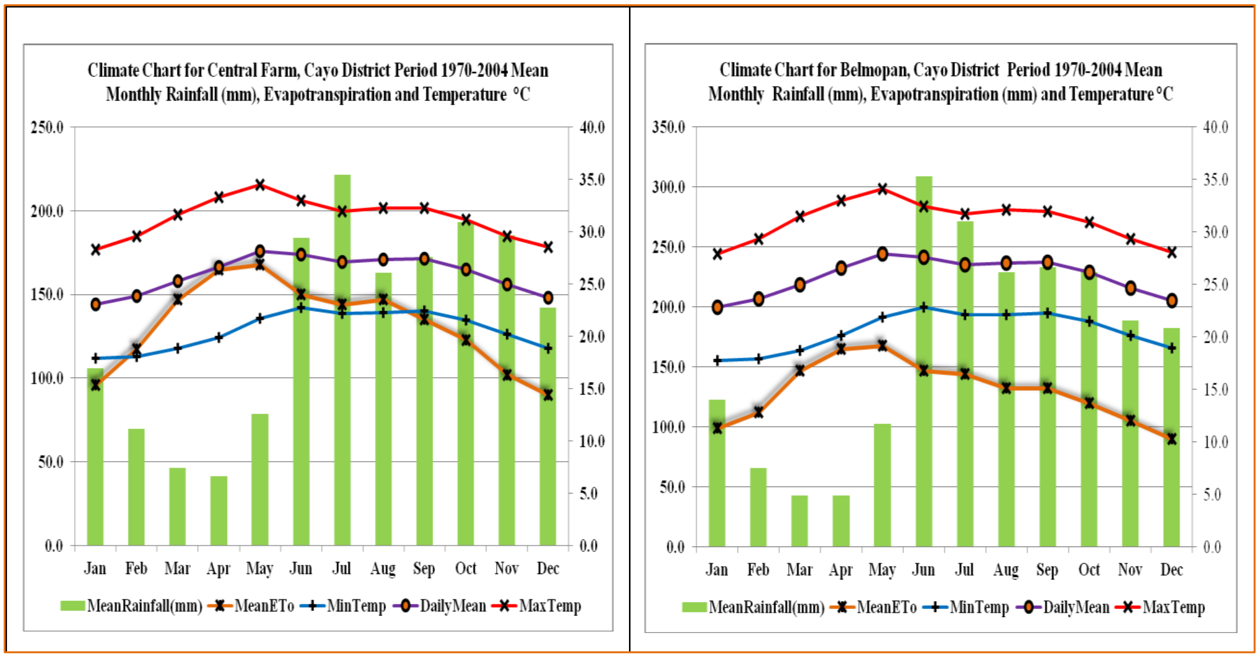


Figure 4.9 (a) and (b): Climate Chart for Central Farm, Cayo District

The warmest month is May, the coolest month is January, and the highest historic maximum temperature recorded in western Belize was 43 °C in May 1976 at Belmopan and 41 °C in May 1974 at Central Farm. The record daily rainfall was 267 mm in April 1983 at Central Farm and 334 mm in June 2002 at Belmopan, associated with a meso-scale convective disturbance over central Belize that undermined the Beaver Dam Bridge on the George Price Highway.

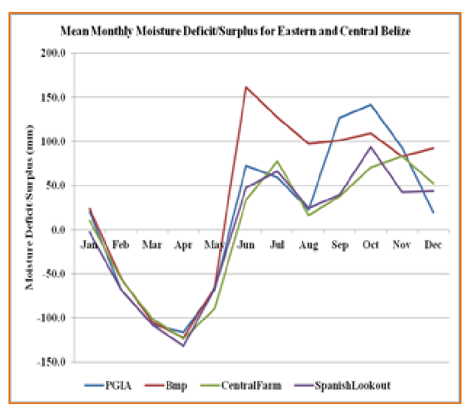


Figure 4.10: Moisture Deficit/Surplus

Figure 6.7 is a Moisture Deficit/Surplus graph (Precipitation P – Evapotranspiration E) for western Belize. Rainfall deficit (Precipitation–Evapotranspiration, P-E) extends from February to May (Figure 6.7). The peak of the water deficit is April. The local climate in the West Central zone is described with a

UNEP aridity index (AI) of 1.0 − Moist. The Annual

Aridity regime is 3 months and the annual Rainfall Deficit is -369 mm at Central Farm to -346 mm at Belmopan. The onset of the rainy season is normally in the first ten days of June. Figures 4.11 (a) – (d) show the mean seasonal rainfall for the Greater Belize river Basin. The higher mean seasonal rainfall in the Basin is concentrated in the elevated terrain of the east-central and southeastern region. During the period DJF, the mean seasonal rainfall in the eastern side of the Basin range from 458 mm – 768 mm, in MAM it range from 200 mm to 244 mm, 572 mm to 768 mm in JJA and 718 mm to 921 mm in SON. The drier region of the Basin is in the northwestern and western areas in DJF, MAM, and JJA, and extends into the higher terrain of the southeast in SON.

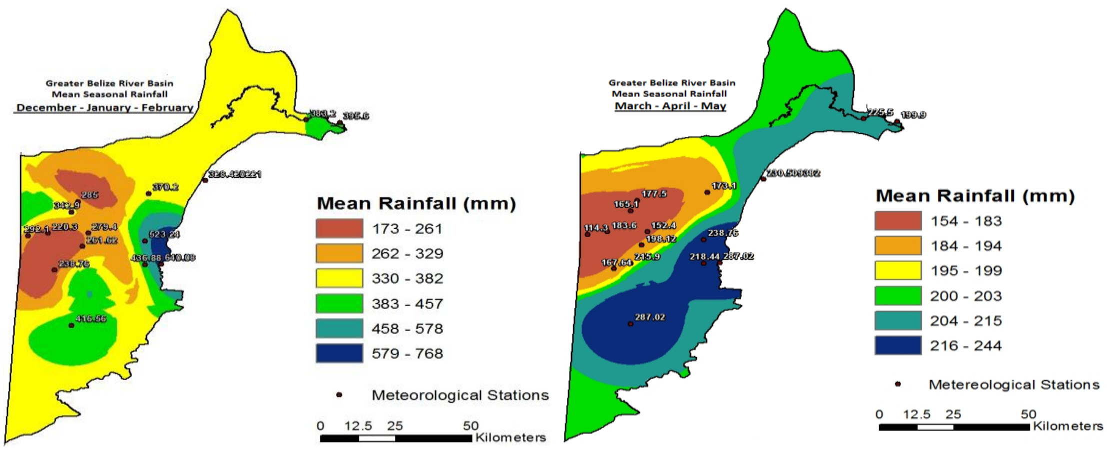


Figure 4.11 (a-b): Mean seasonal rainfall for the GBRB for DFJ, and MAM.

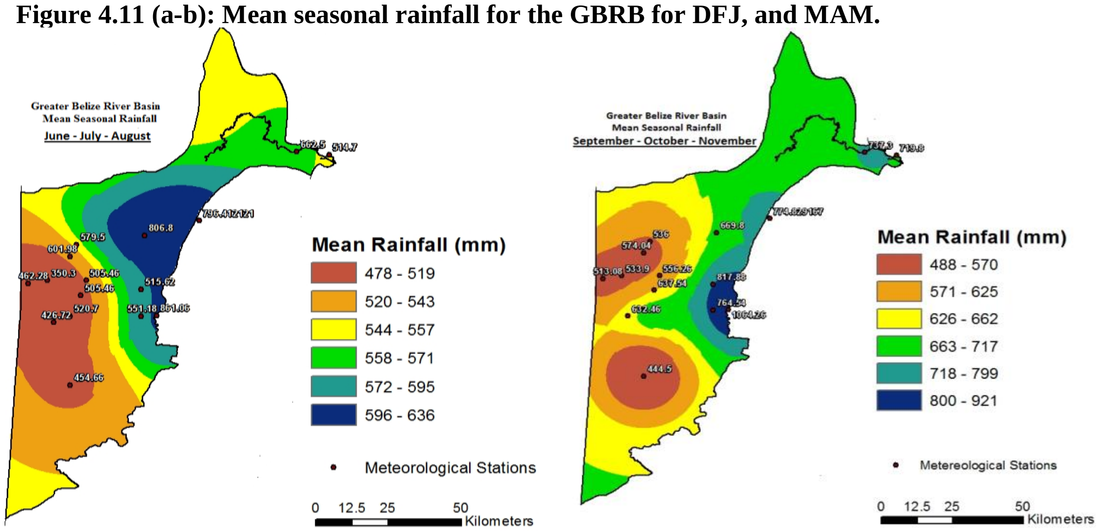


Figure 4.11 (c-d): Mean seasonal rainfall for the GBRB for JJA, and SON.

Table 4.4 provides the seasonal rainfall statistics for key stations in the middle and upper reaches of the watershed. As can be observed, the dry season rainfall accounts for roughly 9 - 14 percent of the mean annual rainfall in the Greater Belize River Watershed, while the rainfall during the cool, transition period is about 18 percent of the mean annual total. The remaining 68 per cent of the mean annual rainfall occurs during the wet months of JJA and SON.

Table 4.4: Seasonal Rainfall Statistics for key Meteorological Station in the Central Zone of Belize

Key Stations in	Mean Seasonal Rainfall (mm)				Annual Mean	Percent of Mean Annual Rainfall (%)			
GBRB (Cayo)	DJF	MAM	JJA	SON	(mm)	DJF	MAM	JJA	SON
PSWGIA	383.2	225.5	662.5	737.3	2008.5	19	11	33	37
Belmopan	370.2	173.1	806.8	669.8	2019.9	18	9	40	33
Central Farm	343.4	164.7	600.7	572.6	1681.5	20	10	36	34
Spanish Lookout	285.0	177.5	579.2	536.0	1578.0	18	11	37	34
Chaa Creek	220.3	183.6	250.3	533.9	1288.1	17	14	27	42
Barton Creek	280.4	151.1	505.4	557.1	1494.0	19	10	34	37
Mollejon	238.8	167.6	426.7	632.5	1465.6	16	11	29	43
Douglas'D Silva	307.3	215.9	520.7	706.1	1750.1	18	12	30	40

(Data Source: 1970-2000, NMS, Belize)

4.2.2 Extreme Rainfall Events

Generally three types of events result in intense rainfall throughout Belize. In June and July tropical waves and disturbance produce widespread thunderstorm activity, which generate intense but localized rainfall. Soil moisture is often below field capacity after the long dry season and runoff would not achieve its full potential, except in urbanized areas. In late August, September and October, Belize normally experience significant and prolonged rainfall during the height of the hurricane season. Substantial runoff occurs, resulting in localized flash floods in the hilly terrain, ponding and inundation along floods plains and low-lying areas. In November through January, significant but less intense rainfall can occur, caused by incursions of frontal systems across the area. During extended and intense dry seasons, ground water table may drop and base flow is the only source of water for the major rivers and tributaries. In the coastal zone of the Belize and Corozal Districts, these recurrent drought conditions result in the advance of the salt-water lens deep into the coastal aquifers. Figures 4.12 and 4.13 show graphs of daily maximum rainfall for some stations in the GBRB prior to 2006.

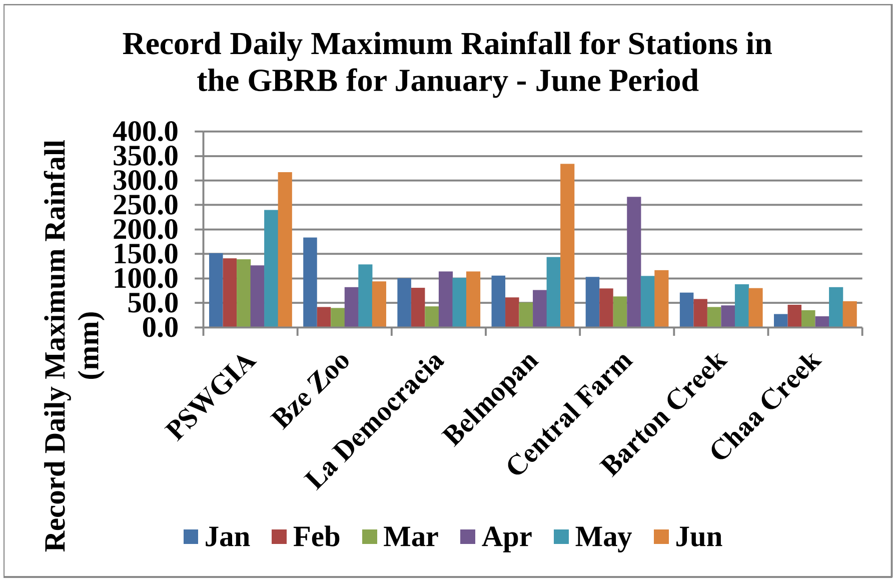


Figure 4.12: Record Daily Maximum Rainfall in the GBRB Jan-June

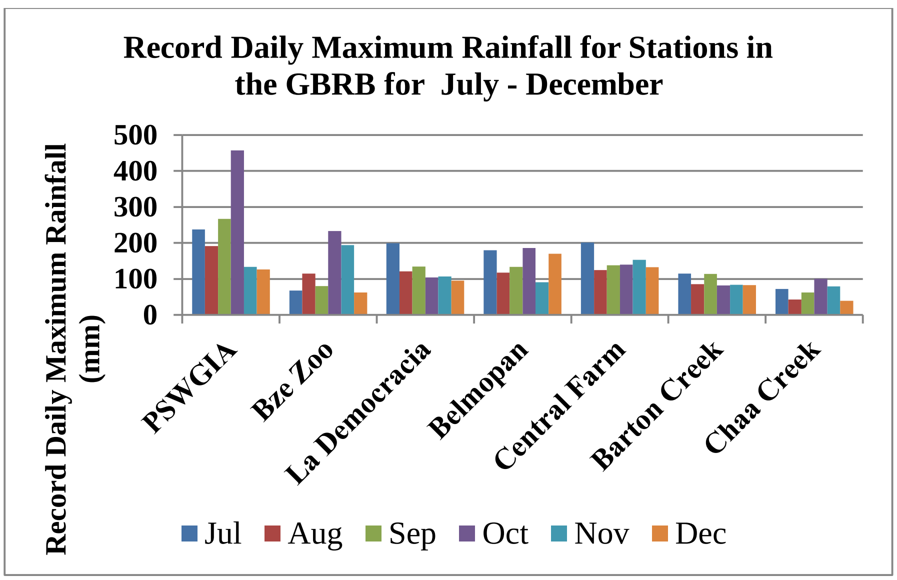


Figure 4.13: Record Daily Maximum Rainfall in the GBRB, Jul. - Dec.

Record daily maximum rainfall of 450 mm was recorded at the Philip Goldson International Airport in October of 2000 associated with hurricane Keith. The second highest rainfall record amounting to 234 mm was recorded at the capital Belmopan in June 2002 associated with a strong disturbance centred in the central region of Belize, which generated a vigorous flood event that severely undermined the Beaver Dam Bridge and caused widespread inundation in the Roaring Creek and Belmopan area. Central Farm also recorded a daily maximum of 267 mm in April 1983, associated with a late season cold front interacting with warm, unstable tropical air.

4.2.3 Tropical Cyclones and Hurricanes

The past two decades saw an upsurge of extreme hydro-meteorological and related events that exposed the vulnerability of the Belize's productive sector, infrastructure and the environment to the destructive effects of the weather. These events ranged from widespread and devastating inundations associated with tropical depression 16 of October 2008 that affected almost a third of country's population that resides and works in the Greater Belize River Basin; to the droughts and heat waves of 2000-2003, and a pandemic Southern Bark Beatle infestation that resulted in a die back of almost 70 percent of Pine forest stands in the Mountain Pine Ridge and the Southern Coastal Pine forest over the three year period of 2001 – 2003. Table 4.5 below is a summary of recent tropical cyclones that made landfall over Belize.

Table 4.5: Tropical Cyclones and Depressions that made landfall on BELIZE, from 2000 to Present

NAME		YR	MONTH	DAY	CATEGORY	SPEED (MPH)	LANDFALL
1	**Richard**	2010	October	24	I	90	20 mls SSW of Belize City
2	**Matthew**	2010	September	25	Tropical Storm	40	Near Monkey River Town
3	**Karl**	2010	September	15	Tropical Storm	60	18 mls NE of Corozal Town
4	**Alex**	2010	June	26	Tropical Storm	65	North of Belize City
5	**TD 16**	2008	October		Tropical Depression		Southern Belize/Honduras/Guatemala
6	**Arthur**	2008	May	31	Tropical Storm	40	Northern Belize
7	**Dean**	2007	August	21	Cat. V	165	Corozal
8	**Iris**	2001	October	8	Cat. IV	145	Stann Creek
9	**Chantal**	2001	August	22	Tropical Storm	60	Corozal & Orange Walk
10	**Keith**	2000	October	1	Cat. V	160	San Pedro Ambergris Caye

Table 4.6 contains a list of six tropical cyclones that affected Belize recently and the estimated costs in losses and damages in US dollars. As can be observed in Table 4.6, the grand total was in the range of 526.2 Million dollars. In the detailed damage assessment per event, it was observed that the agriculture and infrastructure sectors experienced the greatest impacts.

Table 4.6: Estimated costs of impacts caused recent tropical cyclones affecting Belize

No.	EVENT	Date	Sector	Direct Cost	Indirect Cost	Total Damage
			Impacted	US $	US $	US $
1	H. Keith	Oct 1, 2000	ALL	204,779,630	0	204,779,630
2	TS Chantal	Aug. 22, 2001	ALL	8,737,005	11,771,000	20,508,005
3	H. Iris	Oct. 8, 2001	ALL	107,841,500	53,250,925	161,092,425
4	H. Dean	Sep. 21, 2007	ALL	50,279,000	45,350,000	95,629,000
5	TS Arthur	May 31, 2008	ALL	42,806,908	0	42,806,908
6	TD 16	Oct. 30, 2008	ALL	1,390,937	0	1,390,937
						526,206,905

4.3 Overview of the Hydrology of the GBRB

Belize has 39 identifiable watersheds of which 18 are classified as major watersheds and 21 as sub-catchments or sub watersheds, Figure 4.14. Most of these watersheds drain the Maya Mountains and the higher elevation of the interior, and discharge into the Caribbean Sea. The Hydrology Unit of the National Meteorological Service divides the country into four water basin regions, namely: Region 7 in the north, Region 9 in the west and central corridor, Region 11 comprising the coastal plain and coastal slopes, and Region 13 in the extreme South.

4.3.1 Trans-boundary Watersheds.

Belize shares five trans-boundary river basins with neighboring countries. These are: the Rio Hondo Basin with Mexico and Guatemala; the Greater Belize River Basin; the Moho; the Temash River Basin and the Sarstoon River Basin in southern Belize. A small portion of the Usumacinta watershed in Peten, Guatemala extends into the southwestern region of the Chiquibul Forest Reserve in west central Belize.

Figure 4.15 below delineates the watersheds of the Meso-American Barrier Reef System (MBRS), including the GBRB. The elevation is derived from NASA Shuttle Radar Topographic Mission (SRTM) data for 2005. As can be observed, the central and lower reaches of the GBRB

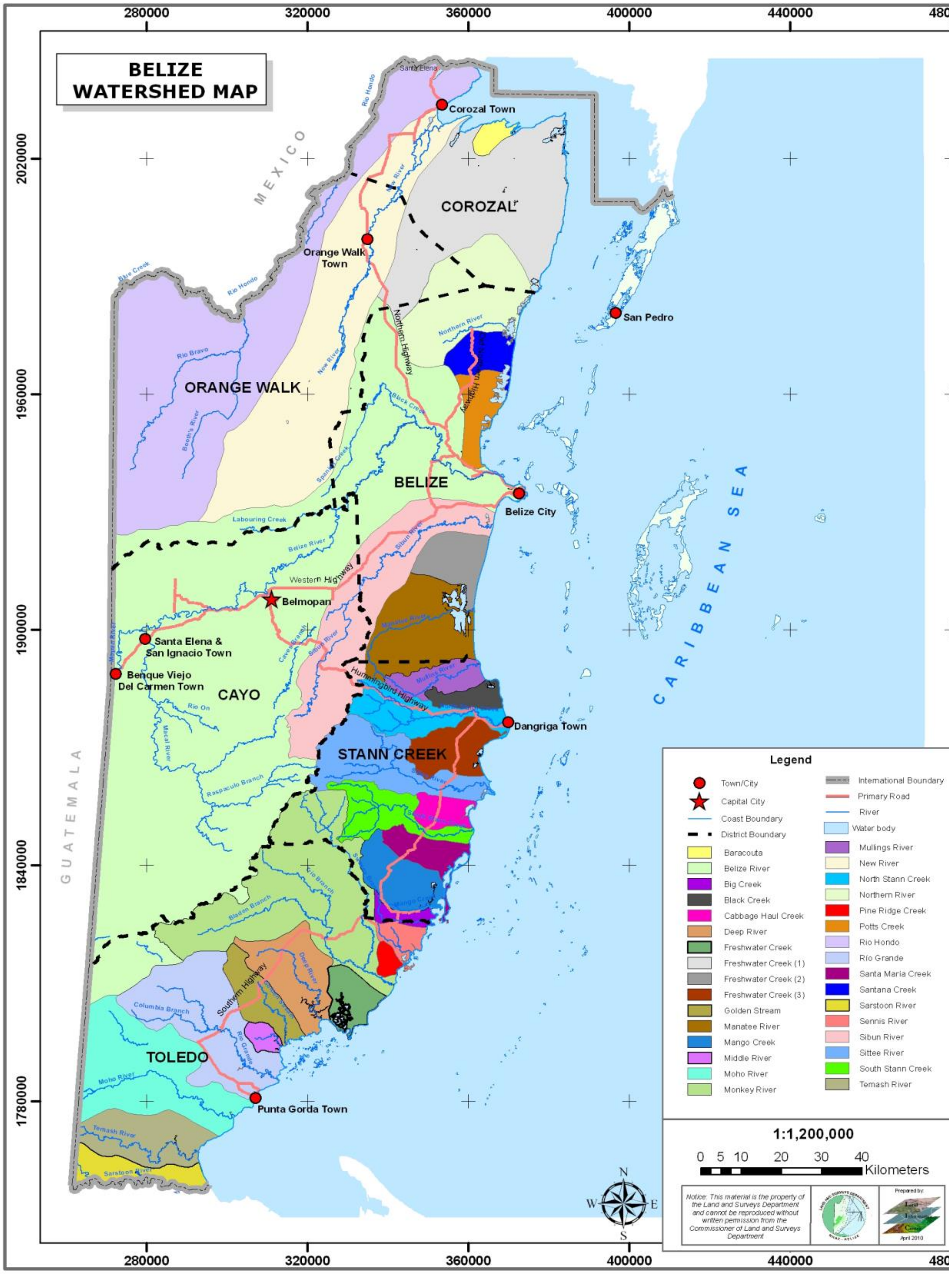


Figure 4.14: Watersheds of Belize (Source: LIC Belmopan, 2013)

is below 140 m, with the higher terrain of the Maya Mountain ranging from 300 to 850 m draining the southern and south eastern sections of the Basin.

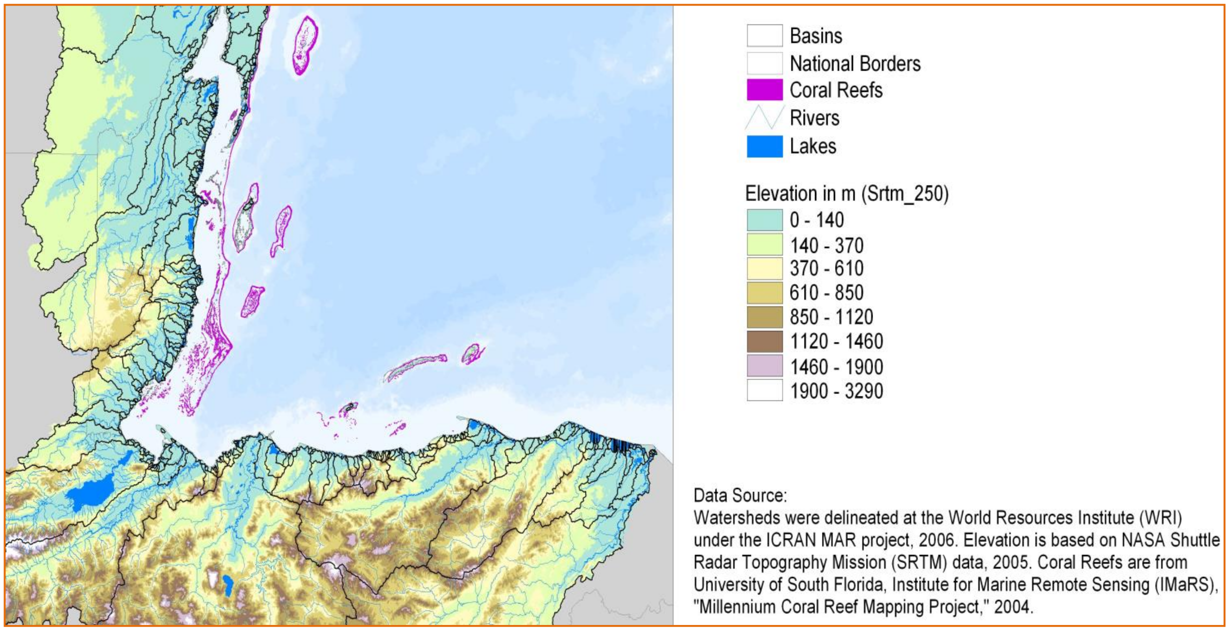


Figure 4.15: Trans-boundary watersheds of the MBRS (Source: WRI, 2005)

4.3.2 Watersheds and Sub-Catchments of the GBRB

The Belize River, the largest within the Belizean territory, originates in the western Maya Mountains and eastern Guatemala. Besides being the largest basin in Belize, it is the most complex watershed. The Western Branch or the Mopan River originates in the southern Maya Mountain at approximately 1000 m AMSL, traverses eastern Peten, Guatemala and joins the Chiquibul River at Cruzadero, Peten. It then meanders northeastward and enters Belize at Arenal. The Mopan then turns northwards for a short distance back into Peten near Melchor de Mencos, then re-enters Belizean territory at Benque Viejo. The Mopan then then continues northeastwards through western Cayo District to its confluence with the Macal River at Branch Mouth, where it becomes the Belize River. The Macal, originates near Baldy Sibun, 1020 m AMSL and travels within Belize receiving contribution from many tributaries before joining the Mopan. The Macal is notorious for its flashy nature whilst the Mopan is a more meandering consistent branch. The topography and physical character of these rivers have a direct bearing on their behavior.

The mid Belize river is a mature river and travels through a well-developed and stable valley. Several major tributaries complement the combined Mopan and Macal contribution, thus maintaining high stages for long periods. Major complementary tributaries include the Iguana Creek, Roaring Creek, and Labouring Creek.

Below Labouring Creek the gradient is very small and the Belize River begins to meander greatly. During periods of high stage flood, waters is forced into the complex Western, Revenge and Northern Lagoon systems in the Crooked Tree area, and Cook's, Cox, and Mucklehony lagoons via Mussel Creek, where it is stored until overland runoff cease. The stored water is then released through Black and Mussel Creeks maintaining flood levels for significant periods of time, before discharging significant amounts of water and sediments into the Caribbean Sea.

In their 2010 study on the vulnerability of the Belizean road systems to flood events, TYPSA identified 10 sub-basins, Figure 4.16. These are: (1) Crooked Tree and Northern Lagoon sub-catchment, (2) Labouring Creek sub-catchment, (3) Beaver Dam Creek sub-catchment, (4) Roaring Creek sub-catchment, (5) Iguana Creek sub-catchment, (6) Barton Creek sub-catchment, (7) the Macal River sub-basin, (8) the Chiquibul River sub-basin, (9) the Mopan River sub-basin, and (10) the Belize River sub-basin. Total area of the GBRB covers about 10,500 km^2. Almost a third of the watershed (3,300 km^2) lies within Guatemala and a little over two-thirds (7,200 km^2) is in Belize.

The lower portion of the GBRB is low-lying, undulating ground with broad flat plains. The plains have shallow groundwater levels and significant standing water, both permanent and seasonal, with characteristically slow-draining lagoons and marshes. These features have slow filling rates and high residence times but do not necessarily add much to the storm water flows that traverse the river from the much larger highland drainage area farther south and west, where considerably more rainfall occurs (DOE, 1995).

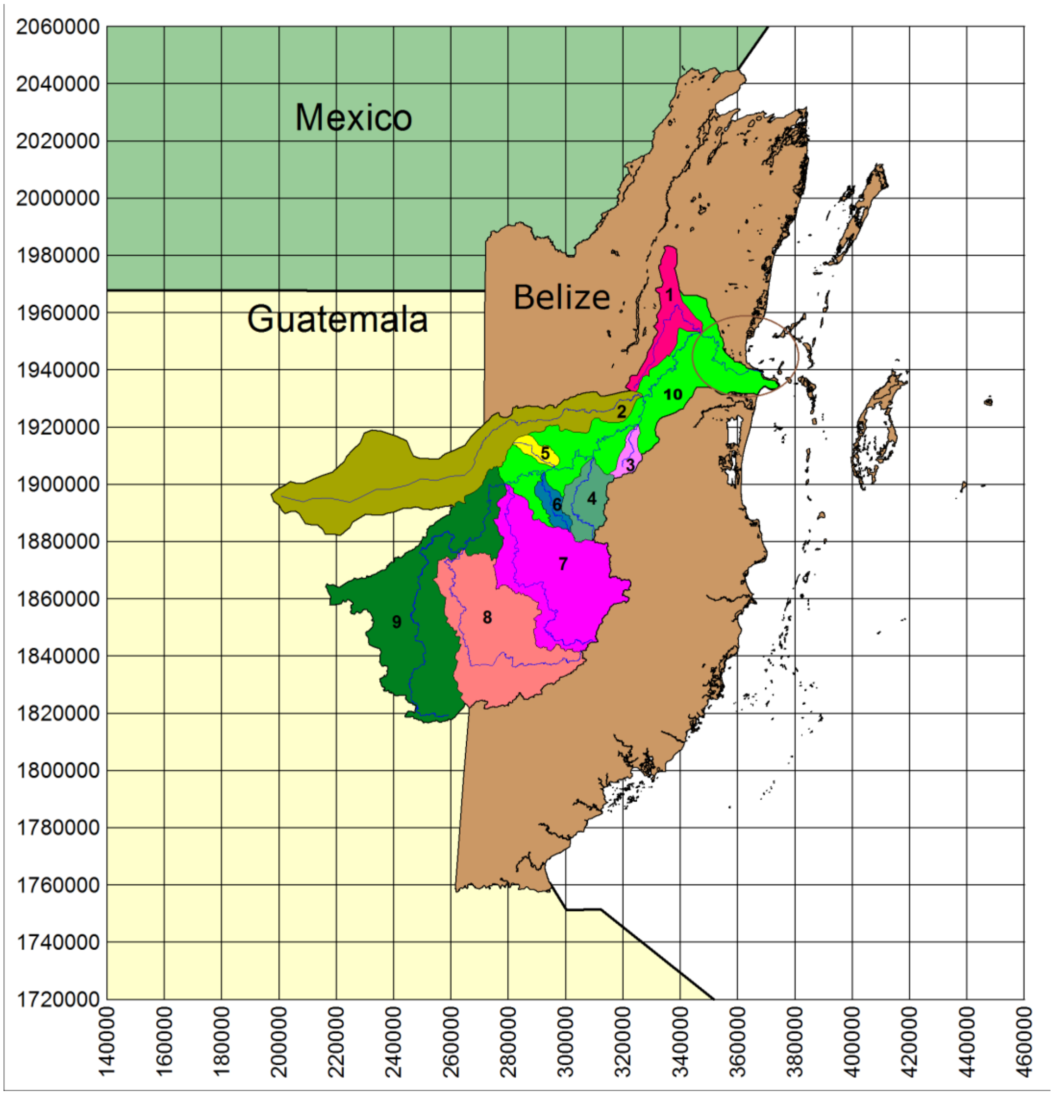


Figure 4.16 Sub-watersheds of the trans-boundary Greater Belize River Basin in Belize and east-central Peten, Guatemala (TYPSA, 2010).

The different travel times and lag-times associated with the runoff from the three distinct sub-basins, namely:

- the distance north draining Western Branch, passing through Guatemala and entering Belize at Benque Viejo;
- the mid-distant northwest-draining tributaries of the Macal River (Eastern Branch); and
- the short flow parts of the main body of the river downstream of San Ignacio, from the north (Spanish Lookout), and from the south Roaring Creek and Barton Creek;

results in an overall attenuated flood curve in which the flood peaks are relatively low, considering the size of the basin and the amount of rainfall received. Added to this natural effect is the artificial flow regime in the Eastern Branch due to the presence of BECOL's two upstream run-of-the-river hydroelectric plant at Vaca and Mollejon, and the Upper Macal River storage facilities and hydro-electric plant at Chalillo. These facilities have contributed in attenuating high flood peaks downstream, after the first of these facilities, the Mojellon run-of-the-river hydro-electric plant, became operational following the restoration to the dam structure which was undermined by a high flood in 2005.

4.3.3 Stream Flows

A summary of the mean annual flow for some of the main rivers and tributaries within the GBRB is contained in Table 4.7 below. The historic mean flow at Mollejon was about 16.2 m^3/s before Chalillo became operational in 2005. The mean annual flow at Benque is estimated as 44.2 m^3/s while upstream in Mopan at Arenal, the estimated mean annual flow is 36.2 m^3/s. Downstream of the Belize at Double Run (the water treatment plant for Belize City and surroundings), the mean annual flow is about 105 m^3/s.

Table 4.7: Mean Annual Flow for River in the GBRB

Site	River	Unit	Period				
			1984-2003	1996-2003	1999-2003	1995-2013	Remark/source
Chalillo Dam	Macal	m^3/s	16.2	13.2	13.4		Mean for periods: 14.3
Mollejon	Macal	m^3/s	19.4	16.4	15.0		Attenuated after Chalillo became operational
Vaca Site A	Macal	m^3/s	25.7	21.9	20.1		Attenuated
Vaca Site B	Macal	m^3/s	25.7	22.2	20.4		Attenuated
Cristo Rey	Macal	m^3/s				32.6	Highly attenuated
San Ignacio	Macal	m^3/s					Highly attenuated
Banana Bank	Belize	m^3/s				60.1	
Big Falls Ranch	Belize	m^3/s				139.0	
Double run	Belize	m^3/s				105.0	
Chiquibul	Chiquibul	m^3/s				19.2	INSIVUMEH, 2004
El Cruzadero	Mopan	m^3/s				15.6	INSIVUMEH, 2004
Arenal	Mopan	m^3/s				36.2	INSIVUMEH, 2004
Benque Viejo	Mopan	m^3/s	44.2			44.2	

(Sources: Gilbert-Green and Associates, 2005 c BECOL Consultant; INSIVUMEH, 2004; NMHS, 2013)

Stream discharge measurements conducted in June and July 2014 for the main channels and some tributaries of the middle and western reaches of the GBRB are summarized in Table 4.8.

The flow at Iguana Creek Bridge (Belize River) was about 45 m^3/s. At the Calla Creek cable-boat crossing (Mopan River) the measured flow was about 24 m^3/s, and at the low-lying bridge at San Ignacio the value was 13.5 m^3/s. The flow at Cristo Rey and San Ignacio are highly variable and controlled by the scheduled water released from BECOL's Chalillo reservoir and the run-of-the-river hydro-electric facilities at Mollejon and Vaca.

Table 4.8: Stream Discharge Measurements of Rivers and Main Tributaries of the GBRB

No.	Site	Mile	LAT	LONG	Rivers / Tributaries	Date	Flow m^3/s	Remarks
1	Calla Creek Cable-boat Crossing	73	17.12	89.13	Mopan	5 Jul-14	**23.67**	Rapids 300 meters upstream, moderate flow. Annual flow at Arenal: 36.16 m^3/s (INSIVUMEH, 2004)
2	Low-lying Wooden Bridge, San Ignacio	70	17.09	-89.13	Macal	28-Jun-14	**13.46**	Controlled flow, varies considerably
3	Central Farm Bridge	62 1/2	17.16	-89.07	Burton Creek	28-Jun-14	**0.03**	Very low, with elevated gravel streambed, numerous obstruction
4	Barton Creek Bridge	60	17.20	-88.96	Barton Creek	4 Jul-14	**0.93**	Low to moderate flow. Rocky bed
5	Iguana Creek Bridge, Blackman Eddy		17.22	-88.91	Belize	28-Jun-14	**45.31**	Very rapid flow of moderate depth
6	Rivera, Roaring Creek	46	17.25	-88.80	Roaring Creek	3 Jul-14	**2.68**	Low flow, elevated gravel streambed above stream level

4.3.4 Sub-basins of the Greater Belize River Basin

4.3.4.1 Upper to Middle Belize River Sub-basin and Iguana Creek

The Belize River watershed, Figure 4.17, drains an area of approximately 1632 km^2 of the main tributary of the GBRB, with elevation above mean sea level ranging from 200 m at the confluence of its two main tributaries, the Mopan and Macal near Branch Mouth Village in the Cayo District, to sea level at its mouth in the vicinity of Haulover Creek just north of Belize City. The Belize River Mouth and Coastal Zone (BRM&CZ) micro-watershed borders the Crooked Tree/Northern Lagoon system (Sub-basin No. 1) in the north and northwest, and extends southeast to the coast in the Ladyville/PSWGIA area and Belize City. It also merges with the Sibun River watershed in the south along the George Price Highway from Hattieville to the coast just north of Freetown Sibun.

Micro-catchment in the ROW of the GPH prone to flash flood within the Belize River Sub-basin are listed below:

1) Red Creek

2) Norland and Garbutt Creek

3) Georgeville

4) Iguana Creek

5) Blackman Eddy

6) S-Curve

7) Teakettle Creek

8) Central Camalote

9) Roaring Creek Bridge

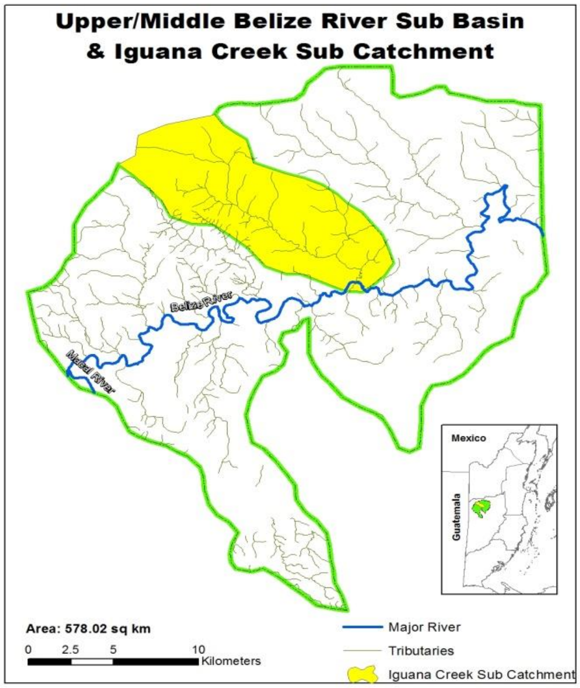


Figure 4.17: Upper/Middle Belize River Sub Basin and Iguana Creek Sub Catchment

4.3.4.2 Mopan and Chiquibul Rivers

The Mopan River has its origin in southern Peten, Guatemala in the vicinity of the community of Mopan 1 in the hilly terrain near the municipality of Dolores, Figure 4.18. The Chiquibul Watershed flows through a large karst landscape that is pocked with sinkholes. The mean annual flow in the Chiqubul River is 10 m^3/s observed near the village of Chiquibul, while the mean annual flow in the Mopan is 36.2 m^3/s. The two hydrological monitoring stations in these rivers in Peten are: Chiquibul and Arenal Villages, respectively. In Belize the hydrological monitoring station for the Mopan River is at Benque Viejo, and the mean annual flow there is 44.2 m^3/s.

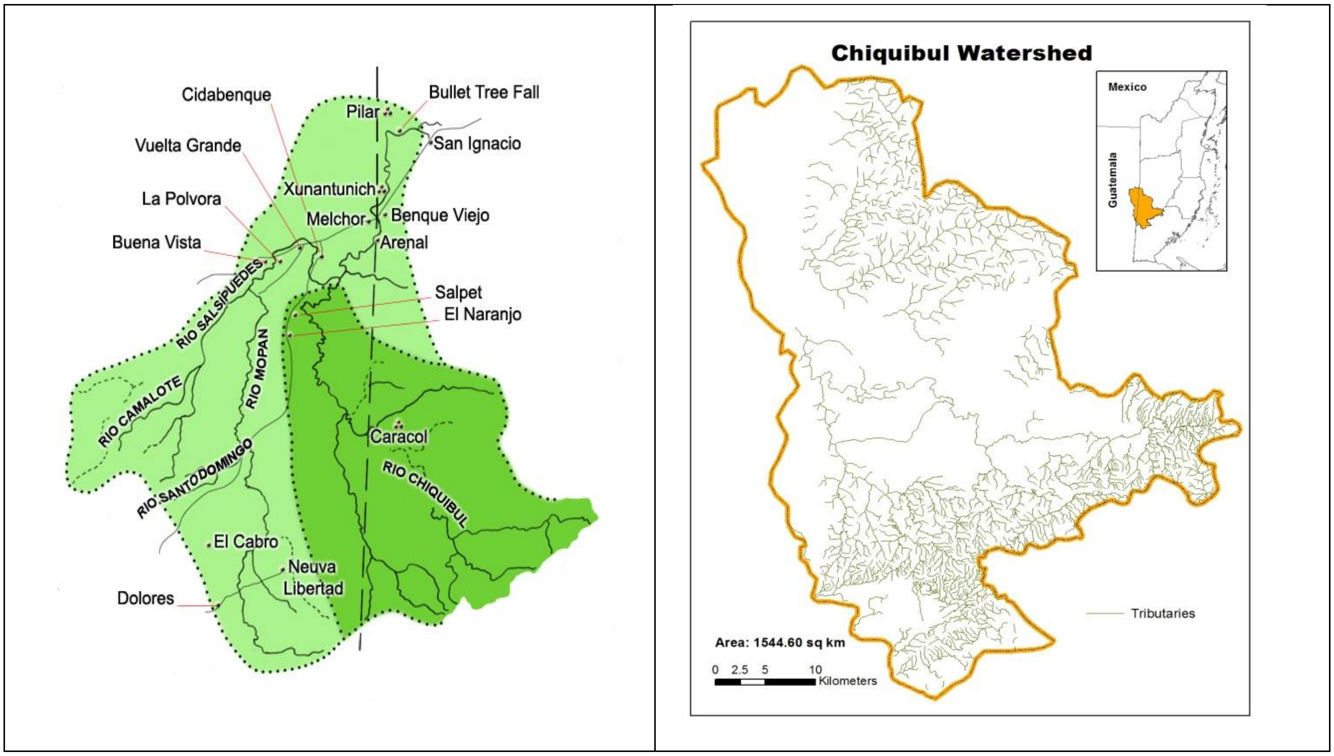


Figure 4.18: Mopan River Watershed and Chiquibul Watershed

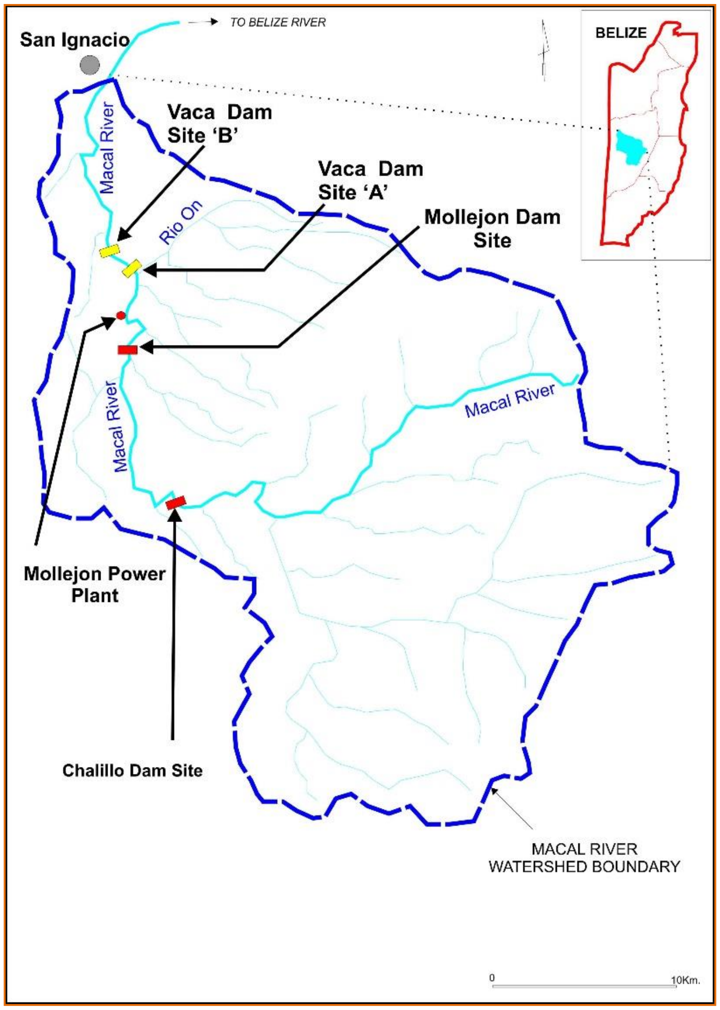
The micro-catchments in the ROW of the GPH prone to flood within the Mopan River sub-basin are: 1) Benque Viejo along the GPH behind RC School; 2) Bridge at the entrance to Benque Viejo del Carmen; 3) Succtoz Village along ROW of the GPH from near basketball court to the exit Culvert

4.3.4.3 Macal River Sub-basin of the Greater Belize River Basin

The Macal River headwaters are made up of many small headwater streams draining out of the Mountain Pine Ridge, Figure 4.19. Very little human activity is happening here out side of selective logging. There are very few inhabited areas, except for a few resorts, Douglas D'Silva Forest Station and

San Antonio. This is an important water gathering ground for the country and should be managed with that in focus.

The flow of the Macal River is regulated by the BECOL's hydroelectirc Macal River Upstream Storage Facility at Chalillo, and the Mollejon and Vaca run-of-the-river hydroelectric plants down stream of the Chalillo dam site. At full capacity the Chalillo reservoir stores 120 million cubic meters of water.



During flood events, excess water entering the dam results in spillage and generates an attenuated flood wave downstream the Macal and Belize River.

Three recent hydrological flood assessments for the Macal River, namely: the OAS commissioned "*Investigation of the flood in the Macal (1995)*" the BECOL " *Maximum Flood and Dam Break Model Study for the Chalillo Facility*", and TYPSA's "*Global Study to Propose Specific Interventions to Reduce the Belizean Road Network Vulnerability to Flooding Events*", provide some measure of the extent of the Maximum Probable Flood affecting areas down stream of the Chalillo Dam site.

Figure 4.19: Macal River Watershed Boundary

Micro-catchment in the ROW of the GPH prone to flashflood within the Macal River Sub-basin

1) San Ignacio / Santa Elena Macal River crossing.

4.3.4.4 Barton Creek Sub-catchment of Belize River

Barton Creek and Roaring Creek drain the northern karst foothill of the Maya Mountain, Figures 4.20 (a) and (b) respectively. Agriculture activity extends from the Mountain Pine Ridge in the south to the Belize River and onwards to Labouring Creek along the northern edge of this area.

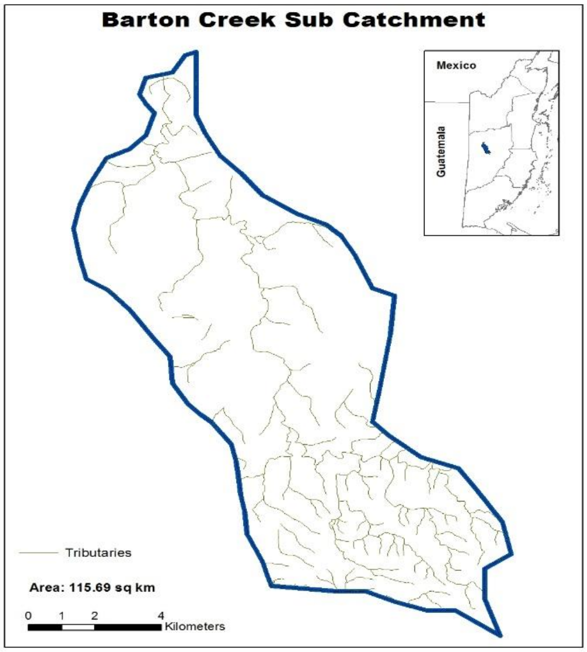


Figure 4.20 (a): Barton Creek sub-basin

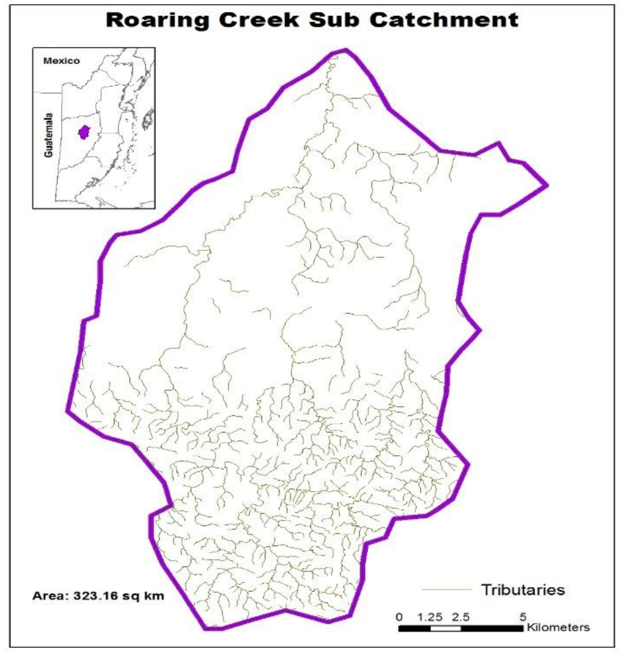


Figure 4.20 (b): Roaring Creek sub-basin

The Barton Creek sub-catchment covers an area of about 115.7 km^2 and like other sub-catchments in the GBRB, consist of dendritic ephemeral and perennial channels. The drainage area of the Roaring Creek is 323.2 km^2. Flow discharge measurements at the Barton Creek Bridge in June 2014 was 0.93 m^3/s, which was relatively low for June, but reflected the below-normal rainfall in the area for the month of June 2014. At the Rivera site on the Roaring Creek near Belmopan, the measured flow in June 2014 was 2.68 m^3/s.

4.4 Rainfall Intensity and Extreme Flood Events

4.4.1 Rainfall Intensity

Rainfall intensity for Central Farm and Philip Goldson International Airport and Central Farm computed from historical for these stations using the Gumbel EV1 distribution are presented in Figure 21 and Table 4.9 below. Rainfall intensities are related to the severity of rainstorm events and the rate of runoff once the soil reaches field capacity. This effect is directly related to the occurrence of flash floods in the Basin which is a frequent phenomenon along many sections of the ROW of the GPH.

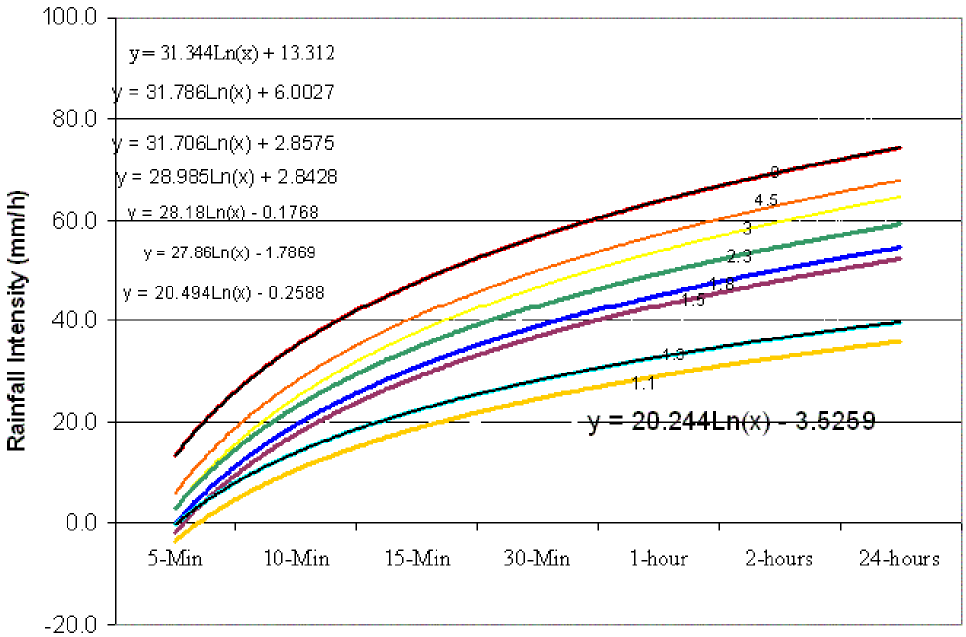


Figure 4.21: Rainfall intensity and Return Period for Central Farm (Source: R. Frutos)

Rainfall intensities and Depth-Duration-Frequency (DDF) curves have engineering applications for culvert and bridge designs.

Table 4.9: Depth-Duration-Frequency table for Philip Goldson International Airport, Belize

Philip S.W. Goldson International Airport Depth-Duration-Frequency (12 years of Rainfall Records 1983-94)									
Duration	**5m**	**10m**	**15m**	**30m**	**60m**	**2hr**	**6hr**	**12hr**	**24h (daily)**
Mean (mm) of highest value	11.2	20.1	28.8	42.2	58.9	72.5	90.7	111.8	149
Std Dev. (mm)	3.1	5.2	13.1	18.4	26.8	25.5	22.3	33.1	46
Return Period									
5 years	14	25	42	61	85	98	113	145	196
10 years	17	29	52	75	106	118	130	170	231
20 years	19	33	62	88	125	136	147	195	265
50 years	22	38	74	106	151	161	168	226	310
100 years	24	42	84	119	170	179	184	250	343
Ratio (d/d24)	0.075	0.13	0.19	0.29	0.39	0.49	0.61	0.75	1
Note: Analysis based on an EVI distribution; BECA International Consultants Ltd, 1994									

4.4.2 Return Period for Maximum Series Flood for the Mopan River

Table 4.10 is a summary of the hydrological statistics for mean, maximum and minimum stage and stream flow on the Mopan River at Benque.

Table 4.10: Hydrological Statistics for the Mopan River at Benque Viejo del Carmen

Benque Viejo	River Level Manually Read [m]												
	Period	1981-2009											
	Jan '88	**Feb '97**	**Mar '97**	**Apr '94**	**May '96**	**Jun '02**	**Jul '81**	**Aug '93**	**Sep '97**	**Oct '07**	**Nov '90**	**Dec '90**	**Annual**
MEAN	0.42	0.31	0.22	0.18	0.17	0.36	0.42	0.4	0.53	0.78	0.71	0.55	**0.43**
MAX 'yr	1.33	0.98	0.58	0.48	1.07	2.93	2.35	1.85	4.79	2.55	2.64	2.42	**4.79**
YEAR	1988	1997	1997	1994	1996	2002	1981	1993	1997	2007	1990	1990	**1997**
MIN.	0.14	0.09	0.04	0.01	0.01	0.01	0.02	0.06	0.09	0.13	0.15	0.12	**0.01**
YEAR	2005	2005	2000	2000	1998	1987	1998	2003	1991	1998	1985	1985	**1987**
Benque Viejo	**Streamflow calculated from manually read water levels [m3/s]**												
	Period	1981-2009											
	Jan '88	**Feb '97**	**Mar '97**	**Apr '94**	**May '96**	**Jun '02**	**Jul '81**	**Aug '93**	**Sep '94**	**Oct '07**	**Nov '90**	**Dec '90**	**Annual**
MEAN	41.6	29.5	21.8	17.9	18	37.3	44.1	39.8	53.6	86	76.8	56.5	**44.2**
MAX 'yr	161	109	57.4	46.2	121	464	343	249	191	384	402	357	**464**
YEAR	1988	1997	1997	1994	1996	2002	1981	1993	1994	2007	1990	1990	**2002**
MIN.	14.6	10.9	7.63	5.83	5.26	5.83	6.41	8.9	10.9	13.8	15.3	13.1	**5.26**
YEAR	2005	2005	2000	2000	2000	1987	1998	2003	1991	1998	1985	1985	**2000**

The daily maximum stream flows were generated by some of the historic flood events in the Mopan River. A graph of the data is presented in Figure 4.22. Table 4.11 is a list of these floods and the date of occurrence.

As can be recalled, Tropical Depression 16 of October 15-25, 2008, generated an unprecedented flood event in the Mopan and Belize River systems, that totally disrupted traffic on the GPH, specifically at the entrance to Benque Viejo Town and San Jose Succotz Village during the period November 15 - 25, 2008, when the water rose an estimated 4 to 5 feet above the highway at some spots. This resulted in total closure of the highway for almost one week, and travellers had to be transported by boat through the flooded highway. Traffic was diverted through a rugged by-pass behind Succotz to Benque Viejo.

An analysis of the maximum streamflow series for Benque was done using three Extreme Value distribution appraoch, namely the Gringorten Equation, the Weibull Distribution and the Gumbel EV1 Distribution.

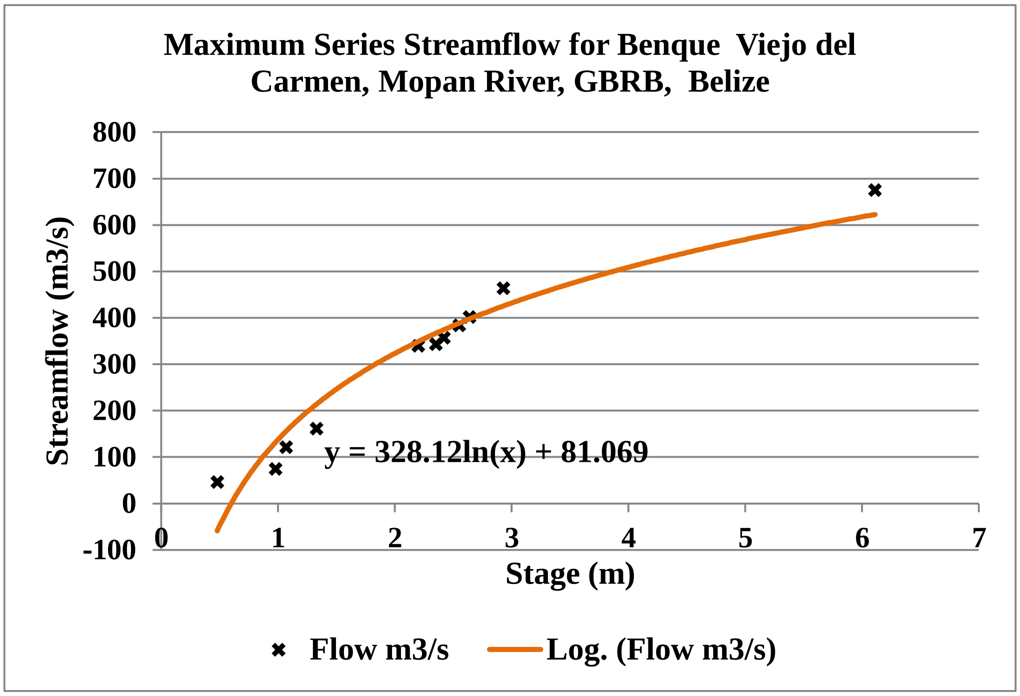


Figure 4.22: Maximum Flood Series and Stage for the Mopan River at Benque Viejo

Table 4.11: Historic maximum stream flow for the Mopan at Benque Viejo

Historic flood related maximum stream flow (m^3/s) for the Mopan River at Benque Viejo					
Year	**Month**	**System**	**Stage (m)**	**Flow (m3/s)**	**Remarks**
1946					Folks reported that similar flood to the 2008 event occurred in 1961 and 1946 in the Succotz Village and Benque area
1961	Oct.	Hattie			Very High stage on the Macal. Moraton area flooded. Mopan not sure how high
1981	July		2.35	343.0	High flow
1988	Jan.		1.33	161.0	
1990	Nov.			402.0	Very high flow
1990	Dec.		2.42	357.0	High flow
1993	Aug.			249.0	
1994	Apr.		0.48	46.2	
1994	Apr.			191.0	
1995	Oct.	TS Roxanne			Mollejon Dam undermined and flood almost reached Burn's Avenue, San Ignacio
1996	May		1.07	121.0	

Table 4.11 (Cont'd): Historic maximum stream flow for the Mopan at Benque Viejo

Historic flood related maximum stream flow (m3/s) for the Mopan River at Benque Viejo					
Year	**Month**	**System**	**Stage (m)**	**Flow (m3/s)**	**Remarks**
1997	Feb.		0.98		
1997	Mar.		0.58		
1997	Sep.		4.79		Very high flow
1998	Oct.	Mitch			
2000	Sep.	Keith			
2002	Jun.	MCC & TW	2.93	464.0	Beaver Dam Bridge on the GPH undermined
2007	Oct.		2.55	384.0	
2008	May-June	TS Authur			Major flood in the Sittee River, washed away the Kendal Bridge
2008	Nov.	TD 16	6.11	674.6	Computed record high flow. Disrupted flow od traffic on the GHP at Succotz Village and entrance to Benque Viejo for an entire week.
2013	Dec.	Prolong Rains	2.2	339.8	Polar Vortex generate very moist and unstable airflow over the NW Caribbean and Belize

The stage and flow for the TD 16 flood at Benque was evaluated from re-assessment of the watermark at the observation site, since the flood level surpassed the 5-meter river gauge that was in place at that time.

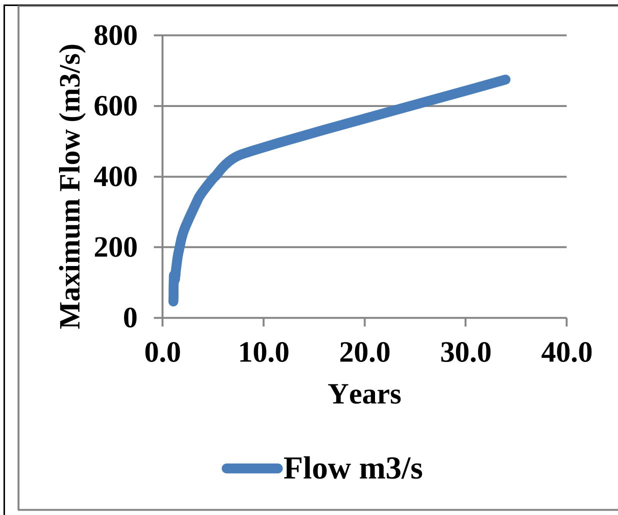


Figure 4.23 a:Return Period for Max Flood on the Mopan River at BVDC, Cayo

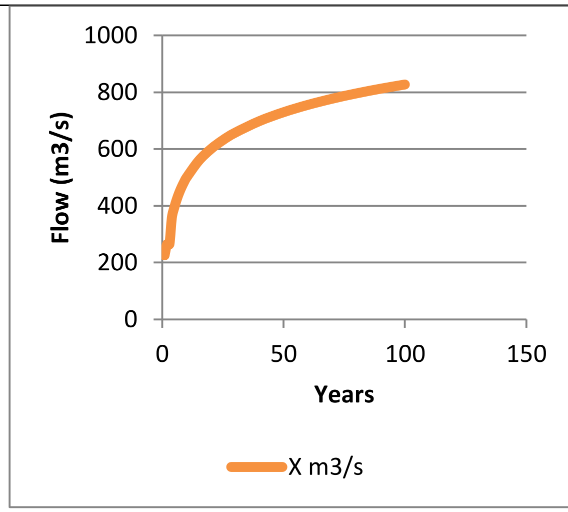


Figure 4.23 b:T-Year Max Flood on the Mopan at BVDC, Cayo

The evaluated stage was 6.11 meters and the computed stream flow estimated from the maximum flow series logarithmic curve was 674.6 m^3/s. The return period from the analysis was 33.9 years, Figure 4.23 (a) for a TD 16-type flood with the Gumbel EV1 distribution. Folks in the area indicated that similar flood events in the Mopan occurred with hurricane Hattie in 1961 and in 1946. An analysis of the T-Year Maximum flood was also evaluated and the resulting curve is presented in Figure 4.23 (b).

4.5 Groundwater Province in the GBRB

Groundwater is product of the rainfall regime and the geology of the landscape. Belize's geology is predominantly limestone, with the notable exception of the Maya Mountains that is composed of igneous, metamorphic, and sedimentary rocks that are from 125-320 million years old. Three main groundwater provinces dominate the GBRB from mid to upper Belize River, the Macal and Mopan River sub-basins (Buckalew, *et al.* 1998). These are the Campur, the Vaca and the Maya Mountain provinces, Figure 4.24.

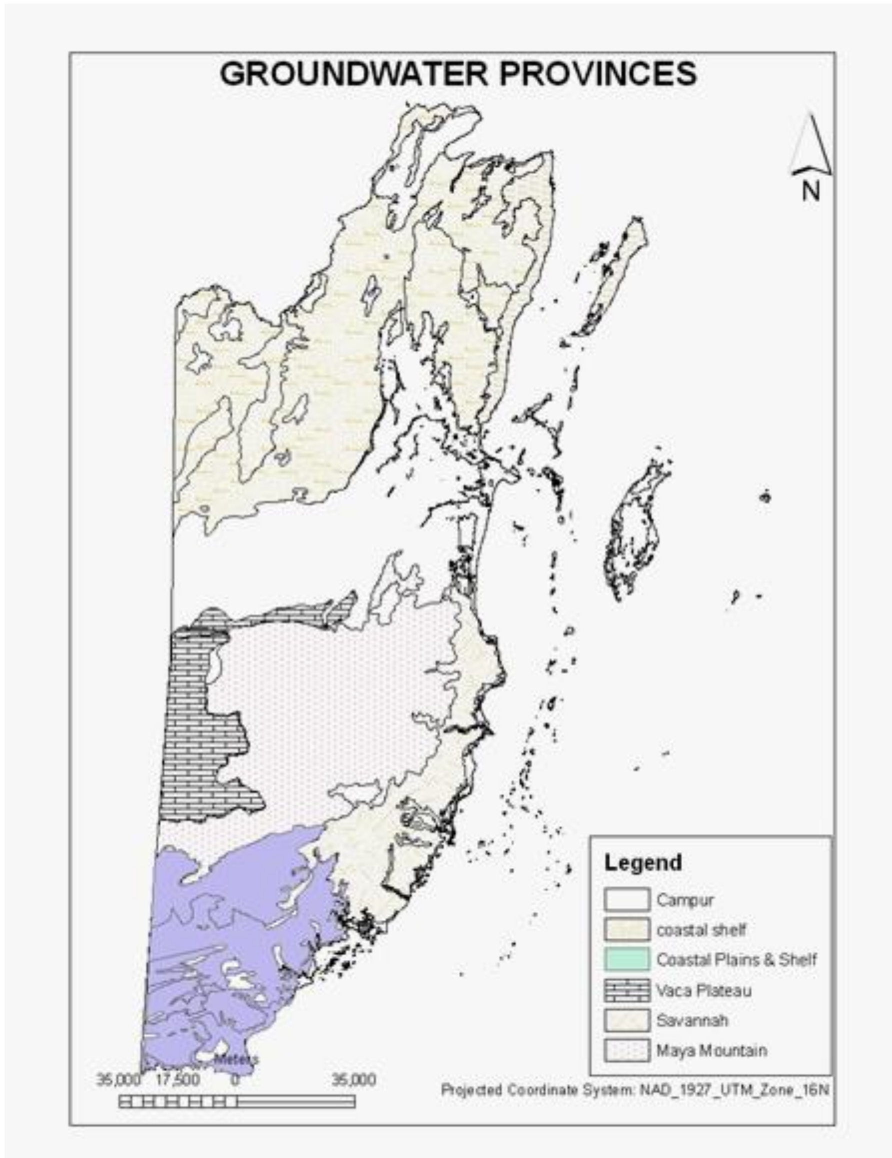


Figure 4.24: Ground Water Provinces of Belize

The Campur: Province coincides with the outcrop of the Campur limestone north of the Maya Mountains extending eastward toward Belmopan and the coast and northward to the boundary of the Coastal Plains & Shelf Province. It includes the northern Cayo District and southern Belize district. In this Province, semi-confined and perched aquifers are primarily quaternary alluvial deposits and Miocene-Pleistocene sedimentary materials that overlie the porous and fractured Palaeocene-Eocene limestone formations. Aquifers in this Province are recharged from direct infiltration and runoff from the Maya Mountains.

Wells in the inland semi-confined aquifers penetrate to depths up to 150 metres with static levels rising to 26 metres below the surface. In the coastal alluvium, deposits well penetrate to a maximum of 32 metres with static water levels rising to near 2 metres below the surface. Confined aquifers were identified at 158 metres in the northeastern portion of this Province.

Maximum inland well yields are near 1125L/min, average hardness is 286 mg/L while in the coastal region maximum yields are near 4000L/min. The confined aquifer yielded 19600 L/min of brackish water.

The Vaca Plateau Province straddles the western border in the northern Cayo district and includes the western slopes of the Maya Mountains. It is composed of fractured and karstic Triassic superior limestone and dolomites. Springs are abundant and aquifers may be semi or unconfined. Aquifers are recharged from surface runoff in the Chiquibul drainage basin.

The Maya Mountains Province: The Maya Mountains Province is composed of late Carboniferous-Permian volcanic material. The rocks have been metamorphosed with abundant dense granitic intrusions. No major aquifer material is expected in this region; however, weathered and fractured metamorphosed mudstones, claystones, phyllites and slates may have exploitable fresh water.

There is no evidence of successful wells tapping this Province. Identification of exploitable groundwater resources in this Province will require advanced remote sensing techniques.

4.6 Water Use and Withdrawals

Internal renewable surface water resources have been estimated at 15.258 km^3/year and internal renewable groundwater resources at 7.51 km^3/year (IGRAC, 2012). The overlap between surface water and groundwater being estimated to be 100 percent, total internal renewable water resources are thus 15.258 km^3/year (Ballesteros, Reyes and Astorga, 2007). The flow of the border river Hondo with Mexico is estimated at 0.864 km^3/year, of which 50 percent or 0.432 km^3/year is counted for Belize. The flow from Mopán and Sarstún rivers from Guatemala is estimated at 6.042 km^3/year. This brings the total renewable water resources to 21.732 km^3/year, Table 4.12. The total actual renewable freshwater resources per capita in Belize were 67.074 thousand cubic meters in 2012.

Table 4.12: Water Resources of Belize			
Renewable freshwater resources:			
Precipitation (long-term average)	**-**	**1,705**	**mm/yr**
	-	**39,160**	**million m^3/yr**
Internal renewable water resources (long-term average)	**-**	**15,258**	**million m^3/yr**
Total actual renewable water resources	**-**	**21,732**	**million m^3/yr**
Dependency ratio	**-**	**30**	**%**
Total actual renewable water resources per inhabitant	**2012**	**67,074**	**m^3/yr**
Total dam capacity	**2013**	**122**	**million m^3**
			Source: FAO Aquastat 2013

The total water withdrawal of 95 million m3/yr is negligible compared to surface water resources. Groundwater is a source for the main towns in the Corozal, Orange Walk, Cayo and Toledo Districts and many rural communities in Toledo and Cayo.

A new Integrated Water Resources Agency has been established (2010) with responsibility to assess the water resources. There is need for aquifer analysis to determine the current yield and sustainability. Abstraction to service rural areas is carried out by drilling a number of wells until a feasible location is found.

Increases in water demand resulting from expansion in the agricultural, industrial and tourism sectors, along with a growing population and watershed destruction make it imperative that urgent attention be given to the proper management, use and understanding of the freshwater resource. The national Integrated Water Resource Management Policy, 2008, highlights that there is a need to conduct a proper and comprehensive assessment of water resources and develop baseline of water quality for the various uses of water.

In relation to the GPH rehabilitation project, water use will be primarily for wetting the road and mixing concrete. Water for such purpose will be available from streams and nearby rivers. Material from road construction and solid waste may enter exposed water channel from surface runoff during heavy rain events in the construction phase. Bottled water will be the preferred water for construction crew.

4.7 Climate Change

The impacts of climate change resulting from global warming are expected to threaten the sustainability of social, economic and ecological systems. Coastal zones in tropical regions are especially vulnerable. Rising sea levels are expected to threaten low-lying coastal areas and islands, with increase evidence of erosion, flooding, inundation, and salinization of surface and groundwater resources.

Climate change is expected to intensify the hydrological cycle. Warmer temperatures caused by an increase in the amount of greenhouse gases are expected to increase the rate of evaporation and the capacity of the atmosphere to hold water vapor. Differential heating between different land and sea surfaces will result in enhanced convection over some areas and increased subsidence in others at different times of the year. This will result in more intense storm events and incidences of drought. Seasons may change by becoming shorter or longer.

Global projections of future sea level rise range from 0.18 to 0.59 meters relative to the average for 1980-1999 by 2099, however sea level rise are not expected to be geographically uniform. Sea level rise in the Caribbean region by the end of the 21st century is expected to range from 0.44 m to 0.70 m for the high climate model scenario.

The future climate for Belize will likely be characterized by increasing temperatures and declining levels of precipitation possibly arising due to a shift in the rainy season and extended dry season. One study projected a median temperature increase of 2.0 degrees Celsius (3.6 degrees Fahrenheit) for the Caribbean region and 3.2 degrees Celsius (5.7 degrees Fahrenheit) for the Central American region, and they project a median decrease in annual precipitation of 12% for the Caribbean region and 9% for the Central American region (Belize and Climate Change: The Costs of Inaction, 2009). Average annual temperatures are expected to increase 3.5 degrees Celsius (6.4 degrees Fahrenheit) over the 90-year period, while average rainfall is expected to decrease by 100 mm (IPCC, 2007). The damages to infrastructure from sea level rise and economic effects to tourism losses being the largest contributor to Belize GDP, will be highly impacted (Belize and Climate Change: The Costs of Inaction, 2009, UNDP). Haites *et al.* (2002) cite potential effects of climate change on the coastal zone, including the loss of beaches due to erosion, degradation of ecosystems (e.g. coral reefs), inundation and damage to infrastructure.

4.8 General Ecology of Project Area

4.8.1 Introduction

This sections deals with the findings of the ecology of the area of study which covers the western part of the George Price Highway (Belmopan/Roaring Creek to the Belize-Guatemala Boarder at Benque Viejo del Carmen) between miles 47.9 and 79.4 and the rehabilitation of Roaring Creek Bridge Mile 48. The area of direct environmental and social influence (ADI) is defined as a band 4 km east and 4 km west of the centerline of the current road along the project length.

4.8.2 Soil Type and Vegetation

In an undisturbed natural environment, floristic patterns are strongly determined by soil types. At the junction of the George Price and Hummingbird Highways, the soil is primarily dominated by alluvial sediments deposited by the movement of water along the Belize River and its various tributaries and floodplains. Underlying this area is Cretaceous limestone, which often occurs as outcrops peaking above the alluvial sediments. This general edaphic pattern carries on throughout the villages of Roaring Creek, Camalote, Teakettle, Ontario, Blackman Eddy (Road Section 1), and on to Unitedville, Georgeville, Central Farm, and Esperanza (Road Section 2). A change occurs at Santa Elena toward the Santa Rosa group of soils, which are deeper and more acidic. A shift in vegetation occurs at this point but extends only a short distance across the Macal River until the limestone outcrops begin again at Cahal Pech. The soils from Cahal Pech to Benque (Road Section 3), consists primarily of shallow deposits inter-bedded between rocky limestone outcrops which themselves are covered in skeletal soils supporting xeric vegetation.

The area is underlain by Cretaceous limestone, which is a part of the larger block extending into the Vaca plateau, Figure 4.25. However, the natural floristic patterns along this corridor have been seriously disturbed and altered by past and present human settlements and activities.

The mahogany industry gave rise to numerous settlements along these river systems with the Belize River becoming the most important. Travel from San Ignacio, which was formerly known as El Cayo, so named because the Mopan and Macal Rivers give the area the form of a caye, was by pit pans. Travel by pit pans was quite an adventure as travellers needed to be well prepared for a very time consuming trip. These settlements along the Belize River became very important stopping and trading places for pit pan travellers.

It is not surprising that the alignment of the section of the George Price Highway from its junction with the Hummingbird Highway to San Ignacio parallels the upper reaches of the Belize River. These communities established along this section of the highway have developed lifestyles that depend on the river system and the highway.

4.8.3 General Flora Description along the George Price Highway

Section 1 Mile 47.9 – 56 Belmopan Junction – Iguana Creek Road Junction

Section 2: Mile 56 – 65 Iguana Creek Road Junction to Red Creek Bridge

In the 1950's, the Mennonites entered into an agreement with the then Governor of British Honduras to settle in Belize. Their contribution to the then colony was to develop the agricultural sector particularly in rotational grain crops and chickens. The Mennonites have since cleared the forests in the western and north-western banks of the upper reaches of the Belize River particularly in areas of Spanish Lookout, Duck Run 1, 2 and 3 and Iguana Creek. These areas are now transformed and used for intensive agriculture to grow rotational crops such as corn and beans. Extensive areas are also used for cattle ranching. In these areas under intensive agriculture, few trees are found. Occasionally, isolated cotton trees (*Ceiba pentandra)* and the Guanacaste trees (*Enterolobium cyclocarpum)* are found and these serve as shade for livestock. Figure 4.26, illustrates the vegetation cover of study area.

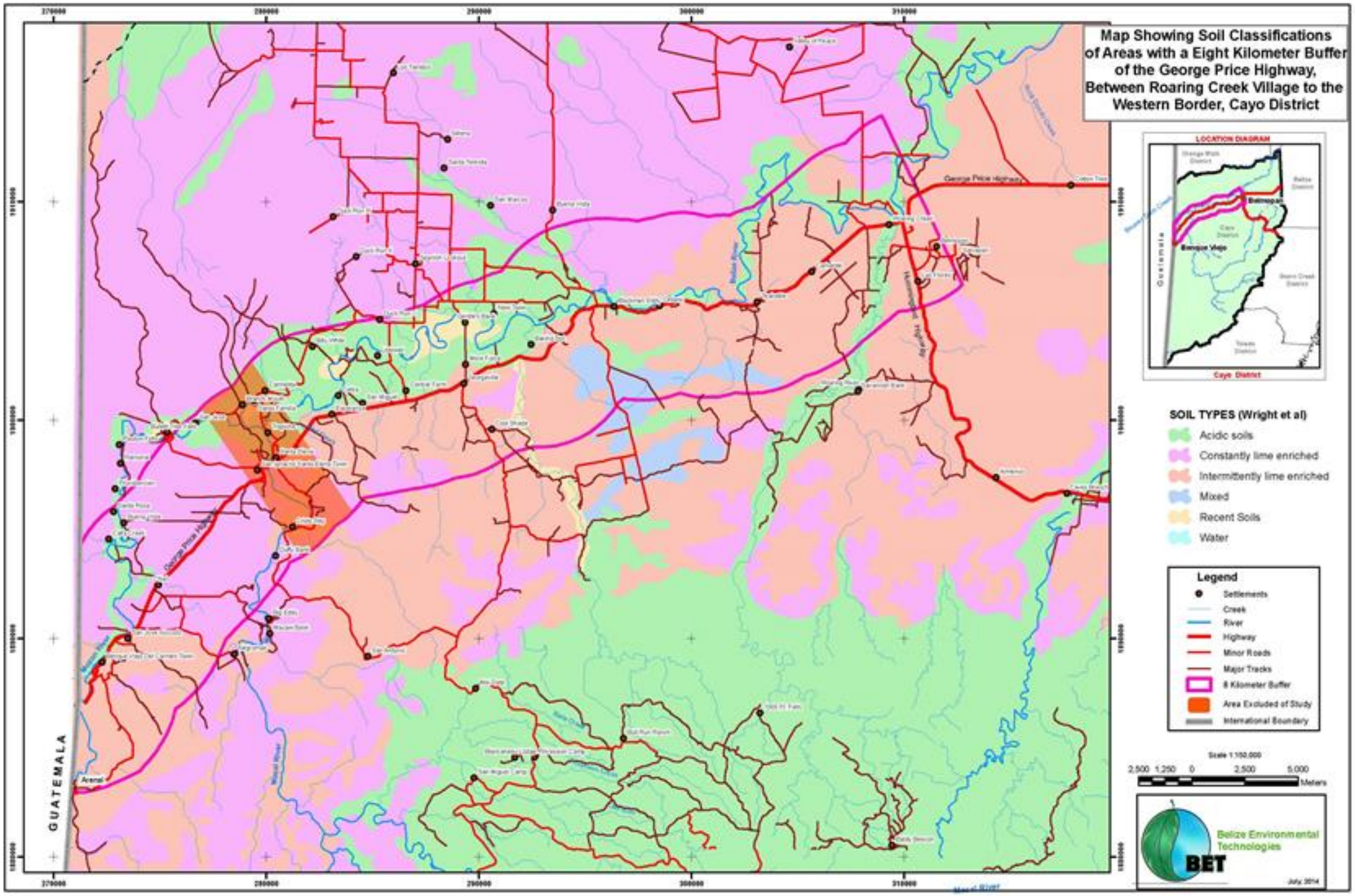


Figure 4.25: Soil Types of Area of Interest.

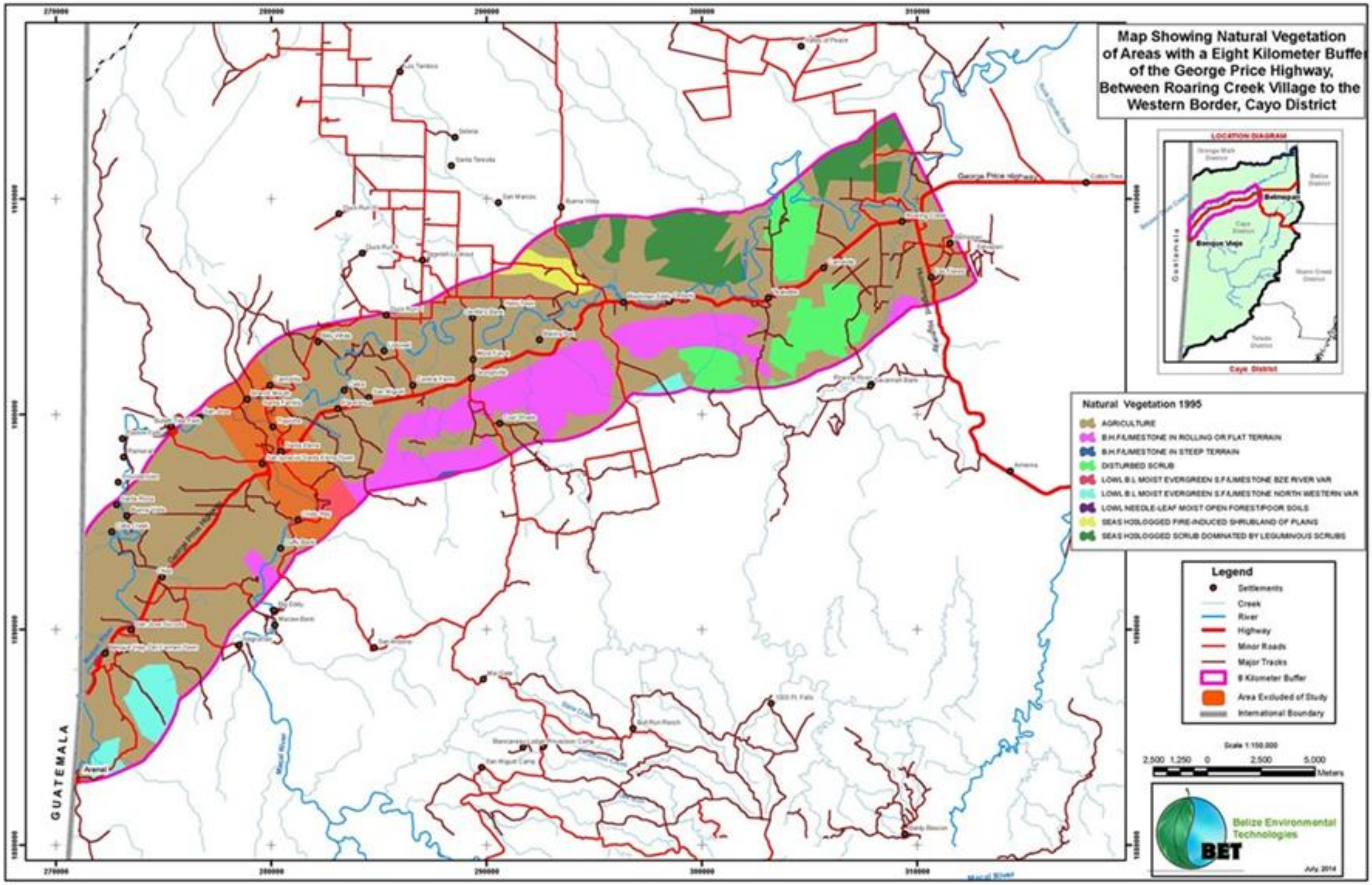


Figure 4.26: 2001 Forest Cover, Vegetation and Settlements.

Large landowners, along the George Price Highway between the areas known as Floral Park to Norland have transformed large tracks of land for cattle ranching and grain crop agriculture. Large citrus orchards and coconut groves have also been planted in these areas. The area known as San Miguel, which is adjacent and to the south of Norland have large citrus orchards and coconut groves.

It is noteworthy to mention that there are teak (*Tectonia grandis)* plantations west of the Guanacaste National Park, east of the Village of Camalote. These also exist west of Blackman Eddy in the Iguana Creek area and both sides along the Warri Head section of the road in the vicinity of the "Z" Curve and in the Negroman area which is located east of Chial (Figure 4.27). In addition, Physic nut (*Jatopha sp.)* has been planted in an area east of Blackman Village. The *Jatropha* seeds were intended to be used for the production of biofuels.

Figure 4.17: (Top L-R) Teak plantation after the "Z' Curve and mechanized maize cultivation. (Bot. L-R) Orange orchard and pasture land.

The various communities along this section of the highway have fruit trees such as mangoes, breadfruits, avocados, plums, mamey and coconuts which are the most commonly planted species in back yard plots.

In the north eastern region of the Maya Mountains, through which a portion of the George Price Highway passes, the forests along the foot hills, have been cleared to give way to cattle ranching. Where these areas have been abandoned early succession secondary forests are colonising. Bay Cedar (*Guazuma ulmifolia)* appears to be the dominant small tree colonizer as it occurs abundantly in dense stands. Cedar *(Cedrela odorata)* also occurs frequently in the upper slopes with a limestone base. The characteristics of these cedars are very branchy due to being affected by the shoot borer *(Hypsophilla grandiola).*

Section 3: Mile 67 -79.4 Buena Vista Street, San Ignacio Town to Benque Viejo Border

The corridor between Cahal Pech to the Belize Guatemalan border supports xeric vegetation on Cretaceous limestone. Agriculture in this section of the corridor is limited to cattle ranching with small areas under intensive agriculture. Intensive agriculture is confined to small areas in the Chial area which is located approximately midway between San Ignacio Town and the Village of Succotz. At the very entrance to Succotz from San Ignacio is a stream that only flows during the rainy season. When the Mopan River is flooded this area tends to inundate making the road impassable. The vegetation along this stream particularly where it empties into the Mopan River is dominated by dense stands of cedar (*Cedrela odorata).* These cedar stands have also sustained infestation by shoot borers. At the very first traffic bump in Succotz is a Monkey Apple tree (*Lacania sp.)* whose Mayan name is Succotz, from which the village got part of its name.

4.8.4 Study Area Flora Survey

4.8.4.1 Survey Methodology

The methodology employed to identify the floral diversity of the study area was to travel the road identifying all trees that were seen. In addition, one 200-metre transect was measured and all trees 10 metres on both sides of the transect were recorded. The transect was randomly chosen on a map and subsequently translated to the ground. Since the vegetation types are very similar due to having been disturbed, it was decided to only measure one transect.

A total of 142 tree species were recorded (see annex ---) along the study area and their locations were labelled as being populated to indicate that the species was identified in a village or settlement; riparian to indicate that it occurs along river or streams and plantations where the tree species were planted in forest plantations.

4.9 Terrestrial Fauna

Habitat lost to wildlife has resulted not only from highway construction but also from timber harvesting, agricultural conversion, urban and residential development, and other factors. Habitat fragmentation is commonly observed in Belize as few species use all the patches of a landscape. Their survival depends on their ability to move from one patch to another. As landscapes become increasingly fragmented by busy roads, housing developments, commercial areas , and other human activities, wildlife habitat is divided into ever-smaller pieces of land for animals to accomplish everything they require; find food and water, establish territory, reproduce, and meet the rest of the specific living requirements. Roads and highways are excellent for connecting people to their destinations, but they can disconnect many wildlife species from essential habitats.Smaller populations are less stable and over time, face extinction from predators or natural causes. They may also be more susceptible to inbreeding and to genetic defects.

Habitat fragmentation threatens all wildlife species that have to cross roads to meet their biological needs. Forest carnivores are particularly vulnerable; they are at risk because of their small populations, low reproduction rates, and large home ranges.

Despite fragmentations, riparian habitats continue to be important for the survival for many species even despite this mosaic landscape. Small troops of howler monkeys have been observed at the Guanacaste National Park, at the “Z” curve and on a site visit (June 21 2014) two howler monkeys were seen near Galen University by the creek side. In addition, iguanas, gibnuts, wild rabbits (agoutis) and the white collared peccaries have been observed using some riparian areas such as in Floral Park, this perhaps is due to the riparian forested habitats that serve as important biological corridors connecting habitats in the north-western region of the Maya Mountains to the riparian forest of the Belize river.

Other wildlife that has commonly been observed along the corridor are: armadillos, foxes, opossums, skunks, coatimundi and squirrels. Farmers have also complained about crops being damaged by wildlife tapirs and peccaries, also about predation of their sheep and cattle by jaguars. For a more comprehensive listing of species encountered along the George Price Highway from its junction with the Hummingbird Highway to the Belize Guatemalan border see Annex V.

4.10 Aquatic Fauna Mopan/Macal/Belize

4.10.1 Introduction

The topography and rainfall in Belize vary considerably causing a parallel variation in freshwater fish faunas, which are associated with different regions. The coast is bordered by mangrove swamps that connect to continental lagoons. This change in habitat provides a transition from brackish to fresh water.

Belize has a total of thirty-five (36) major and minor river catchments or watersheds which drain into the Caribbean Sea. The watersheds can be divided into the northern, central, southeastern and southern watersheds. This information focuses on the central watershed, which includes five rivers of which three of them flow within the area of interest, namely the Belize River, the Mopan River and the Macal River.

4.10.2 Freshwater Fish Species Composition

In regards to the available of data, there is general information on the species occurring within the area and the most comprehensive has been the species listed in previous work by Thomerson & Greenfield (1972, 1997). Other fish species profile for Belize can be accessed in the FishBase website (www.fishbase.org) as well as in the Belize biodiversity (http://biological-diversity.info/Fish_freshw.htm) information website. Independent researchers and consultants have conducted very little technical work in the project area. There exist a little more information on the aquatic ecosystem of the Macal River given its associated developments of three established dams for hydroelectricity generation and post-development assessments of the aquatic ecology.

The continental fish of Belize are classified into three different categories a) freshwater fish that live only on freshwater whose evolution has been freshwater, b) freshwater fish that live primarily on freshwater but that have salt tolerance and have distant relatives from the sea and c) peripheral freshwater fish that have great salt tolerance. It is interesting to note that among the continental fish faunas there are low number of ostariophysans (minnows, catfishes and relatives) (Greenfield and Thomerson, 1997).

The primary freshwater fish are represented by three main families: Characidae, Pimelodidae and Ictaluridae. The secondary freshwater fish are represented by five families: Poeciliidae, Cyprinodontidae, Rivulidae, Cichlidae and Synbranchidae while the peripheral freshwater fish are represented by thirty-five families consisting of seventy-seven species.

4.11 Rapid Fish Survey of the Project Area

A rapid fish survey of was carried out between June and July of 2014 to establish the range of species within the headwaters of the Belize River, including the Mopan and Macal rivers, as well as those species in the three main creeks draining in the mid-reaches of the Belize River – the Garbutt Creek, Barton Creek and the Roaring Creek.

The rapid species assessment was conducted in three major rivers, which include the Mopan, Macal and the upper Belize River from the point of the Roaring Creek/Belize River branch upstream. This was necessary given that the available baseline data is general in context and not site-specific. The survey period coincided with the end of the dry season with all sampled sited having a lotic environment.

Apart from the riverine assessments, three principal creeks draining into the Belize River were sampled. This included the Garbutt Creek passing through Central Farm, the Barton Creek passing through Riverwalk Nursery and the Roaring Creek. All three creeks cross the George Price Highway.

The sampling methods included the used of fine mesh cast nets, hand lines and visual surveys. All species collected were counted, photographed and identified to the species level. The methods deployed have been used extensively in previous species identification efforts, in addition to the use of fish traps for capturing eels and shrimp species as well as the use of electrofishing gears. During the survey, local residents were also interviewed in regards to current fishing activities and other general species observation in the area.

In general, the species distribution within all sampling points was consistent in which a total of 24 fish species were documented during the studies. The species composition was limited to 20 species commonly occurring in all of the sampled sites, with three species found in the three rivers and one species - the Threadfin shad (*Brycon guatemalensis*) was site specific occurring from the Vaca Dam downstream area to Cristo Rey area in the Macal River (Table 4.13). The Threadfin shad can be found in fast flowing waters given their migratory pattern during their life cycle. The small Cichlid species such as the Yellowbelly cichlid (*ex-Cichlasoma salvini*) and the Blue-eyed cichlid (*Cryptoheros spilurus*) were commonly occurring in all sampled sites as well as Green swordtail (*Xiphophorus helleri*), the Shortfin molly (*Poecilia Mexicana*), the 'Butasi' (*Rhamdia laticauda*), Belize silversides (*Atherinella spp.*), Pike killifish (*Belonesox belizanus*) and the Central tetra 'Billum' (*Astyanax aeneus*). The presence of larger cichlids was also recorded, as well as the Blue catfish (*Ictalurus furcatus*) in the area of study.

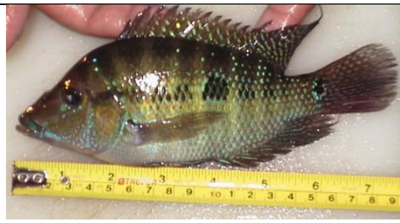
In addition to the species listed above, two euryhaline, diadromous species have been recorded in the main river systems. This include the Tarpon (*Megalops atlanticus*) and the Common snook (*Centropomus undecimalis*) caught by fishers in the past. These species have been reported in previous mercury sampling efforts in the Macal River (BECOL Mercury Assessment Reports, 2000-2013). The presence of the American eel (*Anguila rostrata*) was also observed during the visual surveys as well as species of *Macrobrachium* shrimp.

In general, the fish diversity and abundance were low in numbers in fast flowing shallow areas which ranged between three to six feet in depth with clear waters and highest fish densities found in deeper open areas of smooth laminar flows. The most abundant species recorded was the 'Billum' followed by the Shortfin molly.

Table 4.13. Fish of the Upstream Belize River, Mopan River and Macal River.

Common Name / Scientific Name	**Specimen**	**Occurrence & Feeding behavior** (After Keenleyside, 1979; Thomerson & Greenfield, 1997)	**Common Name / Scientific Name**	**Specimens**	**Occurrence & Feeding behavior** (After Keenleyside, 1979; Thomerson & Greenfield, 1997)
'Billum' Central tetra (*Astyanax aeneus*)		All Sites Herbivorous grazer and adults are primarily zooplanktivore	Yellowbelly Cichlid (*ex-Cichlasoma salvini*)		All Sites Carnivorous
Blue-eye Cichlid (*Cryptoheros spilurus*)		All sites Omnivorous	Green Swordtail (*Xyphophorus helleri*)		All sites Omnivorous and feeding mainly on plankton
Two Spot Livebearer (*Heterandria bimaculata)*		All sites Herbivorous, mostly filter feeder	'Pupsi' Shortfin Molly (*Poecilia mexicana*)		All sites Herbivorous, mostly filter feeder
'Butasi' Filespine Chulin (*Rhamdia laticauda*)		All sites Carnivorous	Mountain Mullet (*Agonostomus monticola*)		Site 1, 2, 3 Omnivorous, mostly feeding on plankton

Firemouth Cichlid (*Thoricthys meeki*)		All Sites Omnivorous	Bigmouth Sleeper (*Gobiomorus dormitor*)		All Sites Highly Carnivorous
Belize Silversides (*Atherinella spp.*)		All Sites Herbivorous	Pike Killifish(*Belonesox belizanus*)		All Sites Carnivorous
Blue Catfish (*Ictalurus furcatus*)		All Sites Omnivorous	'Tuba' Redhead Cichlid (*Paratheraps synspilus*)		All Sites Omnivorous
Baysnook (*Petenia splendida*)		All Sites Highly Carnivorous	Northern Checkmark Cichlid (*Chuco intermedium*)		All sites Omnivorous
Tilapia (*Oreochromis niloticus*)		All Sites Omnivorous, in most displaying filter feeding behavior	'Mus mus' Yellow Jacket Cichlid (*Parachromis friedrichsthalii*)		All Sites Highly carnivorous

False Firemouth Cichlid (*Amphilophus robertsoni*)		All Sites Omnivorous	Threadfin Shad (*Dorosoma petenense*)		Species documented in previous reports. Site: 1 Herbivorous, mostly feeding on phytoplankton
Common snook (*Centropomus undecimalis*)		Species documented in previous reports. Sites: 1, 2, 3 Highly carnivorous	Tarpon (*Megalops atlanticus*)		Species documented in previous reports. Sites: 1, 2, 3 Carnivorous
American eel (*Anguilla rostrata*) – picture taken underwater		All sites Carnivorous	Mayan cichlid (*Cichlasoma uropthalmus*)		All sites Omnivorous, with more tendency in feeding on larger prey

Site 1 – Macal River, Site 2 – Mopan River, Site 3 – Upper Belize River, Site 4 – Garbutt Creek, Site 5 – Barton Creek, Site 6 – Roaring Creek

The survey conducted provides a rapid assessment of the species present within the study area as the methodology used during the survey was the most effective method in capturing the highest probable number of specimens at any given time. However, the validity of any system of assessment is associated with the frequency and period in which the study was conducted. Given the scope of the fieldwork and short time-frame in which the survey was conducted only provides a limited snap shot of some species inhabiting those ecosystems. The total number and distribution of species recorded during the field surveys are more fully described in Table 4.13. For a more comprehensive listing of freshwater fish occurring within the riverine and lacustrine systems of Belize, see Annex V.

4.12 Protected Areas

4.12.1 Protected Areas in the Cayo District

A large portion of the GBRB consists of protected areas. In the Guatemalan portion of the Basin, some 3,200 km^2 is under some form of protection, while the figure for Belize is about 5,700 km^2. The "Maya Mountain-Chiquibul Biosphere Reserve in Peten lies adjacent to the national border and connects with the Chiquibul National Park in Belize. The Chiquibul extends to the southwestern end of the GBRB to include the headwaters of the Mopan River. The Chiquibul connects to the Colombia Forest Reserve and the Bladen Nature Reserve to the south, and the Cockscomb Basin Forest Reserve and the Sibun Forest Reserve to the east. Most of the western Maya Mountain Massif is under some kind of protected status including the Chiquibul, Mountain Pine Ridge and Vaca. Most of the protected areas are to the south of the ROW of the GPH but their indirect influence on the road infrastructure is significant as the headwaters for most of the main rivers originate in these protected areas. Figure 4.28 illustrates the present protected areas in the Cayo District.

There are four protected areas within the ADI zone of influence, namely three declared and mapped archaeological sites and the Guanacaste National Park. The Archaeology section of the report describes the archaeological sites of the area in more detail (see Figure 4.29).

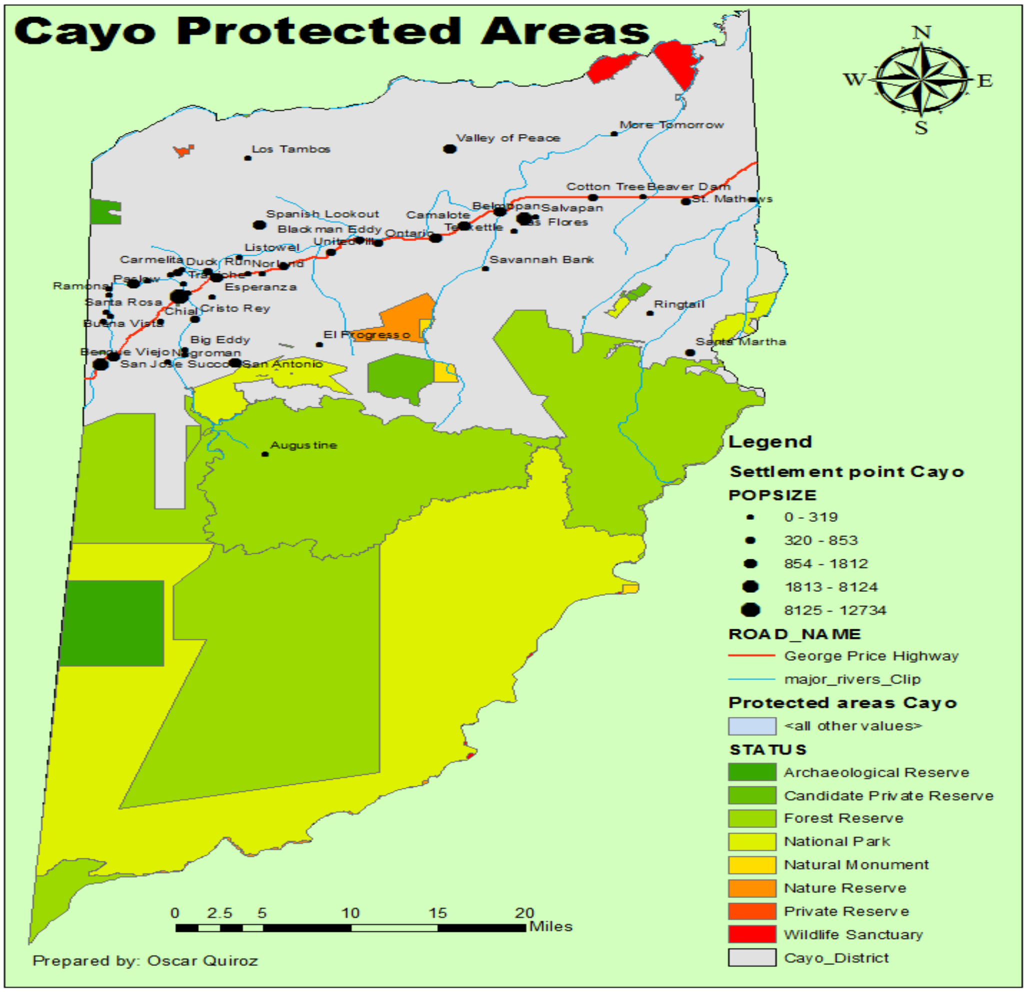


Figure 4.28: Protected Areas in the Cayo District

4.12.2 Guanacaste National Park (GNP)

The Guanacaste National Park is a 20-hectare (50-acre) park deriving its name from a huge old guanacaste, or tubroos, tree that is found within the park (BAS 2014). It is located just north of the capital city Belmopan in the Northeast quadrant of the Cayo District at the junction of the George Price and Hummingbird Highway. It is bordered on the west by the Roaring Creek and on the north by the Belize River. Established as a Crown Reserve in 1973, it gained National Park Status in 1990. The park under the legal responsibility of the Forest Department is co-managed by the Belize Audubon Society.

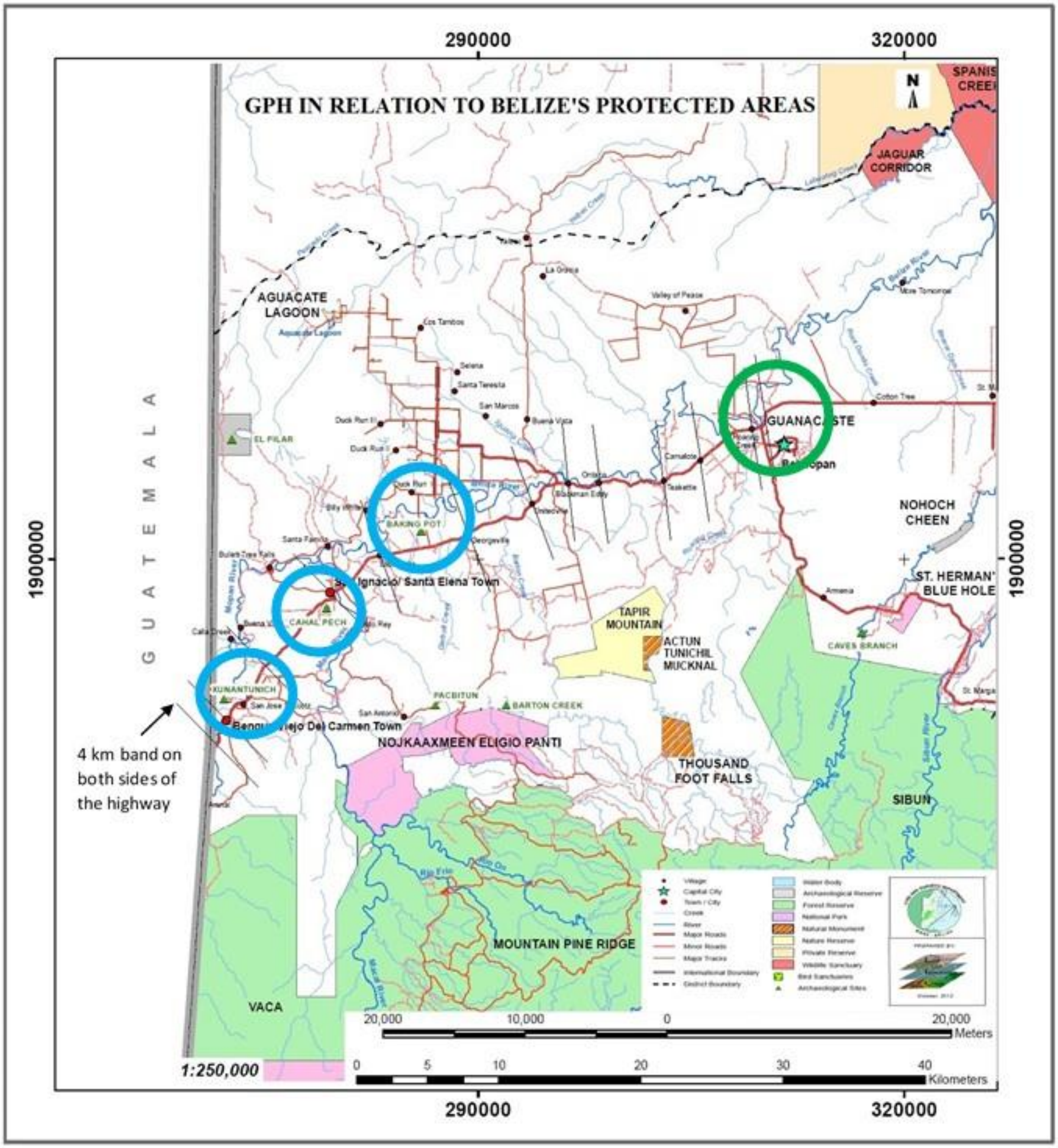


Figure 4.29: Declared Protected Areas in the Area of Study.

4.12.2.1 Forest Cover of Guanacaste

Recovering from use as pasture land before government acquisition, the Park's lush forest is secondary growth with most of its growth in the middle stage of succession. The area's dry season gives the forest cover a semi-deciduous quality. There are two broad forest types in the Park: the more common Cohune Palm forest, and Broad leaf Hardwood forest. The Cohune palm and Broadleaf Hardwood types are often contiguous or intermixed. Within the Broadleaved Hardwood is the riparian forest association found along the riverbanks.

The riparian area is dominated by bri-bri tree (*Inga edulis)* and the sub-dominant species is fig (*Ficus sp.),* bamboos (*Guadua sp.)* and other shrub species are also common These forests have adapted to periodic flooding.

Belize's national symbol, the exotic Black Orchid, is amongst the smallest of the various orchid plant species and one of the nearly 40 species of epiphytes, including mosses, orchids, ferns, bromeliads and lichens that colonize the park trees. Trees such as the Guanacaste (*Enterolobium cyclocarpum),* bukut or stinking toe (*Cassia grandis),* strangler fig (*ficcus sp.)* quamwood (*Schisolobium parahybum),* Rain Tree (*Albizia saman),* Mamey sapote (*Pouteria sapota),* Cotton Tree *(Ceiba pentandra),* Cohune Palms (*Attalea cohune)* and Mahogany (*Swietenia macrophylla*) can be found in the park (see Figure 4.30).

Figure 4.30 (L-R): Guanacaste (*Enterolobium cyclocarpum*) and Bukut (*Cassia grandis*)

4.12.2.2 Mammals and Birds

The wildlife community of Guanacaste consists of the Jaguarundi (Puma yagouaroundi), Kinkajou (Potos flavus), Gibnut (*Agouti paca*), Nine-banded Armadillo (Dasypus novemcinctus), White-tailed Deer (Odocoileus virginianus), along with many species of bats. Reptilian life, such as iguanas can be seen. Over 120 species of birds have been spotted in the park including the majestic Blue crowned Motmot (Momotus momota), Black-faced Ant-trush (Formicarius analis), Belted Kingfisher (Megaceryle alcyon), Smoky-brown Woodpecker (Veniliornis fumigates), Magnolia Warbler (Setophaga magnolia), Red-lored Parrot (Amazona autumnalis), Black-headed Trogon (Trogon melanocephalus), and the Bright-rumped Attila (Attila spadiceus) (see Annex IX).

4.12.2.3 Cultural

Although, no major Maya sites have been discovered inside this track of land, there is a suspected chultun, or Maya underground storage chamber, located in the north-central part of the park awaiting archaeological investigation. Throughout the various walking trails, pottery pieces and other artifacts have been discovered.

4.13 National Agriculture and Trade Show Grounds

Across from the Guanacaste National Park is the National Agriculture and Trade Show grounds. Melina (*Gmelina arborea)*, an introduced species, has been planted along the periphery of this property (see Figure 4.31). Other ornamental trees such as the flamboyant (*Delanix regia),* Mayflower (*Tabebuia pentaphylla),* Madre Cacao *(Gliricidia sepium),* Mahogany (*Sweitenia macrophylla),* Royal Palm (*Roystonea leracea)* and other small tree species have been planted to landscape the show grounds.

Figure 4.31: (L-R) Melina (*Gmelina arborea)and* Madre Cacao *(Gliricidia sepium)*

4.15 Baseline Water and Air Quality and Background Noise

4.15.1 Water Quality

In situ water quality assessments were conducted using the YSI Professional Plus Water probe (See Annex X) at nine (9) sampling sites in the GBRB within the three sections of the proposed rehabilitation project site of George Price Highway on June 28, 2014 (See Annex XI). Water samples from these sites were also obtained, preserved and transported, (in accordance with Standard Methods SOPs), to the Belize Public Health Bureau and the Bowen and Bowen Water Laboratories for biological tests. Similar samples were sent to the Belize Natural Energy Water Laboratory in Spanish Lookout to test for *Oil in Water*.

4.15.1.1 Water Quality Results

The results of these tests are discussed below and summarized in Annex XII.

Water Temperature: Water temperature at the nine sites ranged from 26 °C to about 29.5° C. Ambient water temperature for water bodies in Belize are generally higher during the summer months, so the values recorded are acceptable.

pH: The pH of surface waters is important to aquatic life because pH affects the ability of fish and other aquatic organisms to regulate basic life-sustaining processes, primarily the exchanges of respiratory gases and salts with the water in which they live. Failure to adequately regulate these processes can result in numerous sub-lethal effects (e.g., diminished growth rates) and even mortality in cases when ambient pH exceeds the range physiologically tolerated by aquatic organisms. The pH of water affects the normal physiological functions of aquatic organisms, including the exchange of ions with the water and respiration. **The normal pH range that is considered satisfactory for fish and other freshwater aquatic life is 6.5 -9.0.**

For these samples tested all the pH values are considered to be satisfactory as the minimum pH value obtained was 7.61 with the average value at 7.89. The lowest pH recorded was at the Garbutt Creek (Central Farm and Galen) and the highest at 8.23, which was at the Iguana Creek bridge.

Iron: Generally speaking, few surface water supplies have high enough levels of either to cause problems. Occasionally discharge of acid industrial wastes or mine drainage may increase iron or manganese to problem levels in surface water. Usually iron and manganese do not exceed 10 ppm and 2 ppm, respectively, in natural waters.

For all the samples tested, none of them contained high concentration of iron, as the lowest concentration obtained was <0.01mg/l which was at the Ontario spring, while the highest concentration found was 0.17mg/l at the Macal River (upstream – after the Hawksworth Bridge)

Orthophosphates: If too much phosphate is present in the water the algae and weeds will grow rapidly, may choke the waterway, and use up large amounts of precious oxygen (in the absence of photosynthesis and as the algae and plants die and are consumed by aerobic bacteria.) The result may be the death of many fish and aquatic organisms. Phosphorus is one of the key elements necessary for growth of plants and animals. Phosphates PO4--- are formed from this element. Phosphates exist in three forms: orthophosphate, metaphosphate (or polyphosphate) and organically bound phosphate.

Criteria: The following criteria for total phosphorus were recommended by US EPA (1986):

1. no more than 0.1 mg/L for streams which do not empty into reservoirs,
2. no more than 0.05 mg/L for streams discharging into reservoirs, and
3. no more than 0.025 mg/L for reservoirs.

For these samples, only sample No. 1 and No. 4 were above the recommended maximum of 0.1mg/l. The average orthophosphate concentration for the samples tested was 0.12mg/l, with the lowest concentration at 0.01 mg/l (Roaring Creek – Butte Rows (Quality Poultry) and the highest concentration at 0.4mg/l (Mopan River – junction Benque Viejo and Succotz)

Nitrate: Outside of agricultural practices, nitrates can also come from septic systems and, to a much lesser extent, naturally decaying organic matter (CAST 1992). Nitrate is highly soluble and can thus migrate easily through the soil. Nitrates are naturally formed in the environment by nitrogen-fixing bacteria, as well as in high temperatures such as those found in lightning (Bunce 1993). Nitrogen, like phosphorous, is a required plant nutrient and so is added to soil to improve crop yields. Nitrates are a form of nitrogen, which is found in several different forms in terrestrial and aquatic ecosystems. These forms of nitrogen include ammonia (NH_3), nitrates (NO_3), and nitrites (NO_2). Nitrates are essential plant nutrients, but in excess amounts, they can cause significant water quality problems. Together with phosphorus, nitrates in excess amounts can accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the stream. This, in turn, affects dissolved oxygen, temperature, and other indicators. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L).

The average concentration of nitrate-nitrogen for these samples is 1.3mg/L, with the lowest concentration at 1.1mg/L (which was at 4 sampling sites, namely: (Macal River upstream – after the Hawksworth Bridge, Ontario spring, Roaring Creek by the bridge and Roaring Creek Butte Row (Quality Poultry)). The highest concentration found was at 2.1mg/L, which was Garbutt Creek by Central Farm and Galen University. The nitrate concentration in these samples are considered low and coupled with the low orthophosphate concentration the risk for eutrophication is low at the sites that were sampled.

Sulfate: Anthropogenic sources of sulfate may come from mine drainage wastes through pyrite oxidation, reverse osmosis reject water, cooling tower blowdown, etc. Table 4.14 summarizes the water quality guidelines for sulphates.

Table 4.14: Summary of Water Quality Guidelines for Sulphate

Water Use	Dissolved Sulphate as mg/L SO_4
Drinking Water (Aesthetics)	500
Freshwater Aquatic Life	*100 **50
** Maximum concentration, not to be exceeded at any time. ** Alert level to monitor health of aquatic moss populations on an occasional basis*	

Sulphur is a non-metallic element that occurs naturally in numerous minerals, including barite ($BaSO_4$), epsomite ($MgSO_4 \cdot 7H_2O$), and gypsum ($CaSO_4 \cdot 2H_2O$). Hexavalent sulphur combines with oxygen to form the divalent sulphate ion (SO_4^{2-}). The reversible reaction between sulphide and sulphate in the natural environment is often referred to as the "sulphur cycle".

Natural sources of sulphur include volcanoes, decomposition and combustion of organic matter and from sea salt over the oceans. Particles of sea salt formed by the breaking of myriads of bubbles are an important source of atmospheric sulphate. The atmosphere is the main vehicle for transport of sulphur from various sources.

Sulphates are discharged into the aquatic environment in wastes from industries that use sulphates and sulphuric acid, such as mining and smelting operations, kraft pulp and paper mills, textile mills and tanneries.

In reviewing the data from the samples tested it can be seen that when compared to the normal value for sulfate where freshwater aquatic life may be at risk, all samples had very low concentration of sulfate with the average sulfate concentration at 5.6mg/L and the highest concentration at 13mg/L which was downstream of the Macal River.

Turbidity: Turbidity is a water quality term that refers to fine suspended particles of clay, silt, organic and inorganic matter, plankton and other microscopic organisms that are picked up by water as it passes through a watershed. Turbidity in surface water bodies usually has organic and inorganic matter. Turbidity levels are much higher in water from surface water sources (e.g. streams, rivers, and lakes) than from groundwater sources. Some surface water sources exhibit high turbidity levels during periods of high precipitation. At turbidity of 25 NTU water is considered murky. For all of these samples the turbidity was well below this figure.

The lowest turbidity for these samples was 1.81 NTU at the Roaring Creek bridge. The average turbidity was 4.70 NTU and the highest turbidity was 10.1NTU which was at the river by the Iguana Creek bridge.

Conductivity: Conductivity is a measure of water's capability to pass electrical flow. This ability is directly related to the concentration of ions in the water. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds. The more ions that are present, the higher the conductivity of water. Likewise, the fewer ions that are in the water, the less conductive it is.

The conductivity for the samples are all considered low as the conductivity was considerably less than 1,000uS/cm. The average conductivity obtained was 438µs/cm, with the lowest conductivity reading recorded at 255µS/cm in the Macal River – upstream after the Hawksworth Bridge. The highest conductivity obtained was 587µS/cm by Garbutt – Central Farm and Galen University.

In comparing the lowest conductivity versus the highest conductivity obtained, it can be seen that following the definition of conductivity, the lowest value has a much alkalinity and hardness when compared to the alkalinity and hardness concentration in the sampling site where the highest conductivity was recorded.

Total Dissolved Solids (TDS): TDS combine the sum of all ion particles that are smaller than 2 microns (0.0002 cm). This includes all of the disassociated electrolytes that make up salinity concentrations, as well as other compounds such as dissolved organic matter. Depending on the ionic properties, excessive total dissolved solids can produce toxic effects on fish and fish eggs. In water with a very high TDS concentration, cells will shrink. These changes can affect an organism's ability to move in a water column, causing it to float or sink beyond its normal range. Like the conductivity, the TDS values for all nine sampling sites are also low as again the readings are all well below 1,000mg/L. The average TDS value was 219mg/L, with the lowest TDS recorded at 128mg/L in the Macal River – upstream after the Hawksworth River. The highest TDS was 292 mg/L by Garbutt Creek – Central Farm and Galen University.

Alkalinity: Alkalinity is a measure of the capacity of water or any solution to neutralize or "buffer" acids. This measure of acid-neutralizing capacity is important in figuring out how "buffered" the water is against sudden changes in pH. Alkalinity is important to aquatic organisms because it protects them against rapid changes in pH.
Typical alkalinity range for surface water is 10 – 500mg/L. In comparing the results from all nine (9) sampling sites it can be seen then that all samples were well within the normal range. The average alkalinity concentration for the samples was 197mg/L. The lowest alkalinity concentration was measured at 104 at two (2) sites, namely: downstream and upstream of the Macal River.

Chlorides: Chlorides are present in both fresh and salt water, and are essential elements of life. Chlorides may get into surface water from several sources including:

- rocks containing chlorides,
- agricultural runoff,
- wastewater from industries,
- oil well wastes, and

- effluent wastewater from wastewater treatment plants

Chlorides can contaminate freshwater streams and lakes. Fish and aquatic communities cannot survive in high levels of chlorides.

The chlorides concentration in all the samples was very low as all nine (9) sampling sites recorded 1mg/L chlorides.

Hardness: The two main cations that cause water hardness are calcium (Ca) and magnesium (Mg). Calcium is dissolved in water as it passes over and through limestone deposits. Magnesium is dissolved as water passes over and through dolomite and other magnesium bearing formations. Because groundwater is in contact with these geologic formations for a longer period of time than surface water, groundwater is usually harder than surface water (Table 4.15).

Table 4.15: Calcium Hardness as $CaCO_3$ (mg/L)

Soft: 0-20	**Moderately soft: 20-40**	**Moderately hard: 40-80**
Hard: 80-120	**Very hard: > 120**	

When water passes through or over mineral deposits such as limestone, the levels of Ca^{2+}, Mg^{2+}, and HCO_3^- ions present in the water greatly increase and cause the water to be classified as hard water. From all nine (9) samples analysed and comparing the results to the table above the water can be considered as hard water. The average total hardness concentration was recorded at 245mg/L. The lowest total hardness concentration was measured at 136 mg/L at two of the sampling sites, namely: downstream and upstream of the Macal River. The highest total hardness concentration was measured at 342mg/L which is at the Garbutt Creek – Central Farm and Galen University.

Fluoride: Fluoride is most toxic to freshwater aquatic life and to people undergoing dialysis. Fluoride accumulates, permanently, in the long bones of vertebrates, causing fluorosis, when present in excessive amounts. In Belize, we have very low concentration of naturally occurring fluoride in our water (groundwater and surface water). This was shown in a study done by the Ministry of Health (1999 and 2014).

All nine (9) samples showed very low concentration of fluoride as only three (3) samples measured fluoride concentration slightly above 0.1mg/L (Mopan River – 0.111mg/L, upstream of the Macal River – 0.107 and Barton Creek – 0.115mg/L. The average fluoride concentration was 0.098mg/L

Bacteriological Quality: The *coliform* bacteria group consists of several genera of bacteria belonging to the family *enterobacteriaceae*. These mostly harmless bacteria live in soil, water, and the digestive system of animals. Fecal *coliform* bacteria, which belong to this group, are present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals, and can enter water bodies from human and animal waste. While fecal *coliform* are not pathogenic (disease causing), they are commonly found alongside pathogenic organisms such as those responsible for dysentery, gastroenteritis, and hepatitis A. It is easier to test for fecal *coliform* than for pathogenic organisms; therefore, the presence of fecal *coliform* in a water sample is used to indicate potential contamination. If a large number of fecal *coliform* bacteria (over 200 colonies/100 milliliters (ml) of water sample) are found in water, it is possible that pathogenic (disease- or illness-causing) organisms are also present in the water.

All nine samples showed the presence of fecal *coliform* and *E. Coli* which indicates that the water is being contaminated with fecal matter through human or animal waste, from improperly treated septic and sewage discharges, leaching of animal manure, storm water runoff and domestic animals or wildlife.

The sampling site with the highest fecal *coliform* count (200 fecal coliform/100ml) was by the Roaring Creek Bridge, while the lowest fecal *coliform* count (40 fecal *coliform*/100ml) was by the Garbutt Creek – Central Farm and Galen. The average fecal *coliform* count was 124 fecal coliform/100ml. It should be noted that the WHO Guideline for Total Faecal Coliform in drinking water is 0 counts/100ml. Therefore, these water should not be used as drinking water without first boiling it or chemically treating it. Table 4.16 provides a listing of the acceptable potable water standards and guideline values from BWSL and WHO.

Table 4.16: Acceptable Limits (BWSL) and Guidelines (WHO).

Parameter	Acceptable Limits (BWSL)	Guideline Values (WHO)	Remarks on water quality parameters
Temperature	25˚C	none	
pH	6.5 – 7.5	6.5 – 8.5	Value of 7 indicates a neutral condition
Color		15 TCU	Less than 10 units is unnoticed, water with 100 units resembles black tea
Turbidity	5 units	5 NTU	Pure distilled water turbidity is 0 NTU
TDS	500 mg/l	1,000 mg/l	TDS of 0-1000 mg/L is considered fresh and non-saline
Conductivity	N/A	none	Range of 50-1500 µS/cm found in natural surface water
Hardness (total)		none	Water with hardness less than 120 mg/L is deemed desirable, in excess of 500 mg/L undesirable for domestic and industrial use
Alkalinity	250 mg/l	N/A	Generally acceptable water quality range for alkalinity is 30-500 mg/L
Chlorine-free	N/A	5 mg/l	
Coliform (total)	1/100 ml	0/100 ml	
E-coli	1/100 ml	0/100 ml	
Nitrate - N	10 mg/l	10 mg/l	
Chloride	250 mg/l	250 mg/l	250 mg/L is the acceptable value for drinking water
Fluoride	0.5 – 1.5 mg/l	1.5 mg/l	
Phosphate	N/A	none	
SO_4	250 mg/l	250 mg/l	Concentrations up to 500 mg/L acceptable
Mg^{+}	N/A	none	
Al^{3+}	N/A	0.2 mg/l	
Ca^{2+}	N/A	none	
Fe	0.3 mg/l	0.3 mg/l	
Pb	N/A	0.01 mg/l	

Table 4.16: Acceptable Limits (BWSL) and Guidelines (WHO).

(Source: NARMAP Environmental Water Quality Monitoring Program: Final Report and Annexes, DOE/USAID, June 1995)

4.15.2 Noise and Air Pollution

4.15.2.1 Sound and Noise

It is common practice to define noise simply as unwanted sound. However, in some situations noise may adversely affect health in the form of acoustical energy (WHO 1999). Literature review indicates that ambient noise level is normally below or about 40 decibels (dB). Therefore, levels that exceed this can be considered as noise pollution. It is well documented that exposure to high decibel noise can result in some adverse effects on human health such as acoustic trauma to the ears caused when they are subjected to the sound of an intensity of 85 dB or more without respite.

Table 4.17 provides a summary of the noise levels normally produced by different equipment against ambient noise levels and standards.

4.15.2.2 Results of Noise Level Sampling

Noise levels in eight (8) sampling areas were measured to describe the existing noise environment, and identify major noise sources. Ambient noise levels were measured using a Sper Scientific Sound Level Pen 840018, a full function Type 2[1] sound meter (See Annex X). At all locations a one 15-minute, measurements were taken to estimate the noise level. The results are show in Table 4.18 and 4.19.

Table 4.17: Noise levels of Common Sources

Source of Sound	Distance from Source (m)	Sound Pressure Level Decibels (dB)
Ambient and Standard Noise Levels		
Ambient noise level		40
Normal conversation face to face	1	40 -60
EPA-maximum to protect against hearing loss		70
WHO Maximum –Industrial Work Place		75
Less than for bedroom for good night rest		30
Less than for classroom teaching		35

[1] Meets ANSI S1.4 Type 2 and IEC61672-1 Class 2

Construction Noise Levels		
Air Compressor	15	81
Backhoe	15	80
Chainsaw	1	110
Compactor	15	82
Compactor (Plate)	15	101
Concrete Mixer	15	85
Concrete Vibrator	15	76
Crane Derrick	15	88
Crane Mobile	15	83
Dozer	15	85
Generator	15	81
Grader	15	85
Impact Wrench/Pneumatic Tool	15	85
Jack Hammer	15	88
Loader	15	85
Paver	15	89
Pile Driver (Impact)	15	101
Pump	15	76
Rail Saw (Steel-Stone)	15	90
Rock Drill	15	98
Roller	15	74
Saw	15	76
Scraper	15	89
Shovel	15	82
Tractor without cab	15	120
Traffic (Heavy Equipment)	10	90
Traffic (Heavy Traffic)	15	80-89
Traffic (motorcycle/ATV)	15	96-100
Traffic (Passenger car at 65 mph)	10	77
Truck (Concrete Pump)	15	82
Truck (Dump)	15	88
Truck (Pickup)	15	75

The five junctions sampled gave noise level above the ambient noise level, with Guanacaste/Belmopan and Roaring Creek Junction showing the highest minimum reading (64.5 dB) with almost similar maximum reading (89.1 dB) at Galen University/Central Farm Garbutt Creek (90 dB) and equal averages of 75 dB. This area was also the busiest intersection. The high reading at Guanacaste/Belmopan and Roaring Creek Junction can be attributed to the time of the day and the fluid traffic from Belmopan City to Roaring Creek and from Belize City to Belmopan and vice versa. The medium reading at the GPH/Spanish Lookout junction and the Z

Curve can be attributed to the slowing down of speed due to a bus stop at this junction and the nature of the Z Curve itself slowing down traffic. The Succotz/Xunantunich Ferry Junction had a high minimum reading than the previous discussed reading but lower maximum reading. These readings can be attributed to vehicles slowing down at a speed bump prior to entering the area as they approach the busy tourist Xunantunich ferry junction.

Table 4.18: Noise Level Sampling

Noise Level Sampling (Sat. July 5, 2014)						
			Min	Max	Avg	Observations
#	Sampling Point	Time		dBs		
1	Succotz/Xunantunich Ferry Jct	11:30 AM	55	77	66	Traffic had to slow down due to speed bump
2	Galen University/Central Farm Garbutt Greek	1:42 PM	50	90	75	Free access no obstruction when crossing the bridge
3	CIL Quarry	2:00 PM		40		No traffic
4	GPH and Spanish Lookout Junction	2:34 PM	50	82	65	Continues traffic - bus stop at junction
5	Spanish Lookout (Old Road) Quarry	3:00 PM		45		Near Spanish Lookout Road
6	Ontario (Spanish Town) Quarry	3:30 PM	45	50		On a hill and windy
7	Z Curve	3:45 PM	45	90	65	Truck passing maxing at 90 dB
8	Guanacaste/Belmopan/Roaring Creek Junction	4:20 PM	64.9	89.1	75	Fluid traffic

Below is a sample of the noise level readings of passing by vehicles at the Guanacaste/Belmopan/Roaring Creek Junction. The readings were taken as the vehicle sped by the sampling area. The lowest reading recorded was for the compact car and the highest was that of the motorcycle with a "cheery bomb exhaust" pipe.

Table 4.19: Noise Level by vehicle model

Noise Level - Vehicle Model- Guanacaste/Blmopan/Roaring Creek	
Izuzu Trooper	80.5
Izuzu Rodeo	74.6
Butane Gas Truck (BWL)	84.6
Motor Cycle with a "cheery bomb exhaust"	89.1
Ford Ranger	83.4
Mitsubishi Galant (compact car)	64.9
Dodge Ram Truck	85
GM Van	78

4.15.3 Air Pollution (Dust and Emissions)

Quarrying and its associated activities of excavation, and transportation increase the suspended particulate matter in the air, which is harmful to the health of the workers exposed to this type of environment. Fine dust inhaled by workers leads to diseases related to lungs and liver such as “silicosis”, “bronchitis”, “asthma” and “tuberculosis” (Chauhan 2010). During the site visits to possible quarry sites, the team noted that these sites are far away from any human dwellings and hence, only workers in the area would be affected. During the rainy season, dust may not be a problem; however, during the dry season invariably greater dust pollution does occur making it necessary for greater monitoring and personal protection.

4.15.3.1 Results of Ambient Air Sampling

Baseline data on ambient air was gathered from six sampling sites using a JDC -Flowatch Flow Meter for wind speed, a Casella MicroDust Pro- Particulate Monitor for particulate matter and BW Technologies by Honeywell Gas Alert Multi-Gas (4) Meter for hydrogen Sulfide (H_2S), carbon monoxide (CO), Oxygen (O_2) and combustible gases (%LEL) (See Annex X).

The general weather was fair and sunny with a maximum temperature of 32°C. The wind was blowing from a North –North East direction along the river valley. The wind speed ranged from 1.5 knots at GPH/Spanish Lookout Junction- Iguana Creek to 5 knots at the Succotz Village and Garbutt Creek-Galen/Central Farm. Gusty winds ranged from 5.3 knots at Succotz -Xunantunich Ferry Side to 15.5 knots at Garbutt Creek-Galen/Central Farm.

Table 4.20: Wind Speed and Ambient Air Testing

			Wind		Particulate				
	Recorded for Sat June 28, 2014		Speed	Gust	PM10	H_2S	O_2	CO	LEL
	Sampling Sites	Time	Knots		µg/m3	ppm	%	ppm	%
1	Succotz -Xunantunich Ferry Side	10:30 AM	4.5	5.3	0.2	0	20.9	0	0
2	Succotz -Village Side	10:45 AM	5	6.3					
2	Galen University/Central Farm (Garbutt Greek)	12:30 PM	5	15.5	0.120	0	20.9	0	0
3	Barton Creek	1:54 PM	4	6.7	0.180	BDL	20.9	BDL	BDL
4	GPH/Spanish Lookout Junction (Iguana Creek)	2:34 PM	1.5	7.9	0.04	BDL	20.9	BDL	BDL
5	Z Curve	3:16 PM	4	12.4	0.381	0	20.9	0	0
6	Guanacaste/Belmopan/Roaring Creek Junction	4:20 PM	4	12.2	0.345	0	20.9	0	0

Knots= 1.852 Kilometers Per Hour (KM/HR) BDL = Below Detectable Level

Particulate matter concentrations (PM10) refer to fine suspended particulates less than 10 microns in diameter that are capable of penetrating deep into the respiratory tract and causing significant health damage. The readings ranged from as low as 0.04 µg/m3 at GPH/Spanish Lookout Junction- Iguana Creek to a high of 0.381 µg/m3 at the Z-curve. These readings are considered relatively low and negligible especially when compared to the World Bank published estimates illustrated below. Table 4.21 provides an extract from the World Bank Particulate Matter Concentration Estimates.

Table 4.21: Particulate Matter Concentrations (PM10) World Bank Estimates

	Avg	Avg	
Country Name	**1991-2000**	**2001-2010**	**2011**
	micrograms per cubic meter (µg/m3)		
Belize	**20.37**	**20.05**	**17.98**
Data Source: http://data.worldbank.org/indicator/EN.ATM.PM10.MC.M3/countries/1W?display=graph			

It is also worthy to mention that during the dry season February to May, the country of Belize experience forest and brushfires due to spontaneous combustion of dry undergrowth, agriculture clearing or just wanton burning of these dry vegetation and undergrowth. It is assumed that during these occurrences the PM10 in these affected areas are relatively high (See Figure 4.32).

Figure 4.32: (L-R) GPH roadside brush fire. Haziness of the Cayo valley is due to brush fire smoke.

The detection of hydrogen Sulfide (H_2S), carbon monoxide (CO), and combustible gases (%LEL) were either below detectable level (BDL) or zero indicating the ambient air quality is essentially very clean. Oxygen level at all sites was 20.9%, which is the naturally occurring concentration in atmospheric air.

CHAPTER 5: SOCIO-ECONOMIC SETTINGS

This Chapter of the Environmental and Social Setting Section provides a description of the existing social environment and is underpinned by an analysis of key demographic characteristics, social infrastructure, social values and lifestyles using established indicators. The baseline provides the platform from which to identify any social impacts the community may face, or changes that may occur to the existing social environment, by introducing the proposed Road Rehabilitation Project and enables the identification of effective strategies to help mitigate the negative while maximizing the positive impacts associated with the Project.

5.1 Overview

Geographically the largest and fastest growing administrative district in Belize, Cayo is home to some 80,000 people and covering more than 2,000 square miles of tropical forest, rolling hills, rich pasture land, vibrant rivers and amazing assortment of Maya archaeological sites. It’s the only district which boasts the capital city of Belmopan, the gateway to the Hummingbird Highway and Belize’s south; further west, the twin towns of Santa Elena and San Ignacio and Benque Viejo represent one-of-a-kind border towns with a unique mix of cultures, influenced by neighbouring Guatemala, but also home to a harmonious mixture of Creole ,Maya ,Mestizo, Garifuna, Chinese, East Indian, European and other ethnicities.

Dubbed as the breadbasket of Belize, Cayo produces much of the country’s dairy, meat and agricultural products ranging from the traditional citrus, bananas, maize and vegetables, to newcomers such as mozzarella cheese, yogurt and pastrami. The Mennonite farming community of Spanish Lookout supplies an abundance of poultry and other produce, and the many small family farms keep local markets and shops supplied.

Notwithstanding, in recent times, eco-tourism has now become a mainstay of the economy; Cayo is slowly becoming one of the region’s most vibrant tourism destinations. Via the George Price Highway, Cayo is easily accessible from Guatemala and less than 2 hours from the Belize international airport. Promoted as the "adventure capital", Cayo town is the gateway to many of the natural and culture based tourist attractions within the district including caving, birding, canoeing, horseback riding, tubing, and mountain biking.

The Cayo district has gained the reputation as the Ecotourism Center of Belize with key natural resources including rivers, waterfalls, caves, natural scenery, and diverse flora and fauna. It also boasts more archaeological sites than any other district with a mix of both surface and subterranean sites. The Maya site of Cahal Pech at San Ignacio is the only Belizean archaeological park situated within the confines of a town, and the cave of Actun Tunichil Muknal re-known for its sacrificial human remains, is the most documented site in the country. Although the majority of tourists to the Cayo area visit the District on combined tour packages with other areas in Belize, San Ignacio Town is beginning to establish itself as a destination in its own right. There are a variety of accommodation options available and San Ignacio and its surroundings attract tourists from more varied markets than the other main tourist destination areas of Placencia and San Pedro Ambergris Caye combined.

Implementation of the Destination Management Plan within the Sustainable Tourism Master Plan framework, proposes to reinforce San Ignacio's role as a staging area for the wide range of nature and culture based activities offered, creating a distinctive gateway to the variety of nearby attractions. The new ferry at Succotz, which retained much of the characteristics of the iconic hand-cranked ferry faithfully serving tourists and local visitors for over 3 decades., currently transports an estimated 50, 000 visitors a year and up to 300 visitors daily on peak days.

5.2 Methodology

Baseline information was obtained from multiple sources using varied methods as outlined in Table 5.1; instrument, participants, respondents and institutional contacts are detailed in Annexes XIII - XVII.

Table 5.1: Baseline Data Sources and Collection Techniques

Focus Group Discussions	**Village Chairpersons**
	Educators
	Women
	Youth
	Cyclists
Informant Interviews	**Bus Drivers/Taxi-Operators**
Socio-Economic Survey	**Random Sample: 226 HH in Study Area**
	Purposeful Sample: 34 HH in close proximity to ROW
Statistical Institute of Belize	**2010 Census**
	2000 Census

Focus Group Discussions (FGD) and Key Informant Interviews with Village chairpersons and educators, women and youth from the target communities as well as other frequent road users, viz. cyclists, bus drivers and taxi operators were conducted over the period June-July 2014 by BET.

Figure 5.1: FGD with Village Chairpersons

The Socio-Economic Survey (SES) was conducted during the month of June by BET targeting two principal audiences within the Study Area: a random sample of households drawn from the communities along the existing ROW based on sample size of 232 Household (HH), confidence level of 95% and limits of 7% with overall response rate of 97%; and a purposeful sample of HH in close proximity/within the 100 feet wide corridor.

Additionally, with support from the Statistical Institute of Belize, the 2000 and 2010 Census databases were mined; relevant information on target communities along the ROW was obtained and used to inform the SES design and supplement its findings as per this Report.
Baseline information presented in this sub-section is disaggregated by the three (3) defined Road Sections along the existing ROW. For purposes of the SES, these are defined as:

Road Section I, Mile 47.9 – Mile 56: This 8.1 mile long road section spans the length of the GPH from the Belmopan junction to the Iguana Creek Road junction. This Road Section is the most densely populated; five established villages are found along this section of the existing ROW, viz. Roaring Creek, Camalote, Teakettle, Ontario and Blackman Eddy.

Road Section II, Mile 56 – Mile 65: This 9 mile long road section spans the length of the GPH from the Iguana Creek Road junction to the Red Creek Bridge, Santa Elena Town; three established villages and one community are found along this section of the existing ROW, viz. Central Farm Community, Unitedville, Georgeville, and Esperanza.

Road Section III, Mile 67 – Mile 79.4: This 12.4 mile long road section spans the length of the GPH from Buena Vista Street, San Ignacio Town to the Benque Viejo del Carmen border with Guatemala.

5.3 Population Size and Structure

The communities along the ROW within the Study Area at the 2010 Census had a recorded population count of 19,421, with an equal male/female distribution; and a household count of 4,267, of which one in every four were female headed. The average annual population and household growth for this Area is estimated at 0.4% and 3.2% respectively; disaggregated values by Road Section and individual communities are presented in Table 5.2.

Table 5.2: Population and Household Data

Road Section	Community	2010						2000				Annual % Change	
		Population			Households			Population	Households			Population	Households
		Total	Male	Female	TOTAL	Male Headed	Female Headed	Count	TOTAL	Male Headed	Female Headed		
	Cayo District	75,046	37,445	37,601	16,889	12,717	4,172	65,991	11,520	8,995	2,526	1.4%	4.66%
I	Roaring Creek	1,974	965	1,009	449	293	156	2,120	371	263	108	-0.7%	2.10%
	Camalote	2,562	1,276	1,286	560	417	143	1,686	309	253	56	5.2%	8.08%
	Teakettle	1,746	886	860	359	281	78	1,624	262	203	58	0.8%	3.73%
	Ontario	775	394	381	174	123	51	736	115	78	37	0.5%	5.16%
	Blackman Eddy	533	287	247	110	80	30	518	83	69	14	0.3%	3.31%
	Total	**7,591**	**3,809**	**3,782**	**1,652**	**1,195**	**458**	**6,684**	**1,140**	**866**	**274**	**1.4%**	**4.49%**
II	Central Farm	205	99	106	38	32	6	242	44	38	5	-1.6%	-1.23%
	Unitedville	971	641	621	213	157	56	733	139	100	39	3.3%	5.29%
	Georgeville	922	476	495	190	131	59	701	128	104	23	3.2%	4.88%
	Esperanza	1,262	464	458	286	218	67	1,391	237	184	53	-0.9%	2.05%
	Total	**3,360**	**1,681**	**1,679**	**727**	**539**	**188**	**3,067**	**548**	**426**	**121**	**1.0%**	**3.28%**
III	San José Succotz	2,322	1,142	1,180	472	400	72	2,302	375	307	68	0.1%	2.57%
	Benque Viejo	6,148	3,057	3,091	1,416	1,028	388	6,593	1,174	865	309	-0.7%	2.06%
	Total	**8,470**	**4,199**	**4,271**	**1,888**	**1,428**	**459**	**8,896**	**1,549**	**1,172**	**378**	**-0.5%**	**2.18%**
		19,421	**9,689**	**9,732**	**4,267**	**3,161**	**1,106**	**18,646**	**3,237**	**2,464**	**773**	**0.4%**	**3.2%**

Source: 2010 Census, SIB and BET

Within this Study Area, the distribution of key population of potential interest are presented in Figure 5.2; across the three Road Sections children generally comprise just under half of the population while youth accounts for one in every four persons. School age children account for one in every four residents, while older persons account for approximately 5% of the population on the average.

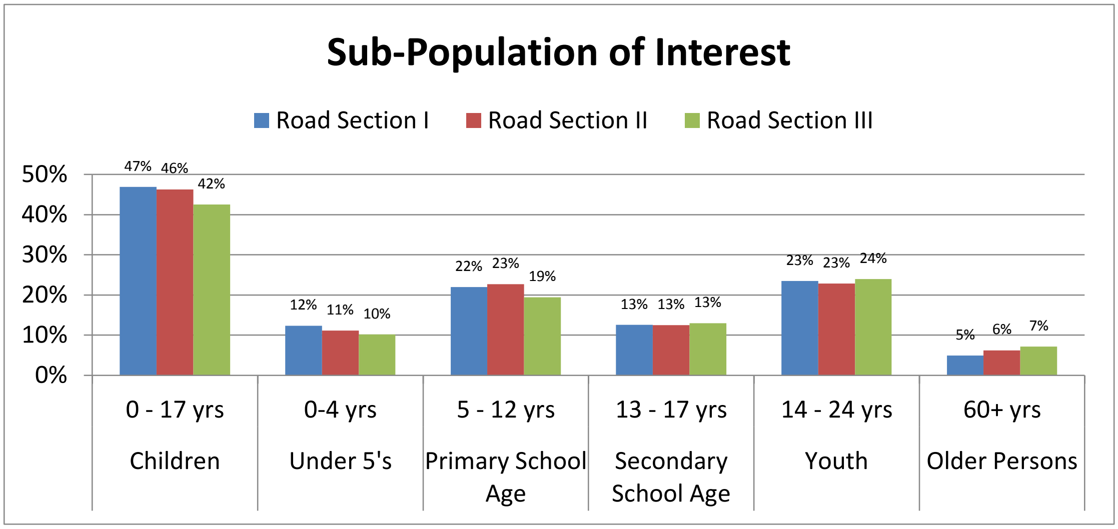


Figure 5.2: Sub-population of Interests

With respect to population structure, communities within the Road Sections across the ROW reflect a very young population demographic, with males slightly outnumbering females across the entire life cycle as presented in Figures 5.3, 5.4 and 5.5 for Road Sections I, II, and III respectively.

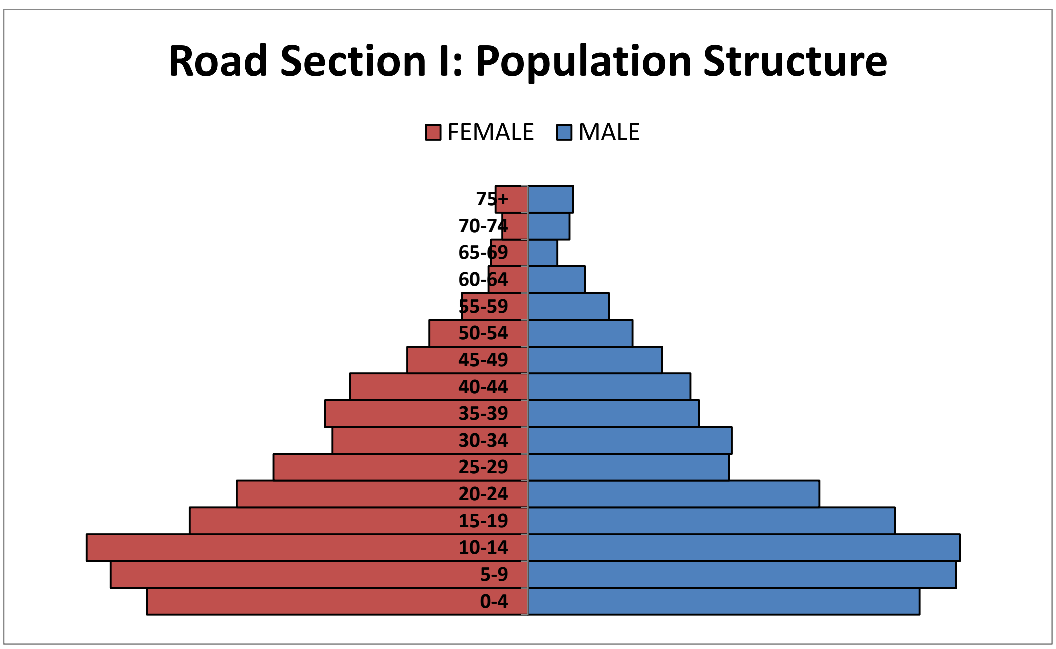


Figure 5.3: Population Structure, Road Section I

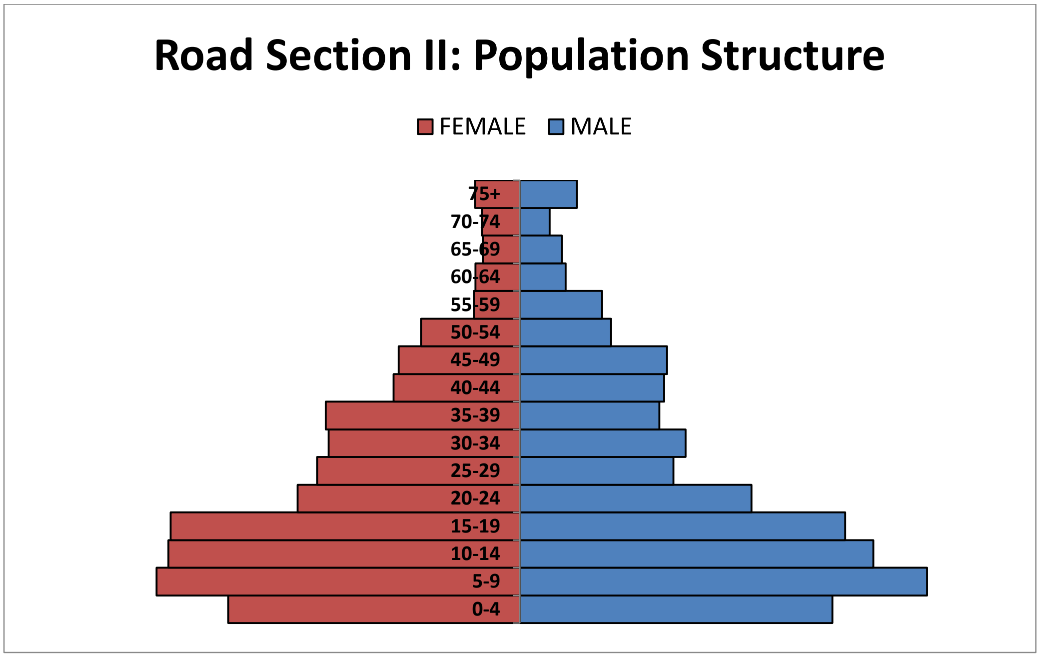


Figure 1.4: Population Structure, Road Section II

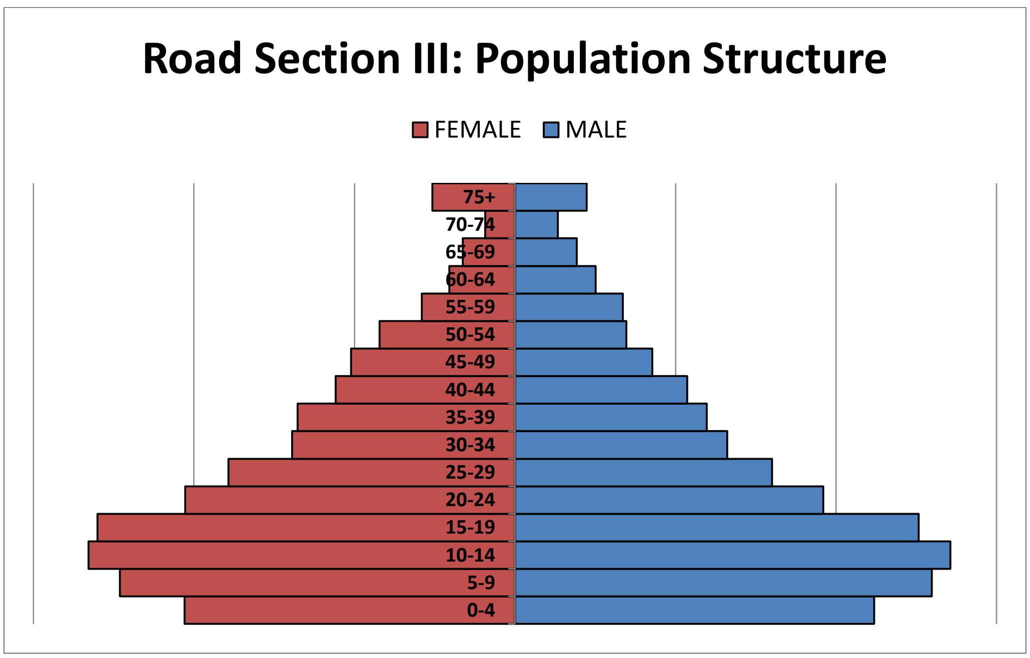


Figure 5.5: Population Structure, Road Section III

5.4 Education

On an average, of every 100 residents, 2 have completed a university level education, 5 a sixth form level education, 11 high school, while 70 have only a primary level education or less; the remainder have undergone some form of VOTECH/certificate level training. Actual distribution across the three road sections is presented in Figure 5.6.

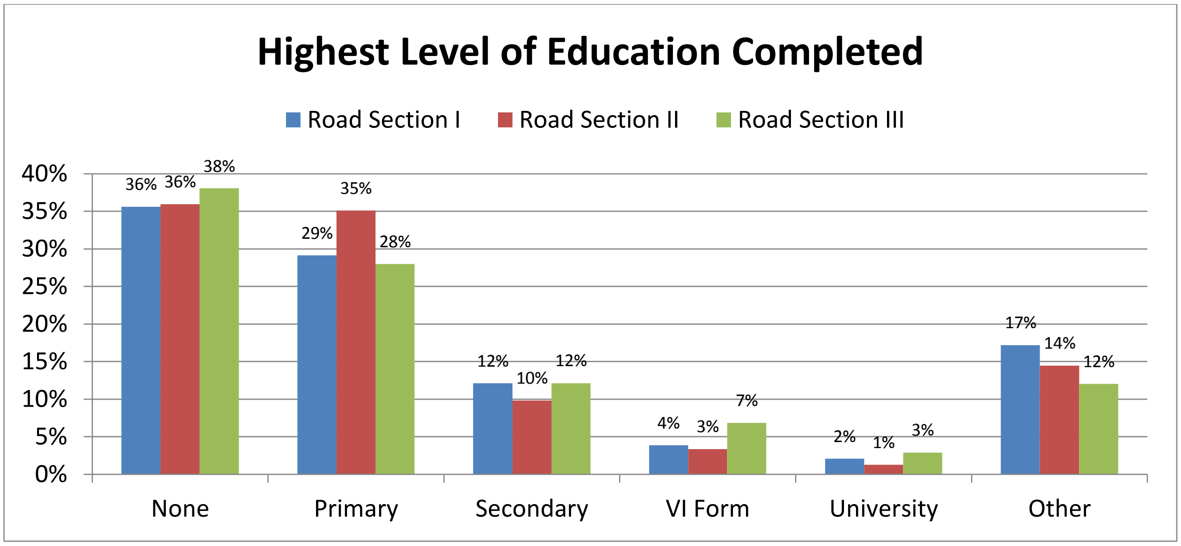


Figure 5.6: Education Level Completed

5.5 Migration

On the average, communities across the Area reflect an emigration rate of just under 5%, i.e. one in every 20 households are reporting members having migrated to a foreign country at the time of the baseline survey, Figure 5.7. On the flipside the proportion of foreign born population resident in the communities across the road sections range from 11% in Road Section II, to as high as 19% in Road Section III, Figure 5.8

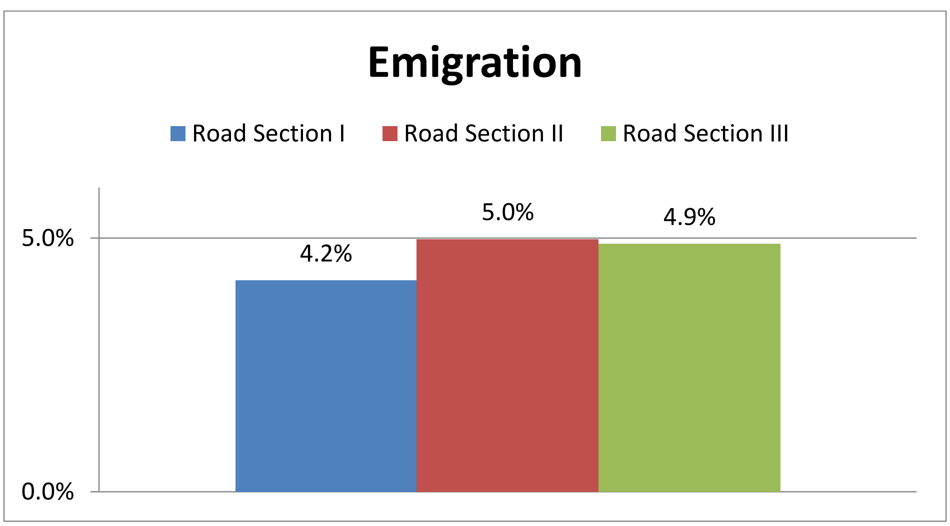


Figure 5.7: Emigration Rate

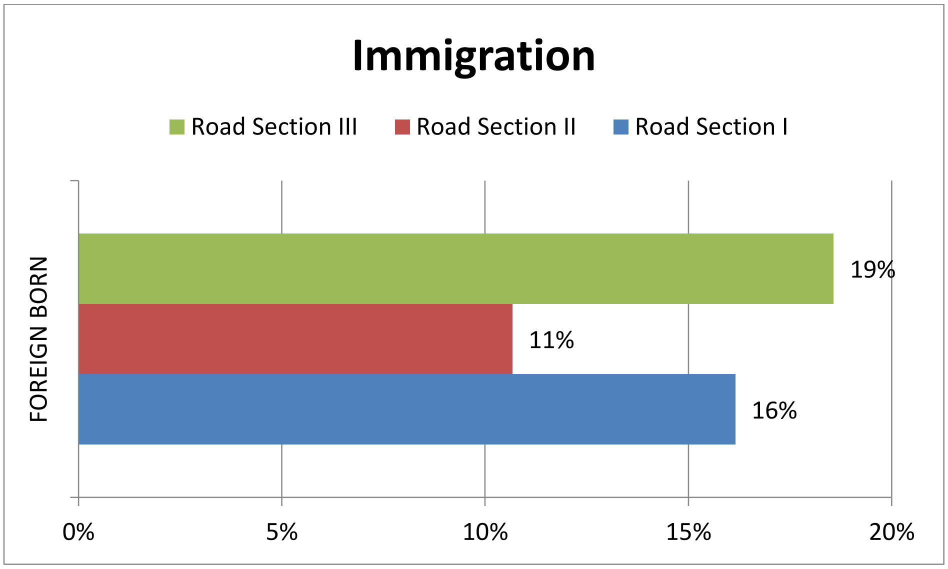


Figure 5.8: Immigration Rates

5.6 Marital Status

Just over 3 in 10 residents are married, while close to 60% have never been married. With close to 50% of the population count being children, this statistic is consistent with wider demographic distribution. The communities within the Area reflect a low rate of divorce/legal separation of around 2% reflecting good family stability; the widowed rate stood at 3%. Disaggregation by road sections is presented in Figure 5.9.

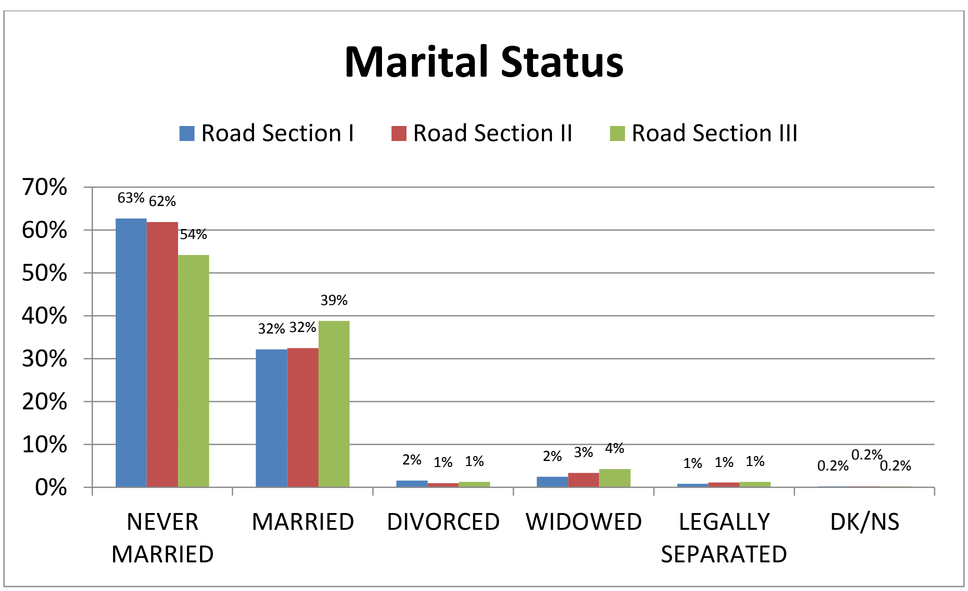


Figure 5.9: Marital Status

5.7 Land and Dwelling Occupancy

On the average, just fewer than 70% of residents in the Area own the land on which their dwelling is built; a significantly higher proportion of residents in Road Section III only have a leasehold title to their land. Distribution across the road sections is presented in Figure 5.10.

With respect to dwelling units, on the average 9 in every 10 are categorized as an undivided private house. Approximately 25% of dwellings pre-date Independence, while the vast majority of the units were constructed prior to the new millennium. An estimated 50% of residents own their dwelling unit free of mortgage and an additional 17% own with mortgage. Distribution of dwelling unit type, year built and occupancy are presented in Figures 5.11, 5.12 and 5.13 respectively.

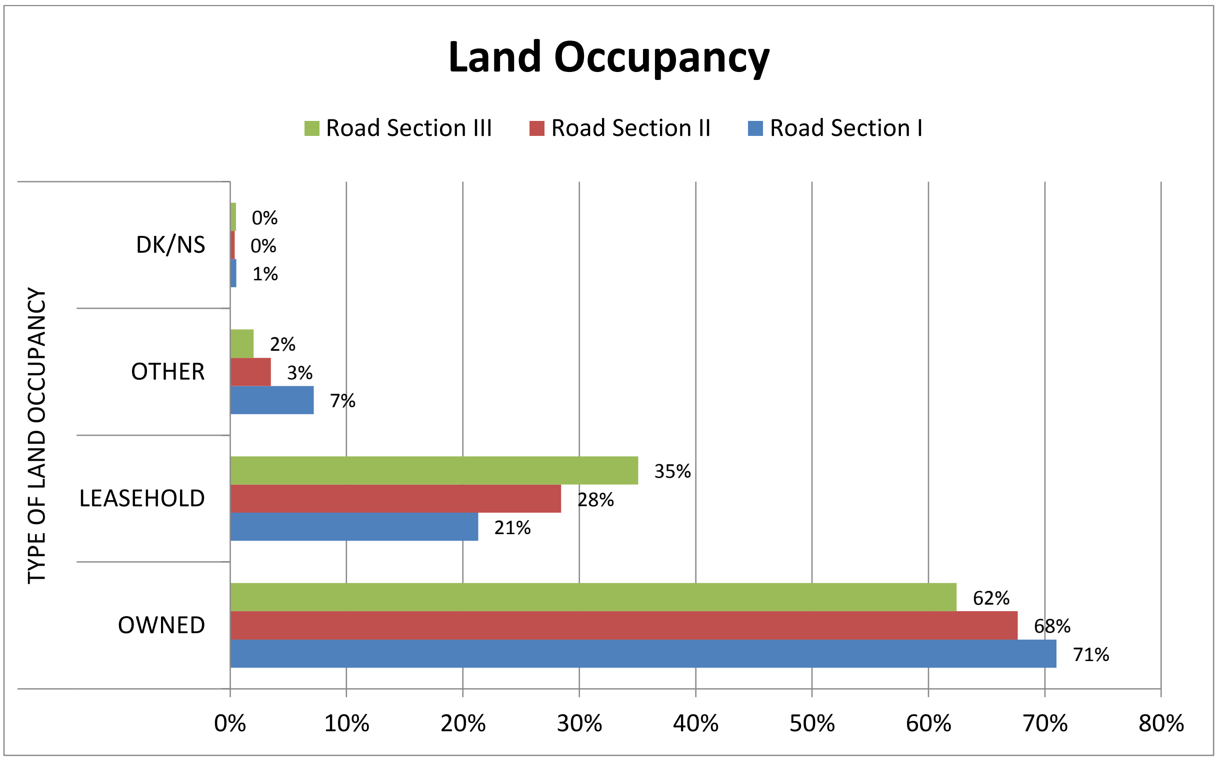


Figure 5.10: Land Occupancy Rate

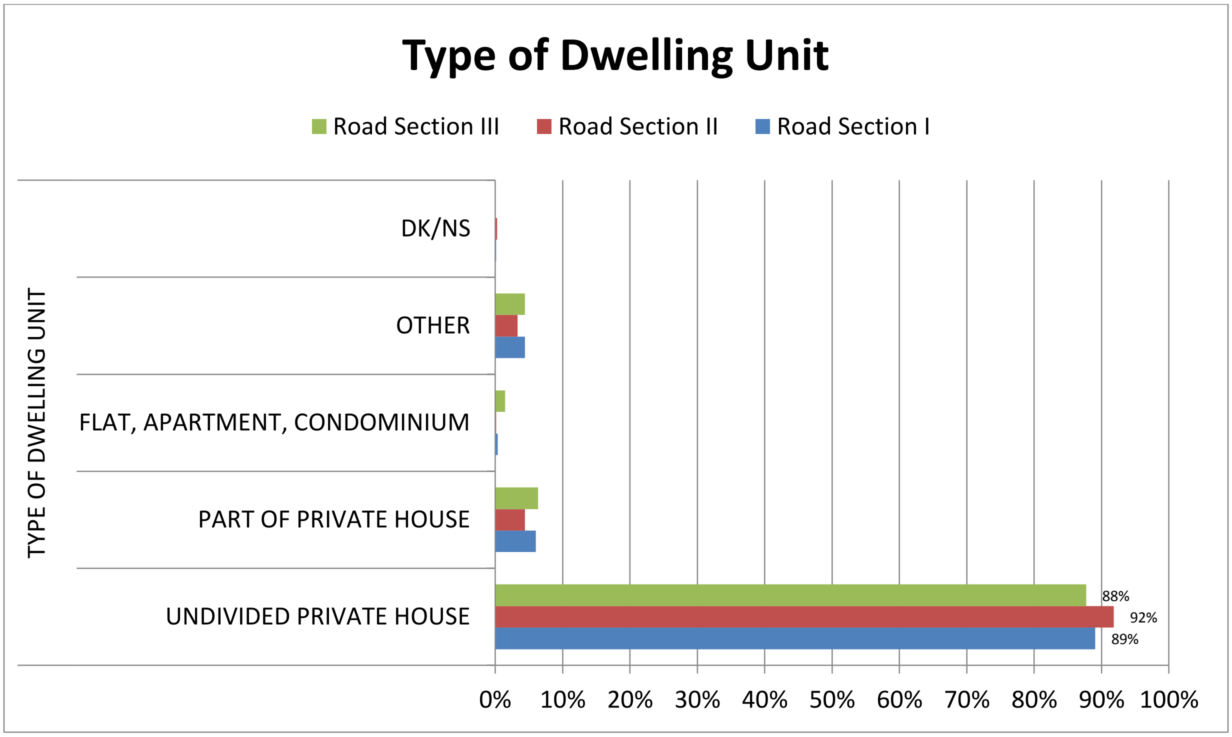


Figure 5.11: Dwelling Unit Type

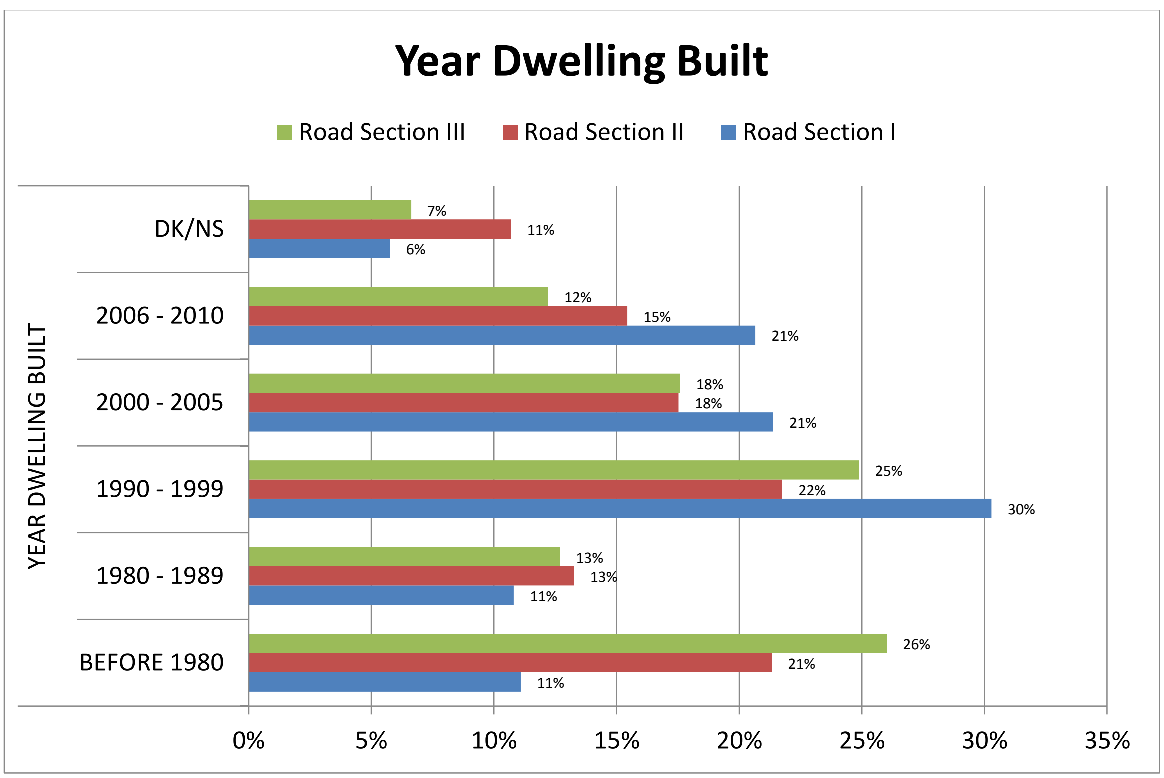


Figure 12: Construction Period

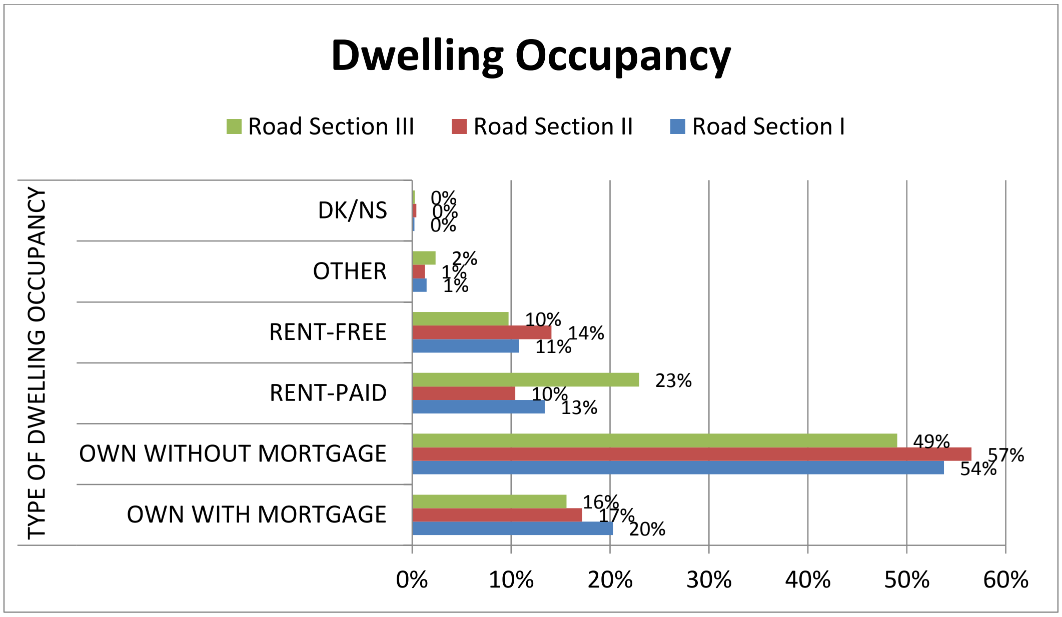


Figure 5.13: Dwelling Occupancy

5.8 Health: General Health, Long Term Illness and Disability

Generally, the residents of the communities in the Study Area appear in overall good health. Arising from discussions with key informants in the communities, no health related issue associated with dengue, malaria or cholera was identified.

While residents across the communities appear in general good health, in a number of cases, primarily related to older persons and to a lesser extent mature adults, the presence of long term illnesses have been identified. The distribution of chronic long-term illnesses by road sections are presented in Figure 5.14.

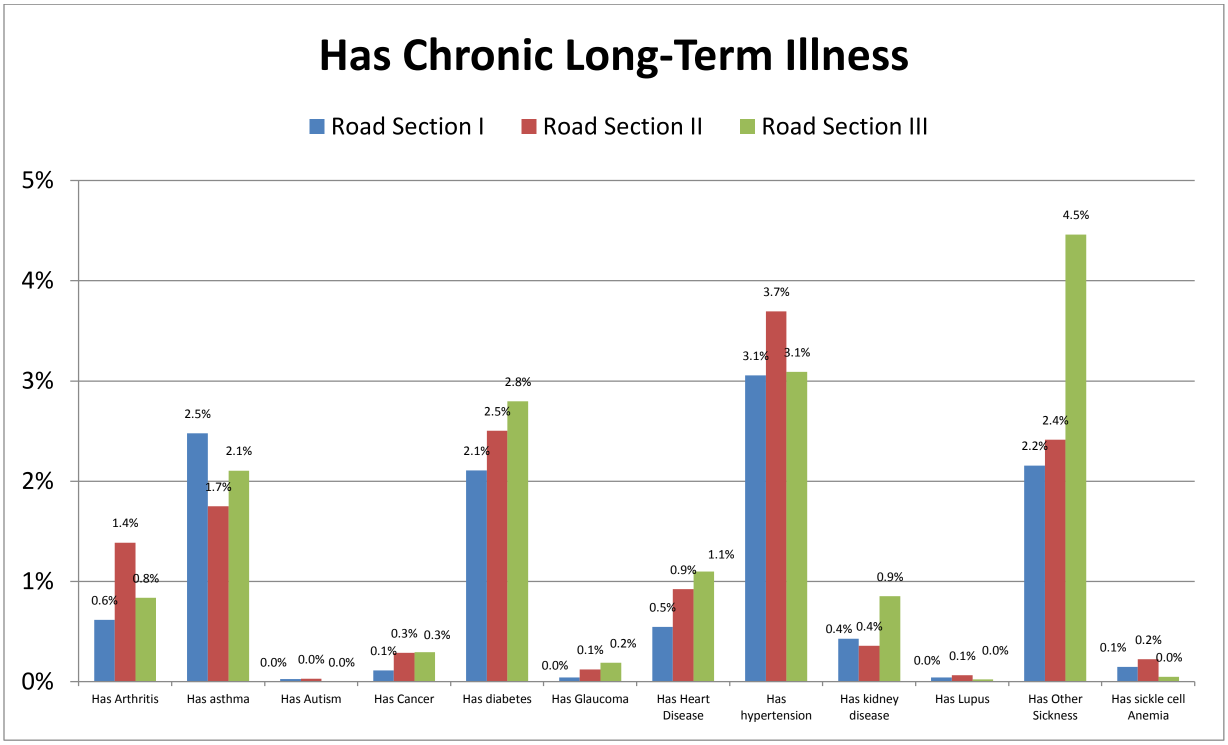


Figure 5.14: Long-Term Illness

With respect to disabilities in communities across the Area, fewer than 1% of residents report some type of disability as measured by reporting 'lots of difficulty/cannot do at all'; most common among these are extreme difficulty seeing and self-care. Distribution across the road sections is presented in Figure 5.15.

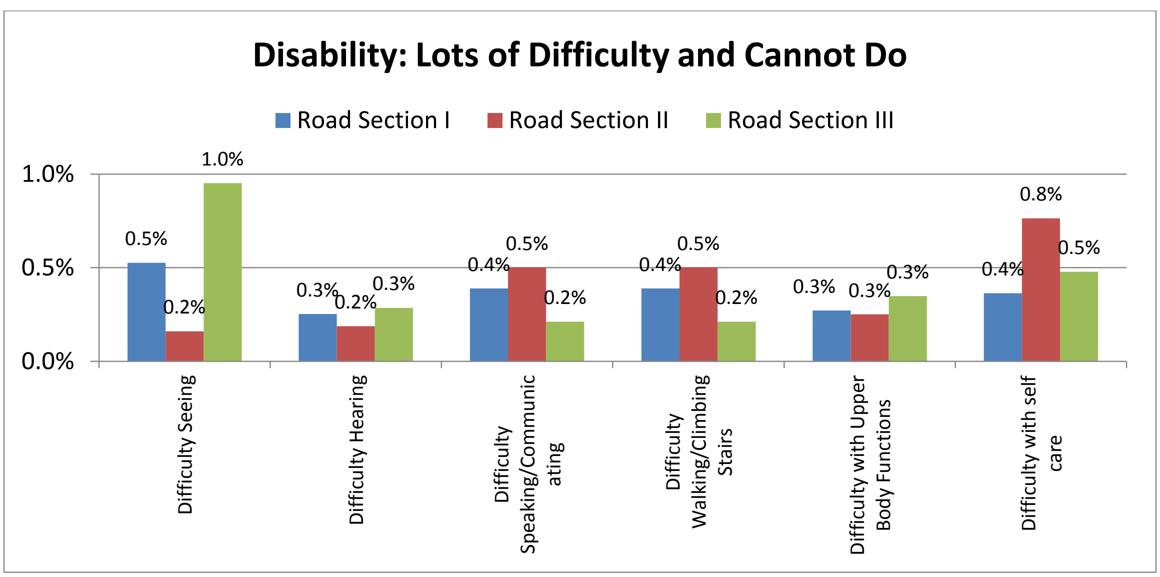


Figure 5.15: Disabilities

5.9 Community Assets and Basic Services

Generally, communities across the road sections enjoy basic amenities, viz. electricity, water, waste disposal, schools, community centres, health centres and police stations which contribute to modern comforts of the residents. Table 5.3. With the exception of Georgeville, San Jose Succotz and Benque, communities lack police sub-stations and health facilities.

Table 5.3: Socio-Economic Assets

Road Section	Community	Infrastructure					
		Community Centre	School	Health	Sporting Facilities	Police Station	Bus Stop
I	Roaring Creek	✓	✓	-	✓	-	✓
	Camalote	✓	✓	-	✓	-	✓
	Teakettle	✓	✓	-	✓	-	✓
	Ontario	✓	✓	-	✓	-	✓
	Blackman Eddy	✓	✓	-	✓	-	✓
II	Central Farm	-	✓	-	-	-	✓
	Unitedville	✓	✓	-	✓	-	✓
	Georgeville	✓	✓	✓	✓	✓	✓
	Esperanza	✓	✓	-	✓	-	✓
III	San José Succotz	✓	✓	✓	✓	✓	✓
	Benque Viejo	✓	✓	✓	✓	✓	✓

The school density along the entire road section is extremely high with some fifteen preschools, primary schools and university campuses located along the existing ROW; mapping of the primary schools is presented in Figure 5.16.

Distribution of community centres and bus stops are rather evenly distributed across the road sections; additionally, the presence of sporting facilities, i.e. softball and football fields and basketball courts offer young persons and the wider communities key moments for social interaction.

Notwithstanding the strong presence of community centres across the ROW, levels of participation of residents in public meetings and wider matters of community governance are reportedly low. Of recent, communities have grown increasingly polarized along political lines; in addition, linkages and relationships among and between local and central governments leave much to be desired (FGD: Village Chairpersons, 2014).

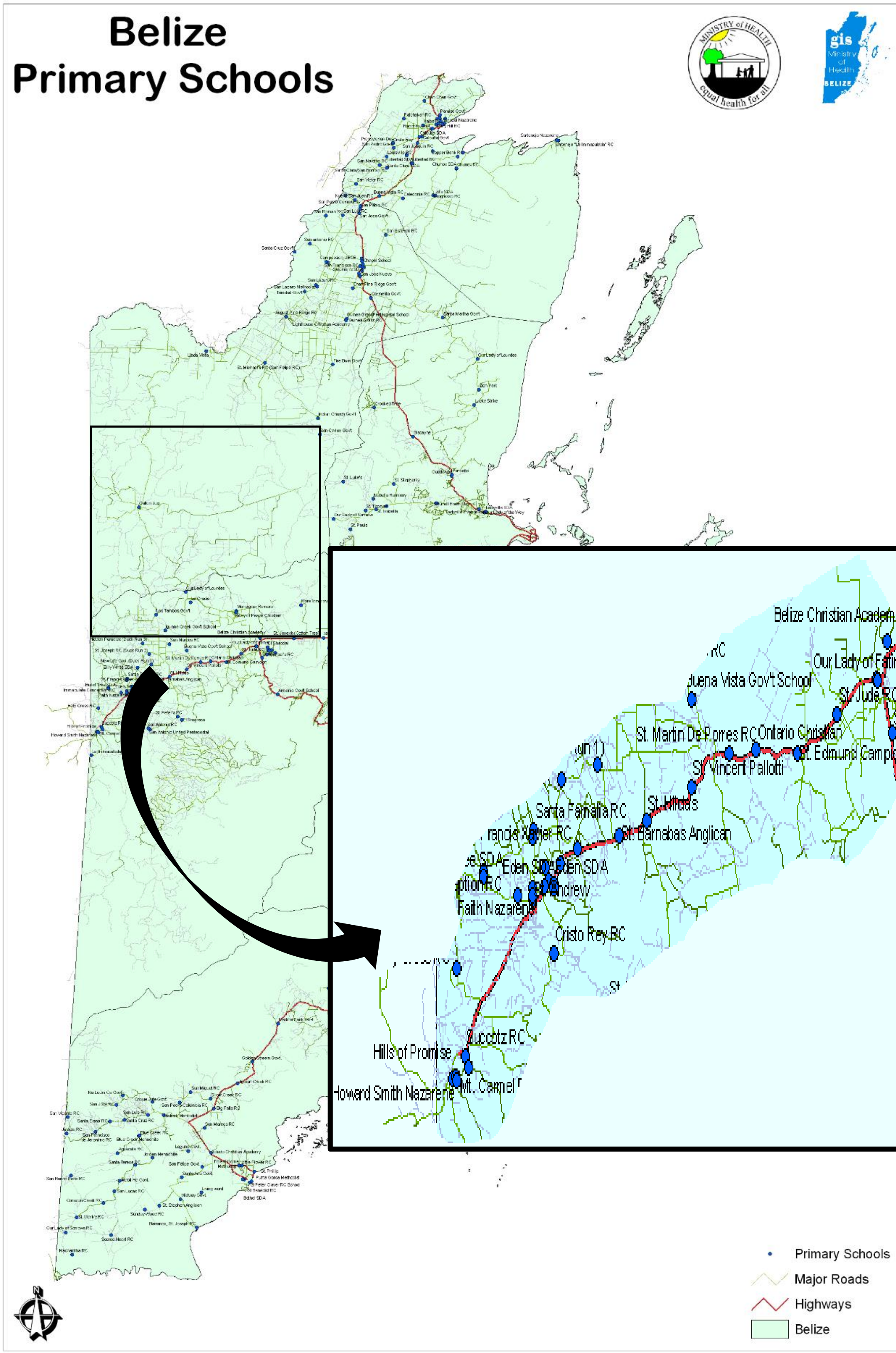


Figure 5.16: Mapping of the primary schools.

5.10 Water Supply

The vast majority of households (> 85%) enjoy water piped directly into their dwelling or yard; for the most part, water pipes are in close proximity to the existing ROW, Figure 5.17. A lesser number of households access water from dug wells, streams/rivers. Distribution is as shown in Figure 5.18.

Figure 5.2: Exposed Water Infrastructure along ROW.

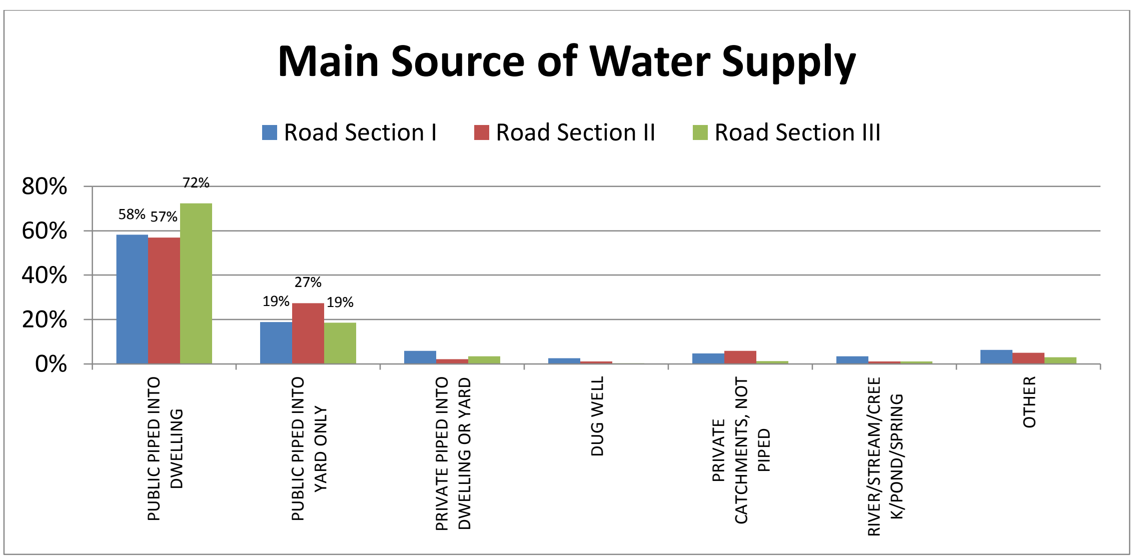


Figure 5.3: Water Supply

5.11 Lighting Source

With respect to lighting source, vast majority of households (> 85%) receive electricity from public source, i.e. national grid; few HH are dependent on kerosene lamps/candles, Figure 5.19.

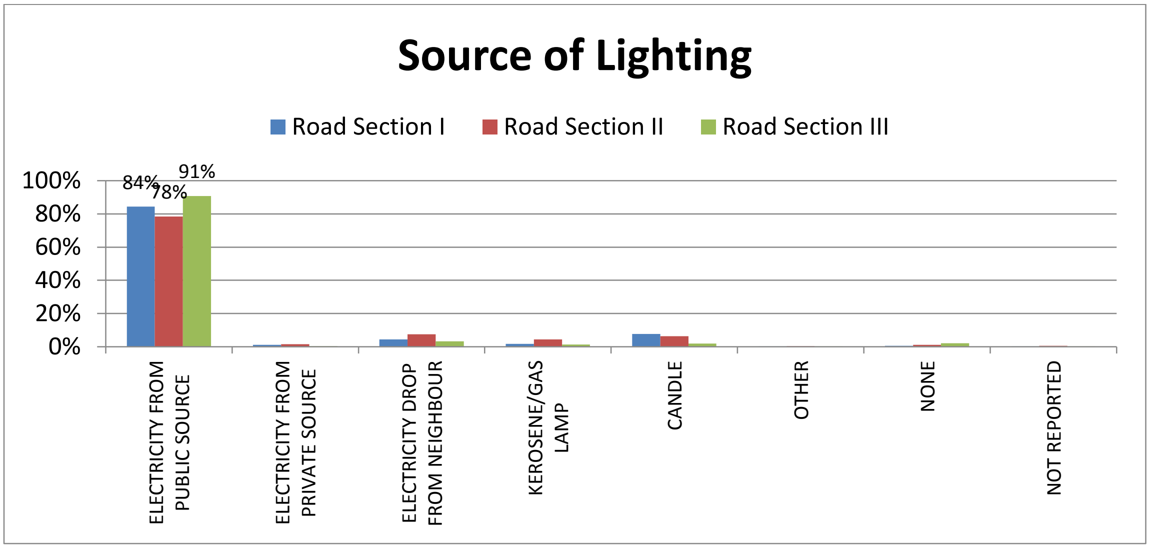


Figure 5.4: Lighting Source

5.12 Waste Disposal

Majority of households (> 50%) in the Area have flush toilets linked to septic tanks with the remainder making use of varied forms of pit latrines for excreta disposal, Figure 5.20.

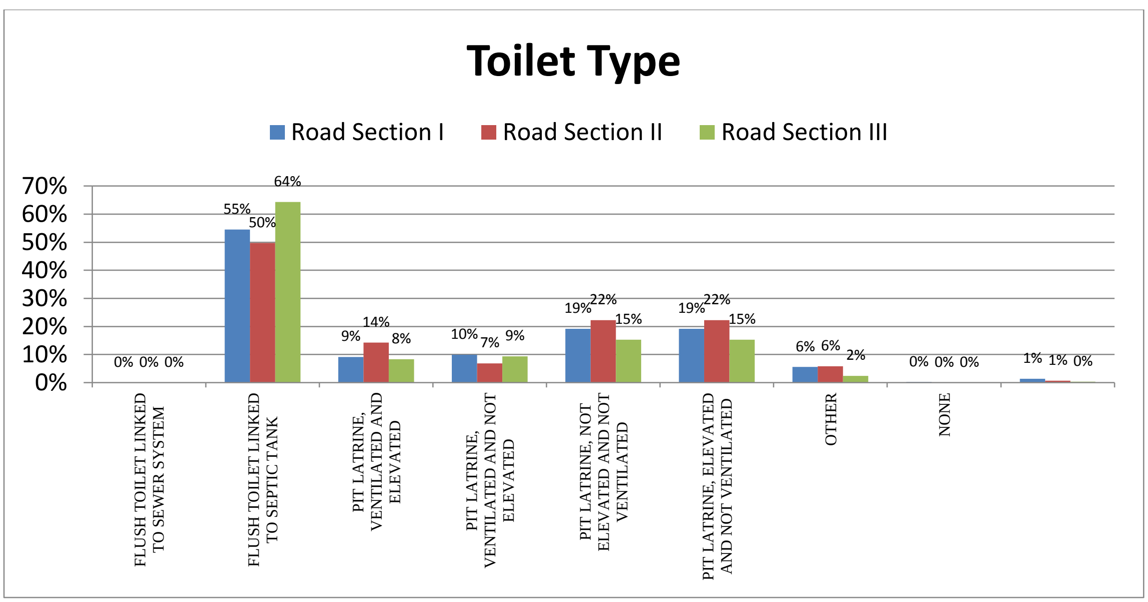


Figure 5.5: Toilet Type

Significant proportion of households within road Sections I and II report the burning of garbage as a primary means of disposal while other make use of the garbage collections service provided by local government, Figure 5.21.

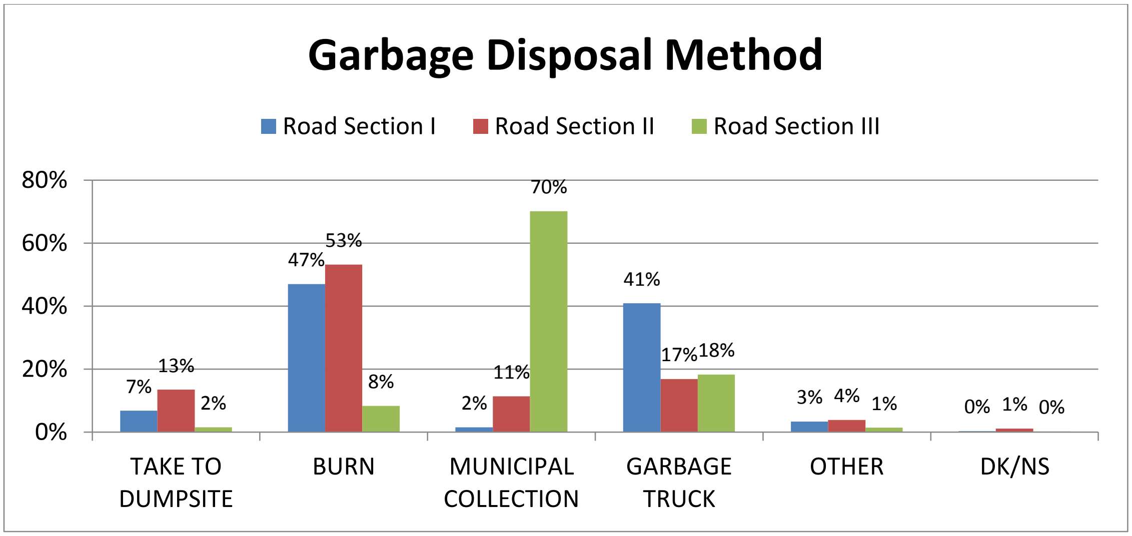


Figure 5.6: Garbage Disposal

5.13 Road Use and General Community Perception

Residents of the communities within the Study Area have expressed an overwhelming level of support for the proposed road rehabilitation project as captured during the SES and FGD. Notwithstanding, a number of concerns were noted as summarized below.

One-half of residents along the ROW rated the condition of the GPH as either poor or very poor. During the rainy season, the road conditions seemingly worsens with 80% of residents indicating poor/very poor road conditions. Furthermore, 65% of residents rated their experience travelling the GPH by vehicle as uncomfortable; while 81% rated their experience as a pedestrian as unsafe. 80% of residents felt that the GPH could improve with proper lighting. At the time of the SES, 15% of residents reported having been involved in an accident/injured on the GPH. "Too many potholes", "too narrow/should be widened", and "no/inadequate space for pedestrians/cyclists" were the top three ranked problems associated with the GPH followed by "no storm water/flooding drainage", speeding and "drunk drivers".

62% of residents indicated that dust from the GPH ‘caused some problems’ with 27% reporting health related issues.

With respect to mode of transport, 46% of residents indicated public transport, followed by use of personal vehicles (35%). From the Survey it was apparent that the GPH forms a critical link for residents in the pursuit of their livelihoods and in accessing basic services.
“Better access to services”, “faster travelling time”, “new job opportunities” and “safer roads, especially for women and children” were among the top ranked benefits of a rehabilitated GPH.

5.14 Comprehensive Knowledge of HIV

Practically all residents (99%) from the communities along the ROW within the Area had heard of AIDS; however, less than 5% had ‘comprehensive knowledge about HIV prevention’, i.e. proportion of respondents who knew of the two ways of HIV prevention AND who knew that a healthy looking person can have the AIDS virus AND who rejected the two most common misconceptions.

5.15 Poverty Distribution

In 2012, the Statistical Institute of Belize produced a national poverty map using small areas estimation technique. As presented in Table 5.4 and further illustrated in Figure 5.22, with the exception of Roaring Creek which falls into Quintile 4, all the remaining communities along the existing ROW fall into Quintiles II or III indicating a general middle to lower middle socio-economic status across the road section (Quintile I = lowest SE status; and Quintile V = highest SE status). The relative socio-economic standings of the communities against the national (221 communities) and district (43 communities) counts are presented in Table 5.4, i.e. national and district ranking respectively.

Table 5.4: Socio-economic Ranking of Select Communities by Road Section

Road Section	Community	Population	WEALTH INDEX QUINTILES	WEALTH INDEX SCORE	National Rank	District Rank
I	ROARING CREEK	1,974	4.00	.5069945	22	1
	CAMALOTE	2,562	3.00	.1167816	53	4
	TEAKETTLE	1,746	2.00	-.3277642	99	11
	ONTARIO	775	3.00	.1145912	54	13
	BLACKMAN EDDY	533	2.00	-.1578479	79	9
II	CENTRAL FARM	205	3.00	.0366835	62	6
	UNITEDVILLE	971	3.00	-.0284924	68	8
	GEORGEVILLE	922	2.00	-.2954268	95	10
	ESPERANZA	1,262	3.00	.1505301	48	3
III	SAN JOSE SUCCOTZ	2,343	3.00	-.0099692	65	7
	BENQUE VIEJO	6,148	3.00	.4448941	27	2

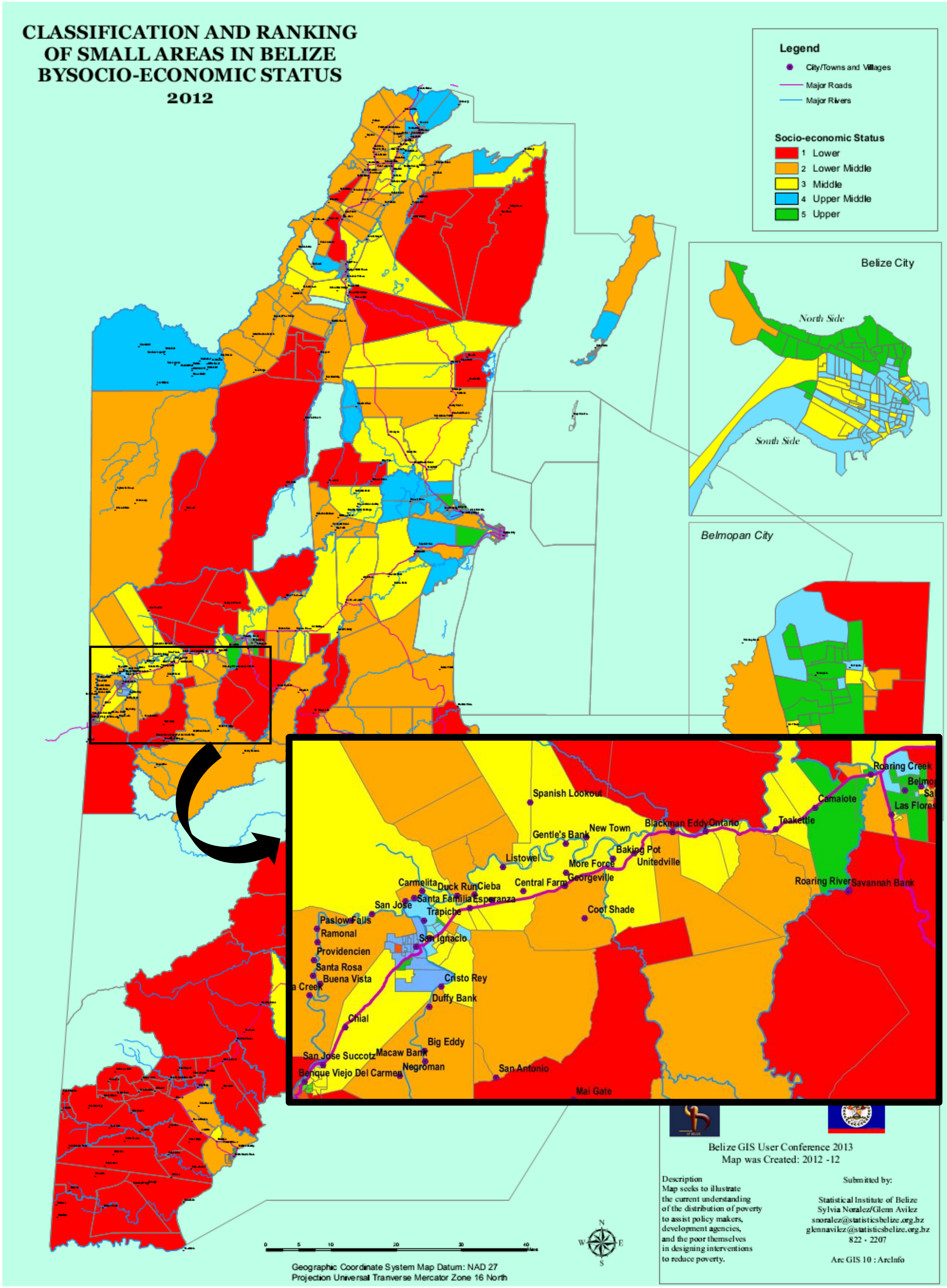


Figure 5.7: Poverty Map

5.16 Cultural Heritage

5.16.1 Archaeological Heritage

In accordance with the Belize Environmental Compliance Protocols and the National Institute of Culture and History Act Chapter 331, a complete archaeological assessment was conducted within the Study Area. The archaeological assessment identified the total extent of archaeological remains within the project area, focusing on locating and recording all structures, sites and cultural features within the area that would be impacted by the road rehabilitation project.

5.16.1.1 Methodology

Areas along the existing GPH corridor were reconnoitred to identify archaeological features within a 50 feet (20m) access corridor on either side of the centre-line of the GPH. Additionally, potential bypasses were also investigated to identify a 30 feet (12m) right of way and a 50 feet (20m) access corridor where minimum disturbances to archaeological features would occur. All possible routes were surveyed using a combination of remote sensing techniques and pedestrian surveys.

The Archaeological Assessment was conducted during the months of June-July, 2014, and focused particular attention on the potential bypasses near Roaring Creek, the Z-Curve just west of Teakettle, and the Succotz – Benque Viejo loop. Investigations of the corridor were conducted with the use of LiDAR survey data, reconnaissance and ground truthing along the corridor, and examination of published archaeological reports.

Prior to field work, maps of the region were acquired and reviewed in an effort to obtain information on the terrain and resources in the Study Area. Subsequently reports of previous investigations in the region, with particular emphasis on the geological, biological and especially archaeological research were reviewed. Information from several of the maps were later integrated a Geographical Information System Database that allowed for the potential routing of bypasses.

For purposes of the Archaeological Assessment, the GPH corridor was divided into three road sections with specific attention to areas where archaeological materials have been recorded. In addition GIS analyses of Light Detection and Ranging (LiDAR) data was utilized where available, to identify possible archaeological features.

Transects

In order to facilitate the pedestrian survey along the potential bypasses, perpendicular transects were created at a distance of 100 feet (40m) along bypass 1 and bypass 2. Transects along bypass 3 were spaced at 50 feet (20m) distance due to the high level of known archaeological features in the area. All transects were created to a total length of 130 feet (52 m) to reflect the primary road corridor (30ft) and the secondary road corridor (50ft on either side of the centre-line of the road width).

A total of 24 transects were created along the southern portion of Bypass 1 along the length of the power line corridor from the Roaring Creek (at the Riviera) to the Roaring River Drive (at Butte Rows). Bypass 2 contained a total of 52 transects along the base of Lucy Hill on an existing old road corridor; In addition 3 parallel transects were created to the south of the existing GPH corridor at a distance of 50 feet (20m) intervals. These parallel transects were placed in order to investigate the possibility of widening the existing road corridor in this area. Bypass 3 contained 3 sets of transects along Alternate Routes 1, 2 and 3. Alternate Route 1 had 47 transects along the existing corridor starting at the junction of the old Negroman road and encompassing the entire power line corridor as per the TOR. Alternate Route 2 contained a total of 37 transects starting at the old Negroman road and extending in a straight line in a southerly direction to the common point of convergence of all 3 routes. Alternate Route 3 has 45 transects starting at the old Negroman road and extending south to the point of convergence.
All existing road corridors and transects were reconnoitred to identify archaeological features visible above surface.

LiDAR Analysis

Analysis of LiDAR data was performed using a high-resolution (1m) DEM and incorporated into a Geographic Information System (GIS) to record architectural features. Calculations for the topographic position index (TPI) were used to identify the location of prehistoric architectural features. TPI values reflect the difference between the elevation in a particular cell and the average elevation of cells within a given study area. Positive values indicate that the cell is higher than its surroundings, while negative values indicating a lower elevation. Significantly high values suggest the cell represents a high point within a specified neighbourhood.

An annular (or doughnut-shaped) neighbourhood was used to classify mounds within 500 m^2 samples of the study area, where only cells between 2 and 10 meters were considered. Threshold TPI values were defined based on standard deviations from the elevation, reflecting the variability of elevation within the defined neighbourhood. The identified mounds were checked visually on a hill shade model and as well as in profile to eliminate modern (e.g., houses) and natural features (e.g., tree growth). Once identified, all sites and structures were visited for the collection of data. This includes location data, site information, and structure information. Numbers and names were assigned to all sites, structures, and features of archaeological significance.

All settlement data was inputted into a Geographical Information System (GIS) database for further insight into geographical relationships and patterning. Since these maps were produced in the World Geodetic System 1984, WGS84 was used as the native projection for all geographical information collected. Finally, site and structure locations and their attributes were inputted and plotted on the base map.

5.16.1.2 Description of Potential Bypasses

Bypass 1 is located within the limits of Belmopan City and Roaring Creek Village. This bypass has three sections starting at the GPH/Hummingbird Highway running in a southern direction for 1240m to the junction of the Hummingbird Highway and Butte Rows at the Quality Poultry Products Belmopan distribution center. From this juncture, the bypass turns in a westerly direction along Butte Rows for a distance of 946m where it joins an existing power line corridor leading west across the Roaring Creek River for a distance of 966.6m and a total distance of 1912.6m. The third section of the bypass extends from the junction of the power line corridor and the Roaring River Drive (RRD) headed in a northerly direction for 770.9 m to the junction of the RRD and the GPH. The bypass encompassed a total of 3923.5m, Figure 5.23.

Figure 5.8: Belmopan – Roaring Creek Bypass

Bypass 2 is located at the western edge of Teakettle Village in an area locally known as the Z-Curve. The possible route identified encompasses an old road access starting just east of the Z-Curve and diverting to the south along the base of 'Lucy' Hill to the west of the Z-Curve; this bypass area encompasses a total length of 1283m, Figure 5.24.

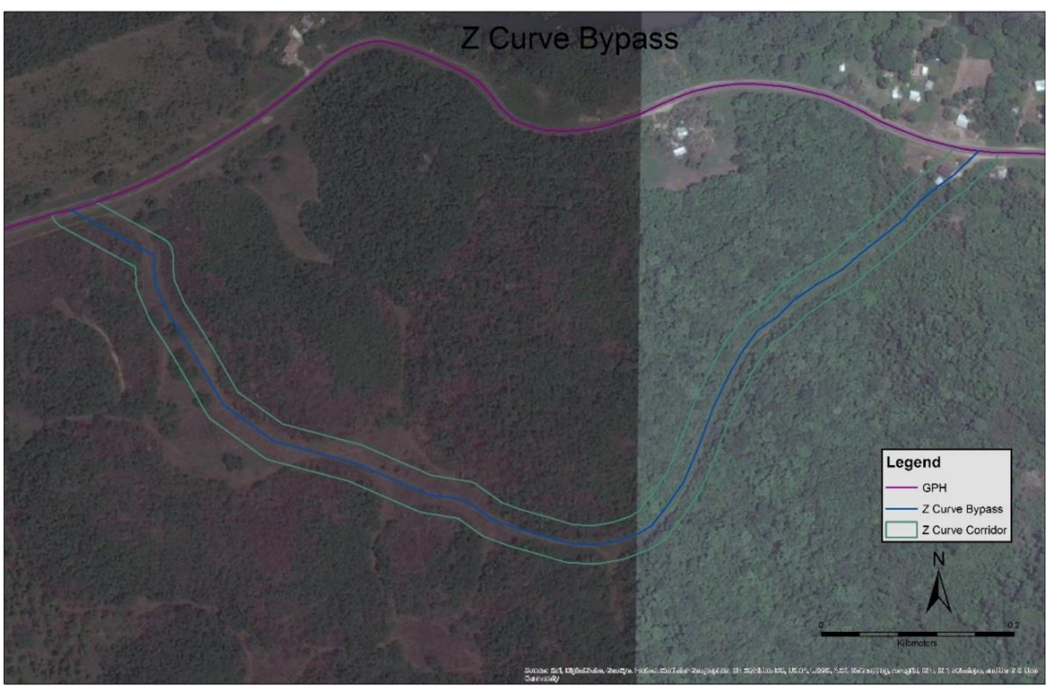


Figure 5.9: Z-Curve Bypass

Bypass 3 is located in the village of San Jose Succotz and extends in a south to south-westerly direction to the town of Benque Viejo Del Carmen. Due to the density of archaeological sites in the area, as well as the presence of modern infrastructure and dwellings, three alternative routes were identified as per the TOR. The three alternate routes converge to the east of Succotz and head south then west by south-west to the GPH in the north eastern edge of Benque Viejo totalling 1683.6m.

Alternate Route 1 starts at the junction of the GPH and the old Negroman Road, just south of the Trek Stop and heads east along the old Negroman Road for a distance of 590.7m. From this point the route turns south for 665m then west for 287.5m along an existing power line corridor. At this point the route converges with an existing feeder road and continues west for 379m to the point where all the routes converge. Alternate route 1 encompasses a length of 1951.2m, Figure 5.25.

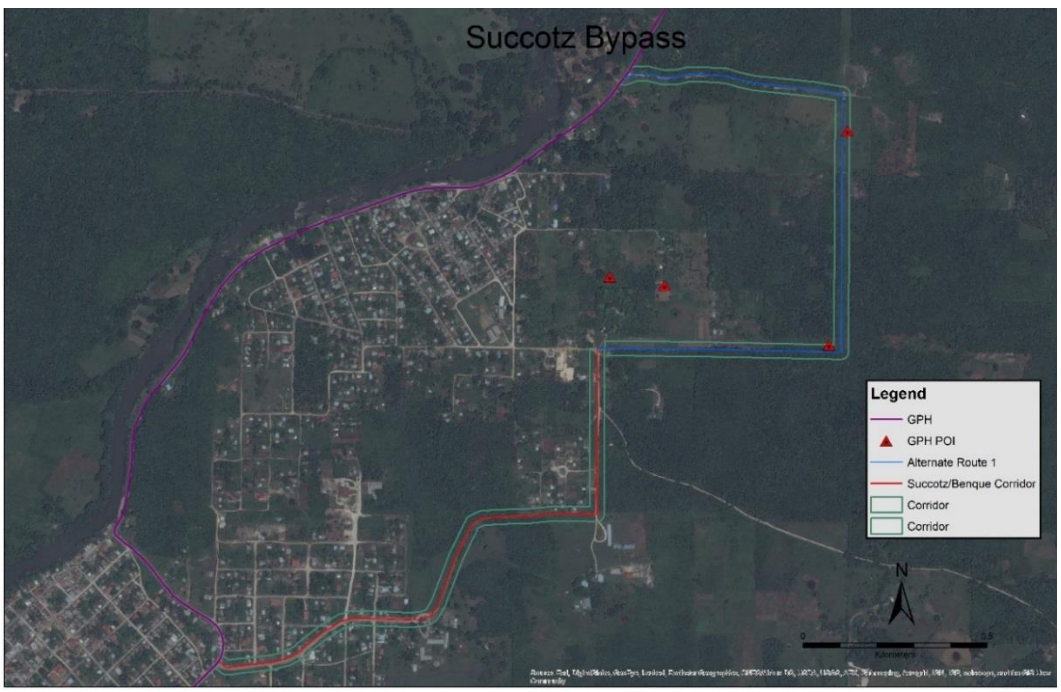


Figure 5.10: Succotz Alternate Route 1

Alternate Route 2 starts at the old Negroman Road and extends for 741.6m south where it converges with the other alternate routes.

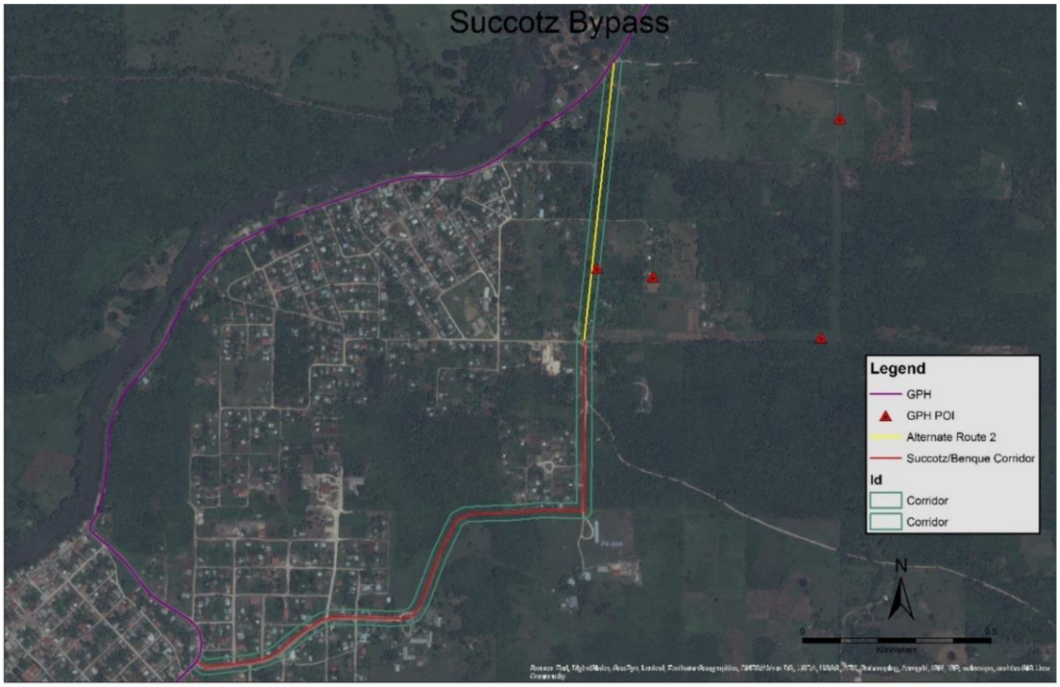


Figure 5.11: Succotz Alternate Route 2

Alternate Route 3, like Alternate Route 2, also starts at the old Negroman road and extends to the south in the form of an arc to the point of convergence of the routes. This route measures 910m in length, Figure 5.27.

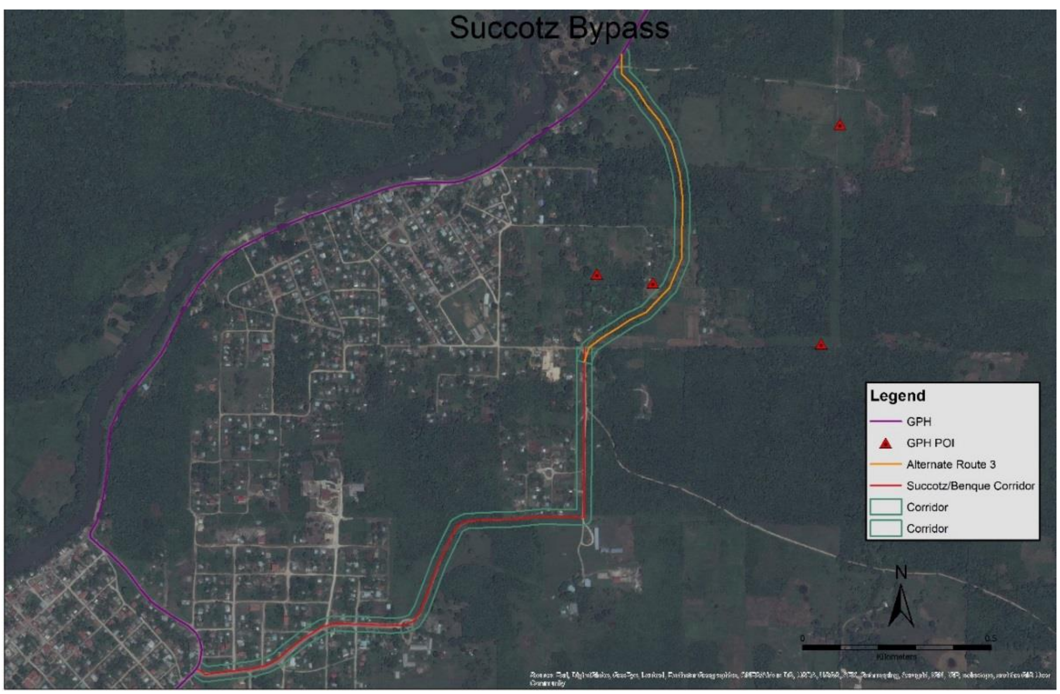


Figure 5.12: Succotz Alternate Route 3

5.16.1.3 Archaeological Assessment: Background

In Belize, archaeological sites generally fall under one of three designated types: Pre-ceramic, Pre-historic Maya, and Historic period settlements. Pre-ceramic sites are sub-divided into two categories, Paleo-Indian and Archaic. The former include the camp sites of the first human inhabitants of Belize and dates 12,000 to 7,000 B.C while the latter spans the period 7,000 to 1,300 B.C. Both phases pertain to occupants who are considered culturally pre-Maya inhabitants. Prehistoric Maya occupation extends from at least 1200 B.C. to the time when contact with the first Europeans was made around 1500 A.D. The Historic Period spans from 1500 to 1900 A.D. and encompasses the time from Spanish contact to the early phase of British colonial settlement.

Paleo-Indian and Archaic occupation is extremely difficult to detect, first because of the extreme age of the remains, and second because these people utilized campsites that leave limited evidence of their presence or that mark the location of occupation zones. Paleo-Indian and Archaic people were also nomadic and semi-nomadic and their highly mobile lifestyle precluded the construction of permanent buildings or settlements.

The assessment identified no evidence for Paleo-Indian or Archaic human activity within the Route Corridor. Notwithstanding, related materials have been found in various locations not too far from the George Price Highway. Evidence for these early people have been reported at Actun Halal, a rock-shelter that is located no more than 4 kilometers east of San Jose Succotz and previous investigations by the BVAR Project at Actun Halal (Awe and Lohse 2007) recovered several Pre-ceramic stone tools in association with bone fragments of several species of now extinct animals (horse, cave bear and some type of large rodent). Less than a kilometer away, at Actun Chechem Ha, BVAR archaeologists also recorded at least three radiocarbon dates that fell well within the limits of the Archaic period. Additional Archaic period remains, in the form of several Archaic projectile points, have been recovered along the Macal River in San Ignacio Town, at Billy White, on the Trapiche Road in Santa Elena, on the north bank of the Belize River near the Iguana Creek Bridge and about 3 kilometers south of the Roaring Creek bridge (Lohse et al. 2006). Other specimens have been recorded at Black Rock, and along Rio Frio near Douglas D'Silva. At the confluence of the Macal and Mopan Rivers, a farmer also discovered the cut proximal end of the femur of a Pleistocene period giant sloth, while kids swimming in the Mopan River near Bullet Tree recovered two molars of an extinct American Mastodon. Both of these animals were exploited by Paleo-Indians and their presence along the two river valleys suggests that there was considerable human activity in the Belize River Valley area towards the end of the Pleistocene era (10,000 to 7,000 B.C.).

Prehistoric Maya occupation in western Belize extends from approximately 1200 B.C. to the tenth century. During this extensive phase of occupation, the ancient Maya population is estimated to have reached close to one million persons dispersed across Belize indicative of the identified archaeological sites, Figure 5.28.

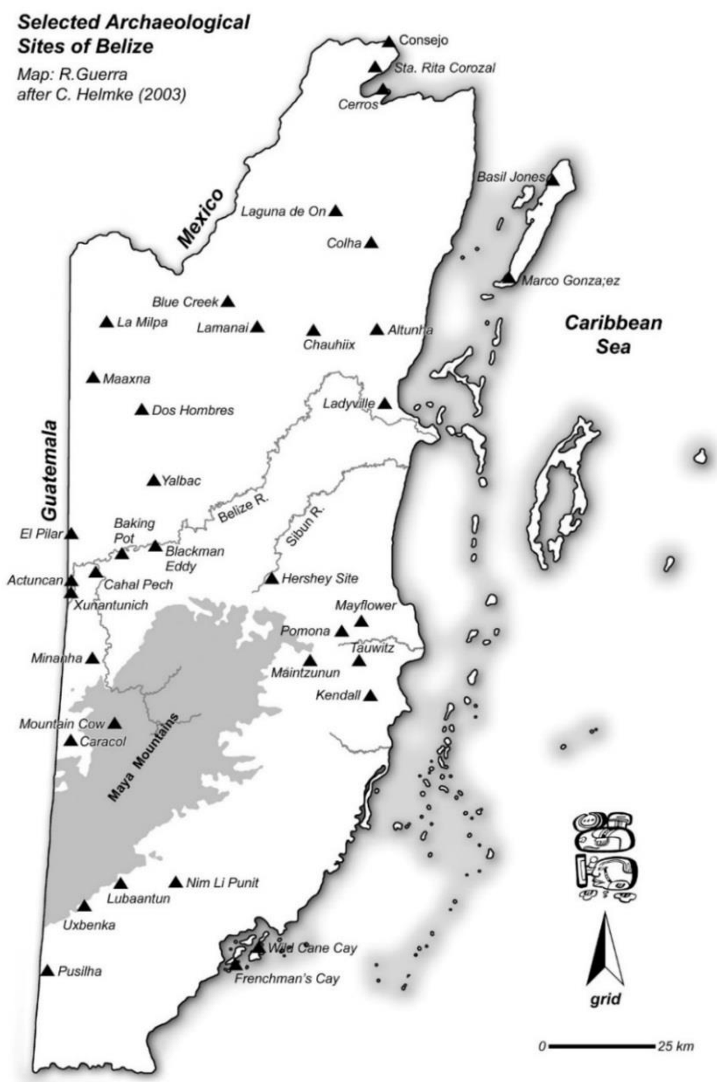


Figure 5.13: ***Map of Belize and Select Archaeological Sites***

Like most riverine areas of the country, the Belize River Valley was densely populated by A.D. 500. Today many ruined cities of the ancient Maya period can still be found on both flanks of the Belize River, Figure 5.29, and along the banks of its two major tributaries, the Macal and Mopan. From East to west, the larger sites include Bacna, Camalote, Blackman Eddy, Lower Dover, Baking Pot, Cahal Pech, Buena Vista, Actun Can and Xunantunich (Audet and Awe 2005, Helmke and Awe 2012). Numerous other smaller centres are dispersed across these major sites.

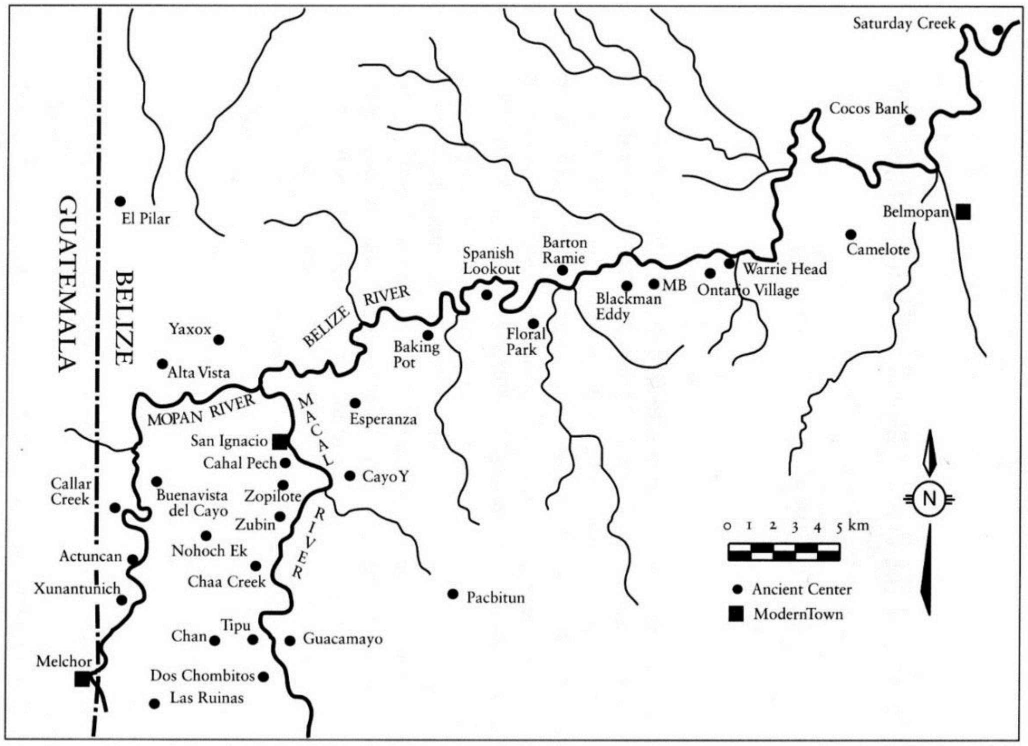


Figure 5.14: Archaeological Sites along the Belize River Valley

Archaeological investigations within the Route Corridor region presently indicate that Maya settlements were first established by at least 1200 B.C. Not too long after, and certainly by 400 B.C., all the other sites had been settled by Maya farmers. Previous surveys have also recorded evidence for extensive agricultural terracing on the limestone hills south of San Ignacio and just east of San Jose Succotz and Benque Viejo del Carmen.

Just before the start of the Historic period, particularly around 900 to 1000 A.D., many of the large Maya cities in western Belize, and the eastern Peten province of Guatemala, were abandoned. This situation was also true of the Maya cities along the Belize River Valley. Eventually, and about two centuries later, several sites were re-occupied by Late Post-classic Maya who likely migrated from the north in Yucatan. These people established new settlements along the Belize River and its tributaries. Some of their sites include the towns of Zaczus (at the juncture of Roaring Creek and the Belize River), Hubelna (upriver from Roaring Creek Village), Chantome (near Baking Pot/Central Farm), and at Tipu, located at Negroman a few kilometres upriver from San Ignacio Town (Awe and Helmke 2014; Thompson 1972). Investigations at the latter site were conducted in the 1980's by Elizabeth Graham of the University of London, England. Results of Graham's (2011, also Graham et al. 1985, 1989) work, and information that was recorded by Spanish explorers (Villagutierre y Soto-Mayor 1983), has allowed for fairly accurate picture of contact-period life along the greater Belize River Valley during the early Historic period to reconstructed.

We now know that sometime during the 14th century, a group of Itza Maya had settled in the vicinity of modern day Negroman and established a large town by the name of Tipu (Jones 1989, 1998). These Itza Maya maintained close ties with their relatives at Tayasal (modern day Flores, Peten, Guatemala) and with the site of Lamanai. When the Spanish began to head into Belize from their base in Bacalar in the Mexican state of Quintana Roo, Spanish priests constructed simple Ramada churches at several communities along the New River lagoon, at Zaczus near Roaring Creek, and at Tipu on the Macal. These churches were dubbed Visita churches because the Spanish kept no permanent clerics in the communities. Instead, Spanish priests would make periodic visits to the towns where they would spend a few weeks celebrating mass and converting the inhabitants to Catholicism. On several occasions, the Maya rebelled, burnt down the churches, and, at times, sacrificed the priests.

In response to these rebellions, and in an effort to complete the subjugation of the Maya, the Spanish mounted a major offensive in 1697. By the end of that year, the Itza capital of Tayasal (modern Flores Peten) finally capitulated (Jones 1998). Thereafter, the Maya in communities along the Belize River (like Tipu, Chantome, and Hubelna) were forcibly removed from their towns and transferred to Encomienda farms further west in Guatemala. When the British moved into the area in the 17 to 1800's they record little to no evidence of Maya settlements along the Belize River Valley. They also established several outposts where they could keep an eye on potential Spanish incursions from the Peten, and for exploiting forest resources for exportation to Europe. One of these settlements was in the location of present day Spanish Lookout. Investigations found no evidence of British Historic Period settlements in the survey area. In contrast, substantial evidence for prehistoric Maya settlements is recorded.

5.16.1.3 Archaeological Assessment: Key Findings

Identification of archaeological heritage located within the Study Area and disaggregated by the three road Sections follow; where there are prehistoric settlements that will potentially be impacted by road construction, these are highlighted and GPS points are provided for them.

Road Section 1: The first section of road extends from Mile 47.9 to mile 56, or from the Belmopan Junction to the Iguana Creek Road Junction. Two of the three proposed Bypasses are also located in this section of the road. The first Bypass extends from the Hummingbird Highway at its juncture with Forest Drive and rejoins the main George Price Highway at the western edge of Roaring Creek Village. The second Bypass is located at the "Z" curve just west of Teakettle. The proposed route for this bypass follows an existing trail for BEL's high power electric lines. Archaeological sites within Road Section 1 include, from east to west, the Riviera Site, Camalote, Teakettle, Warrie Head, Ontario, and Blackman Eddy. The Riviera Site was first reported by Awe and Audet in 2001. The site is predominantly located along the eastern banks of Roaring Creek, just to the south of the proposed Bypass. It is important to note, however, that several small mounds belonging to this settlement are dispersed on both sides of the bypass, particularly in the area around the National Agricultural Fairgrounds. Assessment of the bypass route identified one solitary mound that would be impacted by road construction at GPS coordinate E 308780 N 1908287.

The site center of Warrie Head is located on the north side of the George Price Highway, about 200 meters west of the bridge and about 1.5 kilometers west of the Z curve. The site, which is located on private property belongs to John Searle Sr., was first reported by a Harvard University project in 1954 (Willey et al. in 1965: 310-312). The site is composed of at least three plaza groups and several other solitary mounds. The assessment indicates that there are two sets of mounds belonging to the Warrie Head settlement that can be impacted by the road rehabilitation project. The first of these is located on the south side of the road at GPS point E 300477 N 1905479. This mound appears to have been previously damaged by past widening of the carriageway. The other mounds are part of a small plazuela group and are located across the road from the solitary mound within the Searle property. Their GPS coordinates are E 300583 N 1905461. Although the mounds are situated just inside the wire fence of the Searle's farm, any widening of the highway in this area will certainly damage them, Figure 5.30.

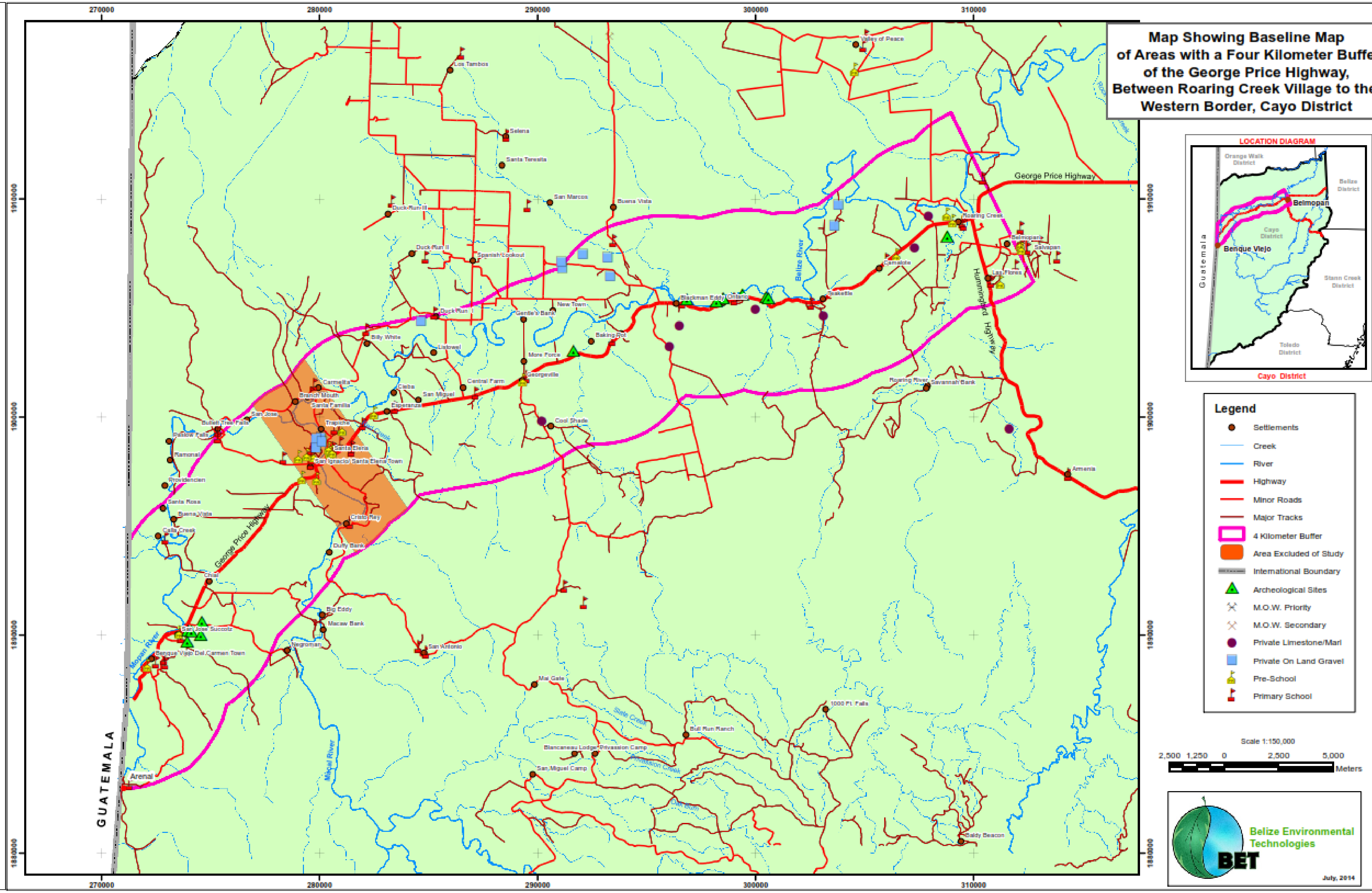


Figure 5.30: Baseline Map showing Achaeological sites, schools etc.

The Ontario Site is located at the eastern entrance of Ontario Village, just south of the Highway near its entrance to the village, Figure 5.31. The site was first recorded by the Belize Department of Archaeology in 1969, and then investigated by James Garber in the late 1990's (Driver and Garber 2004:297-301). While the site core is beyond the 100 feet corridor, there are two plaza groups and a solitary mound on the western edge of the village that could likely be affected by the road rehabilitation project. The GPS coordinates for these mounds are as follows: E 299385 N 1905622; E 298502 N 1905452; E 298190 N 1905301. West of Ontario, near the entrance to Blackman Eddy Village, there is another plaza right along the southern edge of the Highway. The Assessment determined that previous road works totally destroyed the northern mound of the courtyard and damaged a section of the eastern mound. The GPS coordinates for the mounds are E 296830 N 1905387.

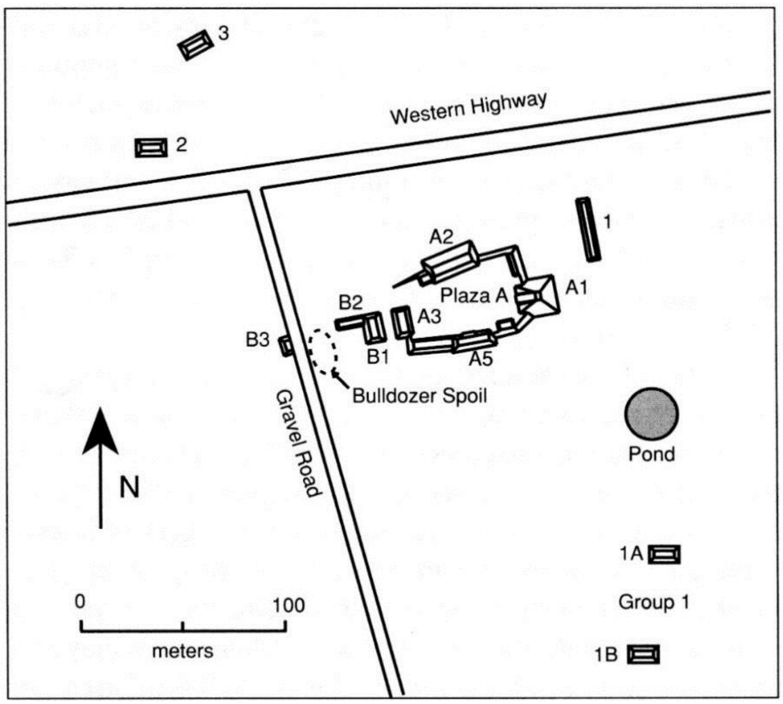


Figure 5.31: Map of Ontario Site

The major site of Blackman Eddy is located on a hill overlooking the junction of the Iguana Creek Bridge road, just south of the speed bump that precedes the turn off that heads to the bridge and Spanish Lookout. From the mid-1990s to mid-2000s, the site was the focus of archaeological investigations by James Garber from Texas State University in San Marcus (Garber 2004a, 2004b).

In the 1980's, a Ministry of Works construction project destroyed several mounds pertaining to this site when they quarried the hill on which the center is located. While the site core remains outside of the route corridor, it is critical that future road crews be made aware of the location of this site to ensure that no further destruction takes place on this major center.

Road Section 2: Road Section II extends from Mile 56 to mile 65, or from the Junction of the Iguana Creek Road to the Red Creek Bridge. Archaeological sites within Road Section 2 include, from east to west, Lower Dover, Floral Park, Baking Pot and Esperanza. Located on the banks of the Belize River, between Little and Big Barton Creek, and about a kilometer north of the Highway, Lower Dover was first reported by a project under the direction of Awe et al. in 2009. Investigations of the site have continued since then under the direction of Jaime Awe and Rafael Guerra.

The site of Floral Park, Figure 5.32 is located about 100 meters west of the Barton Creek Bridge. The site consists of two main mound groups (A and C) with two small mounds (B1 and B2) in between. Floral Park was first reported by Willey et al (1965:310) and briefly explored by James Garber in the 1990s (Driver and Garber 2004). While there is limited concern for potential damage to Group C, the same cannot be said for Group A. Indeed, Structure A2, which is connected to Structure A1 by a low sacbe (causeway) was already damaged by previous widening of the Highway. This mound is a significant structure that likely served as a small temple or shrine. It is therefore imperative that road works avoid this building. GPS coordinates for this mound are E 291633 E 1903038.

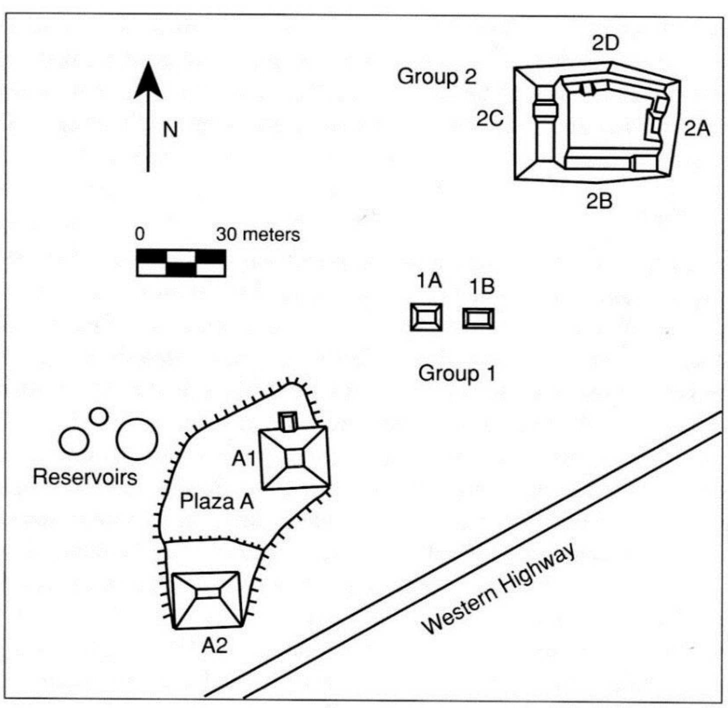


Figure 15: Map of Floral Park

West of Floral Park are the sites of Baking Pot and Esperanza. The latter site has only received limited archaeological attention (Driver and Garber 2004). The former was first reported by Oliver Ricketson in1931. In 1949, Belize’s first Archaeological Commissioner, A.H. Anderson, returned to Baking Pot to conduct salvage operations on Structure A of

Group 2. Anderson's investigations were in response to the bull-dozing of part of the structure by the Public Works Department, who were quarrying the site for fill for a nearby road project. Between 1954 and 1956, as part of his Belize River Valley settlement survey, Gordon Willey from Harvard University conducted a series of test excavations in Plaza 1 of Group 1 and on four house mounds just west of Group 1. Following Willey's (1965) work, William and Mary Bullard (1965) of the Royal Ontario Museum conducted a single season of research in Group 2. After Bullard's 1961 work, no archaeological research was carried out at the site until the Belize Valley Archaeological Reconnaissance (BVAR) Project under the direction of Jaime Awe began investigations in 1992 (Conlon 1993). Since then, BVAR archaeologists have conducted excavations throughout the site (cf. Aimers et al. 2000, Audet 2000, 2004; Audet and Awe 2004, 2005; Conlon 1993,; Conlon and Powis 2004; Helmke and Awe 2012, Helmke et al. 2004, Powis 1992).

Neither the Baking Pot site core or Esperanza are located adjacent to the Highway, thus it is unlikely that they will be affected by planned construction. In contrast, however, there are several ancient canals in the Running W property that can be affected by future construction. These canals are connected to a mound group designated as the Bedran Group that are located on the north side of the Highway, just west of the Running W Meatshop, Figure 5.33. The mounds were previously investigated by Awe's BVAR Project and reported in several publications (see Conlon 1993; Conlon and Powis 2004; Collas et al. 2002).

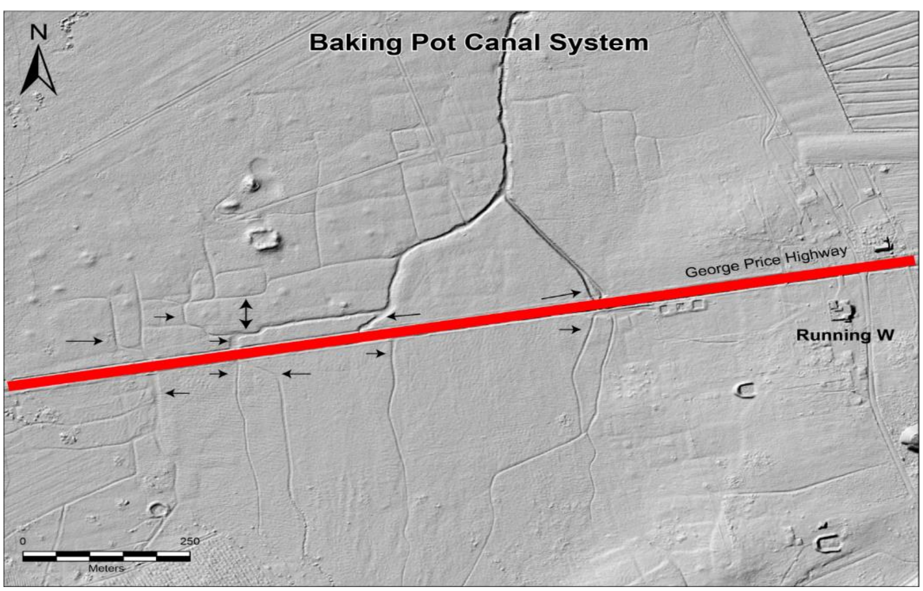


Figure 5.33: LiDAR Image of the Baking Pot Canal System

Road Section 3: Road Section III extends from Mile 67 to mile 79.4, or from Buena Vista Street in San Ignacio Town to the Benque Viejo Guatemala border. Archaeological sites within Road Section III include, from east to west, the sites of Cahal Pech, Buena Vista, Nohoch Ek, Actuncan and Xunantunich. Considerable research has been conducted at all these sites, and except for Nohoch Ek, archaeological investigations remain ongoing at all of them.
Research at Cahal Pech has predominantly been conducted by Jaime Awe (1992, 2013, Awe and Helmke 2005; Awe et al. 2009) and his colleagues (Healy and Awe 1995, 1996). While the site core of Cahal Pech is outside of the route corridor, there is a small courtyard with four mounds located in the Log Cabins property, just east of the Highway near Windy Hills Resort, that lie fairly close to the corridor.

The sites of Buena Vista and Actuncan are located just east and west of the Mopan River respectively, and are in no danger of being affected by construction. In contrast, Nohoch Ek could be affected if the old quarry site near the Western Sanitary Pit is reopened. The latter site is located on a hill overlooking the plant and previous quarry (see Taschek and Ball 2003 for site description).

The last major archaeological site along the route is Xunantunich. While the site center is at a distance from the route corridor, there are a number of settlements in the periphery of this ancient site that could be affected by road construction. This is particularly true of the proposed area for the Succotz Bypass, i.e. Bypass 3. Archaeological features that could be impacted in this area are noted below under the Bypass subsection.

5.16.1.4 Bypass Routes

Bypass 1: Along the proposed bypass in the Belmopan/ Roaring Creek area one small mound was located at GPS coordinates E 308780 N 1908287. This mound falls in the northern extent of the proposed road corridor and will require mitigation measures prior to any construction in the area.

Bypass 2: Along the proposed Z-curve bypass, no archaeological features were identified on transects along the base of Lucy Hill or on the southern extent of the existing road corridor.

Bypass 3: For Bypass 3, three (3) possible alternate routes were identified; these alternative routes were selected along corridors that would have no to minimal impact on archaeological heritage.

Bypass 3, Alternate Route I: Along the proposed Alternate Route I, three small mounded features were identified through LiDAR analysis. However, the pedestrian survey determined that these features were in fact modern bulldozed piles created during the construction of the power line corridor. It must be noted however, that a visual inspection of the area indicated ceramic scatters that must be interpreted as partially of wholly destroyed ancient archaeological features along the corridor. Extreme caution should be taken in the areas of GPS coordinates E. 274592 N. 1890593 and E. 274542 E. 1890012 if this route is decided upon.

Bypass 3, Alternate Route II: A visual inspection of Alternate Route II indicated that there was one archaeological feature present at E. 273947 N. 1890197. Another concern along this route is that it would require the destruction of several prominent modern buildings, including the Good Shepherd Clinic.

Bypass 3, Alternate Route III: Along Alternate Route III, no archaeological features were located in the proposed corridor. However, at GPS coordinates E. 274096 and N.1890174 two small patio groups were identified beyond the western edge of the corridor just beyond the 52m width. Extreme caution must be taken in this area if this route is chosen for construction of a bypass. Lastly, one partially destroyed mound was located at GPS coordinates E. 273915and N. 1889682 along the existing roads from San Jose Succotz to Benque Viejo Town. The width of this existing road and the close proximity of private properties along the route may require the destruction of some modern construction.

5.16.1.5 Existing Quarries

Notwithstanding the undertaking of a full reconnaissance of the existing quarry sites given time constraints, a rapid inspection of the areas around the Teakettle, Georgeville, and the Western Sanitary Pit indicated no surface archaeological features. However, developers must be cognizant of subsurface features especially around the Western Sanitary Pit where the minor center of Nohoch Ek is located. Any horizontal expansion of these existing quarries will require a more systematic survey of the area prior to any mechanized material extraction.

5.16.2 Cemeteries

The presence of two cemeteries in close proximity to the existing ROW in the villages of Roaring Creek and Blackman Eddy have been identified in the wider baseline assessment although these may not necessarily be disrupted by the road rehabilitation Project (Figure 5.34).

Figure 5.34: e.g. of Cemetery in Close Proximity, Roaring Creek Village

5.17 Economically Active Persons and Category of Workers

As reflected in Figure 5.35, the vast majority of economically active residents are employed with the private and government sectors with a lesser proportion being self-employed. Road Section II reflects the lowest proportion of economically active residents, Figure 5.36. Additionally, less than one in three residents are engaged in agricultural activities, Figure 5.37. Mean monthly income stood at BZ$1,050.00. Women and particularly youth are disproportionately represented among the economically inactive population across the three Road Sections.

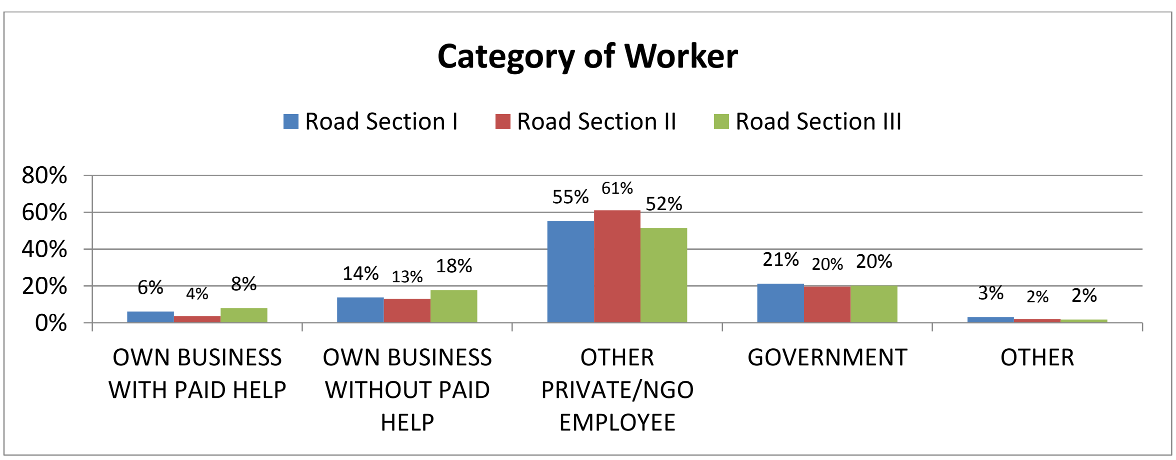


Figure 5.35: Worker Category

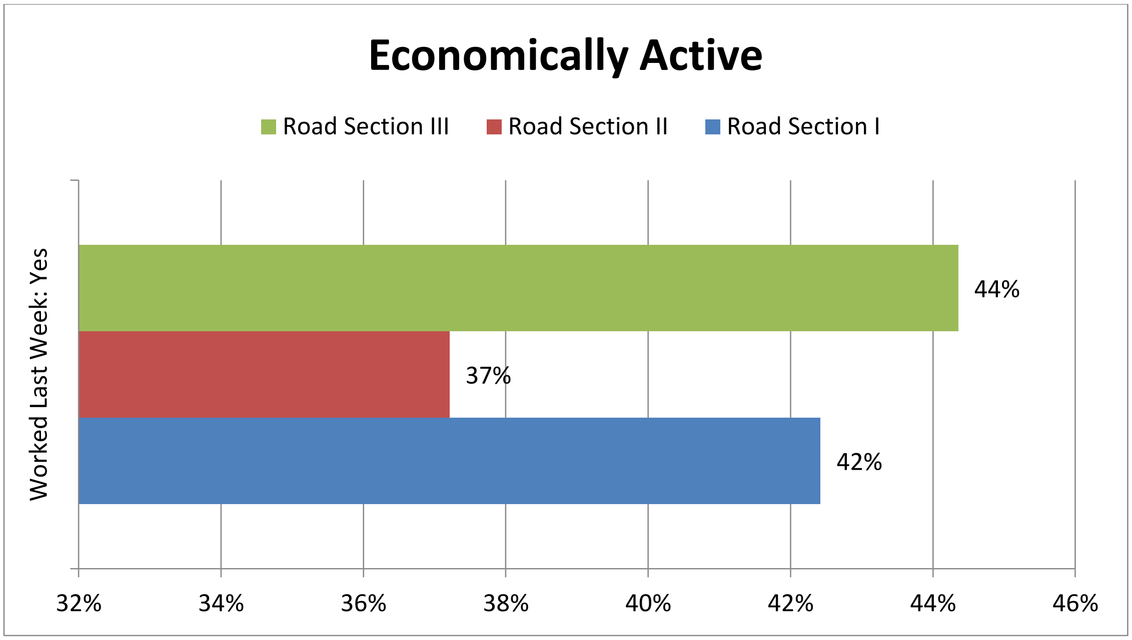


Figure 5.3616: Economically Active Residents

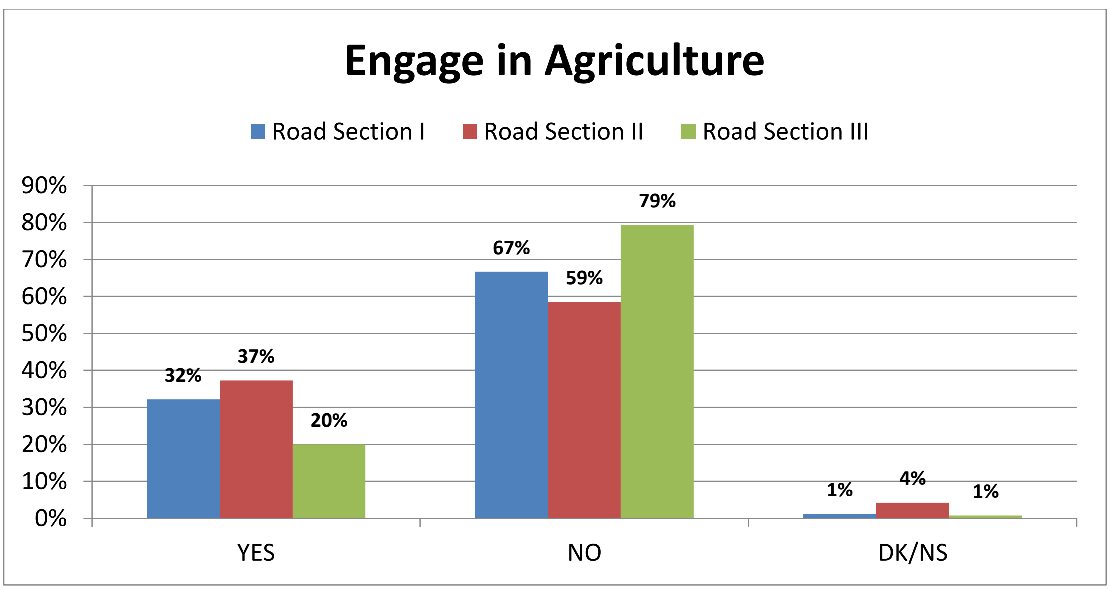
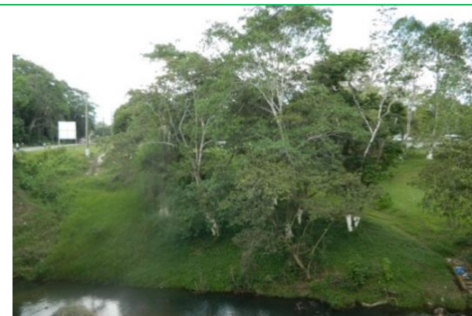
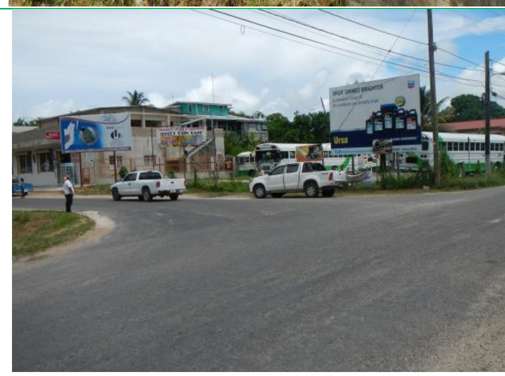


Figure 5.3717: Engaged in Agriculture

5.18 Properties/Structures: Within Existing ROW/100 ft. Corridor

Road Section/ Significance	Community	Type and Description of Property	Image
RS I Proposed location of new Roaring River crossing	Belmopan	Lands located adjacent to the Agriculture Show Grounds in the south-eastern quadrant of the Roaring Creek bridge; portion lies within the existing road buffer and the other portion lies within the actual Show Grounds. Public Land	
	Roaring Creek	Lands located in the south-western quadrant of the Roaring Creek bridge; portion outside the chain link fence lies within the Agriculture Show Grounds boundaries. Parcel within fenced area and containing white concrete structure is Private Property.	
RS III Location of proposed roundabout at entrance to Benque Viejo	Benque	Property with concrete undivided private dwelling located in the north-east quadrant of the Benque Viejo bridge exiting San Jose Succotz; Private Property. Small wooden structure adjacent to the above concrete dwelling formerly served as an old abattoir; Public Property.	
	Benque Viejo; Succotz	Property located in the south-eastern quadrant of the Benque bridge; Private Property.	

<table>
<tr><th>Road Section</th><th>Community</th><th>Type and Description of Property</th><th>Image</th></tr>
<tr><td rowspan="3">RS III Location of proposed roundabout at entrance to Benque Viejo</td><td rowspan="3">Benque Viejo;

Succotz</td><td>Second property located in the south-eastern quadrant of the Benque bridge; Private Property.</td><td></td></tr>
<tr><td>Property located in the north-western quadrant of the Benque bridge housing the bus terminal; Private Property.</td><td></td></tr>
<tr><td>13 Kiosks located at the Xunantunich ferry crossing</td><td></td></tr>
<tr><td>RS III Properties within extreme proximity to existing ROW and likely to be affected</td><td>San Jose Succotz</td><td>Properties with structures along the existing ROW in Succotz approaching and diagonally opposite the Ferry Station from the eastern end; Private Properties</td><td></td></tr>
</table>

Road Section	Community	Type and Description of Property	Image
	San Jose Succotz	Properties with structures along the existing ROW in Succotz approaching and diagonally opposite the Ferry Station from the eastern end; Private Properties	
			
			
		Two additional properties with established structures likely to be impacted; the wooden structure is movable; Private Properties	

CHAPTER 6: ASSESSMENT OF ALTERNATIVES

6.1 The EIA Process and Consideration of Alternatives

As part of the EIA requirement, there is the need to assess alternatives to a proposed development and its associated activities. In considering the implementation of a proposed conceptual plan, there is often a consideration of the various developmental alternatives that a project proponent would have to consider prior to a decision to move forward with the plan. There are usually two or more important developmental alternatives for each proposed activity to think about.

The evaluation of alternatives may encompass a wide range of economic, social, and environmental considerations associated with the various available options. This section focuses on the evaluation of alternatives to the overall proposed development, inclusive of the 'No Action Alternative'. It focuses on the options that are most practical for the proposed Project Area.

Preliminary baseline information indicates that the major issues associated with the rehabilitation of the GPH are those primarily associated with the:

- need to resurface almost the entire length of the road section within the Study Area;
- rehabilitation or replacement of the Roaring Creek Bridge and associated low lying road sections;
- Z Curve, because of the danger it poses to motorists and the precarious nature of this embankment and the instability of the steep adjoining hill side;
- low-lying entrance to Succotz and Benque Viejo and its proposed roundabout.

In addition, baseline information was specifically obtained on a number of alternatives being considered to address these most critical issues, while planning for projected climate change impacts and disaster risk management. This informed the assessment of alternatives discussed below and the final selection of the recommended options.

6.2 The 'No Action Alternative'

In the analysis of the various alternatives, the option with the highest cost benefit, the most technically feasible and with the least residual environmental and social impacts is usually identified as the preferred option.

The no action alternative only becomes a viable option where it is determined that a project's environmental and social impacts would far outweigh any net economic and social benefit, which is not the case in this instance. Although the 'no action alternative' would often result in the least negative environmental impacts, it also has the potential to be the most economically expensive option due to the potential opportunity loss if the project or activity is not implemented.

The **'No Action Alternative'** although discussed and required to be considered, often represents an option in these types of projects, that is not always the least impacting and in the best interest of the general public, or proponent, from an environmental, economic and social point of view. In these instances, both the proponent and regulatory agency need to consider the economic and social opportunities a project of this nature presents in the development of the area.

The project provides a good opportunity for the area to improve its road infrastructure essential in maintaining the economic activities of the Cayo District and further enhance its tourism, and agricultural activities. Hence, the no-action alternative is not an economically viable option. This option would result in the loss of economic opportunities, such as the generation of employment, revenue, foreign exchange, etc. It would also result in the loss opportunity to address issues of flooding, proper drainage, and improved road safety. Moreover, the potential impacts to the environment and resources of the area are for the most part amenable to mitigation, while offering an opportunity for significant benefits to be derived from its implementation.

Hence, the **'No Action Alternative'** is primarily being used as a baseline mark from which to assess the impacts of the proposed implementation of the project. The identification of options was therefore centered on the assessment of alternatives to mitigate against issues of concerns associated with the proposed road rehabilitation activities. A choice was then made on the options that were most economically viable while at the same time resulting in the least negative environmental and social impacts or external costs.

At the end, the success of any project development depends on the implementation of adequate mitigation measures, which are derived by identifying a combination of a lesser environmentally damaging alternatives, and those that are the most economically feasible to implement.

6.3 Critical Areas of Concern and Alternatives

6.3.1 Road Resurfacing

A road surface assessment of the Project Area indicated that almost its entire length would need resurfacing and that only Road Section III appeared to have some engineering design considerations.. The evaluation for road surfacing looked at the following three alternatives: Alternative 1: rehabilitation of the road pavement using a flexible double chip seal surfacing;

Alternative 2: rehabilitation of the road pavement using a semi-structural flexible hot mix asphalt road surfacing; and

Alternative 3: rehabilitation of the road pavement using a rigid (concrete) pavement.

Activity	Alternatives	Parameters to be Considered:		
		Environmental	Social	Economic
Road Surfacing	RS 1: Double Chip Seal	Design life of pavement requires resealing at 7-year intervals based on traffic projections. This option requires proper and timely maintenance to ensure its impermeability to water.	Achieving Design life of 20 years is conditional on timely routine and periodic maintenance Relatively short period of disturbance during construction. MOWT and local contractors are most familiar with this alternative; this alternative also allows for greater employment opportunities and injection of resources into the local economy(multiplier effect). More comfortable ride, greater traction and higher visibility of pavement markings relative to concrete for improved road	Low capital cost ($58/m^2), but higher maintenance cost. This option provides for low initial capital investment and with a robust maintenance program, may be the most economically viable in consideration of the projected traffic volume.

			safety.	
	RS 2: Hot mix	Moderate life cycle requiring less frequent repairs and use of materials.	Moderate life cycle of 16-25 yrs. when correctly applied; MOWT and local contractors have less experience working this alternative limiting the competitiveness of local contractors in the bidding process. Period of disturbance is equatable to that of RS 1. More comfortable ride, greater traction and higher visibility of pavement markings relative to concrete for improved road safety.	Moderate to high capital cost averaging $85/m^{2;}$ cost which almost equates to that of concreting and at a cost of 50% more than that of RS1. The higher initial capital investment renders this option less economically feasible. Only two contractors have capacity to do Hot Mix and therefore maintenance of the Hot Mix pavement will be restricted to two entities giving rise to collusion or monopoly with maintenance works.
	RS 3: Concrete	Longest life cycle requiring few repairs and use of materials. However wear and tear on tires is significantly increased. During the operational phase, this option has the potential to adversely impact residents with pre-existing respiratory illnesses; as well as creating higher noise levels affecting the communities along the ROW.	Longest life cycle (approx. 40 yrs.) but long period of disruption to community life and road users with most uncomfortable ride. This option also offers the least road traction and least visibility of pavement marking compared to asphalt options thus increasing safety risks. The longer construction period may also exacerbate PAPs with respiratory health issues, while restricting the only evacuation route in the event of an emergency.	Highest capital cost $100/m^2$, but could be financially prohibitive for extended road sections with high social cost because of longest disturbance period. Additionally, given the greater construction period the adverse economic impact on this primary evacuation route, the tourism and agricultural sectors amongst others will be more severe than the other options. The inadequate maintenance planning and expansion efforts of

				utilities can be impacted more severely by a rigid pavement.
	RS 4: No action	High environmental cost due to dust, erosion and siltation and frequent material supply as a result of deteriorated road conditions.	High social cost from existing bad road conditions resulting in accidents and deaths; and high vehicle maintenance and transportation costs.	High maintenance costs.

Preferred Option: In consideration of the environmental, social and economic factors, RS 1 would be the preferred option since $1 invested would go 47% further than RS 2 and 72% further than RS 3 in mileage.

6.3.2 Flood Prone Area : Roaring River Crossing and the GPH/HH Junction

An essential component of the George Price Highway Rehabilitation consists in determining the most feasible option for crossing the Roaring River near the George Price and Hummingbird Highway junction. Currently, vehicular and pedestrian traffic cross over this section of the creek via the Roaring Creek Bridge. However, over the past years, the inefficiency of this infrastructure has been evident, particularly during flooding in the area. Flood waters constantly rise in the area and in a few instances, covered the deck of the bridge. Furthermore, there is little indication of significant maintenance measures and the bridge itself is narrow and out of alignment (Anthony Thurton and Associates). There are four alternatives discussed, inclusive of the no-action alternative.

Alternative 1: Keep Existing Bridge

This option is not viable as the deck of the bridge cannot be raised above flood levels. In addition the current bridge alignment and narrow deck pose a traffic risk to motorists and pedestrians. The bridge also does not meet the standards adopted by the Project which will see major bridges having a width of 43 feet [13.1m] including sidewalks and shoulders and 33 feet [10m] where sidewalks are not included. The Roaring Creek Bridge had insufficient deck width and would need an additional 24 feet in width. The lifting and expansion in width will certainly include a substantial amount of retrofit that would make this impractical considering that the retrofit will not address the existing horizontal alignment problem.

Alternative 2: Realign and Raise Roadway and Construct New Bridge Adjacent to the Existing One

This alternative would require that a small narrow section of the Agriculture and Trade Show grounds be acquired as well as two narrow strips of private property on the other side of the bridge to allow for realignment of the highway at the Roaring Creek crossing. The new bridge is proposed to be constructed 1m above the high water level and would be of the required width of 43 feet including sidewalks.

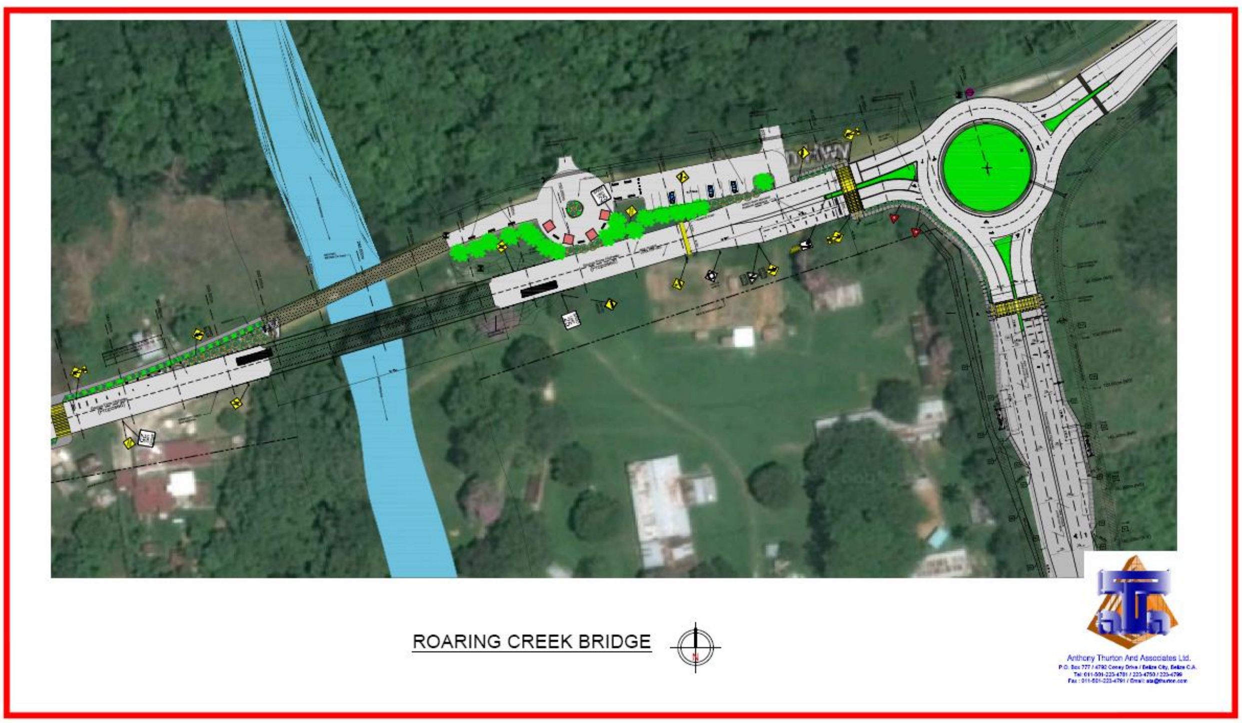


Figure 6.1: Proposed Realignment and New Crossing at Roaring Creek

This alternative would also allow for maintaining the old Roaring Creek Bridge as a by-pass during construction, a tourist attraction and historical landmark, and as a pedestrian and cycle crossing after construction. It would also allow for the relocation of the Guanacaste Park entrance allowing for safer access and egress and the beautification of the remaining open space area, Figure 6.1.

Alternative 3: Detour

The proposed detour is located within the limits of Belmopan City and Roaring Creek Village. It has three sections starting at the GPH/Hummingbird Highway running in a southern direction for 1,240m to the junction of the Hummingbird Highway and Butte Rows at the Quality Poultry Products Belmopan distribution center. From this juncture, the detour turns in a westerly direction along Butte Rows for a distance of 946m where it joins an existing power line corridor leading west across the Roaring Creek River for a distance of 966.6m and a total distance of 1,912.6m. The third section of the detour extends from the junction of the power line corridor and the Roaring River Drive (RRD) headed in a northerly direction for 770.9 m to the junction of the RRD and the GPH. The detour encompasses a total of 3,923.5m, Figure 6.2.

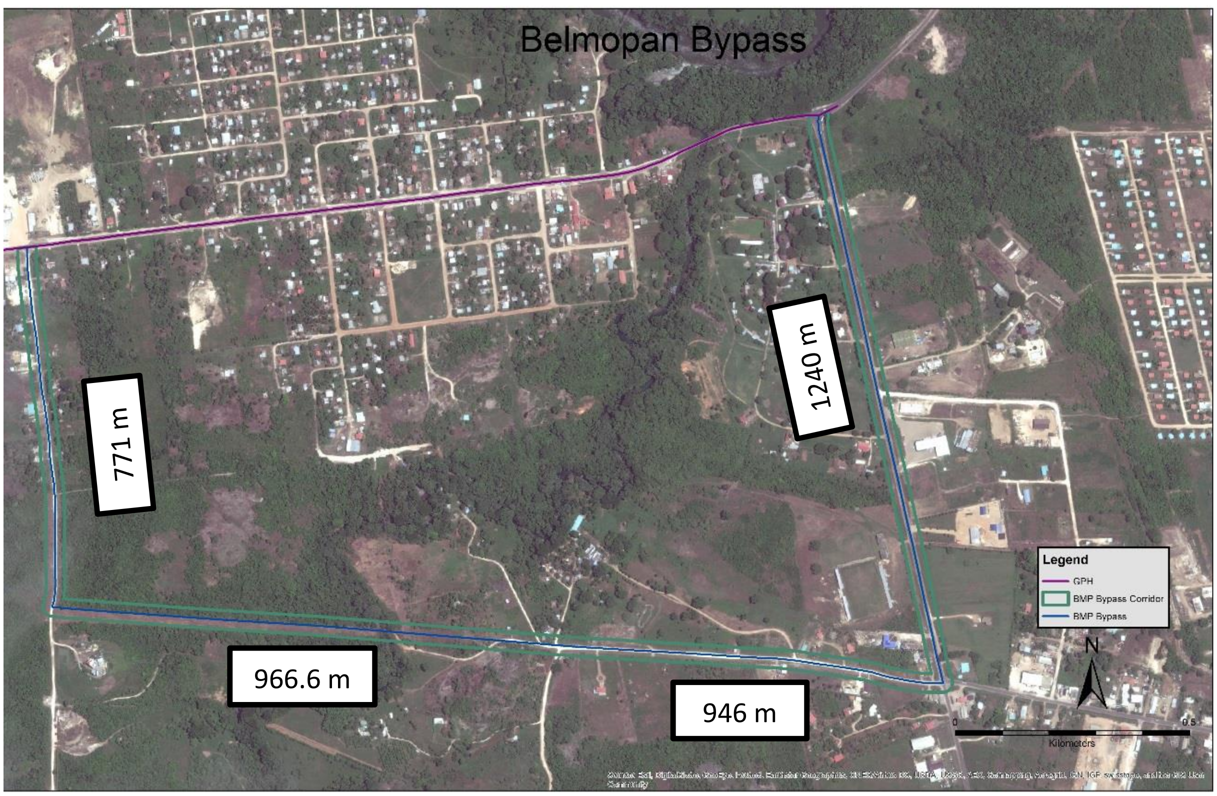


Figure 6.2: Belmopan – Roaring Creek Bypass

This means that this option would require the acquisition of approximately 967m of road ROW from private land owners. On a positive note, this land for the most part is free of any development and runs parallel and adjacent the existing high tension electrical power line access route. The detour would also require the paving of approximately 2.7 km of road and a new bridge crossing near the Riviera. In addition, it would require archaeological mitigation for possibly two archaeological points of interest with an estimated cost of approximately $60,000 BZ per site.

While this alternative would appear to be from a preliminary economic point of view, outside the scope of the current Project, it is recommended that MOWT includes this as part of their future plans to ensure an alternative route across the Roaring River as a disaster risk management response and in the event of a calamity occurring at the GPH Roaring Creek crossing, cutting off that section of the country from the rest of Belize. This proposed alternative is outside the current flood zone and thereby mitigates against flood issues in this area.

Alternative 4: the No-action Alternative

While from an environmental point of view the no action alternative will have the least environmental impacts, its social costs would remain extremely high as a result of unmitigated traffic risks to motorists, cyclists and pedestrians from nearby communities. This cost is exacerbated with the accompanying loss in productivity during flooding conditions when this section of the highway becomes impassable. The long term cost of doing nothing to ameliorate the existing conditions would far exceed any investment cost in implementing a suitable alternative.

Activity	Alternatives	Parameters to be Considered:		
		Environmental	**Social**	**Economic**
Rehabilitation of Roaring Creek Bridge and associated low lying road section	1. Keep and rehabilitate Roaring Creek Bridge. Rehabilitation would require raising and widening of the bridge which is not technically feasible.	Little to no impact on surrounding environment.	Bridge is narrow and out of alignment posing danger to motorists, pedestrians and cyclists.	No capital investment cost but high economic costs when the bridge becomes impassable to traffic.
	2. Realign the road section and construct new, elevated bridge meeting international standards with crossing adjacent to existing Roaring Creek Bridge.	The new elevated bridge would mitigate against impacts of flooding and allow for year round access during disasters. Construction would minimally, adversely impact the Roaring River environment.	Reduced risk to motorists, pedestrians and cyclists allowing for improved aesthetics of Guanacaste area. Little disruption during construction allowing for	Higher cost but allows for maintaining the old bridge as a tourist attraction increasing tourism/economic value of area.

		Improve access to Guanacaste National Park reducing traffic risks to visitors due to current entrance location.	continued use of existing bridge.	
	3. Construct detour around low-lying area (Forest Drive, Butte Row, across Riviera to Roaring River Drive.	Requires clearance of vegetation and further disruption to biota of area. Bridge construction would adversely impact river as a result of siltation and erosion of river banks.	Allow for alternate evacuation route, easier access between BMP and Roaring Creek communities. Land acquisition would impact owners. This option may impact archaeological points of interest.	Highest cost involved with acquisition of ROW, construction and paving of 2.7 km of road and bridge, and archaeological mitigation costs. This option may be outsidee the scope of the current Project.
	4. No action alternative.	Least environmental impacts.	High social cost, inclusive of potential loss of lives.	Very high long-term economic cost.

Preferred Option: The preferred option is to realign the road section and construct a new, elevated bridge meeting international standards with crossing adjacent to the existing Roaring Creek Bridge, Alternative 2.

6.4 Z-Curve

The Z-Curve lies at the western edge of Teakettle Village. It is located at mile 56 and is another critical area in the proposed rehabilitation of the GPH. This area consists of a sharp "Z" curve around a steep rock hill with a prominent drop towards the Belize River on the outside. The area is considered a safety risk because of the danger it poses to motorists, the precarious nature of this embankment and the instability of the steep adjoining hill side. Four alternatives are discussed in this assessment: widen road by shaving hillside to stabilize hill and re-contouring the curve; cut through hill allowing for realignment of road; split the road to allow for 2 single lanes in opposite direction around the hill and the no-action alternative.

Alternative 1: Widen Road by Shaving Hillside to Stabilize Hill and Re-contouring of Curve

This alternative proposes to widen the road by shaving the hillside while at the same time providing for its stabilization. In addition, it would involve the re-countering of the road to allow for the appropriate banking and placement of speed reducers and additional traffic signs. An old road that goes around the hill is proposed to be used as temporary bypass while this activity is taking place. It must be noted that although this section of the highway has been identified as a high risk area, road traffic accident data indicates that very few accidents have been recorded for this spot. This may be as a result of motorists instinctively taking precautionary actions on seeing the hazard.

This option would require no or very minimal acquisition of land and its environmental impacts would be relatively low. However, the risk of accidents occurring at this spot with the potential contamination of the Belize River from the transportation of hazardous substances such as petroleum and bulk herbicide to Big Creek, would remain.

Alternative 2: Cutting Through Hill for Realignment of Road

Alternative 2 involves cutting through the hill such that the horizontal curve is no longer an issue. Again, the old road that goes around the hill is proposed to be used as temporary bypass while this activity is taking place.

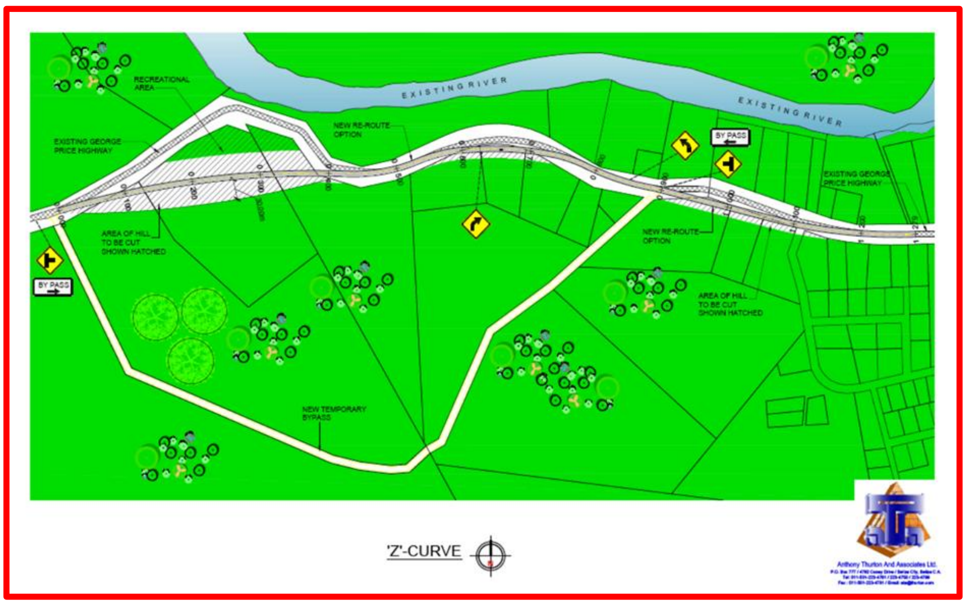


Figure 6.3: Option 2: Proposed Realignment of Road through Z-Curve Hill.

This option will require a significant amount of cutting and earth moving activities to allow for the 100 feet ROW and the proper sloping and stabilization on both sides of the cut with a minimum gradient of 1.5 to 1 ratio.

This alternative would also have the potential to negatively impact the howler monkeys who are frequent visitors to the area; and the potential for siltation and sedimentation of the Belize River if appropriate mitigation measures are not put in place. From a social point of view, the impacts can be considered as moderate since it will require the acquisition of the right of way and a prolonged period of traffic disruption while the hill is being cut.

Alternative 3: Split the Road to Allow for 2 Single Lanes in Opposite Directions around the Hill

This alternative proposes to use an old road that goes around the Z-Curve area, which is also proposed in Alternatives 1 and 2, to be utilized as a temporary bypass during construction. The possible route identified encompasses an old road access starting just east of the Z-Curve and diverting to the south along the base of ‘Lucy’ Hill to the west of the Z-Curve; this bypass area encompasses a total length of 1,283m, Figure 6.4.

This alternative considers the upgrading of the old road to provide for a permanent detour allowing for the flow of traffic in opposite directions around the hill. This option would require the acquisition of considerable amounts of land for the approximately 1,283m length of ROW. This also has the potential for having the highest biodiversity impact of all the alternatives, as it would cut through one of the few remaining forested areas within the Project Area. In addition, this option also has the potential to adversely impact the hydrology of the area if the appropriate mitigation measures are not implemented.

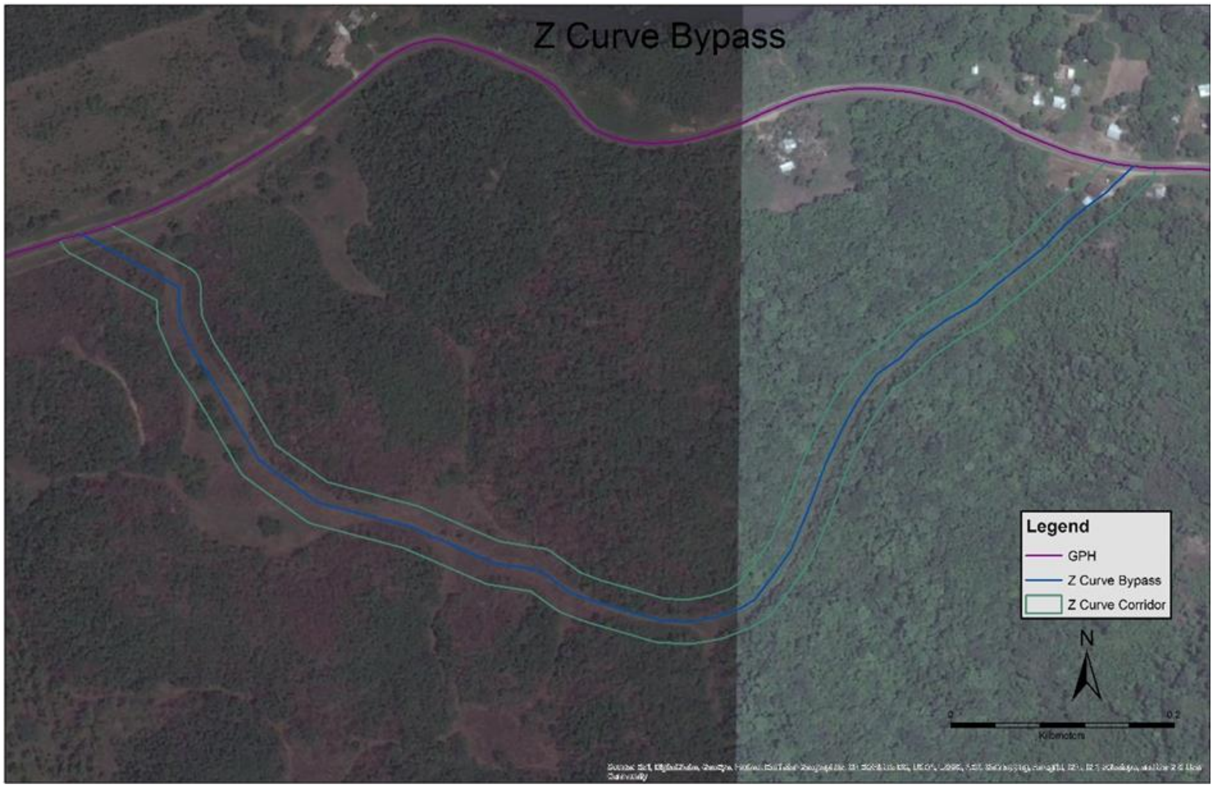


Figure 6.4: Proposed Bypass/Detour around Z-Curve

Alternative 4: the No-action Alternative

The no-action alternative is not a viable option as it would not address the issues identified with this section of the ROW.

Activity	Alternatives	Parameters to be Considered:		
		Environmental	Social	Economic
Road Alignment: Z-Curve	1: Widen Road by Shaving Hillside to Stabilize Hill and Re-contouring the Curve.	Risks to Belize river from chemical spills remain high. Low environmental impacts (erosion and siltation) from construction activities due to minimal shaving. Impacts to wildlife negligible.	Minimal disturbance from shaving as no human settlements in area. Accident risks moderately reduced. Moderate occupational and safety hazards with cutting of hill.	Lower capital investment cost; however exisitng alignment issue remains
	2: Cutting Through Hill for Realignment of Road.	Risks to Belize River from chemical spills significantly reduced. Significant environmental impacts (siltation and sedimentation to BZ River) during construction if not properly mitigated. Moderate impacts to wildlife.	Prolonged disturbance during construction. Accident risk to public significantly reduced due to realignment. High occupational and safety hazard from significant cutting and blasting.	Moderate to high capital cost due to significant earth moving activities. Materials from cuts reduces construction costs for material supply.

	3: Split the Road to Allow for 2 single Lanes in Opposite Directions around the Hill.	Risks to Belize River from chemical spills significantly reduced. Significant environmental impacts to wildlife due to fragmentation of forested area.	Requires significant acquisition of property. Minimal disruption to road users. Minimal impacts to archaeology. Accident risk significantly reduced. Minimal occupational and safety hazard risk.	Relatively high capital cost due to acquisition of properties and construction of approximately 1.3 km of road. This option may be outside the economic scope of the existing Project.
	4: the No-action Alternative.	This option is not considered an alternative as it does not solve issues.		

Preferred Option: The preferred option is to cutting through the hill, as this is the only option which addresses the alignment issues.

6.5 Flood Prone Areas at the Entrances of Succotz and Benque Viejo

These two areas are interrelated and are located in the village of Succotz and the entrance to Benque. Both areas have major natural drains discharging into the Mopan River and draining the upland areas within which these two communities are located. Exacerbating the problem is the fact that these two areas also lie at a point where the Mopan River takes a sharp turn, accelerating the flow of water (energy) at these points where the natural drains discharge.

Recently in 2008, TD 16 flooded 800m of the GPH at the Succotz entrance and about 200m at the Benque entrance, resulting in flood water levels of 5 feet above the GPH at the Succotz entrance and approximately 4 feet at Benque entrance. This event rendered the GPH impassable for about 5 days, severely impacting the social life and economy of the area.

In order to mitigate against flooding in these areas, it would require elevating the low lying areas of the road to a height that is technically viable without significant adverse impacts to adjacent properties. It is also proposed that the road be widened to allow for safer flow of traffic and implementation of international standards proposed for the rehabilitation of this section in the Project Area.

The flooding event of 2008 is calculated to have a return period of 30 years taking into consideration climate change predictions. The low lying sections of the road will be designed for a 20 year flood event. Hence it is to be expected that this section of the road would still remain vulnerable to extreme flood events and there may be the need to identify an alternative detour around the problematic areas to allow for the continued flow of traffic through these communities. So from a disaster risk reduction perspective, it is important that the alternatives identify practical solutions that are environmentally, socially and economically acceptable.

The following four alternatives are discussed: elevating the road to adjust for a 20 yr. flood; a simple link between the highway and the existing road network located in the higher areas in Succotz that would bypass the area for which two alternatives are discussed; and the no-action alternative.

Alternative 1: Elevating the Low-lying Areas to Accommodate a 20 Year Flood

This option would require the construction of a retaining wall along these low areas and the minimal widening of the highway. In addition, there would be the need for the replacement of the culverts crossing the highway for the 2 main natural drains emptying into the river. This would then mean that the bridge at the entrance to Benque would have to be replaced. Elevating the highway would also require that a side road be built to reduce the steep approach to the ferry. These activities, with proper mitigation measures, would have minimal impact to the river bank and the river itself. However it would require the temporary displacement of the kiosks vendors situated near the entrance of the ferry.

Alternative 2: Succotz Bypass Option 1

This option provides a simple link between the highway and the existing road network located in the higher areas in Succotz that would bypass the flood prone areas of the GPH. It starts at the old Negroman Road and extends for 741.6m south where it converges with the streets behind Succotz as shown in figure 6.5.

This option would require the acquisition of land for the ROW and the construction of a bridge. It would also require that the existing streets be paved to allow for climate proofing and the all-weather use of these roads during flood events on the GPH. It would also require mitigation for two archaeological points of interest identified in the area of the proposed ROW. It is recommended that this bypass be designed and constructed to allow for easy and safe access in line with MOWT Street Standards as opposed to international highway specifications..

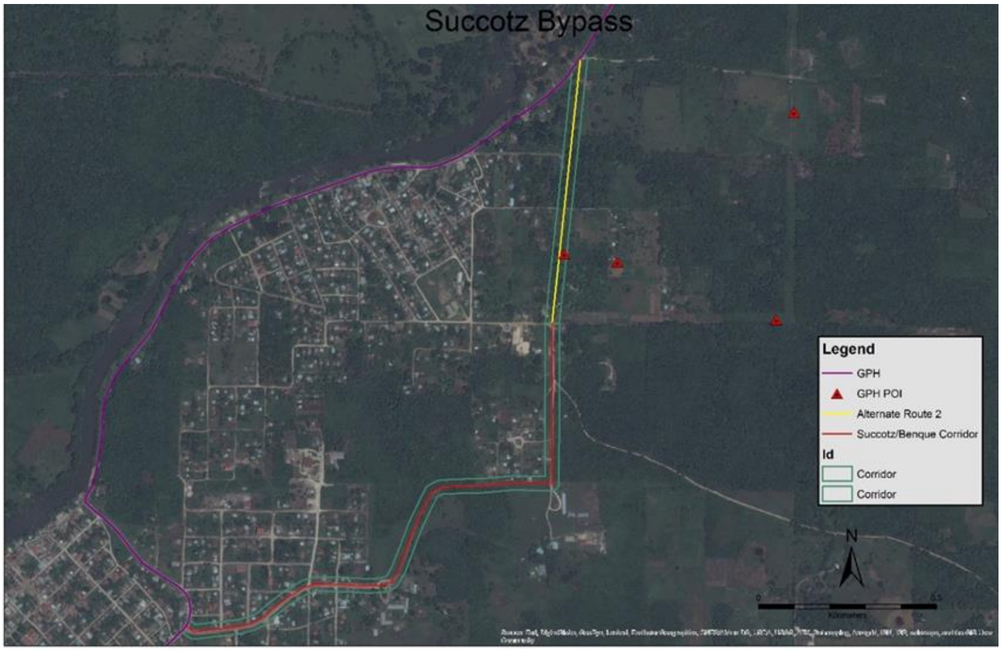


Figure 6.5: Succotz Alternate Route 1

Alternative 3: Succotz Bypass Option 2

Alternative 3 is somewhat similar to alternative 2 and also starts at the old Negroman road and extends to the south in the form of an arc to the point of convergence with the streets behind Succotz as shown in Figure 6.6.

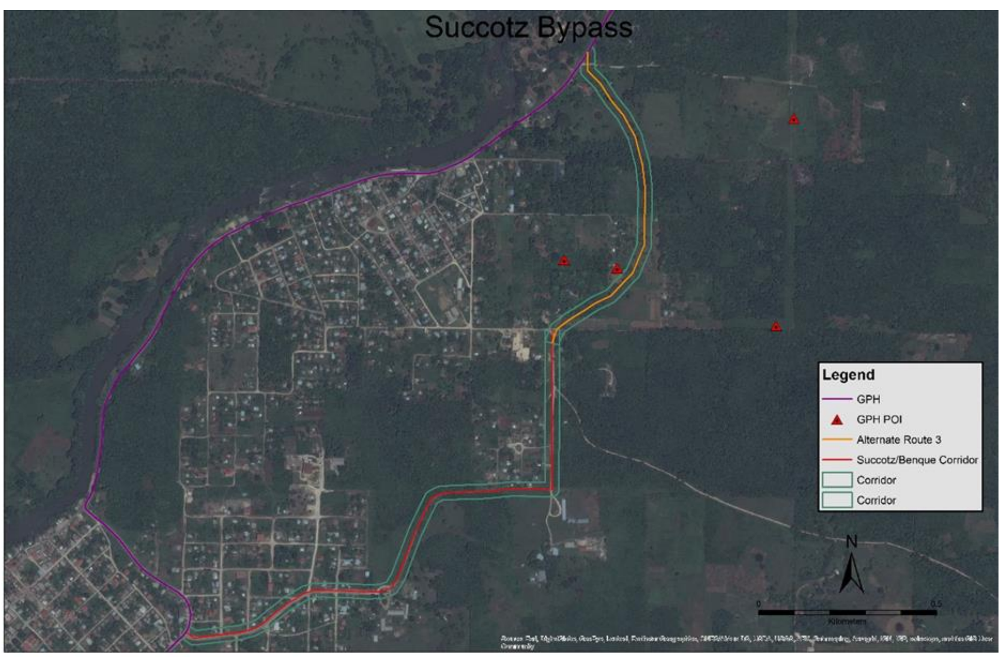


Figure 6.6: Succotz Bypass Option 2

This route measures 910m in length and would require the construction of a bridge but would allow for the avoidance of existing buildings and archaeological points of interest. This option would however require the acquisition of more land in comparison to the Succotz Bypass Option 1 but would also require that the road be paved. It is recommended that this bypass be designed and constructed to allow for easy and safe access in line with MOWT Street Standards as opposed to international highway specifications.

Alternative 4: the No-action Alternative

This option is not considered viable because of the potential social and economic implications on the Succotz and Benque communities and the economy of the area.

Activity	Alternatives	Parameters to be Considered:		
		Environmental	Social	Economic
Elevation of low lying road sections at entrance of Succotz and Benque and construction of roundabout at entrance to Benque	Elevating the Low-lying Areas to Accommodate a 20 Year Flood.	Minimal environmental impacts (sedimentation to BZ River) during construction. Improved drainage from reconstruction and resizing of culverts.	Temporary relocation of vendors and potential loss of livelihoods. Impacts of elevating road to existing properties. Safer access to ferry. Improved safety features for pedestrians.	Moderate to high capital investment associated with relocation of vendors and concreting of road section to withstand 20-yr flooding.
	Succotz Bypass Option 1.	Minimal environmental impact as area is already cleared for urban development.	Acquisition of properties and possible impacts to two archaeological points of interest and two dwellings. Communities remain connected with rest of country at all times.	Cost moderately high.
	Alternative 3: Succotz Bypass Option 2.	Minimal environmental impact as area already developed.	Acquisition of properties and minimal impacts to archaeological points of interest. Communities remain connected with rest of country at all times.	Cost moderately high.
	the No-action Alternative.	This option is not viable. Environmental impact low.	Social impact extremely high as communities remain cut-off from rest of county during flood events.	Long term high economic cost if problem not addressed.

Preferred Option: The preferred option is to elevate the Low-lying Areas to Accommodate a 20 Year Flood in combination with the Succotz Bypass Option 1 as detailed above.

6.6 Proposed Roundabout at the Entrance to Benque Viejo

The construction of the proposed roundabout while providing the municipality of Benque with a clear and more sophisticated modern entrance raises a number of considerations. The proposed location intersects with the exisitng bridge at the entrance of Benque, which is the convergence of several major drains and a number of residential/business properties inclusive of a passenger bus “parking terminal”. Additionally the area is susceptible to flooding from the Mopan river as this is where the river makes a sharp turn and releases its energy in the form of spill over; the 2008 TD 16 flooding is a stark example of this. While the bridge is in fair condition, the quality of the concrete seems to be less than optimal. Additionally, there are some signs of deterioration; overall assessment of this bridge indicates that the current hydraulic radius and deck elevation of the Benque Viejo Bridge is inadequate (ATA 2014). Four options, inclusive of the ‘No Action Alternative’ evaluated below in the table are: Alternative 1: Construction of the proposed roundabout; Alternative 2: Modern engineering of the exisiting T; Alternative 3: Introduce Traffic Lights at the Junction; and Alternative 4: No Action.

Activity	Alternatives	Parameters to be Considered:		
		Environmental	Social	Economic
Proposed Roundabout at the Entrance to Benque Viejo	1. Construct Roundabout and replace bridge.	Low impact; improvements to hydraulics as the old bridge is replaced and drainage system re-engineered.	Significant impact resulting in displacement of human settlement and disruption of livelyhoods; requires significant acquisition of private lands.	High cost due to land aquisitions, area elevation; building of new bridge and drainage system.
	2. Introduce Traffic Lights at the Junction and replace bridge.	No –low environmental impact especially if powered with solor.	No to Low impact but may require public awareness and education campaign.	Low economic cost involved with procurement, instalation and maintenance.
	3. Modern engineering of the existing T and replace bridge.	Low to medium impact associated with construction material for elevation of road section and construction of the T.	Low Impact resulting from disrupted traffic flows and descomforts during construction phase.	Moderate cost due to road elevation and replacement of bridge.
	4. No action alternative.	Low to medium due to poor hydraulics and flooding.	Low to medium cost due to flooding as well as traffic disruption; loss of livelihoods.	Very high long-term economic cost.

Preferred Option: The preferred option is to install traffic lights at the Junction and replace the existing bridge with re-engineered drainage.

CHAPTER 7: ASSESSMENT OF ENVIRONMENTAL AND SOCIAL IMPACTS

This Chapter of the ESIA presents the assessment of the potential environmental and social impacts associated with the proposed road rehabilitation project. For each relevant environmental and social parameter, the potential impacts are discussed. The evaluation of potential environmental and social effects during the ESIA aims to be as accurate and objective as possible, whilst providing as much detail as is available according to the proposed design. Many of the potential impacts have also been taken into account during design of the project through iterative discussions with the design engineers and MOWT. The ESIA is primarily concerned with the identification, assessment and mitigation of significant environmental and social issues and thus an exhaustive list of all potential impacts is not presented here.

In this assessment, the proposed mitigation measures for addressing potentially adverse environmental and social effects are also presented. In some instances, there may be overlapping impacts and mitigation measures due to similar site-specific activities and conditions. As with all road works, the overarching impact is to improve the lives of the resident population, specifically those of the study area. With this in mind, the following provides an assessment of the impacts in accordance with the Terms of Reference.

7.1 Summary of Potential Environmental Impacts

While the proposed rehabilitation project is projected to have significant positive social and economic benefits it has the potential to affect the surrounding air and water quality; exacerbate soil erosion and soil stability, and the hydrology and drainage of the area as well as nearby or adjacent ecosystems within the project area during the construction phase. In addition, to these environmental issues, the activities of the proposed road rehabilitation activities will temporarily, negatively impact the lives of residents of communities along the ROW and road users. It will require the acquisition of small strips of private properties in at least three areas of road alignment and temporarily displace a few roadside vendors and their source of livelihoods. These potential social impacts are discussed in more detail in the subsequent section. However, at the end of the road rehabilitation project there will be significant net positive social benefits and an improved quality of life of the members of these communities and remaining Belizean populace. The assessment provides abatement measures that are tailored to reduce these potential adverse impacts to the point where the impacts are insignificant or within acceptable limits, either through effective design and best practices or through sound Environmental Management System (EMS) of the road rehabilitation activities.

An environmental impact is defined as *"any change to an existing condition of the environment*". The nature of the impacts may be categorized in terms of:

- Direction -positive or negative
- Duration -long or short term
- Location -direct or indirect
- Magnitude -large or small
- Extent -wide or local
- Significance -large or small

Tables 7.1 – 7.3 provides three different types of impact matrix summarizing the potential environmental impacts associated with the road rehabilitation activities, the general road activities, and the critical areas of concerns and major accompanying activities. The first matrix, Table 7.1, assesses the direction, duration, location, magnitude, extent and significance of the projected impacts. Tables 7.2 and 7.3 look at the road activities and provides a quantitative assessment of the impacts on the various environmental elements of concern relative to each other.

As can be seen from the matrices most of the impacts are predicted as either minimal to medium, are very localized and of short duration. The activities with the highest impacts are those associated with the: Construction of Round About at Benque; Realignment of the road section at the Z-Curve; Upgrading of the temporary by-pass for the Z –Curve; Elevation of road section at Succotz; Elevation of the road section at Benque, Table 7.2 .

Table 7.1 : Impact Matrix Assessing the Characteristic of Impacts

	ACTIVITY/IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
		(+)	(-)	Long	Short	Dir.	Indir.	Major	Minor	Wide	Local	Large	Small
General Road Construction Activities	Camp Site Construction		x		x		x		x		x		x
	Extraction of Material		x		x	x			x		x		x
	Transportation of Materials		x		x	x			x		x		x
	Removal of Road Surface		x		x	x		x		x		x	
	Movement of heavy equipment		x		x	x			x		x		x
	Installation of Bridges and Culverts	x		x		x		x		x		x	
	Road Construction		x		x	x		x		x		x	
	Trenching and Drainage		x		x	x		x		x		x	
	Road Alignment		x										
	Blasting		x		x	x		x			x	x	
	Construction of Alternate Route		x		x	x		x			x	x	
	Traffic		x	x		x		x			x	x	
Critical spots	Road Alignments & elevation at R. Creek		x		x	x		x		x		x	
	Construction of New Bridge		x		x	x			x		x		x
	Construction of Bypass at Riviera		x		x	x			x		x		x
	Realignment of Road at Z-Curve		x	x		x			x		x		x
	Upgrading of temporary by-pass for Z - Curve		x		x	x		x			x	x	
	Elevation of Road at Succotz		x		x	x			x		x		x
	Elevation of Road at Benque		x		x	x			x		x		x
	Construction of Retaining Wall Succotz and Benque sections of Road		x		x	x			x		x		x
	Construction of Round About at Benque		x	x		x		x			x		x

Table 7.2 Matrix Quantifying Impacts of Critical Areas

Environmental Effects	Terrestrial Ecosystem				Impacts on land				Aquatic Environment			Air quality and Noise			Water Quality				Hydrology of Area-Rivers and Streams						Total
Development Activities	Habitat loss	Deforestation	wildlife	Protected Areas	Land Use	Erosion	Landslides/slip	drainage	Fish & species loss	Fish Movement	Aquatic Plants	Emissions	Dust	Noise Level	Oil/ hydrocarbons	Siltation-TSS	Bact. contamination	Dissolved Oxygen	Siltation	Flow regime	Drainage	Drinking water	Bank Erosion	Riparian vegetation	
Road Construction	-1	-1	-1	2	0	-2	-1	2	-1	0	0	-2	-2	-2	-1	-2	-1	-1	-2	2	-1	-1	-1	-1	-18
Road Alignments & elevation at R. Creek	0	0	0	0	-1	-2	0	0	0	0	0	-1	-1	-1	-1	-2	-1	-1	-2	0	0	-1	-1	0	-15
Construction of New Bridge	0	0	0	0	0	-2	0	0	0	-1	0	-1	-1	-1	-1	-2	-1	-1	-2	0	0	-1	-1	0	-15
Construction of Bypass at Riviera	-1	-1	-1	0	-1	-2	0	-2	-1	-1	0	-1	-2	-2	-1	-2	-1	-1	-3	-1	0	0	-2	-2	-28
Realignment of Road at Z-Curve	-1	-1	-1	0	-1	-2	-2	-2	0	0	0	-2	-2	-2	-1	-2	-1	-1	-2	-2	0	0	-2	-3	-30
Upgrading of temporary by-pass for Z -Curve	-2	-1	-2	0	-1	-2	0	-2	0	0	0	-1	-2	-2	-2	-2	-1	-1	-2	-3	0	0	-1	0	-27
Elevation of Road at Succotz	0	0	0	0	0	-2	0	-2	0	0	0	-2	-2	-2	-2	-2	-1	-1	-3	-1	-3	-2	-3	-2	-30
Elevation of Road at Benque	0	0	0	0	-2	-2	0	-2	0	0	0	-2	-2	-2	-2	-2	-1	-1	-3	-1	-1	-2	-3	-2	-30
Construction of Retaining Wall Succotz and Benque sections of Road	0	0	0	0	0	-1	0	-1	0	0	0	-2	-2	-2	-2	-2	-1	-1	-3	-1	2	1	-2	-2	-22
Construction of Round About at Benque	0	0	0	0	-2	-1	0	-2	0	0	0	-2	-2	-2	-2	-2	-1	-1	-3	-2	-2	-2	-3	-3	-32
Opening of Detour Behind Succotz	-1	-1	-1	0	-2	-2	0	-2	0	0	0	-2	-2	-2	-2	-2	-1	-1	-1	0	0	0	0	-1	-23

Impacts: -3 High negative; -2 Medium negative; -1 Low negative 0 none; 1 Low positive; 2 Medium positive; 3 High positive

Table 7.3 Matrix Quantifying Impacts of General Road Rehabilitation Activities

Environmental Effects / Developmental Activities		Terrestrial Ecosystem				Impacts on land				Aquatic Environment			Air quality and Noise			Water Quality				Hydrology of Area-Rivers and Streams						Total
		Habitat loss	Deforestation	wildlife	Protected Areas	Land Use	Erosion	Landslides/slip	drainage	Fish Species/ loss	Fish Movement	Aquatic Plants	Emissions	Dust	Noise Level	Oil/ hydrocarbons	Siltation-TSS	Bact. contamination	Dissolved Oxygen	Siltation	Flow regime	Drainage	Drinking water	Bank Erosion	Riparian vegetation	
Construction	Camp Site Construction	0	0	-1	0	0	-1	0	-1	0	0	0	-2	-2	-2	-2	-1	-2	-1	-1	0	-1	-1	0	0	-19
	Extraction of Material	0	0	0	0	0	-2	-2	-1	0	0	0	-1	-2	-2	-1	-2	-2	-1	0	0	0	0	0	0	-16
	Transportation of Materials	0	0	0	0	0	0	0	0	0	0	0	-2	-2	-2	-2	0	0	0	0	0	0	0	0	0	-8
	Removal of Road Surface	0	0	0	0	0	-1	0	-1	0	0	0	-1	-2	-2	-2	-2	0	0	-1	-1	-2	0	-1	0	-16
	Movement of heavy equipment	0	0	0	0	0	0	0	0	0	0	0	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	0	-10
	Installation of Bridges and Culverts	0	0	1	0	0	-1	0	2	0	-1	0	-1	0	-1	-1	-2	-1	0	+2	+2	+2	0	+2	-1	+2
	Road Construction	-1	-1	-1	2	0	-2	-1	2	-1	0	0	-2	-2	-2	-1	-2	-1	-1	-1	-1	-1	0	-1	-1	-19
	Trenching and Drainage	0	0	0	0	0	-2	0	2	0	-1	0	-1	-1	-2	-2	-2	-1	0	-1	0	-1	-1	-1	-1	-15
	Road Alignment	-1	-1	-1	2	0	-2	-2	-1	0	0	0	-2	-2	-2	-2	-2	-1	-1	-1	0	0	0	0	-2	-21
	Blasting																				0	0	0	0	0	
	Construction of Alternate Route	-2	-2	-2	0	-1	-2	0	-2	0	-1	0	-2	-2	-2	-2	-2	-2	-1		0	0	0	-2	-2	-29
	Traffic	0	0	0	0	0	0	0	0	0	0	0	-2	-2	-2	-2	0	0	0	-0	0	0	0	0	0	-8
	Impacts: -3 High negative; -2 Medium negative; -1 Low negative 0 none; 1 Low positive; 2 Medium positive; 3 High positive																									

7.2 Road Rehabilitation Engineering

As earlier noted, the designs of road and bridges, culverts replacements and drainage improvements have all been undertaken with full consideration of the requisite international AASHTO standards and the necessary environmental and social safeguards.

A typical cross-section of the proposed bridges at the Roaring River, Barton Creek, Garbutt Creek, and Red Creek crossings consistent with international standards and taking into account key environmental, social and economic considerations is depicted in Figure 7.1. In this regard, it is proposed that all these bridges be raised above the existing flood lines and their river banks stabilized to mitigate against flooding and erosion respectively. In addition measures are being proposed for upstream and downstream obstruction to allow free flow thereby reducing the potential for flooding. It is also recommended that MOWT explores performance service contracts with local governments for the maintenance of these streams, creeks and drains. In particular, the proposed bridge at Roaring Creek will be a 3-span length bridge raised one-meter above the flood line designed for a 1 in 100 flood return cycle; abutments of the bridge are to be located outside of the main river flow (banks of the Roaring Creek) with stabilization of the river banks to prevent erosion.

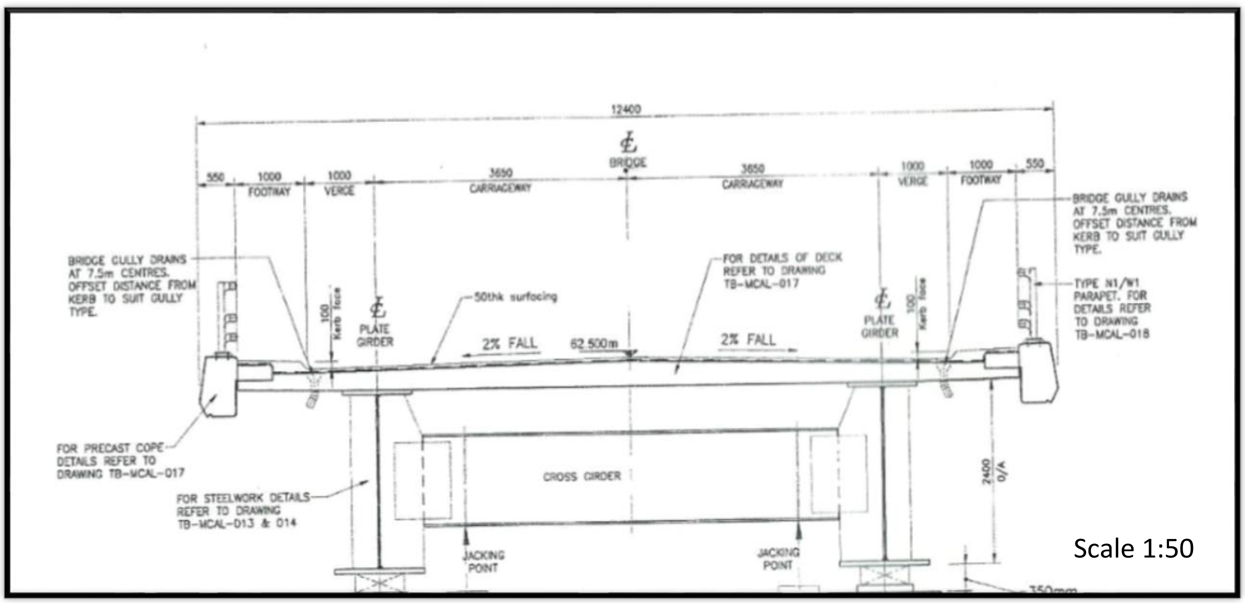


Figure 7.2: Typical Bridge Cross-Section; Source Anthony Thurton and Associates

In similar manner, typical general road cross-section and cross-section through populated communities of the rehabilitated GPH are depicted in Figures 7.2 and 7.3 respectively. As noted in the Figures, road safety designs for pedestrians are completely considered.

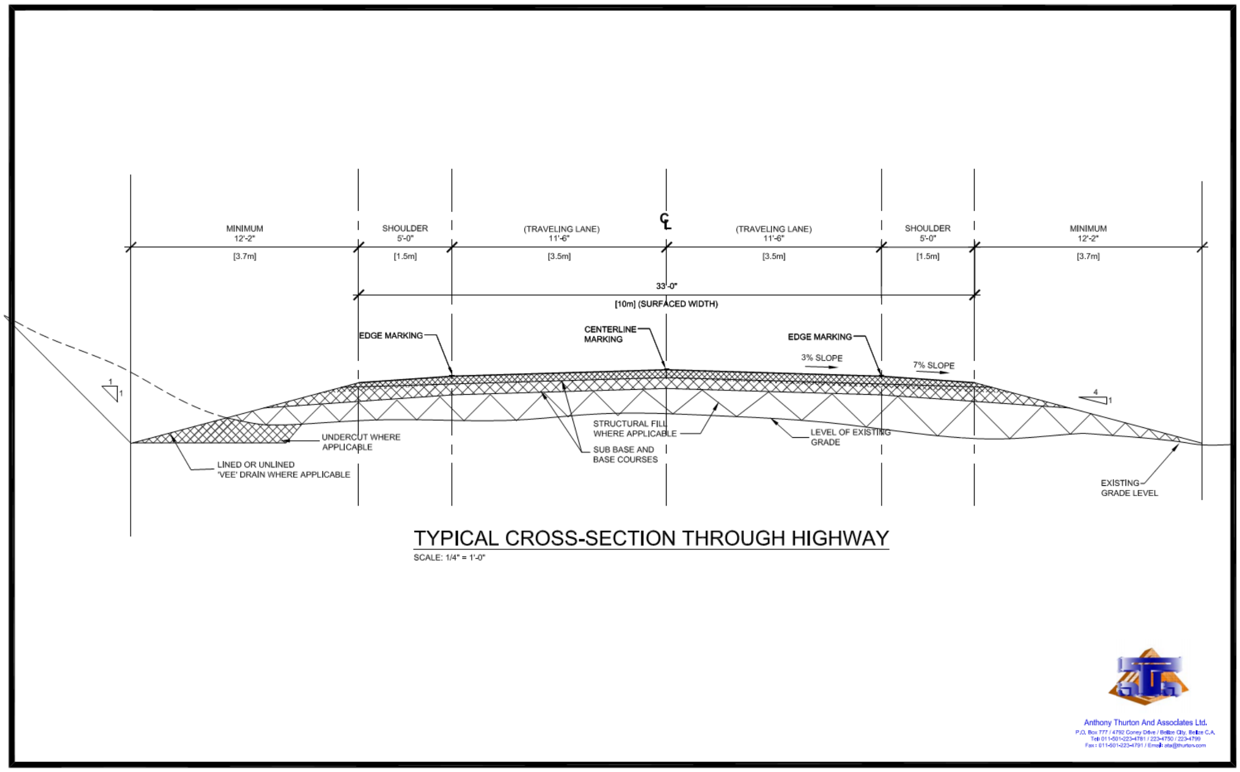


Figure 7.2: Typical Cross-Section Through Highway, Source Anthony Thurton and Associates

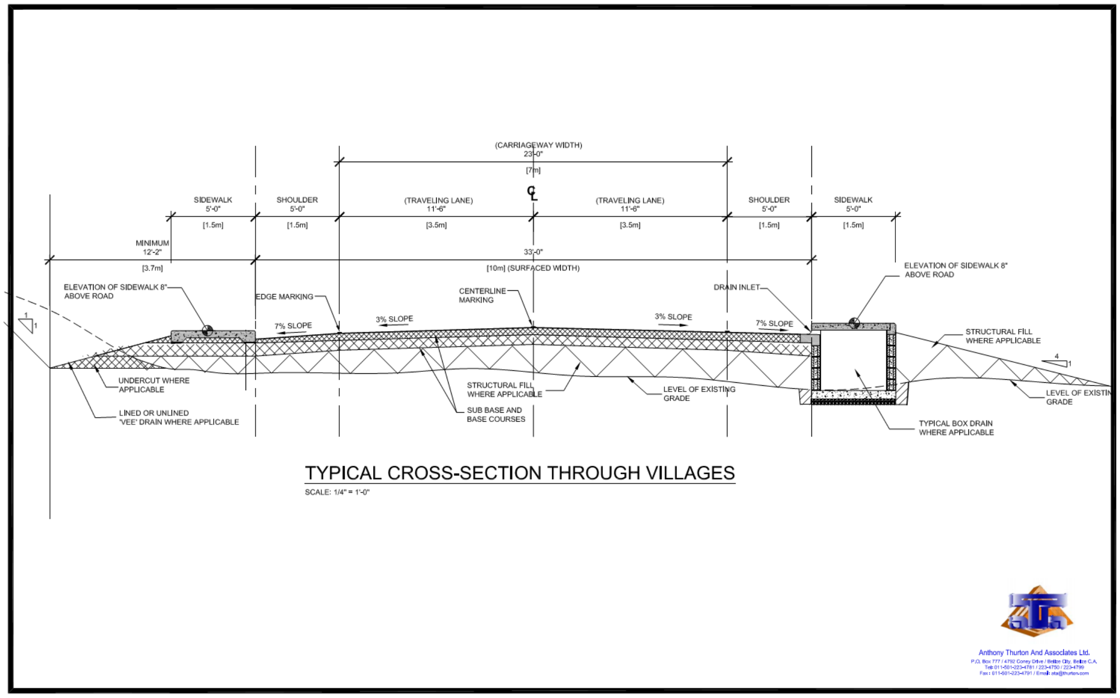


Figure 18

Identified flood areas and recommended mitigation measures for Road Sections across the ROW in the Study Area are summarized in Table 7.4. Consistent with findings from the baseline assessments and based on iterative discussions with the design engineers and MOWT, minimum diameter of replacement culverts is to be no less than 36 inches. Of the 77 identified culverts along the ROW, 65 will require replacement as a result of being undersized or structurally compromised, for detailed breakdown of culverts by Road Sections and culvert size refer to Annex III-A and III-B; additionally, the need for the installation of several new culverts and accompanying drains have been identified to improve flood prone areas, Table 7.4.

Table 7.4: Identified Culverts and Drainage

Road Section	Section I: Mile 47.9 – 56 Belmopan Junction – Iguana Creek Road Junction				
WP	**Latitude**	**Longitude**	**Description of Area**	**Summary Issues**	**Recommendations**
124	17.22357	88.9267	Iguana Creek junction with GPH [Mile 56]	Area for proposed roundabout	Will require proper drainage and culvert
125	17.22499	88.9140	Blackman Eddy-Road point nearest to river just on the curve going into Ontario	Known flooding from river overflow during top gallon	
126	17.22356	88.9091	Just off the curve coming into Ontario (from BM Eddy), Natural spring [Mile 56 ¼]	Road works may interfere with natural spring	Special attention must be given for proper drainage

					and culvert and prevention of contamination
128	17.24749	88.8185	Mile 50 Camalote, lowest point	Flood Area: 2' dia. culverts Concern from residents re: large hole dug to allow for water flow poses risks to children in area	Requires placement of new additional culverts and clearance of drains.
Road Section	**Section 2: Mile 56 – 65 Iguana Creek Road Junction to Red Creek Bridge**				
WP	**Latitude**	**Longitude**	**Description of Area**	**Summary Issues**	
114	17.16750	89.0554	Red Creek Bridge	Bridge abutment needs reinforcing	Stabilize banks and clear obstruction up-stream and downstream
119	17.19088	88.9847	Pine Ridge/Georgeville Junction across from Haltrudes Bennett Football Field	Flood area, narrow drains and small culvert discharging unto private property	Drains need to be widened and redirect drain to run to and along road reserve.
120	17.19204	88.9828	Pine Ridge/Georgeville Junction 2 – Barton Creek Road	Flash flood 2008 TD 16, drainage design issues (height and width), sharp angles, road sinks -drain also acts as dam flooding adjacent property	Drain needs to widened and given a smoother curve at the junction with the Georgeville/ Pine Ridge Road. Drain needs to be redesigned to allow for draining of adjacent propertie.
122	17.21050	88.9402	Opposite Mile 59 Superstore Unitedville	Flood area, natural catchment blocked and culverts too small, water rises approx. 12 inches across road	Drainage obstruction on private property needs to be removed and drain cleared to its original state
Road Section			**Section 3: Mile 67 -79.4 Buena Vista Street, San Ignacio Town to Benque Viejo Border**		
WP	**Latitude**	**Longitude**	**Description of Area**	**Summary Issues**	
106	17.07289	89.1368	Approximately Mile 73.5. GPH Boulevard near Marshalleck Stadium	Area prone to flooding (Mount Carmel Primary School, a designated hurricane shelter.)	Need improvement of existing drainage.
113	17.14025	89.0776	Between Chuc's Service Station and UNO gas station	Flood area.	May require new culvert and redirecting of drain
103	17.14841	89.07911	Near to Chuc's Service Station in front of Gregorio Ramos house	Flood area.	Drainage needs maintenance

7.3 Impacts Related to Geology

7.3.1 Tectonics

The Study area can be considered tectonically inactive as these faults predate all recent deposits and there is no evidence of recent faulting within the study area. However, it is subject to the Cayo Wrench system of NE-SW lateral fault blocks.

7.3.2 Geological Risks and Evaluation

The geological risks within the study area are minimal and subject to very site specific localities, these would need further evaluation along the exact alignment. The identified risks from the rapid field reconnaissance are:

- land slippage, along Section II primarily, in the areas underlain by clays with the gypsum inclusions
- micro slides, from road cut embankments in the marls or vertical cuts in outcropping limestone hillocks
- Rock fall, from thinly bedded fractured limestone/dolomite outcrops exposed in road cuts and in particular along the "Z curve" escarpment.

7.3.3 Material Requirements and Extraction

7.3.3.1 Site selection criteria

In selecting the sites for potential supply of the required volumes of material for base, sub-base and wear-coarse a selection criteria was applied. Each site had to meet the following minimum set of criteria to be eligible for consideration:

- **On-land extraction;** in an effort to reduce the negative impacts to water bodies and aquatic habitats, it was determined that no active river coarse extraction sites would be evaluated (primarily for sourcing of harder gravels for wear coarse)

- **Reduced Footprint;** sites that have the ability to yield large volumes of material within a limited acreage, limestone hillocks with lateral exposure exceeding 20m relative to surrounding topography, gravel sites with gravel deposit extending 5m or deeper.
- **Existing disturbed sites;** evaluation of existing or abandoned quarries that have the potential to provide the volumes required, this is done in order to prevent the additional scarring of undisturbed locations.
- **Proximity to water bodies;** identification of sites that had the potential of utilizing either a closed water system (for washing/screening) or that did not pose the threat of accelerated run off and sediment loading into existing water bodies.
- **Material Specifications;** meets minimal requirements for hardness, compaction rates (limestone/marl) , skid and wear resistance (chert)
- **Proximity to GPH;** using 15 mile buffer limit vs material type vs material suitability

7.3.3.2 Identification of Sites

- Compilation of existing and abandoned quarry sites undertaken.
- Evaluation of material availability from required road cuts for realignment.

- Ranking and weighting against selection criteria was done.
- In field site assessment of each potential site was conducted to examine suitability for adequate material supply as well as site specific conditions.

From the assessment of nineteen (19) existing localities for marl and/or limestone and marl, five (5) sites were selected. Five (5) sites were also selected from the assessment of twelve (12) existing localities for on-land sand and gravel or gravel. An evaluation of the proposed road cuts and road alignments one (1) site was selected for the supply of limestone/marl.

7.3.3.3 Existing Marl and/or Limestone and Marl Sites Selected

Figure 7.4: Western Sanitary Landfill/Benque Quarry

1. MOWT site in Western Sanitary Landfill/Benque Quarry, Figure 7.4

- Located within Section III of the road works, it is operated by MOWT.
- Consists of massive limestone beds with some minor inclusions of marl and clay
- Tan to white in color, microcrystalline
- Can provide materials for all stages of road works; base and sub-base, due to high presence of consolidated limestone and the low percentages of clay and marl inclusions, except wear coarse.

Figure 7.5: Georgeville Quarry

2. Georgeville Quarry (Private), Figure 7.5

- Located within Section II of the road works, operated by Caribbean Investors Ltd.
- Can be considered abandoned.
- Thick overburden of unconsolidated marls with some limestone boulders, lower portions consist of 2m+ thick, heavily fractured limestone.
- Requires drill and blast for the production of material.
- Can provide materials for all stages of road works (base and sub-base), due to high presence of consolidated limestone. The highly fractured nature is due to the tectonic setting and is not an indication of lack of hardness, the lower massive beds of limestone are classified as “marble grade” limestone due to their hardness. Also the almost lack of clay or marl within these lower portions make it ideal material, except for wear coarse.

3. Society Hall Blackman Eddy (Private), Figure 7.6

- Located within Section I of the road works, operated by Belize Roadway Construction
- Active quarry site
- Consists of thin to medium bedded limestone with some inclusions of marl or clay
- Material can be acquired by ripping; crushing and screening would be required.

- On site assessment would limit the use of this material to sub-base only; further detailed testing would be required to evaluate suitability for use as base, as the initial hardness observed along with the high percentage of marl and clay would be an area of concern.
- Not suitable for wear coarse.

Figure 7.6: Society Hall Blackman Eddy

4. Society Hall Blackman Eddy (private), Figure 7.6

- Located within Section I of the road works, operated by Belize Roadway Construction I
- Located within Section I of the road works, operated by Excel Construction Ltd.
- Active quarry site
- Consists of thin to medium bedded limestone with approximately 15-20ftt of marl overburden, the limestone beds exhibit some inclusions of marl or clay
- Material can be acquired by ripping; crushing and screening would be required.
- On-site assessment would limit the use of this material to sub-base only; further detailed testing would be required to evaluate suitability for use as base, as the initial hardness observed along with the high percentage of marl and clay would be an area of concern.
- Not suitable for wear

Figure 7.7: Society Hall Blackman Eddy (private)

7.5 Agua Viva, Hummingbird Highway (Private), Figure: 7.7

- Although this site is located outside of the immediate zone of influence, it was still identified as it is readily accessible and has the capacity to yield high volumes of high quality crushed limestone material.
- Active quarry site operated by Belize Road Way Construction.
- Consists of thinly bedded limestone ranging in thickness from 0.5m to 1 m with little to no marl or clay
- Material can be acquired by ripping; crushing and screening would be required.

Figure 7.7: Agua Viva, Hummingbird Highway

- Material can be acquired by ripping; crushing and screening would be required.
- This site has been evaluated as it has the potential to yield materials for both base and sub-base, the low presence of marl and clay and the initial onsite assessment of hardness, indicate that this site should meet or exceed the required strength and compressibility requirements for crushed aggregate for base and sub-base.
- Not suitable for wear coarse.

The other locations evaluated have been eliminated as the material available from these sites is either below specification or the sites cannot yield adequate volumes without significantly increasing their footprint.

7.3.3.4 On-land Gravel Sites Selected

A general area with multiple locations has been identified for the supply of on-land gravel, Figures 7.8.and.7.9). The lower areas of Spanish Lookout in the Iguana Creek area, has been identified as the preferred site for the supply of wear coarse material for asphalt mix. This material type is quartz in the form of chert nodules with some agate ranging from cobble to boulder size, unconsolidated material associated with a red to grey mottled clay.

Figure 7.8 Iguana Creek Area Gravel Beds

The deposits range in depth from 2m to in excess of 12m and can be quarried by simple scraping and removal, requiring screening and crushing. This material has been shown to have superior wear and skid resistance (Tunich Nah 2004) in other applications and is currently being used by the Ministry of Works in other road upgrade/maintenance projects along the GPH.

The other locations have been eliminated because of their proximity to water bodies and pose too high a risk for potential runoff of sediments from the extraction sites into either the Belize River (Young gal area localities) or the Macal River (Branch Mouth area localities). In addition, in particular in the Branch Mouth area, the yield of gravel suitable for crushing and screening would be below the required volumes.

Figure 7.9: Iguana Creek Area and Materials

7.3.3.5 Road Cut/Road Realignments

Several areas requiring cutbacks for road realignment have been identified. In general, these areas are small, yielding small volumes of material that can be quickly and easily incorporated into the base of any immediate area requiring elevation along the proposed road works.

Figure 7.10: Z- Curve

One site (Z-Curve) however, requires major realignment and excavation for the GPH upgrade Figure 7.10. The lateral exposure along the existing road is in excess of 30m and the material varies from overburden (5m+/-) and then grades from marl to limestone and marl at depths exceeding twenty five feet, (final boreholes along proposed road cut will indicate exact stratigraphic column and composition. It is assumed from the current exposure that 90+ % of this material can be incorporated in the base and sub base.

7.3.4 Soils and Impact on Road

Within the study area a total of twenty (20) test pits were dug to an approximate depth of 3.5m or deeper, along the existing road alignment, to examine material suitability and competencies (sieve analysis, soaked CBR, atterburg limits, etc,) as part of the Feasibility Study by A Thurton and Associates. These studies are important to identify and describe the various soil types and characteristics within the three sections of the proposed GPH upgrade (see test location map).

In general, two different soil types/profiles were encountered along the GPH, these are consistent with the underlying geology. The areas overlaying the late Tertiary Red Bank Group exhibited thin to moderate black organic rich soils, overlaying grey to red mottled clays, with some areas showing higher percentages of sands. The clays grade downward into stiffer clays with cobble to boulder size inclusions of cherts, and various river deposits (igneous derived cobbles and pebbles), some areas exhibited limestone boulders in the clay matrix. (See below extracted test pit results that show typical soil profile- Plates 1 to 6).

The areas overlaying the Early Tertiary El Cayo Group typically consist of thin black organic rick soils overlaying tan to white marls with cobble to boulder-size limestone pieces that grade either in thin consolidated lime stones or into stiffer tight marls with larger limestone fragments. Some profiles have exhibited thinly bedded lime stones, and others have some clay and sand inclusions (see below extracted test pit results that show typical soil profile).

aTa Lab **INSPECTION PIT**

CLIENT:	Ministry Of Works and Transport	**DATE OF TEST:**	July 10, 2014
PROJECT:	George Price Highway	**JOB NO:**	J1944/14
LOCATION:	Roaring Creek Bridge	**TECHNICIAN:**	Anthony Thurton Jr.

INSPECTION PIT 2

TYPE OF BORING : TRENCH EXCAVATION
DIAMETER OF BORING : NA
WATER TABLE : NONE FOUND

DEPTH FT / INS	SOIL LEGEND	DESCRIPTION OF STRATA
0'-0"		BLACK SOIL
0'-6"		ORANGE - BROWN CLAY WITH SOME STONE AND BOULDERS.
1'-0"		GRAY CLAY
1'-6"		
2'-0"		
2'-6"		
3'-0"		
3'-6"		
4'-0"		
4'-6"		
5'-0"		
5'-6"		
6'-0"		
6'-6"		
7'-0"		
7'-6"		
8'-0"		
8'-6"		
9'-0"		
9'-6"		
10'-0"		
10'-6"		
11'-0"		
11'-6"		
11'-8"		

DESCRIPTION: NO WATER TABLE WAS OBSERVED, HOWEVER SIGNIFICANT FUMES (PRESUMED TO BE GASOLINE) WAS DISSIPATED DURING AND AFTER THE EXCAVATION.

Plate 1

aTa Lab — INSPECTION PIT

CLIENT:	Ministry Of Works and Transport	DATE OF TEST:	July 10, 2014
PROJECT:	George Price Highway	JOB NO:	J1944/14
LOCATION:	S CURVE	TECHNICIAN:	Anthony Thurton Jr.

INSPECTION PIT 4

TYPE OF BORING : TRENCH EXCAVATION
DIAMETER OF BORING : NA
WATER TABLE : NONE FOUND

DEPTH FT / INS	SOIL LEGEND	DESCRIPTION OF STRATA
0'-0"		
0'-6"		BLACK SOIL
1'-0"		
1'-6"		
2'-0"		CREAM SAND, GRAVEL WITH SOME CLAY, COBBLE STONES AND BOULDERS.
2'-6"		
3'-0"		
3'-6"		
4'-0"		
4'-6"		BLACK SOIL WITH SOME GRAVEL AND CLAY.
5'-0"		
5'-6"		
6'-0"		
6'-5"		

DESCRIPTION: NO WATER TABLE WAS ODSERVED.

Plate 2

aTa Lab — INSPECTION PIT

CLIENT:	Ministry Of Works and Transport	DATE OF TEST:	July 10, 2014
PROJECT:	George Price Highway	JOB NO:	J1944/14
LOCATION:	Red Creek Bridge	TECHNICIAN:	Anthony Thurton Jr.

INSPECTION PIT 12

TYPE OF BORING : TRENCH EXCAVATION
DIAMETER OF BORING : NA
WATER TABLE : NONE FOUND

DEPTH FT / INS	SOIL LEGEND	DESCRIPTION OF STRATA
0'-0"		
0'-6"		BLACK SOIL
1'-0"		
1'-6"		SOME WHITE MARL, CRUSHED SAND, GRAVEL WITH COBBLE STONE AND BOULDERS.
2'-0"		
2'-6"		
3'-0"		BROWN CLAY WITH GRAVEL AND BOULDERS.
3'-6"		
4'-0"		
4'-6"		
5'-0"		
5'-6"		
6'-0"		
6'-6"		
7'-0"		

DESCRIPTION: NO WATER TABLE WAS ODSERVED.

Plate 3

aTa Lab — INSPECTION PIT

CLIENT:	Ministry Of Works and Transport	**DATE OF TEST:**	July 10, 2014
PROJECT:	George Price Highway	**JOB NO:**	J1944/14
LOCATION:	San Jose Succotz	**TECHNICIAN:**	Anthony Thurton Jr.

INSPECTION PIT 19

TYPE OF BORING : TRENCH EXCAVATION
DIAMETER OF BORING : NA
WATER TABLE : NONE FOUND

DEPTH FT / INS	SOIL LEGEND	DESCRIPTION OF STRATA
0'-0"		
0'-6"		BLACK SOIL
1'-0"		
1'-6"		WHITE MARL WITH GRAVEL AND BOULDERS.
2'-0"		
2'-6"		
3'-0"		BROWN CLAY, SAND & GRAVEL WITH BOULDERS AND COBBLE STONES.
3'-6"		
4'-0"		
4'-6"		
5'-0"		
5'-6"		
6'-0"		

DESCRIPTION: NO WATER TABLE WAS ODSERVED.

Plate 4

aTa Lab — INSPECTION PIT

CLIENT:	Ministry Of Works and Transport	**DATE OF TEST:**	July 10, 2014
PROJECT:	George Price Highway	**JOB NO:**	J1944/14
LOCATION:	Garbutt Creek Bridge	**TECHNICIAN:**	Anthony Thurton Jr.

INSPECTION PIT 11

TYPE OF BORING : TRENCH EXCAVATION
DIAMETER OF BORING : NA
WATER TABLE : NONE FOUND

DEPTH FT / INS	SOIL LEGEND	DESCRIPTION OF STRATA
0'-0"		BLACK SOIL
0'-6"		BROWN SAND WITH GRAVEL AND BOULDERS.
1'-0"		
1'-6"		
2'-0"		WHITE MARL WITH GRAVEL.
2'-6"		
3'-0"		
3'-6"		BROWN SAND WITH GRAVEL, COBBLE STONE AND BOULDERS.
4'-0"		
4-5"		ROCK FRAGMENTS.

DESCRIPTION: NO WATER TABLE WAS ODSERVED.

Plate 5

aTa Lab **INSPECTION PIT**

CLIENT:	Ministry Of Works and Transport	DATE OF TEST:	July 10, 2014
PROJECT:	George Price Highway	JOB NO:	J1944/14
LOCATION:	Barton Creek Bridge	TECHNICIAN:	Anthony Thurton Jr.

INSPECTION PIT 9

TYPE OF BORING : TRENCH EXCAVATION
DIAMETER OF BORING : NA
WATER TABLE : NONE FOUND

DEPTH FT / INS	SOIL LEGEND	DESCRIPTION OF STRATA
0'-0"		BLACK SOIL
0'-6"		BROWN SAND WITH GRAVEL AND COBBLE STONE.
1'-0"		
1'-6"		WHITE MARL, GRAVEL WITH COBBLE STONE AND BOULDERS.
2'-0"		
2'-6"		
3'-0"		
3'-6"		
4'-0"		BROWN SAND WITH GRAVEL, COBBLE STONE AND BOULDERS.
4'-6"		
5'-0"		
5'-5"		

DESCRIPTION: NO WATER TABLE WAS ODSERVED.

Plate 6

7.3.5 Mitigation Measures to Reduce Earth Movement Activities Impacts

The contractor will employ Best Management Practices and engineering standards during earth moving operations. Careful soil stripping and storage, as well as site restoration will ensure that the potential geological impacts are minimized. Road cuttings and embankments will be adequately sloped to stabilize and restore impacted areas as well to prevent soil erosion due to heavy rains. Measures also include soil restoration and planting with appropriate vegetation to ensure stabilization of slopes at Z-curve.

General recommended mitigation measures:

- Road side slopes and cuts should have slopes of 1.5:1 ratio to prevent land slippage from road cut embankments and rock fall from thinly bedded fractured limestone/dolomite outcrops exposed by road cuts, especially at the Z-curve. In Section 2, there is evidence of microslides in areas underlain by clays with gypsum inclusions.

- Erosion Control Blankets or the use of fiber-web geo-synthetics, Figure 7.11 are recommended for the stabilization of the cut slopes at the Z-curve. The use of these materials are to enhance the growth of natural vegetation important in providing long-term stability to the slopes.

Figure 7.11 Geo/synthetic mesh

- To prevent excessive siltation during the cutting of the Z-curve, storm-water will be diverted away from construction area and storm-water generated within the construction area will employ the use of check dams, Figure: 7.12, along the storm-water drains before discharging into the receiving environment.

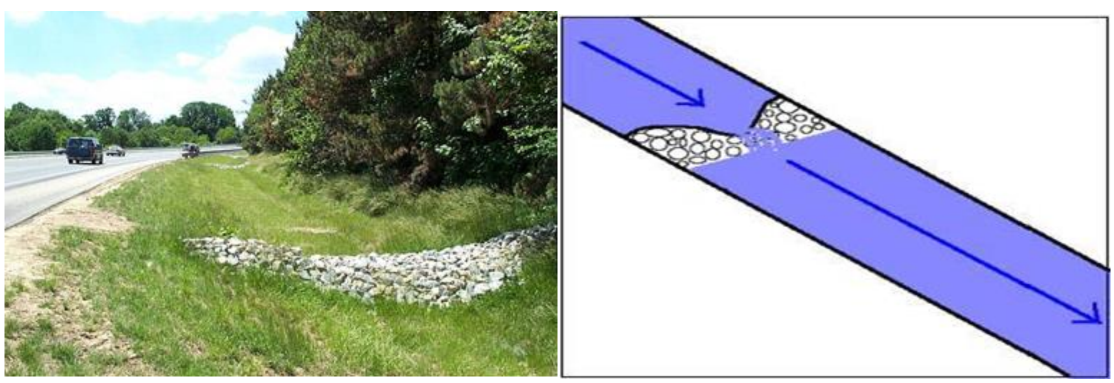


Figure: 7.12 Check dam made of gravel

- The construction of bridge abutments for the proposed Roaring Creek Bridge will involve the installation of mitigation structure such as wing dams made of sand bags or the use of silt curtains, Figure 7.13, to prevent excessive siltation of the Roaring Creek. These structures will be deployed to enclose the construction area within a semi-circle that extend to no more than the mid- point of the width of the creek to allow for unimpeded water flow Figure 7.14. Following construction work, the silted area within the wing dam or silt curtain will be cleared of excessive sediments before their removal. In addition, these activities will be programmed to take place during the dry periods.

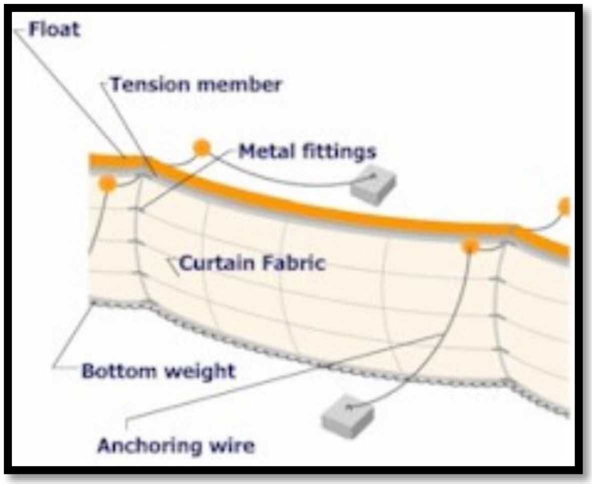


Figure 7.13: Wing Dams

Figure 7.14: Installed Dam

- To reduce the impacts associated with materials supply, only sites that meet the set of pre-determined criteria will be utilized. Based on these criteria, several sites were eliminated due to environmental, archeological and geological impacts associated. To further mitigate the impacts on any one specific selected site, the extracted volumes will be shared among the different sites to reduce the environmental impact footprint.

- Extraction of materials will be done by leveling sites evenly and preventing ponding. The disturbed areas will be restored to as close as their original natural state as possible.

- Material from the surface stripping of the existing road will be stockpiled at various locations throughout the project where it will used to rehabilitate the village streets of communities along the ROW. The discarded road surface has good reuse potential thus ideal for village streets.

7.3.6 Land Use Impacts

The negative environmental impacts associated with land use and tenure is expected to be minimal during both phases of the project. As discussed, the land use of the study area consists of both developed (residential, community, agricultural and municipal lands) and undeveloped lands that are located within the buffer zone.

7.4 Hydrology

7.4.1 Impacts on Hydrology from Construction Impacts

Road rehabilitation activities and upgrade or construction of alternative by-passes have the potential to impact the hydrology of the project zone in two key aspects: discharge of contaminants to the receiving waterways and water bodies, and changes in the hydrology of an area or micro-catchment due to topographic changes (e.g. excavation and fill).

Table 7.5 indicates that the activities with the greatest potential to negatively impact the hydrology of the area are those in connection with the following works:

1. the road reconstruction activities, including culvert replacement and re-alignment and raising of the GPH through Succotz Village and the entrance of Benque Viejo;
2. the re-alignment of the Z-curve, and the opening of a temporary detour at the section of the highway; and
3. the construction of the new Roaring Creek Bridge and realignment and raising of that section of the road.

Table 7.5: Activities to Impact Hydrology

Environmental Effects / Developmental Activities	Oil/ hydrocarbons	Siltation-TSS	Bact. contamination	Dissolved Oxygen	Siltation	Flow regime	Livelihood	Drinking water	Bank Erosion	Riparian vegetation	Ground Water	Total
Road Construction	-2	-1	-1	-1	-2	2	-1	-1	-1	-1	0	-9
Road Alignments at R. Creek	-2	-2	-1	-1`	-2	0	-0	-1	-1	0	0	-10
Elevation of Road at R. Creek	-1	-2	-1	-1	-2	0	0	-1	-2	0	0	-10
Construction of New Bridge	-2	-3	-2	-2	-3	-1	0	0	-2	-2	0	-17
Realignment of Road at Z-Curve	-3	-3	-2	-2	-2	-2	0	0	-2	-3	0	-19
Upgrading of temporary by-pass for Z -Curve	-2	-2	-2	-2	-2	-3	0	0	-1	-0	0	-14

Elevation of Road at Succotz	**-2**	**-2**	**-1**	**-1**	**-3**	**-1**	**-3**	**-2**	**-3**	**-2**	**0**	**-20**
Elevation of Road at Benque	**-2**	**-2**	**-1**	**-1**	**-3**	**-1**	**-1**	**-2**	**-3**	**-2**	**0**	**-18**
Construction of Retaining Wall Succotz and Benque sections of Road	**-2**	**-2**	**-1**	**-1**	**-3**	**-1**	**2**	**1**	**-2**	**-2**	**0**	**-17**
Construction of Roundabout at Benque	**-2**	**-2**	**-1**	**-2**	**-3**	**-2**	**-2**	**-2**	**-3**	**-3**	**0**	**-26**
Opening of Detour Behind Succotz	**-2**	**-2**	**-1**	**-1**	**-1**	**0**	**0**	**0**	**0**	**-1**	**0**	**-8**
Impacts: -3 *High negative*; -2 *Medium negative*; -1 *Low negative* 0 *none*; 1 *Low positive*; 2 *Medium positive*; 3 *High positive*												

Table 7.6 provides a summary of the potential impacts on the hydrology of the study area associated with the main critical areas along this section of the GPH, which will require special attention.

Table 7.6: GPH Rehabilitation and Impacts to Hydrology

Activity	Preferred Option	Impacts to Hydrology	Mitigation
1. Road Surface Upgrading and Culvert replacement	Replace road surface and make it impermeable with double chip seal; Standardization of culverts size and design (42-inch diameter, concrete cylindrical)	Reduced impact to hydrology as compared to current road; improved drainage and water flow as a result of culvert upgrading.	Possibly combine road surfacing with concrete in critical flood prone sections to minimize degradation and sedimentation to drains and streams.
2. Succotz Village and Benque Viejo entrance road upgrade, and By-pass	…Elevate low-lying areas of GPH through Succotz and entrance to Benque Viejo to accommodate 20-year flood event …Alternate 3: Succotz By-pass Option 2	Sedimentation to Mopan River during construction if proper mitigation measures not implemented. Improved drainage from re-construction and resizing of culverts, and improved culvert alignment. River bank stabilization along critical section	Install barriers or silt traps to minimize sedimentation into river Standardize culverts and improve/maintain drainage Stabilize river bank at critical sections
3. Re-alignment of the Z-Curve, and the opening of a temporary detour	Cutting of Z-Curve hill and rehabilitation of a temporary by- pass	Possible contamination of Belize river from sedimentation and petroleum products	Use geotextiles to stabilize slopes and reduce erosion, use check dams to trap sediments, and put in place a pollution prevention program.

		Impacts to drainage from rehabilitation of temporary by-pass	
4. Roaring Creek Bridge and Realignment and raising of road	Opt. 2: Re-align the road section approach to bridge and construct new, elevated bridge meeting international standards and crossing adjacent to existing Roaring Creek Bridge …construct Roaring Creek By-pass from Forest Drive, Butte Row, across Riviera to Roaring River Drive	New, elevated bridge would mitigate against impacts of flooding. Improved and reliable evacuation transit during time of disaster. Potential impacts on the Roaring Creek during construction phase, in the form of increased sedimentation loads and contaminants / solid waste entering creek if mitigation measures not implemented.	Install wing dam and sediment curtain to reduce the entry of soil and debris into the Roaring Creek during construction. Implement proper disposal of waste material away from water sources. Stabilize river bank and other bridge embankment to avoid erosion

7.4.2 Mitigation Measures to reduce Impact on Hydrology

The following measures are recommended to ensure that road upgrading activities do not have a significant adverse impact on the hydrology of the immediate and downstream areas of water sources:

1) **Road re-construction activities, including culverts replacement and realignment of the GPH through Succotz Village and entrance to Benque Viejo del Carmen**

- Install barriers or curtains to trap and prevent the movement or accidental spillage of solid matter such as soil, stripped pavement, contaminants, debris, and other pollutants and waste into streams, watercourses (perennial or ephemeral), and underground water sources. Particular care should be given to sediment contamination in the vicinity of water intake pump, or sections of river and streams used for recreational or domestic purposes.
- De-watering and watering work for structure foundations or earthwork operations adjacent to, or encroaching on streams or watercourses shall be undertaken in such a manner to prevent muddy water and eroded material from entering the streams or watercourses by construction of intercepting ditches, wing dams, by-pass channels, barriers, settling ponds, etc.

- As far as possible, turbidity increases in streams and rivers resulting from construction activities shall be avoided.
- All wastewater from construction operations shall discharge into temporary settling ponds or similar wastewater receiving structure before being released into streams, watercourses, or other surface waters.
- Proper storage of waste oil, grease and other contaminant shall be available on all construction camps to avoid the entry of such material into streams, watercourses, or other surface water.
- Runoff of storm water during construction shall be diverted to temporary natural settling ponds where practical and possible to avoid direct flow of construction storm water into streams, rivers, or other surface water with the construction of check dams along drains.
- To minimize ponding and potential damming of natural waterways as a result of construction activities, all burrow sites shall be managed to provide for free drainage following extraction of fill material.
- Construction sites shall be rehabilitated to reduce impacts from erosion.

2) **Re-alignment of the Z-curve, and the opening of a *temporary detour* at that section of the highway**

The proposed re-alignment of the Z-curve will keep the existing road running along the upper, southern banks of the Belize River. A cut of about 200 feet wide will be done through the hill along a straight route that will converge with the existing road on the opposite side of the hill. The cut will bevel down to the regular width of a two-lane highway at the level of existing road and the sides will be stabilized at a gradient of 1.5 to 1, so as to minimize slippage. A detour will be established around the southern periphery of the hill to facilitate the flow of traffic during construction. The following are recommendations to ensure that road upgrading activities at the Z-curve does not significantly impact on the hydrology of the immediate and downstream areas of water sources:

- Install barriers or curtains to trap and prevent the movement or accidental spillage of solid matter such as soil, stripped pavement, contaminants, debris, and other pollutants and waste into streams, watercourses (perennial or ephemeral), and underground water sources.

- Erosion Control Blankets or the use of fiber-web geo-synthetics are recommended for the stabilization of the cut slopes at the Z-curve. The use of these materials is to enhance the growth of natural vegetation important in providing long-term stability to the slopes.

- To prevent excessive siltation during the cutting of the Z-curve, storm-water will be diverted away from construction area and storm-water generated within the construction area will employ the use of check dams along the storm-water drains before discharging into the receiving environment.

- Proper storage of waste oil, grease and other contaminant shall be available on all construction camps to avoid the entry of such material into streams, watercourses, or other surface water.
- Have a designated and secure site for dumping stripped pavement and excavated soil away from riverbank and streams.

3) Construction of the new Roaring Creek Bridge

- Install wing dam or sediment curtains to reduce the entry of soil and debris into the Roaring Creek during construction of bridge
- All solid waste including vegetation, stripped pavement material, discarded metals and others shall be safely secured at a site away from the Roaring Creek, the Belize River and other water bodies.
- As far as possible, turbidity increases in streams and rivers resulting from construction activities shall be avoided
- Contractors shall have an Emergency Plan to secure worksite in the event of an impending Hurricane flood emergency

7.4.3 Operational Phase of Upgraded GPH

It is expected that when the new rehabilitated highway becomes operational the impacts to the hydrology and drainage of the area would have been greatly improved as opposed to the existing road since the project intends to replace all problem culverts with more appropriate ones and to improve the current road drainage system.

It is envisioned that the upgraded western corridor of the GPH shall have positive impact on the hydrology of the sub-basins through which the GPH traverses. The road designed is for a 20-

year lifespan, and the upgrade of the Succotz-Benque Viejo segment for a 20-year Flood Event and the Roaring Creek Bridge is being designed for a 100-year Flood Event. Some recommended activities to avoid impacts to the hydrology of the area arising from the upgraded GPH are:

- Regular inspection of bridges and culverts, and replacement of damaged culverts.
- Regular maintenance of culverts and inflow and outflow drainage, in collaboration with communities.
- Ensure periodic road maintenance or resurfacing as recommended in the Road Maintenance Manual
- Proposed by-pass in flood prone sections of the western corridor of the GPH should be upgraded to paved, all weather alternative routes in the event of future, disruptive flood events. The designs shall ensure that such by-passes shall have minimal impacts on the hydrology of these areas.

7.5 Environmental Impact: Noise, Vibration and Air Pollution

7.5.1 Sound and Noise

It is common practice to define noise simply as unwanted sound. However, in some situations noise may adversely affect health in the form of acoustical energy (WHO 1999). Table 7.6 below provides the Second Schedule (Regulation 42) Noise Level from the Pollutions Regulations, which establishes the noise level standards for Belize.

There are three main sources of noise that will affect the road construction crew and communities along the GPH area of interest, namely, noise from construction, transportation, and from residential and leisure areas.

Table 7.7: Second Schedule (Regulation 42)

NOISE LEVELS

Noise Level According to the dB (A) Scale (as defined by the International Electronics Commission)

Duration of the Noise	Structure									
	A		B		C		D		E	
	D	N	D	N	D	N	D	N	D	N
1. More than 9 hrs	60		60		70		70		85	
2. More than 3 hrs, less than 9 hrs	70		70		75		75		90	
3. More than 30 mins	75		75		80		80		100	

4. More than 30 mins		**45**		**45**		**45**		**45**		**90**
5. More than 15 mins, less than 1 hr	**70**		**70**		**90**		**90**		**105**	
6. More than 10 mins, less than 30 mins		**45**		**50**		**50**		**50**		**90**
7. More than 5 mins and less than 15 mins	**70**		**85**		**100**		**90**		**90**	
8. More than 2 mins and less than 5 mins	**90**		**95**		**100**		**100**		**95**	
9. Less than 10 mins		**50**		**70**		**70**		**70**		**80**
10. Less than 2 mins	**100**		**100**		**105**		**100**		**110**	
Noise from infrequent (less than 4 time per week) explosions	**109**		**109**		**114**		**114**		**114**	

D= Day N=Night

Structure A: any building used as a hospital, convalescent home, old age home, or school.

Structure B: any residential building.

Structure C: any building in an area that is used for residential and one or more of the following purposes: commerce, small-scale production entertainment.

Structure D: any residential apartment in an area that is used for the purpose of industry commerce or small scale production

Structure E: any building used for the purposes of industry, commerce, or small-scale production in an area use for the purposes of industry, commerce, or small-scale production.

7.5.1.1 Construction and Transportation Noise

The assumption is that ambient noise levels, which are constant in nature, will increase and will be comparatively higher during the construction phase of the highway either due to the operation of heavy equipment at the work sites or by the traffic to and from the specific work sites. Trucks, tractors and heavy machinery like excavators also generate noise levels beyond tolerable limits. The noise levels at a construction site operation ranges from 96 to 125 dB. These are above the limits of 75 dB prescribed by WHO for day time industrial areas. The exposure for longer periods to these higher levels of noise is likely to affect the ear diaphragms of the workers (Chauhan 2010) if the use of PPE’s is not made mandatory. The noise could also be a nuisance to the community along the George Price Highway. Table 7.8 below compares the various noise levels associated with various activities and construction equipment.

7.5.1.2 Residential, School and Leisure Area Noise

On the project area along the George Price Highway, there are various villages and one town which comprise mainly of residential houses and some commercial establishments (shops and “pop and mom” restaurant/bars) and 10 primary schools near the road side. Very often these commercial and leisure uses can generate high levels of noise, for example, entertainment noise from a boom box or live band vary from 112 dB to 115 dB , as well as noise from street activity associated with the night time economy. It is envisioned that with the start of the road construction and the installation of workers campsites, commercial and leisure activities may increase and such noise can be a problem to the none-participating community including schools.

7.5.1.3 Effects of Noise on wildlife

The greatest difficulty in summarizing the effect of road noise on wildlife is the fact that very few studies have directly addressed the impact of noise from roads (i.e. the background sound that accompanies varying volumes of traffic) (FHWA, 2014). Wildlife faces far more problems than humans because of noise pollution since they are more dependent on sound. Animals develop a better sense of hearing than we do since their survival depends on it. Studies have shown that noise can have a detrimental effect on wild animals, increasing the risk of death by changing the delicate balance in predator or prey detection and avoidance.

However, because the rehabilitation of the GPH will occur along an existing highway any additional impact from noise on wildlife is assessed as minimal and the general mitigation measures prescribed for noise pollutions would suffice in addressing impacts to wildlife.

7.5.1.4 Noise Attenuation and Mitigation

Noise pollution from the construction sites and material transportation is predicted to average 12 hours per day. The study has documented the level of background noise for critical areas along the GPH that will be used as baseline data to compare against when monitoring for noise levels from construction activities. The construction company should therefore ensure that the construction work plan is well thought out to ensure daylight-working hours and not to exceed 12 working hours.

This in itself helps to control noise pollution since noise generation will be limited to 12 hours. In addition the contractor will ensure that vehicular transportation, earth moving equipment and hand tools shall be maintained and fitted with mufflers (where appropriate) during operation. Equipment and vehicles shall also be turned off when not in use. Carry out regular checks on site equipment to ensure it is running smoothly and efficiently. In quiet zones such as School Areas, heavy equipment should avoid having to reverse; therefore reducing the use of reversing beepers when possible and workers should be asked to work quietly and to avoid speaking too loudly.

The road construction company will need to employ best practices in all their activities related noise emissions. These include the proper maintenance of construction equipment and the proper muffling of operating equipment and ensuring that workers wear Personal Protection Equipment

Table 7.8: Comparative Noise levels

Source of Sound	Distance from Source (m)	Sound Pressure Level Decibels (dB)
Ambient and Standard Noise Levels		
Ambient noise level		**40**
Normal conversation face to face	**1**	**40 -60**
EPA-maximum to protect against hearing loss		**70**
WHO Maximum –Industrial Work Place **Less than for bedroom for good night rest** **Less than for classroom teaching**		**75** **30** **35**
Construction Noise Levels		
Air Compressor	15	81
Backhoe	15	80
Chainsaw	1	110
Compactor	15	82
Compactor (Plate)	15	101
Concrete Mixer	15	85
Concrete Vibrator	15	76
Crane Derrick	15	88
Crane Mobile	15	83
Dozer	15	85
Generator	15	81
Grader	15	85
Impact Wrench/Pneumatic Tool	15	85
Jack Hammer	15	88
Loader	15	85
Paver	15	89
Pile Driver (Impact)	15	101
Pump	15	76
Rail Saw (Steel-Stone)	15	90
Rock Drill	15	98
Roller	15	74
Saw	15	76
Scraper	15	89
Shovel	15	82
Tractor without cab	15	120
Traffic (Heavy Equipment)	10	90
Traffic (Heavy Traffic)	15	80-89
Traffic (motorcycle/ATV)	15	96-100
Traffic (Passenger car at 65 mph)	10	77
Truck (Concrete Pump)	15	82
Truck (Dump)	15	88
Truck (Pickup)	15	75

(PPE) (e.g. earplugs to minimize the effect of noise). Consideration should be taken to construct noise barriers, such as temporary walls between noisy activities at the work site and the schools nearer to the read side. High noise generating activities, in excess of 75 dBA including blasting, the use of jack hammers, pile driving and rock crushing activities be restricted to daylight hours, particularly in proximity of existing residential areas – namely within the vicinity of the road.

7.5.2 Vibration

7.5.2.1 Effects on Human

Although vibration pollution is not a new concept, there are *no legal standards that limit exposur*es to vibration; however, the Team felt that exposure to whole-body vibration should be taken into consideration. Whole-body vibration is vibration transmitted to the entire body via the seat or the feet, or both, often through driving or riding in motor vehicles (including tractors and off-road vehicles), through standing on vibrating floors (e.g., while attending to machinery) or using tools (e.g. while operating a jack hammer). Long and constant exposure to whole-body vibration causes back pain. These impacts are mostly limited to the construction workers with negligible impacts to residents along the ROW. However, heavy vibrations can impact roadside structures and in so doing indirectly impact residents along the ROW.

7.5.2.2 Effects on Surrounding Constructions

Depending on the equipment and method employed, road construction activity can result in varying degrees of ground vibration that causes vibrations to spread through the ground with diminishing strength with distance. Buildings and other structures near the road project site will respond to these vibrations, with varying results ranging from no perceptible effects to slight damage at the highest levels. However, ground vibrations from construction activities very rarely reach the levels that can damage structures (WSDOT 2004). The construction activities that typically generate the most severe vibrations are blasting and impact pile driving.

7.5.2.3 Mitigation Measures for Vibration Impacts

Whole-body vibration levels can often be reduced by using vibration isolation and by installing suspension systems between the operator and the vibrating source. In situations, such as those workers using a jack hammer, job rotation, rest periods, and reduction in the intensity and duration of exposure can help reduce the risk of adverse health effects. *All workers should be advised of the potential vibration hazard.* Construction vibration should be assessed in cases where there is a significant potential for impact from construction activities. Such activities include blasting, pile driving, and drilling or excavation in close proximity to sensitive structures.

7.5.3 Air Pollution: Dust and Emissions

7.5.3.1 Impacts of Air Pollution

Road construction activities have the potential to significantly, adversely affect air quality. The release and dispersion of dust will occur as a result of earth moving operations during site preparation and the transportation of material, movement of heavy construction equipment and traffic. In addition, the operation of heavy machinery will adversely affect air quality through the emission of air pollutants beside the dispersion of dust. The effect of construction –related dust development and air pollution will be of short duration and localized.

Quarrying and its associated activities of excavation, and transportation increase the levels of suspended particulate matter in the air that can be harmful to the health of the workers exposed to this type of environment. Fine dust inhaled by workers can lead to diseases related to lungs and liver such as “silicosis”, “bronchitis”, “asthma” and “tuberculosis” (Chauhan 2010). During the site visits to possible quarry sites, the team noted that these sites are secluded and far from human dwellings and hence, only workmen in the area would be affected from quarrying activities with impacts from these sites limited to the transportation of materials. During the rainy season dust may not be a problem; however, during the dry season invariably greater dust pollution does occur making it necessary for greater monitoring and personal protection.

During the construction phase of the GPH, the worksite will see the removal and replacement of and filling with road materials. These tasks along with the vehicular traffic associated with them, invariably will cause dust and emissions pollution.

Air pollution through emissions occurs with the operation of the construction equipment and vehicles. Issues of concern are with the generation of smoke, which will be monitored as suspended particulate matter and chemical emissions such as carbon monoxide, VOCs, SOx and NOx forming smog, which is detriment to human health impacting more profoundly individuals with respiratory ailments. The impacts from these emissions will be primarily localized and are not predicted to significantly increase the baseline measurements, which were all below detectable limits for all locations. The individual that would be more directly impacted by this issue are the road construction workers Table 7.9 below provides the standards set by GOB :

Table 7.9: Regulation 6 Concentration of Air Contaminant				
		Concentration in micro grams per meter cube		
	SPM	**SO_2**	**CO**	**NO_x**
A. Industrial and mixed Use	**500**	**120**	**5000**	**120**
B. Residential and Rural	**200**	**80**	**2000**	**80**
C. Sensitive	**100**	**30**	**1000**	**30**

7.5.3.2 Air pollution Mitigation Measures

The Department of the Environment, through the Pollution Regulations, has developed mechanisms to monitor and control air and noise pollution. These Regulations prohibits the releases into the environment of contaminants, unless done so with a permit issued by the Department of the Environment and at acceptable levels of contaminants from certain installations.

The regulation states that no person shall cause or permit a building or its appurtenances, open area, **or road or alley to be used, constituted, repaired, altered** or demolished without taking reasonable precautions to prevent particulate matter from becoming airborne. It requires that dust and other types of particulates be kept to a minimum by such measures as wetting-down, covering, landscaping, paving, treating, detouring or by other reasonable means.

The regulation further states that “no person shall cause or permit the extracting, crushing, screening, handling or conveyance of materials or other operations likely to give rise to airborne dust without taking reasonable precautions, by means of spray bars or wetting agents, to prevent particulate matter form becoming airborne.” The regulation also prevents any person from discharging into the atmosphere any contaminant from a gasoline or diesel engine in excess of the quantity specified by the Minister for a motor vehicle operating under normal conditions.

To mitigate against the occupational hazards associated with the generation of dust and emissions, workers will be required to use appropriate PPE’s. In addition, dust suppression measures will need to be employed to reduce the negative effect these could also have on resident population. In regards to communities and municipalities, the level and thus significance of such impact can be reduced by avoiding haulage of material through village streets. Where this cannot be totally avoided, another effective mitigation measure would be to require contractors to regularly water the haul routes in sensitive sections during dry periods.

The impact of air and dust pollution can best be minimized at source by proper maintenance and hauling of construction equipment and by providing appropriate protective working gear (masks, goggles etc.) as required. The protective gear or PPE will also be given to the workers at the quarry or while cutting the Z-curve since suspended particles will prevail as a result of material extraction, especially during the dry season.

Contractors will need to apply water or other dust suppressants measures. Other preventative measures such as fencing off or placing barriers to slow down traffic and in instances limit or prevent entry to third parties at construction areas (Z- curve and quarries). To avoid unnecessary emissions, contractors will adopt the practice of shutting off equipment whenever they are not in use. They will also ensure that their vehicle fleet and construction equipment are serviced on a scheduled basis to maintain good operation standards. If purchasing new equipment for the project, ensure that these have factory installed emission control devices.

Other general mitigation measures that can be implemented to avoid the impact of air pollution include:

- Utilization of methods and devices that control, prevent or minimize the discharge of contaminants to air including smoke, dust or soil, including appropriate storage of potentially 'dusty' material.
- Avoid burning of materials, particularly in proximity to residential areas (for example the nearby communities).
- Use dust suppressants along with the application of water to control dust pollution.
- Limit speed around construction zone, place barriers to slow down traffic
- Shut down equipment when not in use and maintain vehicles and heavy equipment in good operating conditions.
- Plan site properly for the placement of equipment and construction storage material

- Dust causing activities and storage of sand should be located away from sensitive areas and downstream of prevailing winds. Enclose stockpiles or keep them securely sheeted. Avoid the use of long-term stockpiles. Keep stockpiles or mounds away from the site boundary, watercourses and surface drains.
- Ensure that all loads entering and leaving site to be covered and that vehicles and heavy equipment are in good operational conditions.
- Erect effective barriers around dusty activities near schools and other sensitive areas.

7.6 Water Quality

7.6.1 Impact Assessment of Road Rehabilitation on Water Quality

Impacts associated with this cluster will be primarily confined to areas that are prone to flooding, water bodies along the highway, such as the stream running along the side of the road from a natural spring in Ontario, and areas traversed by creeks and streams where placement or replacement of culverts, bridges, and drainage are required. Another area where water quality could be impaired is the portion of the road directly adjacent to the Mopan and Belize River where major construction activities will take place. These areas are at the Succotz and Benque entrances and at the Z curve.

Construction activities can adversely impact water quality by means of the following;

1. discharges of contaminants to receiving waterways and water bodies
2. accidental spillage of fuel, oils or cementious material,
3. earth moving activities increasing the potential for erosion and siltation.
4. The water quality parameters of specific interest that will need to be monitored are turbidity, total suspended solids, oil in water and total and fecal coliforme.

The water quality parameters of specific interest that will need to be monitored are turbidity, total suspended solids, oil in water and total and fecal coliforme.

TSS/Turbidity: Suspended **solids** in water can be measured by measuring for total suspended solid (TSS) or turbidity. Turbidity is a water quality term that refers to fine suspended particles of clay, silt, organic and inorganic matter, plankton and other microscopic organisms that are picked up by water as it passes through a watershed. Turbidity in surface water bodies usually has organic and inorganic matter. At turbidity of 25 NTU water is considered murky. For all of these samples the turbidity was well below this figure. The lowest turbidity for these samples was 1.81 NTU at the Roaring Creek Bridge. The average turbidity was 4.70 NTU and the highest turbidity was 10.1NTU which was at the river by the Iguana Creek bridge for the month of June. These figures can vary significantly depending on the time of year.

Bacteriological Quality: All nine samples showed the presence of fecal *coliform* and *E. Coli* which indicates that the water is being contaminated with fecal matter through human or animal waste, from possibly several sources, These sources could be from any of or a combination of the following:

1. improperly treated septic and sewage discharges,
2. leaching or surface runoff of animal faeces from domestic animals(pastures)
3. faeces from wildlife.

The sampling site with the highest fecal *coliform* count (200 fecal coliform/100ml) was by the Roaring Creek Bridge. The average fecal *coliform* count was 124 fecal coliform/100ml. It should be noted that the WHO Guideline for Total Faecal Coliform in drinking water is 0 counts/100ml. Therefore, these waters should not be used as drinking water without first boiling or chemically treating. Table 7.10 provides a listing of the acceptable potable water standards and guideline values from BWSL and WHO. Bacteriological contamination could be adversely affected from improper sanitary facilities for construction workers and basecamp activities.

Table 7.10: Acceptable Limits (BWSL) and Guidelines (WHO) Drinking Water

Parameter	**Acceptable Limits (BWSL)**	**Guideline Values (WHO)**
TSS	50 mg/l	
Coliform (total)	0/100 ml	0/100 ml
E-coli	0/100 ml	0/100 ml

Oil in Water: The water analysis for oil in water at the nine sampling points indicates that three areas sampled, namely Ontario Natural Spring, Roaring Creek Bridge and Roaring Creek Rivera are above the DOE standards by 2.71 mg/L, 2.98 mg/l and 4.96 mg/L (Table 7.11). The rest of readings were negligible.

Table 7.11: Oil in Water Analysis

Oil in Water Analysis									
Sampling Pts.	1	2	3	4	5	6	7	8	9
River/ Tributary	Mopan Benque/ Succotz Jtc.	Macal Upper Sream	Macal Lower Stream	Garbutt Creek	Barton Creek	Belize Iguana Creek Bridge	Natural Spring Ontario	Roaring Creek Bridge Area	Roaring Creek Rivera Site
ppt	0.00076	0.00059	0.00029	0.00155	0.00146	0.00073	0.01271	0.01298	0.01496
mg/L	0.76	0.59	0.29	1.55	1.46	0.73	12.71	12.98	14.96

Oil in water levels could be adversely affected as a result of accidental spills of fuel or oils and from leakages of these from heavy equipment. It is therefore advisable that when rehabilitating the GPH no new oil and grease contaminant reaches the three above mentioned sampled sites. The sites should be continuously monitored to ensure that they are within national standards. Table 7.12 provides the effluent standards for oil and grease in water as established by the Environmental Protection (Effluent Limitations) (Amendment) Regulations 2009 (SI 102-2009).

Table 7.12: Effluent standards for oil and grease in water

Environmental Protection (Effluent Limitations)(Amendment) Regulations 2009 (SI 102-2009)		
Effluent	**Effluent Standards mg/l**	**Schedule**
Plastic and Synthetics	**10.0**	**First**
Food Processing	**15.0**	**First**
Service Industry	**10.0**	**First**
Soft Drinks Bottling Stds.	**10.0**	**First**
Other Industries or Commercial Activities	**10.0**	**Second**

7.6.2 Mitigation Measures to prevent Impacts to Water Quality

The following measures are recommended to avert adverse impact on the water quality of the surrounding area as a result of road rehabilitation activities:

- Minimize problems with soil erosion and sedimentation from earth moving activities by employing BMP for soil erosions as recommended in the section on geology.
- .Construction activities should be managed to prevent entrance, or accidental spillage, of solid matter, contaminants, debris and other pollutants and wastes into streams, water courses.
- Provide proper sanitation facilities for worker at work spots and base camps.

- Dewatering road sections under construction or earthwork operations adjacent to or encroaching on streams or water works or watercourses shall be conducted in a manner to prevent muddy water and eroded materials from entering the streams or watercourses by constructing of intercepting ditches, check dams, wing dams, siltation curtains, by-pass channels, barriers, settling ponds.
- Ensure the responsible storage and handling of petroleum products especially during refueling. Limit this activity as much as possible. Maintain equipment in good operational conditions -free from any oil and fuel leaks.
- In the event of a spill, use absorbent material to clean up and place contaminated material in a plastic drum that is to be kept covered at all times and report any spill immediately to DOE.
- Ensure that any aboveground fuel storage tank is placed within a bunded area that is able to contain more that 120% by volume of the largest tank. Store waste oil within bunded area in sealed plastic containers and contact DOE for final disposal.
- Construction workers will be required to ensure that the area is kept free from litter at all times and that all domestic waste are properly containerized and disposed of.
- No motor vehicle or equipment of any other type shall be washed in any river or stream.
- All proposed campsite locations will be submitted to DOE for vetting. The campsites will be located away from any waterways with the required human amenities, which will be serviced on a regular basis.

7.7 Ecological Impacts

It is important to note that the impacts to the study area will be temporarily minimal because much of the associated impacts had already occurred when the road was first constructed. This minimal impact will mostly be to established habitats that have developed a higher level of tolerance. Nevertheless, there will be short-term impacts that can temporarily affect the general biodiversity of the area and these needs to be addressed.

7.7.1 Impacts on Ecology from General Road Construction Activities

Overall, the road rehabilitation project is assessed as having minimal impact to the ecology and biodiversity of the study area and would not require any changes to the design of the proposed road because it follows an existing highway corridor. Campsite employees can pose temporary problems with respect to wildlife hunting along undeveloped areas which can adversely impact wildlife species, particularly those traditionally hunted. It is recommended that employees are informed of a no-hunting policy which will be enforced by management.

The sourcing of fill materials or quarry sites is of special interest. The project will use existing quarries that have little to no ecological value of significance even with substantial expansion. The project intends to distribute the extraction of materials from those that have been identified, thus reducing the potential impacts to one or a few sites. This will also eliminate potential impacts associated with identifying new sites that can result in substantial habitat loss resulting in a loss in biodiversity. It is projected that the quarry sites will remain active long after the project has concluded and as such it is recommended that mitigation measures focus on best management practices such as even levelling and the prevention of ponding, erosion and sediment control, dust suppression and restoration of exhausted areas. The impacts of the proposed activities could have positive impacts on the Guanacaste National Park by relocating its current entrance to allow for better access and egress to it.

7.7.2 Mitigation of Impacts on Wildlife

A number of design features are recommended for consideration to avoid potential adverse effects on fauna and flora. These include the following;

- Given the importance of the savannah/riparian to lowland broadleaf forest and wildlife in the area, the ecological investigation recommends that disturbance to the forest habitat be kept at a minimum during construction.
- Care should be made to preserve the natural landscape by preventing any unnecessary destruction, scarring or defacing of the natural surroundings in the vicinity of the work. This also includes the proposed road alignment along the Z Curve where a proposed wooden crosswalk or bridge will be constructed for the baboons to walk on. As explained, the project plans to cut the hillside to re-align the road in this area and thus this bridge will stem from the top of the hill to the old surface road that will be preserved and reserved as a nature walk area.
- Regular maintenance of culverts and drainage system to maintain and improve the existing hydrology of the study area (minimizing potential for die back of vegetation areas).

> **Box 7.1: Wildlike Crossing Coordinates**
>
> -Between the villages of Unitedville and Georgeville: 17 deg 11 min 59.60 sec N and 88deg 57'59.04"W.
>
> -At Warree Head 17 deg 13'29.82" N and 88 deg 52'29.56"W (exists).
>
> -Between San Ignacio and Succotz 17deg07'03.59"N and 89deg06'17.58"W.

- Placement of three box culverts to provide for passage of wildlife during the operational phase of the project. This is an important feature to ensure the survival and movement of wildlife connectivity minimizing road-kills. These will be used as pilots to study their effectiveness in reducing road kills occurring in these areas.
- Posting of safety signage to signal wildlife crossing and prevent mortality especially at areas of high wildlife populations.
- The increase buffer zone between the Guanacaste Park and new bridge alignment can be seen as a positive impact that will ensure the protection of the general wildlife that inhabits the park.
- In terms of the road side vegetation, all trees and shrubbery, that is not specifically required to be cleared or removed for construction purposes, shall be preserved and shall be protected from damage. Disturbed areas such as campsites and others will be vegetated where possible and seeded.

7.8 Climate Change Impacts and Disaster Risk Management

7.8.1 Hazards

Hazards are potentially damaging phenomena, whether natural or man-induced. Belize is located in an area prone to natural hazards. Foremost among these is the annual occurrence of North Atlantic tropical cyclones and hurricanes that reach the northwestern Caribbean or develop over the Caribbean area itself. The records also show that Belize is prone to eastern Pacific tropical cyclones that traverse northern Central America and impact the country directly or indirectly. Associated hazards include high winds, storm surges, torrential rains, flash floods/inundations, and tornadoes.

Secondly, Belize is bordered by three Central American countries that themselves are prone to volcanic eruptions, earthquakes, tsunamis, and mudslides. Even though, historically, Belize has not been impacted directly in a major way by these latter occurrences, it has experienced secondary impacts (SWI/NEMO, 2010). A thorough understanding of these phenomena, their intensities, frequency of occurrence and likely impacts are paramount in reducing Belize's vulnerability to these hazards.

7.8.2 Risks

Risk is the potential damage that could arise from the occurrence of a hazard with a given degree of uncertainty. Risk is the probability of occurrence of a hazard. There is also a need to distinguish between *risk* and *hazard*. A *hazard* is a source of danger, while *risk* involves the likelihood of a hazard developing into some adverse occurrence that may cause loss, injury, or some other form of damage. *Risk* may also be defined as: *Risk = Hazard x Probability of occurrence.* It should be noted that the consequences of *risk* may be contained if safeguards are put in place. However, hazards cannot be reduced to zero unless the hazard itself is removed.

7.8.3 General Information on Risk Analysis and Risk Assessment.

Risk analysis allows for an evaluation of what *hazard* can occur, the likelihood of its occurrence (probability of occurrence), and the consequences of its occurrence. Risk assessment takes this a step further to address the importance of these consequences, if they do occur. Based on these definitions, it can be seen that *risk analysis* may be carried out in an objective manner, while *risk assessment* is much more subjective and should include public policy makers. It is also necessary to introduce the term *risk management*. *Risk Management is the process of implementation of actions required to quantify, mitigate and control risk. Risk Management* is closely related to the concept of safeguards according to the SWI-NEMO Report.

In summary, the *risk analysis* and *assessment* phases require the interaction of the scientific analysts with public policy makers. The scientific analysts provide the required information and put the risk analysis in context. It is imperative that the policy makers understand fully the nature of the risks and the cost implications of alternative remedial courses of action.

Another term that must be introduced is that of *Vulnerability*. This is defined as: *the proportion (as a % or as an index from 0 to 1) of what could be damaged (human life, property, etc.) in a given place in the case of the occurrence of a given natural phenomenon or hazard.*

In Disaster Risk Management (DRM) several criteria can be used to determine levels of vulnerability. These may include but are not restricted to: population density and annual growth rates, Human Development Indicators set against long-term urban growth rates, and real adjusted GDP per inhabitant set against illiteracy percentages, or set against child mortality rates. From these indicators, population density and growth rates provide an initial baseline assessment of a country's vulnerability, on the basis that countries with higher population densities are more vulnerable. Another major vulnerability criteria is poverty, which is useful in characterizing the sectors of a society that are most vulnerable to disasters. Housing and infrastructure in disaster-prone area increases a country's vulnerability.

Vulnerability data compared with natural hazard information can be used to define potential *risk levels*. For Belize, an evaluation of the vulnerability of individual Villages or communities has been facilitated through a review of available infrastructure, as well as the ability of the community to respond to natural disasters.

7.8.4 Assessment of Man-made Hazards Within GPH

Man-made hazards that can impact the George Price Highway rehabilitation project zone and the GPH resilience include: a Chemical Fires and Spills and b) Oil Spills

These man-made hazards are becoming more evident along the proposed GPH rehabilitation zone with the transportation of crude oil via oil tankers from the BNE Spanish Lookout oil field to the Big Creek port in Independence. Hazardous substances and material enter Belize from the western and northern border frequently and transported via the GPH to their final destination within Belize or elsewhere.

7.8.5 Impacts

Impacts, either negative or positive, caused by natural or man-made hazards on communities or infrastructure are evaluated through *risk analysis* and *risk assessment* that determine the consequences and importance of the impacts and hence the intensity of the hazards.

7.8.6 Mitigation

Mitigation is the measures necessary to reduce the negative impacts of the hazards. The IDB promulgates *ex-ante* risk reduction measures to reduce Belize's vulnerability to natural hazards. Through its country programme, the IDB continues to support the Government of Belize through

NEMO, in strengthening the country's resilience to natural hazard. In this connection, the EIA for the GPH rehabilitation project addresses the risks and vulnerability of the re-habilitated highway investment and communities along the ROW to natural and man-made hazards.

7.8.7 Risk of Communities to Hazards along the ROW of the GPH

Table 7.13 below is a summary of the risks to natural hazards that communities along the ROW of the GPH face from time to time. As can be observed, most of these communities are vulnerable to both natural and man-made hazards.

Table 7.13: Hazards and Risk faced by communities along the ROW of the GPH

Location / Risks / Hazards	Roaring Creek	Camalote	Teakettle	Ontario	Blackman	Unitedville	Georgeville	Central Farm	Esperanza	San Ignacio/Santa Elena	San Jose Succotz	Benque Viejo
Flooding	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
High winds	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Landslide			Yes							Yes	Yes	Yes
Earthquake								Yes	Yes	Yes	Yes	Yes
Volcanic Ash	Yes							Yes	Yes	Yes	Yes	Yes
Chemical fire & spill	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Oil spills	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

7.8.8 Hydro-meteorological Risks and Impacts on the GPH

Extreme hydro-meteorological events in the form of flash floods, inundations, and high-winds associated with the passage of tropical cyclones and hurricanes have direct and indirect impacts on the GPH. Indirect impacts that exacerbates the hurricane related hazards are land use changes in the sub-basins and micro catchments of the GBRB. These impacts can change the hydrology of the catchments resulting in increased runoff, increased siltation and clogging of channels. Undersize and skewed culverts and poor drainage or lack thereof at critical spots along the highway that impedes the free flow of storm water, the lack of proper maintenance of stream channels and culvert outlets and discharge channels, and high vegetation along the ROW that fall and obstruct traffic during tropical cyclone events are of concern.

7.8.9 Tropical Cyclone and Hurricanes

A review of the North Atlantic hurricane annals for the past 107 years reveals that Belize sits snugly along the re-curving track of the infamous Cape Verde Islands hurricanes. It also lies along the pathway of the western Caribbean storms that so often ravaged Central America with deadly force, and end up exhausting their latent energy over some part of Belize, before regaining their strength once they are over the warmer waters of the southwestern Gulf of Mexico. As a result, Belize has had numerous encounters with hurricanes and tropical storms with tremendous damage and costs to its infrastructure and economy.

Tropical storm Arthur of May 31, 2008, which formed just offshore central Belize from the remnants of eastern Pacific tropical storm Alma, was the cause of five deaths in Belize. Tropical depression 16 of October 2008 generated devastating floods which impacted almost a third of the population of the country and cause some US $1.4 million in damages. In October, 2010 Cat I hurricane Richard made landfall along the southern coast of the Belize District, and travelled WNW across the central mainland through southern Belize district and northern Cayo District. The estimated cost of damages to housing and agriculture was in the range of US $ 24.6 million.

The climatology for North Atlantic hurricane activity indicates a cyclical trend in periods of high and low hurricane activity in the Basin. Figure xx shows NOAA's seasonal Accumulated Cyclone Energy (ACE) since 1950. It highlights the recent surge of ACE in the Basin, which started in 1995 and began phasing out after 2012 (Table 7.13). The previous period of high ACE was from 1950 to 1969. Hence, there is an 18-years cycle of high and low hurricane activity in the North Atlantic Basin. This high ACE periodic cycle will very likely be shortened in the projected warmer climatic conditions of the 21st century. Meanwhile, another analysis from NOAA show an increasing trend from 15 to 22% in the percentage of Cat 4 and Cat 5 hurricane for the period 1985-2005 for the North Atlantic Basin (Figure 7.14). In short, it is very likely that over the next few decades tropical cyclone frequency, intensity and spatial distribution globally, and in individual basins, will vary from year to-year and decade-to-decade (SPM-WG I, IPCC, 2013). Recent research has shown that we are experiencing more storms with higher wind speeds, and these storms will be more destructive, last longer and make landfall more frequently than in the past. Because this phenomenon is strongly associated with sea surface temperatures, it is reasonable to suggest a strong probability that the increase in storm intensity and climate change are linked.

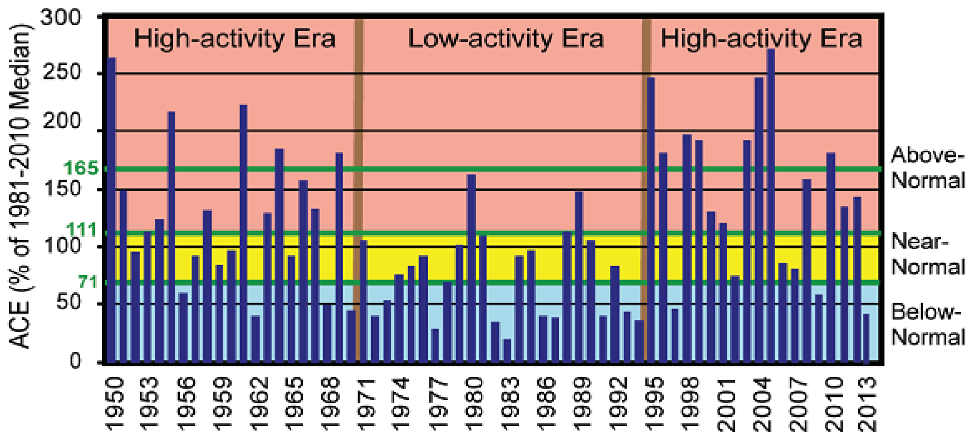


Figure 7.15: NOAA's Accumulated Cyclone Energy (ACE) index expressed as percent of the 1981-2010 median value. ACE is calculated by summing the squares of the 6-hourly maximum sustained wind speed (kt) for all periods while storm is at least tropical storm strength. Pink, yellow, blue shadings correspond to NOAA's classification for above – near -, and below-normal seasons, respectively. The 165% threshold for a hyperactive season is indicated. Vertical brown lines separate high – and low-activity eras.

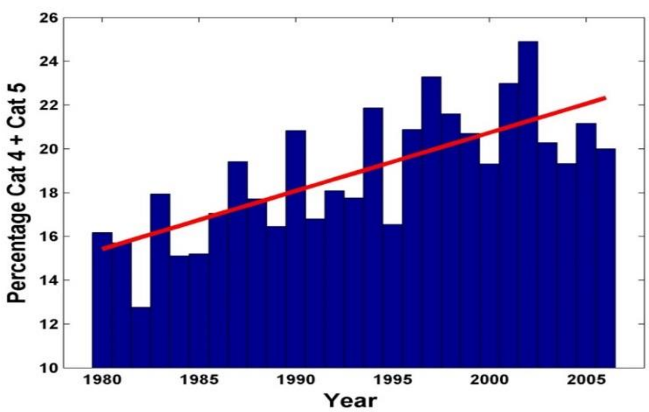


Figure 7.16: Percentage increase in Cat 4 and Cat 5 hurricane for the North Atlantic Basin

The upgraded GPH will remain vulnerable to hurricane related hazards during its projected 50 years life-span. Consequently, a series of mitigation measures are being recommended to increase the resiliency of the rehabilitated GPH to the negative impacts of hurricane related hazards.

7.8.10 Floods

7.8.10.1 Flash floods

Flash floods are frequent in the hilly terrain along the western corridor of the GPH, particularly during the wet season. Flash floods are generated by high intensity rain events associated with tropical cyclones and tropical disturbances such as tropical waves, upper air cold core lows, meso-scale convective complex, and prefrontal convective squall lines.

On November 19 2013, a strong convection in the upper Barton Creek sub-catchment generated intense thunderstorms and rapid rainfall runoff over an already saturated landscape. The result was a sudden flashflood in the Garbutt Creek that sent a flood wave down to the Garbutt Creek Bridge and over the GPH around the Galen University. The water rose in excess of two feet over some sections of the road at that locality, and the sudden and strong current scoured the highway shoulders and the Garbutt Creek banks adjacent to the bridge. The event was over in less than three hours. High runoff, damming and unsustainable land use in the upper sub-catchment was attributed to this flash flood.

7.8.10.2 Inundations

Inundations in the major watersheds of Belize are generally associated with tropical cyclones and occasionally with deep instability connected with the interaction of cold air mass and the warm, moist tropical air mas in the western Caribbean and northern Central America. Three major floods that stand out are:

- The 1979 September – November rain events that generated widespread floods in the lower reaches of the GBRB in the Belize District. Rainfall gauges at the International Airport and in Belize indicated that the total rainfall recorded increased from 19.4 cm in September to 58.4 cm in October, then to 38.1 cm in November and 37.1 cm in December. This long stretch of rainfall resulted in extensive livestock deaths. During that period, the road between the Airport and Belize City was severely damaged in several places. The rainfall during the latter part of the period was associated with the interaction of the strong cold front with warmer tropical air over Belize and Yucatan.

- In August 1995, the San Ignacio area was flooded. During this event, the run-of-the-river dam at Mollejon was breached at its sides. This flooding was as a result of a strong tropical disturbance.
- Later in October, 1995, Hurricane Roxanne resulted in flooding in the Rio Hondo and Corozal areas. Five villages had to be evacuated as a consequence of this event.
- During late October and early November, 2008 extensive floods in the Mopan generated by the heavy runoff associated with the passage of Tropical Depression #16 across southern Peten, Guatemala, affected the flood plain areas of the GBRB. The flood waters reached some 4 to 5 feet at some sections of the GPH in Benque Viejo and Succotz Village in the Cayo District. The 5-meter river staff gauge at the Benque Viejo hydrological monitoring site was submerged. The extrapolated maximum flood stage at Benque Viejo was 6.11 meters for this event. **A statistical analysis for extreme flood events at Benque using the Gumbel EV1 distribution resulted in a Return Period of 33 years for the 2008 flood event in the Mopan.**

7.8.10.3 Mitigating Against Flooding

A recommendation to help minimized the impacts of floods on communities and infrastructure and to improve the monitoring of floods in Belize is to automate the river stage monitoring stations at critical sites in the upper and middle reaches of the major watersheds. In addition, the Hydrological Department should utilized the numerical model rainfall projections and the NMS radar products as tools to aid in flood forecasting.

Another recommendation to reduce the impacts of future floods in Belize is to improve flood mapping in all watersheds using modern technology such as Lidar generated high-resolution digital elevation maps (DEMs), at 1 m to 0.5 m resolution. By over-laying Lidar DEM maps with flood stage maps using the ArcGIS software, the hydrologist can produce higher resolution flood maps that can be used in planning, development and disaster risk management. Figure 7.17 and Figure 7.18 are LiDAR generated 1-meter resolution maps of the flood zone along the GPH in Succotz Village, that help the EIA preparers and engineers determine the actions needed for the road upgrade in this section and determining an alternative route from Succotz to Benque Viejo during an emergency.

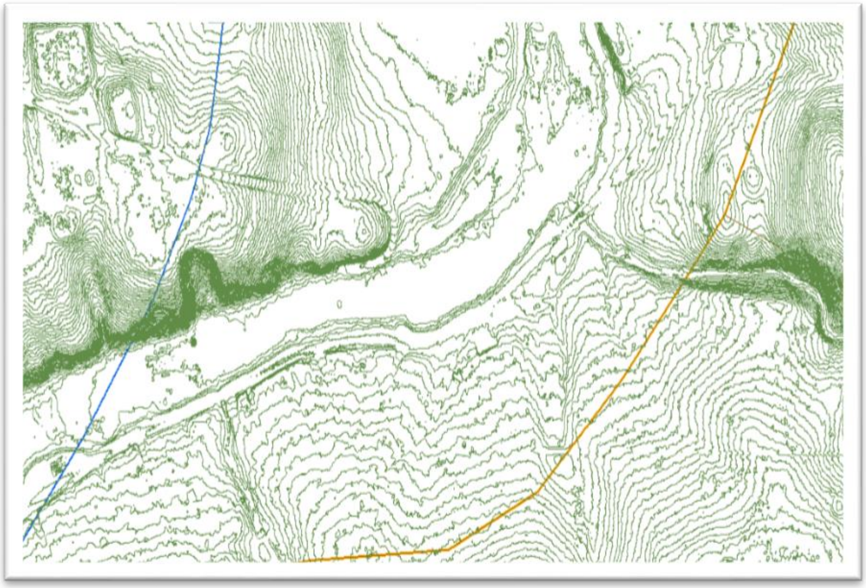


Figure 7.17: 1-meter resolution Lidar generated map of the Succotz Village flood zone, showing the Mopan River channel, the adjacent GPH, the track up to the Xunantunich Maya Ruins two main stream channels in the Village. The Blue and Yellow lines are the GIS map Mopan River and GPH projections.

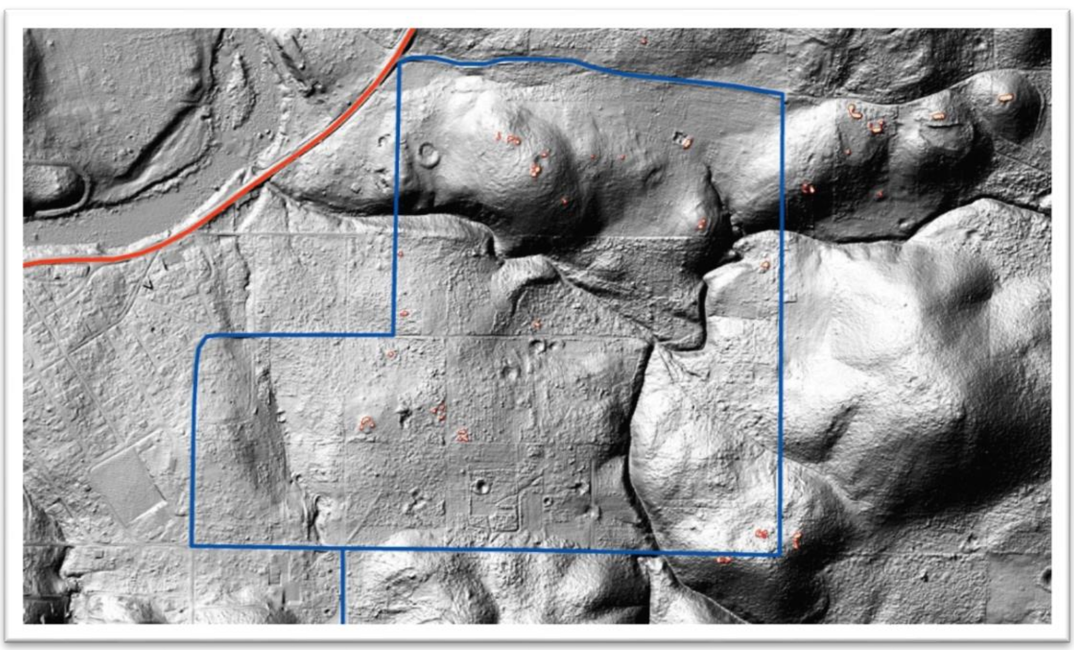


Figure 7.18: High-resolution LiDAR image of the landscape in Succotz Village showing options for the Succotz Village – Benque Viejo del Carmen By-pass.

7.9 Impacts of Climate Change on the Rehabilitated GPH

Climate and climate change related effects have had and will continue to have direct and indirect impacts on the GPH. Some of the more significant impacts are:

- Road pithing and potholes caused by extended and torrential rainfall.
- Road subsidence and culvert collapse resulting from saturated sub-soil during extended and intense rainfall events (e.g. GPH Miles 9 – 13 during TD #16-flood event in 2008).
- Road shoulder scoring and massive erosion caused by flash floods (e.g. flash flood event at GPH – Mountain Pine Ridge junction at Georgeville during TD # 16, 2008; and flash flood event at the Garbutt Creek Bridge, Central Farm/Galen University in November 2013).
- Flooding of bridges caused by high intensity rainfall and voluminous runoff in upper watersheds of the Roaring Creek sub-catchment, Iguana Creek Bridge, Red Creek Bridge, San Ignacio Low-lying Wooden Bridge, and Benque Viejo del Carmen Bridge.
- Flood water at the Roaring Creek Bridge reached an estimated height of about 1 foot above the bridge rails during TD #16 flood event in October-November 2008, disrupting the flow of traffic for a couple days.
- An estimated 800 meters of the GPH submerged under 4 to 5 feet of water in Succotz Village and entrance to Benque Viejo, resulting from upstream runoff in the Mopan River during the passage of TD #16 (October 2008) over the highlands of southeastern and eastern Peten-Guatemala.
- Half-a-foot to near two feet of water flooding the GPH at the following spots: Central Camalote; Teakettle; Natural Spring at Ontario; Blackman Eddy; Unitedville; Georgeville; Caracol just before Juan's Farm; Garbutt Creek Bridge near Galen University; GPH junction with Baking Pot Road (Spanish Lookout); Running W culvert); Central Esperanza Village; Red Creek Bridge; Buena Vista Street (before Chuc's Gas station, San Ignacio); Succotz Village; and entrance to Benque Viejo Town.

7.9.1 Mitigation for Tropical Cyclone and Extreme Weather Event Impacts.

The following measures are recommended to reduce the risks to the rehabilitated GPH posed by future tropical cyclones and flash-flood events.

Mainstreaming risk reduction during highway upgrade and maintenance:

- At sections where lifting the existing road to avoid flash floods and inundation is impractical or may adversely affect the local hydrology; it is recommended that such sections be re-constructed with concrete, which is much more resistant to flowing or standing water.
- As far as possible, all culverts that are recommended for replacement be of appropriate size and design but no less than the minimum a standard size and design (i.e. 42-inch diameter, ferro-concrete). Inlets and outlets of culverts should also be properly designed and constructed to allow for the free flow of runoff.
- Side drains should be designed, constructed and maintained to minimize ponding and overflow onto the highway or inundate private property
- All sections recommended for road re-alignment should have the proper drainage to avoid damming or obstructing surface runoff from either side of the road.
- Hillsides that are cut for the purpose of road realignment (e.g. the Z-curve near Teakettle) should be stabilized to avoid slippage or landslide during torrential rain events.
- MOWTs is recommended to request the establishment of a 'C*ost Center*' in the annual budget for river and stream channel/drainage maintenance and upkeep. It is recommended that this activity can be carried out jointly with the local community, so that the latter can have ownership in the upkeep and maintenance of village culverts and drainages along the ROW of the GPH.
- The River and Channel/Culvert cost center should also have allocation for trimming and clearing tall trees and vegetation along the ROW of the upgraded GPH.
- All approach to bridges and the deck of bridges along the upgraded GPH should be at least one meter above the maximum flood stage.

- Concrete Box culverts of adequate dimensions should be placed at specific spots along the rehabilitated GPH to serve as animal crossings. The aim is to reduce wild animal killing and avoid road accidents.
- MOWTs should liaise closely with MNR&A and the Forest Department and Department of Environment to collaborate in efforts to promote sustainable land use practices for farmers and other stakeholders. This should help reduce siltation and damming of river and stream channels that exacerbate the impacts of flash floods and inundations along the GPH.

7.10 Dam Break Risk

The Belize Electric Company Limited (BECOL) Upper Macal River Hydroelectric Facilities at Vaca, Mollejon, and Chalillo are now fully operational and generating about 55% of Belize's energy needs. In accordance with the April 5, 2002 Environmental Compliance Plan (ECP), BECOL, in collaboration with NEMO and other stakeholders, developed and operationalized a Dam Safety *Emergency Preparedness Plan* (EPP), specifically under the Chalillo Hydroelectric Project. According to BECOL, the dam is designed to meet and exceed all standards for dam safety, however the plan was developed in the interest of public safety should an unlikely emergency scenario arise.

The EPP is designed to deal with any problem experienced with the integrity of the Chalillo Dam structure. As indicated earlier, the EPP was formulated in conjunction with relevant agencies responsible for activities during natural disasters in the area of public safety. While the dam is designed not to fail, a monitoring plan for recording changes in dam structure and hydrology is in place, and compliments the response measures outlined in the EPP should an emergency related to a dam failure occurs.

The dam break study and assessment done in preparation of the Chalillo EPP indicated that the *Probable Maximum Flood* (PMF) for the Macal River would generate a higher river flow than a dam break (120 million m^3), under normal weather conditions. The vision of BECOL and the disaster emergency agencies of Belize is that a well-tested EPP will increase public safety and reduce property damage in the event of a dam break emergency.

The purpose of the EPP is to:

- Provide a plan, which facilitates public safety by notifying all appropriate authorities;
- Provide information to all stakeholders to allow for an informed evaluation to be made during emergency events;
- Provide plan of action for foreseeable flood emergencies affecting safety of the Chalillo Hydroelectric Facility and affected property downstream;
- Provide for a plan of action to carry out repairs and reduce the impact of any such event where possible.

In summary, the plan is intended to assist BECOL, local community authorities, the District Emergency Management Organization (DEMO), the National Emergency Management Organization (NEMO), and other agencies in responding swiftly and effectively in the event of a dam safety emergency at the Chalillo Hydroelectric Facility.

There are sections of the upgraded GPH that are at high risk to a dam break flood event. Although the probability of such an event is small throughout the projected 50-year lifespan of the Chalillo dam, the possibility of such an event still hangs over the head of all communities and interests downstream of the dam. Figure 7.19 above shows the predicted extent of the dam break flood in the San Ignacio-Santa Elena area in connection with a dam break scenario. Dam Break flood maps for areas downstream of San Ignacio / Santa Elena have been prepared. The worst case scenario with the greatest extent of flood is projected for a dam beak at full capacity during a major storm event affecting Belize is depicted in with the red line.

Mitigation measures to reduce the impacts a dam break flood on the western corridor of the GPH are limited to the durability and water-resistance of the road surfacing material used during re-construction, and firmness of the road foundation.

Figure 7.19: Spatial extent of a dam break flood in the San Ignacio/Santa Elena area

7.11 Tropical Cyclone Projections for the Late 21st Century

Based on available studies, the WMO team concluded the following regarding tropical cyclone projections for the late 21st century, assuming that the large-scale climate changes are as projected by the IPCC AR4 A1B scenario (quoted from Box 1 of the Nature Geoscience report):

"**Frequency**. It is likely that the global frequency of tropical cyclones will either decrease or remain essentially unchanged owing to greenhouse warming. We have very low confidence in projected changes in individual basins. Current models project changes ranging from -6 to -34% globally, and up to +/-50% or more in individual basins by the late twenty-first century.

Intensity. Some increase in the mean maximum wind speed of tropical cyclones is likely (+2 to +11% globally) with projected twenty-first century warming, although increases may not occur in all tropical regions. The frequency of the most intense (rare, high-impact) storms will more than not increase by a substantially larger percentage in some basins.

Rainfall.Rainfall rates are likely to increase. The projected magnitude is in the order of +20% within 100 km of the tropical cyclone centre.

Genesis, tracks, duration, and surge flooding. We have low confidence in projected changes in tropical cyclone genesis-location, tracks, duration, and areas of impact. Existing model projections do not show dramatic large-scale changes in these features. The vulnerability of coastal regions to storm-surge flooding is expected to increase with future sea-level rise and coastal development, although this vulnerability will also depend on future storm characteristics." (Knutson, 2011).

7.12 Social Impacts and Mitigation Measures

The social impact assessment is designed to ensure that the Project's potential impacts on individuals and groups of people are understood, so that positive impacts can be enhanced by Project design while negative ones are mitigated, without compromising the economic efficiency of the MOWT Road Project and its benefits for project affected persons (PAPs). Ideally, this should be achieved without negative impacts.

The focus group discussions, findings from the baseline socio-economic survey and analyses identify potential positive and negative impacts on individuals and groups of people during different stages of the Project in a transparent manner and, in accordance with International standards and in a way that engages stakeholders so that they can make 'informed decisions' for impact/risk mitigation.

To complement the Social Impact Assessment, Social Risk considerations are identified with the aims to:

- Identify potential risks to stakeholders and to the Project;
- Avoid potential risk by suggesting precaution or risk mitigation, taking into account any future actions, Project developments and/or outside risk (Project context risk) that may impose social stress or conflict;
- Advise Project Managers of stakeholders' expectations and grievances; and
- Promote consensual decision-making and realistic participation in agreements for problem solving and/or risk mitigation.

7.12.1 Methodology

The methodology used for assessing the significance of environmental impacts for the Project, described in Chapter 7, Section 7.1 of this ESIA has been adapted to assess social impacts. This adapted methodology is described below.

7.12.1.1 Impact Indicators, Valued Receptors and Project Phases

For the Social Impact Assessment, an impact indicator is defined as any human/ social/environment indicator considered important or valuable and thus meriting consideration in the SIA process. The process of selecting impact indicators considered, amongst other things, national, regional and local context, legal status, cultural value, and accounted for the perceptions of national, local government, international, national and/or local non-governmental organizations and the Project's directly and indirectly affected people.

Valued Receptors (VRs) are individuals, groups of individuals, different communities, local areas or groups of communities, regional, national and international populations.

The methodology used to assess impact significance differs from that for environmental VRs described in Section 7.1 in that the 'human environment' comprises social, health, cultural, demographic and economic aspects and it is not possible to categorise the 'sensitivity' of social VRs to different impacts simply as 'low', 'medium' or 'high'. This is because the 'sensitivity' of social VRs relates to a complex mix of the vulnerability of different groups and individuals to Project impacts and to the public perception of Project impacts. This is important because public perception of potential impacts is a key factor in relation to social risk, i.e. even if there is no clearly apparent scientific basis for a perceived impact, it still may contribute to social risk if people believe a Project activity may have a negative or positive impact. The social impact evaluation methodology is explained in the subsequent section, Section 7.12.

Sources of key social issues impacting the Road Project that may occur across life cycle stages are presented in Table 7.14.

Table 7.14: Key Social Issues Across Road Project Cycle

MOWT Road Project Phase/Activity	Social Issue
Construction	Noise and Dust
	Impeded Access
	Site Safety
	Temporary and Permanent Land Take
	Construction Labour Force
	Employment and Employment Practices
	Community Relations and Cohesion
Operation	Company and Worker Relations with Community
	Employment and Employment Practices
	Waste Management

7.12.1.2 Methods and Criteria

Social impacts may be caused by different Project activities and may be direct, indirect or cumulative in nature. As noted above, due to the fact that it is not possible to definitively classify the 'sensitivity' of social VRs, unlike environmental VRs, the evaluation of the significance of social impacts has necessarily, some differences to that used in Section 7.1 to classify environmental impacts.

In contrast, the social impact evaluation used the following three basic criteria for assessing the significance of an impact:

- Magnitude: The importance of the impact for people's quality of life, health, livelihoods and social relations;
- Spatial extent: Also known as the impact area of influence which is the population and/ or geographical area over which the impact is experienced. In the case of the MOWT Road Project, this is defined as local communities across the ROW within the Study Area subdivided by the defined Road Sections; and
- Duration: The length of time or level of permanence over which the impact will be experienced.

Table 7.15 outlines the criteria for measuring magnitude, extent and duration. Scores for magnitude, extent and duration range from 1-5, allotted according to an evaluation of the highest criteria that might be expected to result from each impact. Each potential impact is then allocated a significance ranging from very low to very high, based on a combination of the impact's magnitude, extent and duration. The significance of each impact is given a score from 1-5, or (very low to very high). This is calculated as an average of the three scores for magnitude, extent and duration as shown in Table 7.15.

Table 7.15 Criteria for Asessing Social Impacts

Significance [1 ↔ 5]	Magnitude [1 ↔ 5]	Extent [1 ↔ 5]	Duration [1 ↔ 5]
Very low	Slight/negligible impacts on quality of life, resulting in no measurable impact on lives, livelihoods or health	Immediate vicinity of a Project site One or more but less than 10 persons affected	Temporary; lasting less than one month
Low	Minor measurable impacts on lives, assets, livelihoods, quality of life and temporary health impacts/minor injury	Less than 25 people affected; localised	Up to a year; health or livelihood impacts that require recovery period of days/weeks
Moderate	Considerable measurable impacts on livelihoods or assets; major health effects/injury Considerable discontent in the community/labour force	Multiple Project sites; more than 25 people affected; extensive coverage in media	Up to two years; long term health/livelihoods implication for affected people
High	Major measurable adverse impacts on people's assets, livelihoods or quality of life. Full compensation/mitigation unlikely. Health effect or injury causing permanent disabilities or fatalities.	Multiple Project sites More than 100 people affected Extensive coverage in media	Up to five years; permanent effects on people's health/livelihoods

Very High	Massive adverse impact on quality of life, living standards and/or livelihood. Multiple fatalities Social conflict resulting from actual/perceived Project activities leading to violence threating the lives of staff/community	Extensive populations and coverage in media	Long term impacts; permanent/irreversible

7.12.2 Identified Social Impacts

Before the social impact issues are evaluated according to the criteria in Table 7.15, the potential impacts as perceived by the PAPs and identified through analyses are presented below. Impact discussions were guided by the categories and indicators set out in Table 7.16.

Table 7.16: Socio-economic Impact Categories, Indicators and Nature of Impact

Impact Category	Impact Issue/Indicator	Nature of Impact (Positive or Negative)
Community Governance, Organisation and Local Institutions	✓ Community governance/ participation ✓ Access to decision-making ✓ Representative community organization	The Road Project has the potential to positively impact community governance and contribute to restoring public confidence in local and central level government. The ability of individuals to influence Project decision-making processes and protect their interests may be negatively or positively impacted by the Project, partially dependent on effectiveness of consultations. Outside of the legally established village councils, PAPs communities have no/limited presence of representative organizations (NGO/CBO). Project stakeholder engagement could support or undermine these organizations i.e. potential positive or negative impact according to Consultation process.
Social Services and Community Infrastructure	✓ Water infrastructure ✓ Electricity infrastructure ✓ Roads and Access to Public Transport ✓ Education infrastructure and service	Water lines across the Road Sections are located in front of yard and in extreme close proximity to the existing ROW are completely exposed; Access to water source may be negatively impacted during the construction phase. Electric poles fall within the 100 feet corridor and in some instances in extreme close proximity to existing ROW. Access to electricity may be negatively impacted during the construction phase across select areas of the Road Sections. Sewage systems and waste disposal practices are generally adequate across PAPs communities; the Project is expected to have low adverse impact and with proper mitigation measures reduced to negligible. Construction vehicles may put pressure on/negatively impact the Public transport and road system; access routes for pedestrians, animal carts and cars could be blocked by construction vehicles. In the medium to long term however, positive benefits are associated with the Road upgrade. Education infrastructure and services may be positively or negatively impacted by the Road Project. With the upgrade to international standards of the GPH, come improved road safety for pedestrians (special attention to school children) which will positively impact. Additionally, dust and noise from construction and increased traffic flow from transportation of

		materials could adversely impact on educational services.
Socio-Demographic Characteristics	✓ Population: Structure and In-migration ✓ Social cohesion ✓ Poverty/vulnerability and Social exclusion ✓ Temporary/ Permanent Land Take	No impact on the population structure is projected; however, job-seeking in-migration may negatively impact social and cultural aspects of PAP communities due to differences in socio-cultural lifestyles. Social cohesion in neighbouring communities could be adversely impacted by differential access to Project opportunities and influx of Project workers. Project costs and benefits could reduce or increase vulnerability of specific groups of PAPs, i.e. positive or negative impacts The widening of existing road where necessary or creation of detours may require land take and may affect people's property. This may also lead to change in lifestyles and livelihoods. Residents of this area will also be affected by construction activities including disturbance, increased pressure on resources and services. Land take would also occur where land will be acquired for contractor's camps, gravel pits and hard stone quarries. However, the upgrading of the road is expected to cause minimal adverse impact since the Project is designed in such a way that minimum private land will be affected.
Economic Environment	✓ Costs of goods and services ✓ Socio-economic development	The influx or Project workers may negatively impact the cost (inflation) of basic goods and services. The Project may impact the socio-economic development of neighbouring communities positively and/or negatively.
Employment, Livelihoods and Income Generating Activities	✓ Employment ✓ Skills ✓ Development of Businesses and informal livelihood activities.	Employment is a potential positive impact of the Project, directly through employment on the Project and indirectly through livelihoods. Poor governance practices and lack of skills however limit access to jobs which could be a negative impact. Project employment and training could positively impact the local skills base. Businesses and livelihood activities may be indirectly positively impacted by the Project.
Cultural Heritage	✓ Archaeological sites/mounds/points of interests ✓ Cemeteries	The Road Project has the potential to positively impact on established sites though enhancement as tourist destinations for increased opportunities for livelihoods and overall added economic benefits/development of the wider area. In similar fashion, the Project also has the potential to negatively impact archaeological mounds within extreme close proximity to the ROW as well as identified Cemeteries if the necessary precautions are not taken.
Health	✓ Health problems related to pollution ✓ Communicable disease ✓ Injury ✓ Occupational Health	The Road Project has the potential to positively impact pollution related health problems in the long term but may negatively impact during construction. Influx of labour force and transport workers may increase exposure to communicable diseases. Construction, transport and operations could expose workers and local people to the risk of injuries or accidents. The Road Project may positively or negatively impact Occupational Health.

Using the impact analysis criteria, potential positive and negative impacts of the MOWT Road Project and perception of impacts have been assessed; these are presented in the subsequent section, Section 7.12.3.

7.12.3 Socio-economic Impacts and Proposed Mitigation Measures

This section analyses perceived impacts with those identified on the basis of observation, consultation, and the SES baseline survey. The discussions assess impacts in relation to each category, specifying which Project Phase and the significance of each impact, proposed mitigation and the significance of each impact after mitigation (residuals).

7.12.3.1 Community Organisation and Local Institutions

7.12.3.1.1 Potential Impact Issues

Access to Decision-Making: In both the construction and operations phases, a potential impact may be the improvement or continued exclusion of women and men from access to decision-making about development Projects in their area. Up until now, it has not been the norm for residents to be consulted on Projects in their area. MOWT's approach to Stakeholder Engagement therefore has the potential to impact on the current lack of access to decision-making either positively, by improving means for local people to influence Project decision making (through broad based on going consultation mechanisms, the Grievance mechanism), or negatively, by raising expectations on access to decision-making and then failing to deliver – which could have implications for the wider social risk context of the Project.

Representative Community Organizations: The communities reached through consultation and the socio-economic survey in essence have no organizations able to represent and lobby for the interests of local women and men outside of the legally established village councils. Most

respondents' preference for passing on Project information of jobs, benefits etc. was through direct means.

In both the construction and operations phases the Project is likely to have highly significant impacts on the standing, capacity, coverage and support for/of the village councils. These impacts could be positive, if MOWT works with the village councils who are committed to being inclusive of all groups within their communities as opposed to those that merely seek to serve partisan interests, and marginalize the vulnerable.

7.12.3.1.2 Significance

As the PAPs are not used to being consulted it is difficult to assess the significance of risk of the potential positive or negative impacts of the consultations on social cohesion; early indications coming out of the focus group discussions and socio-economic survey are that PAPs have welcomed MOWT's approach to early sharing of information, consultations and engagement with respect to the Road Project. The true test however, will be in the "eating of the pie" to see how well community concerns are addressed by the Project and the level of confidence generated as a consequence, or vice versa.

7.12.3.1.3 Mitigation Measures

MOWT is committed to continued consultation to ensure that it works with representative community organizations like the village councils and contractors who are open to hiring of socially marginal groups for broader based Project support.

Additionally, service contracts for maintaining the rehabilitated GPH could be explored with the village councils across Road Sections to strengthen ties between local and central government and demonstrate tangible commitments with respect to ensuring the hiring of locals with special emphasis on women and youth.

7.12.3.1.5 Evaluation after Mitigation

Should effective consultations occur, the impacts on access to decision-making and community representation could potentially be positive. There are already signs that consultation has contributed to some good relationship building with residents and village councils. Notwithstanding, engagement by the socio-economic survey team also identified and allayed the fears of PAPs likely to be affected by road alignment, e.g. kiosks vendors at the Succotz Ferry crossing. Support in these Communities is generally overwhelming in favour of the Road Project with a few sceptics given prior promises by government.

7.12.3.2 Social Services and Community Infrastructure

7.12.3.2.1 Potential Impact Issues

Water and Electricity Infrastructure: During the construction phase a potential adverse impact is disturbance of the electricity supply for the communities across the ROW; additionally, with majority of HH accessing piped water into dwelling/yard and the fully exposed water lines in the road buffers, it is highly likely that there will be significant interruptions.

Transport, Mobility and Accessibility: These are concerns for many members of affected communities; e.g., participants in focus group discussions stated that "the problem will get more complicated"; "traffic will get worse, especially with public transportation"; "our kids will be late for school and we may get late to and from work". The Project will also rely on a significant number of transport vehicles, both for the transport of Project equipment and for Project staff, which may contribute to traffic congestion on roads further exacerbating issues of increased travelling time for students and workers.

Education Infrastructure: Focus group discussions and the socio-economic baseline survey indicated that educational infrastructure in Project affected communities is rather adequate. It is not anticipated that the potential influx of job seekers, or Project workers moving to the area would place any additional strain on the infrastructure since it is not anticipated that significant numbers of workers are likely to move to the Project affected communities with their families. With the upgrade to international standards of the GPH comes improved road safety for pedestrians (special attention to school children) which will positively impact. Additionally, dust and noise from construction and increased traffic flow from transportation of materials could adversely impact on educational services.

7.12.3.2.2 Significance

Project impacts on electricity cables and water lines could potentially be moderate to high; impacts on transport infrastructure could also be potentially be high, especially during the construction phase, when there will be many trips a day during peak periods.

Impacts on pedestrian and road access to communities could be moderate, increasing commuting time for local residents and thus affecting livelihoods, and presenting a problem for emergency vehicle access to communities. Project impact on education infrastructure is expected to be low.

7.12.3.2.3 Mitigation Measures

MOWT is committed to using appropriate construction mitigation measures and due diligence to ensure that people will not be negatively impacted. Thus the location/re-location of the electric poles/lines and water lines will be duly considered and coordinated action with service providers will be proactively pursued.

7.12.3.2.4 Evaluation after Mitigation

If the electricity poles/cables and water lines are not damaged by the Project activities due to appropriate mitigation measures that are effectively and timely communicated to the PAPs, the risk of negative social impact is low.

However, stress on public transport and transport infrastructure remains moderate despite proposed mitigation measures due to limited influence the Project can have on public transport systems infrastructure. Impact on education services will be reduced to low significance.

7.12.3.3 Socio-Demographics

7.12.3.3.1 Potential Impact Issues

In-Migration: Strong recommendation to source workers locally is proposed; notwithstanding, due to the lack of appropriate skilled labour in the area there is a risk that workers will have to be sought from outside the Project Area. There are risks related to in-migrant populations discussed below in terms of social cohesion and inclusion and in terms of health impacts of communicable disease. Furthermore, the already male skewed population structure may change further to include even more males of working age. The influx of workers, risks impact on social cohesion by introducing new/different demographics into these established communities inclusive of concerns by residents of sexual harassment of women and sexual exploitation of adolescent girls by a predominantly male work force.

Social Inclusion: The Road Project is one of few projects in Belize, and certainly in the Project Area to include community residents, representatives and leaders in consultations that have influenced the Project design. In the long run, however, the Project could decrease/or increase

vulnerability depending on the way it consults and makes Project benefits available to the full range of community members. This is dependent on the effective implementation of the Social Management Plan (SMP) and Participatory Public Participation (PPP) Plan.

Poverty, Vulnerability and Social exclusion Project costs and benefits could reduce or increase vulnerability of specific groups of PAPs, i.e. positive or negative impacts, via differential treatment of groups across communities with respect to employment opportunities and potential inflation caused by short term demands on goods and services.

Child and Adult Protection: Project has the potential to negatively impact communities as it relates to sexual exploitation of adolescent girls and harassment of women by a predominantly male workforce.

7.12.3.3.2 Significance

Significance is moderate to high as there may be negative impacts of uncontrolled in-migration, as well as spill over protection effects; the fact that most of the Project affected communities are already populated areas however, means that Project workers would only represent a small population element.

7.12.3.3.3 Mitigation Measures:

MOWT to require contractors to develop policies for workers induction and a socio-culturally appropriate code of conduct for interacting in communities inclusive of training on gender related issues inclusive of sexual harassment of adult females, sexual exploitation of adolescent girls and HIV and AIDS training; the latter could be arranged through the Ministry of Human Development, Women’s Department.

Source labour from local communities insofar as requisite skills allow with special quota for women to balance the population structure.

7.12.3.3.4 Evaluation after Mitigation

After mitigation the significance remains low to moderate, given that most of the potential impacts of the Project on socio-demographics are outside the control of Project managers. However, good social policies have the desired effect of reducing negative impacts and enhancing the positive; to this end the code of conduct and gender training become appropriate measures.

7.12.3.4 Economic Environment

7.12.3.4.1 Potential Impact Issues

Perceived Economic Development: The Project could have both positive and negative impacts on the economic environment. This mix was reflected in the perceptions of community members of the potential economic impact of the Project. Overall respondents engaged in income-generating activities thought there would be some positive impacts on the economy, e.g. Succotz.

National Economic Development: The Project will contribute positively on the development of the national economy. During the life of the Project, the Government will realize significant revenues, taxes and customs duties; furthermore, it will engage Belizean contractors and sub-contractors thus promoting national GDP growth. Construction material will also be purchased. Data from the SIB indicates that in 2013, import trade via the Benque border totalled in excess of BZ$ 220 M while exports stood at BZ$ 10 M. Additionally, data from BTB for 2013 indicates that a total of 156, 000 visitors had entered Belize via the Western Border validating the importance of this section of the GPH for commerce and connectivity to the Americas.

Local Economic Development: In communities across the Road Sections, there was the perception that the Project may lead to positive impacts on local economic development due to increased traffic flow and greater influx of tourists in the area. Positive influences on local economic development could derive from: job opportunities for local residents; and multiplier effects on local ancillary services (local restaurants, shops, transport). The Project could have both negative and positive influences on socio-economic development in communities. Negative influences may derive from increased inequality between vulnerable groups and Project employees.

Cost of Goods and Services: The purchase of local goods and services by the construction labour force (e.g. use of local shops and restaurants, and accommodations) could potentially lead to positive and negative impacts. Positive impacts include creating local economic development and employment. However, a negative impact may be inflation in an area in which there is a poor and vulnerable population already experiencing difficulties in making ends meet. As the

Project is located across a populated rural/peri-urban area characterised by many demographic and economic processes it is unlikely that local inflation or economic development could be attributed to the Project.

7.12.3.4.2 Significance

Whilst there is significant potential for positive economic benefits of the Project, the extent to which it is likely to lead to economic development and or inflation depends on the Project approach. Given that the Project is only one economic factor in the area there is low-moderate risk of it contributing to local inflation of prices.

7.123.4.3 Mitigation Measure

The MOWT will take into account the socio-economic baseline context and require of its contractors, consultations with village councils as it relates to employment.

7.12.3.4.4 Evaluation after Mitigation

As positive and negative impacts are considered, and given that there is limited scope to mitigate against local inflation without undermining local economic benefits (by for example requiring workers not to buy local goods and services) the impact remains low to moderate (i.e. considered neutral positive/negative) after mitigation.

7.12.3.5 Employment, Livelihoods and Income Generating Activities

7.12.3.5.1 Potential Impact Issues

Access to Project Employment: This is a key priority for PAPs across the three Road Sections, which is not surprising given the levels of poverty and unemployment as revealed by the socio-economic baseline survey and poverty mapping data, SIB(2012).

While there was an expectation across the affected communities that the Project would lead to job opportunities for local people, this was tempered by concerns about real access for local people to Project employment. A major concern across all communities relates to poor governance practices (corruption and nepotism) with the belief that locals lack the connections to get jobs and that contractors would normally bring in their own teams. Another concern was that local people would lack the skills to get jobs on the Project. This was a particular concern among youth and women.

In the light of these concerns about whether local people would actually be able to access Project jobs, there was the attitude amongst some community members that Government's commitment to providing jobs for local people is only propaganda and will not be fulfilled in practice

Gender: In terms of equal opportunities for accessing Project employment, while many community members do not believe that Project job opportunities will reach all sections of the community, in some cases there was the belief that new job opportunities could benefit youth, and would include women and poor people in the area. In fact, access to Project employment may be more problematic for some valued receptors such as women. In particular, unless equal opportunities are promoted, it may be more difficult for women to access employment opportunities as many of the jobs are in male stereotyped professions and because of local social attitudes towards women working in road works projects.

Vulnerable Groups: In particular residents with low literacy level may also have trouble accessing job opportunities if they are advertised in written media compounded by the fact that they also lack the skills base needed by the Project and opportunities to upgrade skills may be outside the immediate scope of the Road Project, unless an on the job training component is integrated to support the upgrade of their skills similar to the city infrastructure and C.A Boulevard projects.

Skills Development: Project investment in skills development for construction could increase the employability of locally recruited workers in the long term by upgrading skills bases to standards required by the construction industry. If workers are trained to take some of the jobs, there is medium potential this could contribute to social development in the long term. The approach utilized by Government for the demolition of the old City Centre and the C.A. Boulevard could serve as a practice frame as earlier noted.

Informal Livelihood Activities: A number of small businesses and women and men engaging in informal livelihood activities could be affected by the Project. Businesses in the right of way include street vendors selling fruit, vegetables and other goods from carts (e.g. Mennonites) and souvenirs (kiosks vendors at Succotz Ferry). Many of these vendors believe that increased Project traffic and the presence of workers will be a positive impact for their businesses. However, it is also possible that, unless managed appropriately, increased congestion and

pollution from traffic could negatively impact these businesses. Businesses by the Succotz Ferry in Road Section III will require relocation and may suffer temporary loss of income; they may also be impacted by dust during construction. One perceived negative impact that relates to livelihoods of local households is land acquisition, which local residents believe might result in forced resettlement to facilitate alignments of the GPH.

Temporary/Permanent Land Take: The replacement of the bridge at the Roaring River crossing, widening of existing road where necessary and/or creation of detours may require land take and may affect private property. Land take would also occur where land will be acquired for contractor's camps, gravel pits and hard stone quarries. However, the upgrading of the road is expected to cause minimal adverse impact since the Project is designed in such a way that minimum private land will be affected.

7.12.3.5.2 Significance

In both construction and operational phases of the Project, there is an opportunity for maximizing positive impacts on local employment through involving unskilled (and where possible skilled) labour from all Project communities. However, although the generation of employment opportunities resulting from Project activities are expected as a positive impact, there is a risk that conflicts could arise between local residents and new comers or outsiders over such employment opportunities. Furthermore there is high risk that, unless Project employment and contractors are managed appropriately, the recruitment procedure could be less than transparent, meaning that people without connections would not get access to Project opportunities – namely employment and other livelihood benefits. This could lead to a moderate risk of social conflict.

7.12.3.5.3 Mitigation Measures

The MOWT and contractors will work actively to promote local access to Project employment in both the construction and the operations phases. To do this MOWT and contractors will apply transparent and fair employment policies and work with local village councils to source local labour.

Additionally, constant communication and due lead time will be given to vendors with support for relocation in the interim; where private land take is absolutely unavoidable, market-value compensation to owners will be employed after due consultation process managed by the MOWT.

7.12.3.5.4 Evaluation after Mitigation

Effective implementation of the recommended mitigation measures, designed to ensure that skills development and Project employment are accessible to local people, the risk could be reduced to low. However, the fact that much of this work will have to be carried out by contractors and sub-contractor presents a level of uncertainty. In addition, even if a high proportion of Project jobs do go to local people, this cannot make a significant positive impact on local livelihoods, given the population sizes and levels of unemployment in Project affected communities. Given the high level of expectations about Project employment in local communities described above risk remains moderate, even after mitigation.

7.12.3.6 Cultural Heritage

7.12.3.6.1 Potential Impact Issues

Archaeological Sites, Mounds/Points of Interests and Local Cemeteries: The Road Project has the potential to positively impact established sites though increased volume of visitors and enhancement as tourist destinations for increased opportunities of livelihoods and overall added economic benefits/development of the wider area. In similar fashion, the Project also has the potential to negatively impact archaeological mounds within extreme close proximity to the ROW as well as identified graveyards if the necessary precautions are not taken.

7.12.3.6.2 Significance

Archaeological points of significance are mostly located in the wider Study Area, with few instances of mounds within close proximity to the existing ROW. As identified by the archaeological assessment, the particular areas of interest within the three road sections as are as follows:

Road Section 1: Camalote, Teakettle, Ontrario and Blackman Eddy have scattered mounds and plazuelas within the existing carriageway buffer zone or road corridor;

Road Section 2: Lower Dover, Floral Park, Baking Pot and Esperanza also show signs of mounds, plazuelas and patios that are of archaeological interest; again, these are located within the road corridor ; and

Road Section 3: The sites of Cahal Pech, Buenavista, Nohoch Ek, Actuncan and Xunantunich are well established sites that are partially within the road buffer zone.

7.12.3.6.3 Mitigation Measures

Mitigation measures suitable to conserve and preserve existing mounds is paramount and as such the Project will employ the following:

- The proposed road works will be limited to the existing track and road width;
- Safety barriers will be erected to protect the existing mounds, plazuelas and patios that are within the buffer zone;
- GPS readings were taken to register the locations that the road works would need to consider;
- Preferred alternate routes were chosen to avoid direct impact to archaeological mounds and plazuelas as indicated in the Archaeological Assessment and Road Alternative Identification.

In general, to avoid potential adverse impacts on archaeological remains, it is recommended that an archaeologist undertake further investigate work prior to initial clearance. Initial investigation would include excavation of test pits along the route. Should the investigation uncover substantial archaeological findings a more detailed investigation would be required to be undertaken with the Department of Archaeology.

7.12.3.6.4 Evaluation after Mitigation

Given the location of the archaeological points of interest and the deliberate decision to avoid and where already exposed, protect these mounds/sites it is projected that the risk after mitigation will be low.

7.12.3.7 Health Impacts Resulting from Pollution

7.12.3.7.1 Potential Impact Issues

The key health problems identified during the baseline study and focus group discussions relate primarily to chronic illnesses (diabetes, hypertension, etc.) and to some degree respiratory health (dry cough, difficult breathing, chest wheezing/asthma) and thus the valued receptors most at risk from negative impacts are those already vulnerable to respiratory problems e.g. school children, asthmatic children/adults, smokers and the elderly. From the Focus Group discussions it is clear that the PAPs consider there is a high risk of the Project contributing to air pollution and thus causing further health risks in the short-medium term. Asthmatic children will be significantly negatively impacted by increase in dust. Pollution (quality of life associated with environment conditions) is the major respiratory health risk factor raised by the local communities.

7.12.3.7.2 Significance

The impacts of the Project on pollution related health problems are potentially high during construction, especially for susceptible VRs (those with existing respiratory problems, children and women who spend most of the day at home). The impacts during the operational phase are considered potentially moderate.

7.12.3.7.3 Mitigation Measures

During the construction phase, a rigorous health and safety plan will be implemented to ensure excavation and construction activities minimise dust and noise-related pollution for the workforce, neighbouring communities and schools. Mitigation Measures will be clearly communicated to the PAPs to reduce stress caused by uncertainty.

7.12.3.7.4 Evaluation after Mitigation

The significance of pollution impacts on health after mitigation measures would be low for operational impacts and moderate-low for construction impacts.

7.12.3.8 Communicable Diseases

7.12.3.8.1 Potential Impact Issues

Employment opportunities may attract in-migration to the Project Area as well as use other workers. Thus, there may be associated negative impacts to health of PAPs due to transfer of disease. Hygiene and health problems on the construction site may be caused by pools of standing water, which may create habitats for insect disease vectors such as eye infection.

Additionally, the baseline survey showed extremely low levels of comprehensive knowledge of HIV and AIDS, which further contributes to the potential for increased transmission.

7.12.3.8.2 Significance

The significance of increased exposure to communicable disease is difficult to assess at this point as the strategy for hiring workers has not yet been defined and the level of existing migrant workers in the affected communities is unknown. Notwithstanding, the Project may likely exacerbate the situation on HIV/AIDS and Sexually Transmitted Infections (STIs) due to workforce that will be away from home and has higher disposable income. There may also be possible impact of immigrant workers who would bring social disruption of communities where construction campsite and accommodation will be located which can lead in some cases to marriage breakups during the construction period. This is exacerbated if construction workforce is brought from elsewhere. There could also be increased drug and alcohol abuse mainly during construction period and communicable diseases (food and water-borne) and road traffic construction related accidents. Given the population sizes of the communities and the low levels of comprehensive knowledge of HIV-AID and literacy levels, it is anticipated that the contribution of the Project to communicable disease will be moderate to high.

7.12.3.8.3 Mitigation Measures:

The MOWT through the PEU and its contractors are required to implement HIV/AIDS awareness, prevention and control activities aimed at construction workers and the communities in the Project Area in line with the Environmental and Social Management Plan.

Additionally good hygiene and health practices in line with the overall health and safety plan are to be observed.

7.12.3.8.4 Evaluation after Mitigation

With mitigation measures in place the impact of the Project on the levels of communicable diseases in communities and amongst Project workers and their families, should be low to moderate.

7.12.3.9 Injury and Accidental Health Damage

7.12.3.9.1 Potential Impact Issues

Project activities, in particular construction activities, could expose workers to the risk of accidents. Transport vehicles and traffic in the area could expose both workers and residents to the risk of traffic accidents. Community members are concerned about the possibility of accidents and emergencies. Thus there is a risk of small scale but potentially frequent traffic and construction accidents and less frequent but potentially larger scale operations accidents both of which could impact on the health and safety of workers and local communities. This concern is further exacerbated by the limited emergency services and access to these services along the ROW.

7.12.3.9.2 Significance

Risk of accidents from construction and operations is of high significance to communities, in particular risk of accidents from increased traffic.

7.12.3.9.3 Mitigation Measures

While a major incident may be improbable, the nature of activities in the Area means the development, communication and implementation of a robust Preparedness Plan are essential both for local communities and workers. Health care providers should be consulted in developing this plan; Develop traffic control measures to limit the risk of construction, operational and transport accidents which, could endanger the health of community members;

Conduct a road safety campaign to reduce the risk of traffic accidents for community members, particularly important for children;

7.12.3.9.4 Evaluation after Mitigation

Due to the impossibility of completely safeguarding against unanticipated accidents, specifically traffic accidents, significance after mitigation will be reduced from high to moderate.

7.12.3.10 Worker Health and Safety

7.12.3.10.1 Potential Impact Issues

Construction and operational activities could expose workers to health and safety risks. In particular, the following activities could have negative health impacts: noise and dust from demolitions and excavations (stress, ear and eye problems); working with heavy equipment (strains and accidents); heavy lifting, and working under noisy conditions (hearing and stress/psychological impacts). Excavations and transportation of materials may cause further health and safety negative impacts. Occupational health and emergency health services for the construction labour force will be at risk of negative health impacts which cannot be quantified, until clear plans emerge. The need for an on-going, proactive workers health and safety plan applies for the full life cycle of the Project.

7.12.3.10.2 Significance

Without an operational/fully functional Health and Safety plan and health training for workers the risks of worker health and safety are high.

7.12.3.10.3 Mitigation Measures:

MOWT to require contractors to adopt strict construction and operation practices with best technology and health and safety training to ensure the safety of its workers.

7.12.3.10.4 Evaluation after mitigation

With occupational health protection in place, significance of risk of damage to health should be reduced from high to moderate.

Table 7.17 provides a summary of the potential impact issues, significance, mitigation measures and residuals.

Table 7.17: Summary Matrix of Impacts Significance and Mitigation

Impact Category	Aspect/Impact	Valued Receptor	Nature ±	Magnitude [1 ↔ 5]	Extent [1 ↔ 5]	Duration [1 ↔ 5]	Significance [1 ↔ 5]	Proposed Mitigation/ Means to Enhance Positive Impacts	Significance After Mitigation
Community Governance, Organisation and Local Institutions	**Community governance/ participation** The Road Project has the potential to positively impact community governance and contribute to restoring public confidence to some degree in local and central level government.	PAPs, communities, local and central governments	(+)	2	3	2	2	Continued consultation by MOWT to ensure that it works with representative community organizations like the village councils and contractors who are open to hiring of socially marginal groups for broader based Project support; Explore service contracts for maintaining the rehabilitated GPH with the village councils across Road Sections to strengthen ties between local and central government and demonstrate tangible commitments with respect to ensuring the hiring of locals with special emphasis on women and youth	+
	Access to decision-making The ability of individuals to influence Project decision-making processes and protect their interests may be negatively or positively impacted by the Project, partially dependent on effectiveness of consultations.	PAPs, communities, local and central governments	(+)/(-)	3	3	3	3		+
	Representative Organizations Outside of the legally established village councils, PAPs communities have no/limited presence of representative organizations (NGO/CBO). Project stakeholder engagement could support or undermine these organizations i.e. potential positive or negative impact according to Consultation process.	PAPs, communities, local and central governments	(+)/(-)	3	3	3	3		+
Social Services and Community Infrastructure	**Water infrastructure** Access to water source may be negatively impacted during the construction phase.	PAPs along existing ROW across Road Sections	(-)	4	4	3	4	MOWT is committed to using appropriate construction mitigation measures as earlier noted and due diligence to ensure that people will not be negatively impacted. Thus the location/re-location of the electric poles/lines and water lines will be duly considered and coordinated action with service providers will be proactively pursued.	1
	Electricity infrastructure Access to electricity may be negatively impacted during the construction phase across select areas of the Road Sections	PAPs along existing ROW across Road Sections	(-)	4	4	3	4		1
	Roads and Access to Public Transport Construction vehicles may put pressure on/negatively impact the Public transport and road system. In the medium to long term however, positive benefits are associated with the Road upgrade.	PAPs along existing ROW across Road Sections	(-)/(+)	3	3	3	3		2
	Education infrastructure With the upgrade to international standards of the GPH come improved road safety for pedestrians (special	School children, teachers and PAPs along existing	(-)/(+)	3	3	3	3		1

	attention to school children) which will positively impact. Additionally, dust and noise from construction and increased traffic flow from transportation of materials could adversely impact on educational services.	ROW across Road Sections							
Socio-Demographic Characteristics	**In-migration** could disrupt local culture and the in- migration of single male workers could cause social problems and affect social cohesion	Women, adolescent girls and in general PAPs along existing ROW across Road Sections	**(-)**	3	4	3	3	MOWT to require contractors to develop policies for workers induction and a socio-culturally appropriate code of conduct for interacting in communities inclusive of training on gender related issues inclusive of sexual harassment of adult females, sexual exploitation of adolescent girls and HIV and AIDS training; the latter could be arranged through the Ministry of Human Development, Women's Department. Additionally training for workers and the communities on the mandatory child abuse reporting law should be required Source local labour force insofar as requisite skills allow with special quota for women to balance the population structure imbalance.	1-2
	Social Cohesion Social cohesion in neighbouring communities could be adversely impacted by differential access to Project opportunities and influx of Project workers	PAPs along existing ROW across Road Sections	**(-)**	2	3	2	2		1
	Poverty/vulnerability and Social exclusion Project costs and benefits could reduce or increase vulnerability of specific groups of PAPs, i.e. positive or negative impacts	Socio-economically vulnerable groups (quintiles I, II & III) along existing ROW across Road Sections	**(+)/(-)**	1	2	3	2		1-2
	Child and Adult Protection Project has the potential to negatively impact communities as it relates to sexual exploitation of adolescent girls and harassment of women by predominantly male workforce	Adolescent females and women from communities along ROW	**(-)**	3	3	3	3		1-2
Economic Environment	**Costs of Goods and Services** Influx or Project workers may negatively impact the cost (inflation) of basic goods and services.	PAPs along existing ROW across Road Sections	**(-)**	1	1	3	2	The MOWT will take into account the socio-economic baseline context and require of its contractors, consultations with village councils as it relates to employment.	1-2
	Socio-economic Development The Project may impact the socio-economic development of local communities, wider Cayo area and the country of Belize positively and/or negatively particularly as it relates to tourism and cross-border trade.	PAPs along existing ROW across Road Sections, surrounding communities, businesses and tourism destinations	**(+)/(-)**	2	1	2	2		+

Employment, Livelihoods and Income Generating Activities	**Employment** Employment is a potential positive impact of the Project, directly through employment on the Project and indirectly through livelihoods. Poor governance practices and lack of skills however limit access to jobs which could be a negative impact.	Men, Women and Youth from PAPs along existing ROW across Road Sections; special attention to youth and women	**(+)/(-)**	2	3	3	3	The MOWT and contractors will work actively to promote local access to Project employment in both the construction and the operations phases. To do this MOWT and contractors will apply transparent and fair employment policies and work with local village councils to source local labour Additionally, constant communication and due lead time will be given to vendors with support for relocation in the interim; where private land take is absolutely unavoidable, market-value compensation to owners will be employed after due consultation process managed by the MOWT	3
	Skills Project employment and training could positively impact the local skills base	Men, Women and Youth from PAPs along existing ROW across Road Sections	**(+)**	1	1	3	1		1
	Development of Businesses and informal livelihood activities Businesses and livelihood activities may be indirectly positively impacted by the Project.	SME, roadside and kiosk vendors	**(+)/(-)**	3	3	4	3		3
	Temporary/Permanent Land Take Replacement of the Roaring River crossing bridge, the widening of existing road where necessary and/ or creation of detours at the Z-curve may require land take and affect people's property. However, the upgrading of the road is expected to cause minimal adverse impact since the Project is designed in such a way that minimum private land will be affected and where absolutely unavoidable, compensation at market value will occur.	Private land owners affected by land take	**(-)**	1	1	1	1		+
Cultural Heritage	**Archaeological Sites, Mounds/Points of Interests and Local Cemeteries** The Road Project has the potential to positively impact established sites though increased volume of visitors and enhancement as tourist destinations for increased opportunities of livelihoods and overall added economic benefits/development of the wider area. In similar fashion, the Project also has the potential to negatively impact archaeological mounds within extreme close proximity to the ROW as well as identified Cemeteries if the necessary precautions are not taken.	PAPs, kiosks vendors, tour guides, local businesses, communities along ROW and wider Cayo area	**(+)/(-)**	2	3	4	3	To avoid potential adverse impacts on archaeological remains, it is recommended that an archaeologist undertake further investigate work prior to initial clearance. Initial investigation would include excavation of test pits along the route. Should the investigation uncover substantial archaeological deposits a more detailed investigation would be required. It is recommended that such work is undertaken in close consultation with the Department of Archaeology. The proposed road works will be limited to the existing track and road width; Safety barriers will be erected to protect the existing mounds, plazuelas and patios that are within the buffer zone;	1

								Preferred alternate routes were chosen to avoid direct impact to archaeological mounds and plazuelas as indicated in the Archaeological Assessment and Road Alternative Identification.	
Health	**Health impacts related to construction pollution (dust, noise …)** The Road Project has the potential to positively impact pollution related health problems in the long term by reducing volume of dust from current ROW but may negatively impact during the construction phase due to pollution	Health vulnerable residents and workers	**(+)/(-)**	2	3	3	3	During the construction phase, a rigorous health and safety plan will be implemented to ensure excavation and construction activities minimize dust and noise-related pollution for the workforce, neighbouring communities and schools. Mitigation Measures will be clearly communicated to the PAPs to reduce stress caused by uncertainty.	1-2
	Communicable Disease Influx of labour force and transport workers may increase exposure to communicable diseases inclusive of HIV-AIDS	Health vulnerable residents and workers	**(-)**	2	3	5	3	The MOWT through the PEU and its contractors are required to implement HIV/AIDS awareness, prevention and control activities aimed at construction workers and the communities in the Project Area in line with the Environmental and Social Management Plan. Additionally good hygiene and health practices in line with the overall health and safety plan are to be observed.	1-2
	Injury Construction, transport and operations could expose workers and local people to the risk of injuries or accidents.	Residents and road users	**(-)**	2	3	4	3	Development, communication and implementation of a robust Preparedness Plan are essential both for local communities and workers. Health care providers should be consulted in developing this plan; Develop traffic control measures to limit the risk of construction, operational and transport accidents which could endanger the health of community members; Conduct a road safety campaign to reduce the risk of traffic accidents for community members, particularly important for children;	3
	OHS Worker health and safety could be compromised unless managed properly	Workers	**(-)**	3	2	3	3	MOWT to require contractors to adopt strict construction and operation practices with best technology and health and safety training to ensure the safety of its workers in line with the OSH Bill.	2

7.12.4 Social Risk Context

Despite the mitigation measures being put in place to reduce negative impacts and enhance positive impacts, the Project potentially faces social risks due to the national and local context in which it will be operating. To complete the impact risk assessment, the social risk context, over which the Project has little or no control, is presented below.

Past Relationship between Government and PAP Communities Reveals a level of mistrust that many local residents have for central governments and to a lesser extent the village councils in the Study Area. These are based on a perception that promises by governments in the past have not been honoured and that local people are generally not the beneficiaries of employment opportunities generated by these development projects…"so what will be different this time around", commented one resident. There is high risk this mistrust will continue unless appropriate mitigation through effective consultation occurs. Responding to this mistrust requires on-going engagement, transparency and effective implementation of agreed social and environmental management measures; to this end, the risk could be reduced to medium/low.

Socio-Political Structures that may exclude PAPs from Project Benefits: A frequent concern expressed by PAPs was that poor governance practices (corruption/nepotism) meant that job opportunities only reached those with contacts in local/national power structures. Established social structures and exclusion also mean that there is very high risk of only 'connected' groups gaining from Project benefits, if these are not managed through a transparent and effective decision-making process. If local residents are excluded form Project benefits due to existing power structures, the Project runs high risk of both increasing vulnerability and social exclusion and of creating resentment against the MOWT, and by extension the Government of Belize. Likewise women and youth may also be excluded from Project benefits unless special attention is directed to them.

Chapter 8 Environmental and Social Management Plan

8.1 Environmental Management Plan

This section of the ESIA Report provides a summary of the assessment of the potential environmental impacts the project could have on the environmental and social setting of the study area. In most cases, it is possible to reduce potential adverse impacts to the point where the impacts are insignificant or negligible, either through effective design, the use of green technologies and best practices or through sound operational management of the road rehabilitation project and its accompanying activities.

The key in any successful mitigation measure is to adequately identify the potential negative impacts and their implications and to develop a supporting environmental management plan. As with all management functions, effective management tools and best practices based on a process of constant improvements is what is required. The implementation of environmental management standards, best practice, and the use of established protocols is important in helping to reduce environmental impacts as measured by some objective criteria. Thus the environmental management plan proposed for this road rehabilitation project and supporting activities involves the close integration of the following:

1. *Environmental Impact Mitigation Plan* – Impact mitigation is the most critical component of the environmental study process. It aims to prevent adverse impacts from occurring and keeps those that do occur within an acceptable level.
2. *Environmental Monitoring* – Environmental monitoring provides information that can be used for documentation of the impacts that result from the construction and operational activities. This information enables more-accurate prediction of the associated impacts and the necessary feed- back mechanism essential in adjusting the EMP. Therefore, the monitoring system is a platform of measuring projected impacts and also in identifying unanticipated adverse impacts or sudden changes in impact trends essential in the implementation of an environmental management program based on the concept of constant improvement.

8.1.1 Environmental Impact Mitigation Measures

Identifying the appropriate mitigation measure for an identified impact must take into consideration its cost- effectiveness as these have the potential for significant financial implications. The outcome however must effectively address the impact with little or no residual repercussion to the environment. Thus, there will be continuous mitigation measures throughout the project's cycle that will be implemented to protect and conserve the environment and social setting of the study area as best as possible.

Considering the continuous improvement in impact mitigation, the implementation of the project's ESMP will have as its objectives to:

1) find better alternatives and ways of doing things;
2) enhance the environmental and social benefits of the road rehabilitation project;
3) avoid, minimize or remedy adverse impacts; and
4) Ensure that residual adverse impacts are kept within acceptable levels.

8.1.2 Mitigation Plan for Environmental Impacts

Table 8.1 provides a summary of the proposed mitigation measures to ameliorate the negative impacts of the Environmental issue identified in the impact assessment section of the ESIA. This table forms the basis of the of the environmental and social management plan in a summarized form.

Table 8.1 provides a summary of the Proposed Mitigation Measures					
Activity	Environmental Effects	Mitigation Measure(s)	Monitoring Indicator(s)	Monitoring and Reporting Frequency	Party(ies) responsible.
GEOLOGY					
Earth movement while cutting slopes at Z-Curve.	Land slippage and microslides.	Road side slopes and cuts should have slopes of 1.5:1 ratio.	Engineering instrumentation proof to be provided.	Monitor monthly and quarterly	PEU and contractor
	Rock fall.	Use of erosion control blankets or fiber-web geo-synthetics for stabilization of cut slopes.	Visual inspections.	Monitor monthly and quarterly	PEU and contractor
Earth movement while constructing abutments at RC Bridge.	Siltation.	Diversion of storm water from construction area.	Visual inspections.	Monitor weekly and report monthly	Contractor/PEU
		Use of check dams along storm water drains.	Visual inspections.	Monitor during construction activities	Contractor/PEU/DOE
		Use of wing dams made of sand bags or use of silt curtains.	Visual inspections.	Monitor during construction activities	Contractor/PEU/DOE
		Works to take place during dry periods.	Visual and documentary proof to be provided.	Monitor weekly and report monthly	Contractor/PEU/DOE
Earth movement while mining materials at quarry pits.	Man induced land denudation.	Material volumes extracted from different sites.	Visual and documentary proof to be provided.	Monitor weekly and report quarterly	PEU/DOE
	Ponding.	Extraction sites levelled evenly.	Visual inspections.	Monitor weekly and report quarterly	Contractor/DOE
HYDRO-LOGY					
Construction activities through Succotz Village and entrance to Benque Viejo del Carmen.	Pollution of streams, watercourses and underground water sources.	Install barriers/curtains / prevent accidental spills., store stripped surface material away from water source	Visual inspections and laboratory testing of nearby water bodies.	Monitor weekly and report monthly	Contractor/PEU/D OE
De-watering/ watering work for structure foundations/ earthwork operations adjacent to/ encroaching on streams or watercourses.	Pollution of streams or watercourses.	Construction of intercepting ditches, by-pass channels, barriers, settling ponds, etc.	Visual inspections and laboratory testing of nearby water bodies.	Monitor weekly and report monthly	Contractor/PEU/D OE
Discharge of waste water.	Pollution of streams, watercourses and other surface waters.	Discharge wastewater into temporary settling ponds/similar structures.	Visual inspections and laboratory testing of nearby water bodies.	Monitor weekly and report monthly	Contractor/PEU/D OE
Storage of waste oil, grease and other contaminants at workers camps.	Pollution of streams, watercourses and other surface waters.	Proper storage facilities in all construction camps.	Visual inspections, documentary proof to be provided and laboratory testing	Monitor monthly and quarterly	PEU and contractor

			of nearby water bodies.		
Storm water runoff during construction.	Pollution of streams, rivers and other surface waters.	Diversion of storm water to temporary, natural settling ponds.	Visual inspections and laboratory testing of nearby water bodies.	As required	PEU/DOE
Mining fill materials from burrow sites.	Ponding and damming of natural waterways.	Provide for free drainage following extraction.	Visual inspections.	Monitor weekly and report monthly	Contractor/PEU/DOE
Re-alignment of the Z-curve, and the opening of a *temporary detour* at that section of the highway	Pollution of streams, watercourses and underground water sources.	Install barriers/curtains to prevent contaminants, debris, and other pollutants entering water bodies.	Visual inspections and laboratory testing of nearby water bodies.	Monitor weekly and report monthly	Contractor/PEU/DOE
Storage of waste oil, grease and other contaminants.	Pollution of streams, watercourses and other surface waters.	Install proper storage facilities	Visual inspections, documentary proof to be provided and laboratory testing of nearby water bodies.	Monitor weekly and report monthly	Contractor/PEU/DOE
Storing stripped pavement and excavated soil.	Pollution of river banks and streams.	Store all stripped pavement and excavated soil away from river banks and streams.	Visual inspections.	Monitor weekly and report monthly	Contractor/PEU/DOE
Construction of the new Roaring Creek Bridge	Sedimentation of Roaring Creek.	Install wing dam and sediment curtain.	Visual inspections.	Monitor 2 times per week during construction-report monthly	Contractor/PEU/DOE
DISASTER RISK MANAGEMENT					
Extreme hydro-meteorological events in the form of flash floods, inundations, and high-winds associated with the passage of tropical cyclones and hurricanes.	Land use changes in the sub-basins and micro catchments of the GBRB which changes the hydrology of the catchments resulting in flooding from increased runoff, increased siltation and clogging of channels.	Install minimum 42 inch diameter, ferro concrete culverts and properly designed inlets-outlets.	Visual inspections and engineering instrumentation verification.	Monitor monthly and quarterly	PEU and contractor
		Design, construct and maintain drains to minimize ponding and overflow onto highway or inundate private property.	Visual inspections and engineering instrumentation verification.	Monitor quarterly and report annually	PEU/DOE
		Construct drainage along all realigned sections to avoid damming or obstruction of surface runoff on either side of road.	Visual inspections and engineering instrumentation verification.	Monitor monthly and quarterly	PEU and contractor
		Stabilize hillsides to avoid slippage or landslide during torrential rain events.	Visual inspections and engineering instrumentation verification.	Monitor monthly and quarterly	PEU and contractor
		Construct all approaches to bridges and the deck of bridges above the	Visual inspections and engineering instrumentation	As required	PEU/DOE

		maximum flood stage.	verification.		
		Regularly maintain stream channels, culvert outlets and discharge channels.	Visual inspections.	Monitor quarterly and report annually	PEU/DOE
		Keep high vegetation cleared along GPH ROW.	Visual inspections.	Monitor quarterly and report annually	PEU/DOE
		Use of "double chip seal" with proper maintenance program for pavement to withstand rainfall, floods, inundation and extreme heat..	Visual inspections and engineering instrumentation verification.	Monitor monthly and quarterly	PEU and contractor
		Use concrete surfacing where lifting of road impractical.	Visual inspections and engineering instrumentation verification.	Monitor monthly and quarterly	PEU and contractor
		Promote sustainable land use practices among farmers to reduce siltation and damming of stream channels, making flash floods and inundations worse.	Documented proof of promotion activities.	Monitor quarterly and report annually	PEU/DOE
NOISE					
Construction activities such as blasting, jack hammering, pile driving, rock crushing etc.	Noise above tolerable levels.	Work during daylight not exceeding 12 hrs.	Visual and auditory inspections and documented proof of working hours and complaints by villagers.	Monitor weekly and report monthly	Contractor/PEU/DOE
		Maintain and regularly check tools fitted with mufflers where appropriate.	Visual and auditory inspections.	Monitor weekly and report monthly	Contractor/PEU/DOE
		Construct noise barriers between work sites and communities.	Visual inspections and engineering instrumentation verification.	As required	Contractor/PEU/DOE
		Ensure workers wear PPE.	Visual inspections.	Monitor daily and report weekly and monthly	Contractor/PEU/DOE
Operating construction vehicles such as trucks, tractors, excavators, etc.	Noise above tolerable levels.	Work during daylight not exceeding 12 hrs.	Visual inspections, documented proof of working hours and complaints from villagers	Monitor weekly	Contractor/PEU/DOE
		Maintain construction vehicles fitted with mufflers where appropriate;	Visual inspections and documented complaints from villagers.	Monitor weekly and report quaterly	Contractor/PEU/DOE

		turn off when not in use; avoid reversing.			
		Ensure workers wear PPE.	Visual inspections.	Monitor daily report monthly	Contractor/PEU/DOE
VIBRATIONS					
Operating construction vehicles, equipment and tools.	Back injury to workers from whole body vibrations.	Use vibration isolation and suspension systems. Alternate activity among workers	Visual inspections.	As required	Contractor/PEU/DOE
	Damage to property in vicinity and along ROW.	Assess vibration impacts to property and discontinue where damage imminent.	Documented complaints from villagers.	As required	Contractor/PEU/DOE
AIR					
Earth movement operations, transportation of materials and operation of heavy machinery.	Release and dispersal of dust.	Ensure workers wear PPE.	Visual inspections.	Monitor daily report monthly	Contractor/PEU/DOE
		Use dust suppressant measures.	Visual inspections and documented complaints from villagers.	Monitor as required and report monthly	Contractor/PEU/DOE
		Avoid haulage of materials through village streets and ensure loads are covered.	Visual inspections and documented complaints from villagers.	As require report quarterly	Contractor/PEU/DOE
		Regularly water haul routes in sensitive areas during dry periods.	Visual inspections and documented complaints from villagers.	As require report quarterly	Contractor/PEU/DOE
		Store dusty material in appropriate locations.	Visual inspections and documented complaints from villagers.	As require report quarterly	Contractor/PEU/DOE
		Limit and enforce speed around construction zone.	Visual inspections.	Monitor daily report monthly	Contractor/PEU/DOE
		Erect barriers near schools and sensitive areas.	Visual inspections and engineering instrumentation verification.	As required and report monthly	Contractor/PEU/DOE
Operating construction equipment.	Generation of smoke and other contaminants.	Shut off equipment when not in use and maintain in good operating condition.	Visual inspections and documented complaints from villagers.	Monitor daily report monthly	Contractor/PEU/DOE
		Ensure equipment has emission control devices.	Visual inspections and engineering instrumentation verification.	Monitor weekly report monthly	Contractor/PEU/DOE
WATER QUALITY					
Construction activities near flood prone areas, streams, creeks and	Soil erosion	Employ BMP	Visual inspections.	See above	See above
	Sedimentation and pollution of streams,	Provide proper sanitation facilities at workers camps.	Visual inspections and laboratory testing	Weekly inspections and report quarterly	Contractor/PEU/DOE

near rivers at Z-Curve.	watercourses and rivers.		of nearby water bodies.		
		Construct intercepting ditches, check dams, wing dams, siltation curtains, by-pass channels, barriers, and settling ponds.	Visual inspections and laboratory testing of nearby water bodies.	Same as above	Same as above
		Ensure responsible storage and handling of petroleum products and maintain equipment free from oil and fuel leaks.	Visual inspections and documentary proof provided.	Weekly inspection report monthly	Contractor/PEU/DOE
		Maintain spill clean-up kits and report spills to DOE.	Visual inspections and documentary proof provided.	As required	Contractor/PEU/DOE
		Erect above-ground fuel tank in bunded area and store waste oil in sealed containers and contact DOE for disposal.	Visual inspections and documentary proof provided.	As required	Contractor/PEU/ DOE
		Properly containerize and dispose of domestic waste at workers camps.	Visual inspections and documentary proof provided.	Weekly inspection and report monthly	Contractor/PEU/DOE
		Ensure no motor vehicle washed in river or stream.	Visual inspections and laboratory testing of nearby water bodies.	Monitor weekly report quarterly	DOE /Contractor
		Locate camp sites away from water ways and provide amenities.	Visual inspections.	As required	Contractor/PEU/DOE
ECOLOGY					
Construction activities near sensitive ecological areas.	Noise pollution affecting wildlife.	Schedule work between 8 to 12 hours per day.	Visual inspection and documentary proof of working hours provided.	Monitor weekly and report monthly	Contractor/PEU/DOE
		Fit equipment with mufflers and turn off when not in use.	Visual and auditory inspections.	As required	Contractor/PEU/DOE
		Service and maintain construction heavy duty equipment.	Visual and auditory inspections.	As required	Contractor/PEU/DOE
	Adverse impacts to flora and fauna.	Minimize potential for die back of vegetation areas by regular placement and maintenance of culverts and drainage system.	Visual inspections.	Same as above	Contractor/PEU/DOE
		Place box culverts to provide passage of fauna under road to other side.	Visual inspections.	Monitor quarterly report annually	DOE
		Post safety signs for wildlife crossings.	Visual inspections.	Monitor and report as required	PEU

		Preserve all roadside trees and shrubbery not required to be cleared.	Visual inspections.	Monitor weekly and report quarterly	Contractor/PEU/DOE
		Vegetate and seed disturbed areas of campsites.	Visual inspections.	Monitor as required and report quarterly	Contractor/PEU/DOE
		Designate work areas and camp sites "no hunting zones."	Visual inspections.	Monitor as required and report quarterly	Contractor/PEU/DOE

8.1.3 Environmental Monitoring Requirements

Monitoring is a supportive component to the aforementioned mitigation measures. As such, the monitoring program is intended to provide information necessary to ensure that the recommended mitigation measures set out in the design of the rehabilitated road works are implemented in accordance with the requirements of existing legislations and recommended mitigation measures. The result of monitoring are also used to determine the need for additional measures at an early stage. In addition, compliance monitoring by DOE is also supported by a series of other environmental monitoring requirements using predetermined key indicators to ensure that pollution or other related problems are discovered in time to prevent or repair adverse effects.

There are numerous advantages in implementing a monitoring program to track the course of the road rehabilitation works. In essence the monitoring will provide:

- Information that will enable more accurate prediction of impacts;
- Warn the Contractor of unanticipated adverse impacts to the environment;
- Information that can be used to evaluate the effectiveness of the mitigation measures; and
- Ensure that all the respective targets and deadlines are met in an environmentally responsible manner.

8.1.4 Proposed Monitoring Program

The monitoring program has been developed not only in relation to satisfying the requirements of the ESIA process, but also as a consequence of the proper implementation of the proposed road works. The parameters chosen for the monitoring program are those that have been identified primarily for the construction phase of the project since upon completion, the impacts during operation would be minimal and with net positive environmental and social impacts.

8.1.4.1 Water Quality Monitoring

Water quality monitoring is often recommended for road construction to provide assurance of compliance with regulatory and contract requirements and to ensure that the quality of the surface and ground water at risk are not compromised. The project will encourage the implementation of monitoring where there is potential for adverse environmental impacts from the proposed works. The water quality monitoring program aims to effectively identify potential water pollution problems associated with road construction, the cause of the problems and the mechanisms to manage any identified issues.

A range of monitoring techniques is discussed in this section. A combination of field tests with probes and laboratory analysis is provided. The use of probes for water quality analysis is a good means to undertake water quality monitoring at reasonable cost.

8.1.4.1.1 Objective of Water Quality Monitoring

The principal objective of this monitoring program is to provide direction on water quality monitoring issues for the phases of project development, construction and implementation. Other objectives also include the conservation of water, protect the quality of water resources and preserve the ecosystems. Other key objectives are to:

- Implement the monitoring program to monitor potential flood prone areas, impacted river and streams and drainage water as a result of construction activities.
- Analyze collected water samples using the Standard Methods for the Analysis of Water and Wastewater.

8.1.4.1.2 Sampling Sites

The project will entail both construction and post construction monitoring sites. During construction, monitoring will be generally undertaken upstream and downstream of the works. The sampling sites during post construction will be less than those of the construction phase, but more representatives of the identified impacts such as site runoffs on receiving waters. Sampling sites include but are not limited to:

- Where the five bridges will be upgraded namely Roaring Creek, Barton Creek, Garbut Creek, Red Creek and Benque Viejo bridge.
- At the identified drainage areas at Roaring Creek, Camalote, Teakettle, Blackman Eddy, Georgeville, Central Farm, Red Creek Succotz and Benque at Mile 73 during rainy season.
- At locations in close proximity to the Belize River such as the Z Curve and Roaring Creek and the Mopan River at Succotz.

Table 8.2: Sample Sites Location and Coordinates

SITE			Coordinates	
ID#	Description River/Tributary	Way Point	Lat	Long
1	Mopan - Benque/Succotz	WP1	17.0787	-89.1367
2	Macal-Upper Stream	WP 2	17.1569	-88.0686
3	Macal-Down Stream	WP3	17.1734	-89.0718
4	Garbutt Creek - Central Farm/Galen Uni.	WP4	17.1591	-89.0662
5	Barton Creek –Riverwalk	WP5	17.2038	-88.9558
6	Belize - Iguana Creek Bridge	WP6	17.2235	-88.9091
7	Ontario Natural Spring	WP7	17.2607	-88.7895
8	Roaring Creek Bridge	WP8	17.2513	-88.795
9	Roaring Creek Riviera/Butte Rows	WP9	17.2513	-88.795

8.1.4.1.3 Sampling frequency

As the construction works mainly have an impact on the receiving waters during times of site discharge, upstream and downstream samples should be taken as soon as practical following rainfall events. Rainfall events refer to times when runoff from the site is entering the receiving waters through on-site sedimentation controls such as silt_curtains or when sedimentation traps require maintenance discharge to restore their design capacity. Samples should be collected at the rate of:

- Two samples per month during periods when rainfall results in any discharge from the site or when discharging from a point source such as controlled sedimentation basin discharges.
- Two sample per month during times when there is no rainfall.

Post construction monitoring will be collected twice per month. If a number of results demonstrate that the site or parts of the site have stabilized, the sampling frequency and sampling locations may be reviewed and reduced or discontinued.

8.1.4.1.4 Monitoring Parameters

Construction monitoring samples will be analyzed for:

- pH
- Total suspended solids (TSS)
- Turbidity (where a correlation with TSS is sought and a portable probe is available)
- Oils and grease (visual assessment). If oils and grease are visually evident, a sample will be forwarded to the laboratory for analysis. Values should not exceed 10 mg/l.
- Total Coliforme and Ecoli analysis
- Possibly other parameters may be identified following construction activities.

(Note: pH and turbidity should be recorded in-situ with a portable probe and meter. Turbidity measurements may be substituted for TSS analysis provided a correlation has been established between the two parameters on a site specific basis within the project).

8.1.4.1.5 Turbidity Measurements as a Trigger for Site Management

Turbidity measurements should be taken at all sampling sites during construction using either a portable turbidity meter or turbidity tube. A portable meter is preferred to a turbidity tube as the results obtained from using a turbidity tube may be limited by the variability of the eyesight of users and may not be highly accurate.

Turbidity measurements have the advantage of providing site management with immediate data, while TSS may take one week or more to be analyzed and reported. Where routine turbidity measurements show that a receiving water body is being negatively impacted, additional measurements can be taken with the probe to further determine the source.

Post-construction monitoring parameters will be the same as those used during the construction of the project. Individual parameters that may be added include Dissolved Oxygen and Temperature. Other parameters may be withdrawn where it is demonstrated that it is no longer a concern such as the control of erosion where re-vegetation has stabilized the soil.

8.1.4.1.6 Interpretation of Results

The monitoring program will incorporate a feedback loop to provide rapid dissemination of the results (either visual, in-situ or laboratory) to the contractor to ensure problems are rectified as soon as possible. If repeated results demonstrate that the site or parts of the site have stabilised, upstream and downstream sampling parameters, frequencies and locations will be reviewed in order to reduce or discontinue monitoring.

Table 8.3 WQ Template with File Numbering System

Date:							
FILE	**Sample Location**	**Dissolved Oxygen (mg/l)**	**Ph (Units)**	**TSS (mg/l)**	**Turbidity (NTU)**	**F. Coliform (count)**	**E. Coli (count)**
0001	1						
0002	2						
0003	3						
0004	4						
0005	5						
0006	6						

8.1.4.1.7 Reporting and Responding to Exceeded Criteria

The program will include a process for reporting and responding to exceeding the water quality criteria and/or targets for the project that should include but not be limited to:

- validation of result(s) showing exceeded criteria
- repeated or further monitoring.
- investigation to determine cause and source of the exceeded criteria
- review of pollution controls and/or construction activities or procedures

- Reporting to the Contractor.
- Reporting to the Department of the Environment.
- Documentation of all of the above.

8.1.4.2 Ambient Air Quality

This Ambient Air Quality Plan will monitor air and noise pollution generated as a result of the construction activities and post construction operation. The plan aims to address the control of fugitive and airborne dust emissions as well as vehicular exhausts emissions and related above normal noise generation. The sources of air and noise pollutants at the different phases of the road rehabilitation project are categorized as follows:

i) *Construction Phase*: Construction works include road surface removal, movement of vehicles, transportation of materials, camp erection, infrastructure provision and any other infrastructure activities. The major temporary air pollution is dust generated as a result of these construction works.

ii) Operational Phase: The major permanent sources of air pollutants are the vehicle emission from traffic on the roads.

8.1.4.2.1 Objectives

The primary objective of this monitoring plan is to formulate a strategy for controlling, to the greatest extent practicable, fugitive or airborne dust emissions and exceeding levels of noise disturbances. This will be accomplished by identifying specific sources and activities that have the highest potential to produce or generate the disturbances. This plan describes the engineering controls necessary to minimize and control dust emissions from those sources and activities as well as the reduction of noise generated by the activities. As necessary, the scope of this plan will be revised to reflect changes in dust control strategy as site conditions or activities may change in the future.

As a precautionary and control measure for this project, the monitoring plan will be used as a standard operating procedure (SOP). This plan will be used:

- To eliminate origins of dust and excess noise from the project during construction activities;
- To identify the potential air and noise migration pathways;
- To monitor for dust, emission and noise produced by site activities; and
- To implement corrective actions as the need arises.

This plan is being prepared and submitted with the understanding that it can be modified to accommodate actual site conditions as they arise and in conjunction with all safety and health precautions.

8.1.4.2.2 Sampling Sites

The sampling sites for the proposed monitoring phase, in particular for ambient environmental quality will not only be limited to the road rehabilitation works but to all applicable locations. This includes the project site itself as well as the quarries and transportation routes for both new material and reclaimed surface materials. Of particular interests is the alternate route for San Jose Succotz where by the route entails transiting through an urban area. In summary, the sample sites include the following general area:

- Project sites along the different communities;
- At biological sensitive areas as identified in the impact assessment;
- Points of Interest (POI) as stated by the contractor; and
- At the different designated quarries.

Table 8.4: Ambient Air and Noise Sample Locations

SITE			Coordinates	
ID#	Description River/Tributary	Way Point	Lat	Long
1	Mopan - Benque/Succotz	WP1	17.0787	-89.1367
2	Macal-Upper Stream	WP 2	17.1569	-88.0686
3	Macal-Down Stream	WP3	17.1734	-89.0718
4	Garbutt Creek - Central Farm/Galen University	WP4	17.1591	-89.0662
5	Barton Creek –Riverwalk	WP5	17.2038	-88.9558
6	Belize - Iguana Creek Bridge	WP6	17.2235	-88.9091
7	Ontario Natural Spring	WP7	17.2607	-88.7895
8	Roaring Creek Bridge	WP8	17.2513	-88.795
9	Roaring Creek Riviera/Butte Rows	WP9	17.2513	-88.795

8.1.4.2.3 Sampling Frequencies

The sampling frequency for these parameters will vary but it is recommended that a sample be taken at the peak hours of each working day to get a maximum variant. Thus air and noise samples must be taken:

- Once per day, preferable during peak hours so maximum variance may be compared to early morning reading;
- Once per month at designated POI.

8.1.4.2.4 Monitoring Parameters

Sample parameters for dust or air borne pollutants, vehicular emissions and noise pollution include the following:

- *Air and dust pollutants* – Suspended Particulate Matter, Sulpher Dioxide, Carbon Monoxide and Nitrogen dioxides;

- *Noise Pollution* – limits will be set as those described in the Noise Levels according to the dB (A) Scale (as defined by the International Electronics Commission).

8.1.4.2.5 Interpretation of results

The monitoring program will incorporate a feedback loop to provide rapid dissemination of the results (either visual, in-situ or laboratory) to the contractor to ensure problems are rectified as soon as possible. If repeated results demonstrate that the site or parts of the site have stabilized, then the parameters will be reviewed in order to reduce or discontinue monitoring.

Table 8.5: Environmental Quality Template with File Numbering System

Date:							
FILE	**Sample Location**	**SPM**	**SO_2**	**CO**	**NO_x**	**Noise levels**	**Blank**
0001							
0002							
0003							
0004							
0005							
0006							

8.1.4.2.6 Reporting and responding to exceeded criteria

The program will include a process for reporting and responding to exceeding the limits set by the DOE's Pollution Regulation criteria as follows:

Table 8.6: Regulation 6 – Concentration of Air Contaminants

		Concentration in micrograms per meter cube			
		SPM	SO_2	CO	NO_x
A.	Industrial and Mixed Use	500	120	5000	120
B.	Residential and Rural	200	80	2000	80
C.	Sensitive	100	30	1000	30

8.2 Monitoring Cost

The monitoring will incur a cost to the project and therefore a budget allocation will be required. Environmental monitoring of the road rehabilitation will be done by assigned qualified personnel and with the assistance from the Department of the Environment. The project intends to attach a technician from the Department of the Environment to the project so he/she can be a part of the monitoring team. This capacity building measure should benefit the Department's role in identify the impacts, institute mitigation measures and devise a monitoring plan to verify its effects and make corrective actions. The costs presented below in Table 8.6, are all indicative and will be refined at the start of the construction contract.

Table 8.7: Monitoring Plans

Monitoring Plans	Indicative Costs ($)	Duration	Notes
Water Quality – transportation to sampling sites, collection and storage and analyzing all samples.	20,000	Pre and post construction (2 months)	Sample includes parameters and assigned personnel
Environmental Quality – monitoring of air and noise pollution.	25,000	Pre and post construction (2 months)	Costs include purchase of monitor meter

8.3 General Reporting Requirements

In the general context of the monitoring plan, there must be established target goals and objectives in terms of monitoring the anticiapted impacts. The results of these plans must be reported to the DOE as part of their requirement. Likewise, any adverse or potentially adverse impact must be reported immediately to the DOE and PEU as well as other regulatory agencies. Table 8.7 provides a template that could be used by the PEU/ Doe Officer assigned to the project to monitor compliance with the ECP and ESMP.

Table 8.8: Monitor compliance with the ECP and ESMP

Name of Person Filling Form:____________________________				Date:__________________	
Activity	**Environmental Effects**	**Mitigation Measure(s)**	**Monitoring Indicator(s)**	**Monitoring and Reporting Frequency**	**Party) responsible.**
List all activities in ESIAthat received a "negative determination with conditions." ***Do not list any other activities.***	List main environmental effects that require mitigation	If mitigation measures are well-specified in the ECP quote directly from ECP If they are not well-specified in the ECP define more specifically here.	Specify indicators to (1) determine if mitigation is in place and (2) successful. For example, visual inspections for seepage around pit latrine; sedimentation at stream crossings, etc.)	For example: "monitor weekly, and report in quarterly reports. If XXX occurs, immediately inform project manager or DOE."	**If appropriate, *separately* specify the parties responsible for mitigation, for monitoring and for reporting.**
Signature of Person completing Form:____					

8.4 Social Management Plan

Based on the findings presented in Chapters 6 and 7, the MOWT will undertake a number of specific mitigation and management measures to ensure that the Road Project minimizes or avoids any negative impacts and maximizes potential positive social impacts.

The Social Management Plan (SMP) describes the overall management and monitoring of these mitigation measures. It specifies the responsibilities, timings, institutional structures, human resources and estimated annual costs required to effectively implement MOWT's social management plan.

In tandem with adaptive management strategies, the SMP will need to be updated and adapted throughout the Project's lifecycle, as impacts change according to Project development, social context changes and Project milestones are attained. Recommendation is for the SMP to be formally reviewed and updated bi-annually through the second year of operations and periodically as appropriate thereafter to be led by the M&E Officer within the established PEU, MOWT. The aim is to ensure that the social and economic environment, workers, Project stakeholders and PAPs do not suffer adverse impacts during the development and life cycle of the Project and enjoy access to social and economic benefits. The SMP contains: a breakdown of mitigation measures, key performance indicators, targets, responsibilities, and estimated annual costs; key obligations of the lead construction contractor/s; and described responsibilities and mechanisms for implementation and monitoring of the SMP inclusive of: management and staffing structures; and means for monitoring and reporting on SMP performance

8.4.1 Social Impact and Risk Management

The Government of Belize is committed to social protection of its PAPs; to this end, this section outlines management measures that have been developed in order to minimize or avoid negative Project impacts and maximize Project benefits. These include:

Social Impact Management Measures: Specific mitigation and management measures for each impact identified in the SIA with a description of the social performance targets that MOWT and its Contractors will strive to meet, measured using specified Key Performance Indicators (KPIs);

Management of Social Risk: Social risk will be managed through mitigation and a Participatory Public Participation Process, inclusive of a Grievance Mechanism, and developing good relationship with stakeholders and PAPs through effectively managing impacts;

Social Management Mechanisms: It is recommended that the MOWT through its PEU implement two key social management mechanisms: a Grievance Mechanism, which provides the structure to respond either where the social impact mitigation measures are not functioning as envisaged, or when unanticipated social impacts (for which mitigation measures have not been developed) arise; and the establishment of part-time Community Liaison Officers, one for each Road Section for the construction phase and at least one year into the operational phase of the Project life cycle. These mechanisms are key to managing social risks by ensuring effective relationships with Project stakeholders and PAPs.

8.4.1.1 Management of Social Mitigation Measures

Table 8.1 outlines the recommended and subsequently agreed management targets and measures for the social impacts identified and presented in Chapter 7, Section 7.2. For each of the impacts identified, this Table specifies:

- The Key Performance Indicator used to assess the extent to which an impact is effectively managed; these KPIs will be updated and reviewed throughout the life of the Project;
- The Target or the level of the KPI that the Project will commit to achieving; to this end close collaboration with local village councils is recommended;
- The Mitigation and Management Measures developed and agreed to manage impacts. Some management measures cannot be defined at this point, either because they will be the responsibility of Project contractors who have not yet been hired, or because the Project design is evolving. In these cases the management measure when defined will be adequate to meet the KPI target as specified;
- The Party Responsible for development and implementation of the relevant management measures for each impact, including both construction contractors and MOWT team as relevant; and,
- The indicative Cost associated with effective implementation of the mitigation and management measure.

Table 8.9: Summary Impacts, Mitigation, KPI and Targets, Responsibility and Costs

Impact	KPI	Target	MOV	Responsibility	Mitigation/Management Measure	Cost
Community Governance, Organization and Local Institutions						
Community Governance/ Participation The Road Project has the potential to positively impact community governance and contribute to restoring public confidence to some degree in local and central level government. Access to decision-making The ability of individuals to influence Project decision-making processes and protect their interests may be negatively or positively impacted by the Project, partially dependent on effectiveness of consultations. Representative Organizations Outside of the legally established village councils, PAPs communities have no/limited presence of representative organizations (NGO/CBO). Project stakeholder engagement could support or undermine these organizations i.e. potential positive or negative impact according to Consultation process.	Number of consultation meetings conducted Distribution and participation rate of participants at consultation meetings PAPs level of satisfaction with village council representation wrt the Road Project consultations	At a minimum, 3 meetings during construction phase; and at least 1 during operation phase 60% of PAPs are satisfied with village councils' representation	Meeting attendance sheets Performance monitoring survey	Project Coordinator (PC)[Community Relations Focal Point], M&E Officer and 3 CLOs (1 per Road Section) as members of the MOWT-PEU	Continued consultation by MOWT to ensure that it works with the village councils and contractors who are open to hiring of socially marginal groups for broader based Project support; Explore service contracts for maintaining the rehabilitated GPH with the village councils across Road Sections to strengthen ties between local and central government and demonstrate tangible commitments with respect to ensuring the hiring of locals with special emphasis on women and youth	60 k p.a. PC 45 k p.a. M&E O 18 k [3 CLOs]
Social Services and Community Infrastructure						
Water infrastructure Access to water source may be negatively impacted during the construction phase.	Number of HH who report water interruptions Average length of time water supply is interrupted	Water supply is uninterrupted by the Road Project	Site visits Grievance database Performance monitoring reports	PEU, MOWT	MOWT is committed to using appropriate construction mitigation measures as earlier noted and due diligence to ensure that people will not be negatively impacted. Thus the location/re-location of the electric poles/lines and water lines will be duly considered and coordinated action with service providers will be proactively pursued.	Cost of protection/shifting water lines borne by GOB/village councils
ectricity infrastructure Access to electricity may be negatively impacted during the construction phase across select areas of the Road Sections	Number of HH who report electricity interruptions Average length of time electricity supply is interrupted	Electricity supply is uninterrupted by the Road Project		PEU, MOWT		Cost of protection/relocation electric/poles/lines borne by BEL
Roads and Access to Public Transport Construction	Grievances related to	No legitimate unresolved	Grievance	PEU, MOWT		

vehicles may put pressure on/negatively impact the Public transport and road system. In the medium to long term however, positive benefits are associated with the Road upgrade.	traffic/transport [lateness to school/work]	grievances related to traffic/transport	database		Regular spraying of water at least twice a day in high-traffic and/or high population density areas., inclusive of school zones by water bowsers	
Education infrastructure With the upgrade to international standards of the GPH come improved road safety for pedestrians (special attention to school children) which will positively impact. Additionally, dust and noise from construction and increased traffic flow from transportation of materials could adversely impact on educational services.	Grievances related to construction impacts on schools along the ROW [noise, dust…] Proportion of school children/teachers/parents who report safer road conditions	No legitimate unresolved grievances related to Project impact on schools along ROW 95% of PAPs reporting safer road conditions for pedestrians	Grievance database Performance monitoring surveys	PEU, MOWT		Standard component of the road contract; absorbed with Project costs
Socio-Demographic Characteristics						
In-migration could disrupt local culture and the in-migration of single male workers could cause social problems and affect social cohesion	% of workers hired from local PAPs communities Number of grievances about workers' conduct Number of sexual exploitation/harassment cases investigated and substantiated	At a minimum 30% of workers sourced locally No unresolved grievances related to workers' conduct 100% of sexual exploitation/harassment cases investigated in line with Zero Tolerance Policy	Employee records Grievance database Human Services/Police Administrative reports	PEU, MOWT	MOWT to require contractors to develop policies for workers induction and a socio-culturally appropriate code of conduct for interacting in communities inclusive of training on gender related issues inclusive of sexual harassment of adult females, sexual exploitation of adolescent girls and HIV and AIDS training; the latter could be arranged through the Ministry of Human Development, Women's Department./independent social worker Source local labour force insofar as requisite skills allow with special quota for women to balance the population structure imbalance. Additionally training for workers and the communities on the mandatory child abuse reporting law should be required	Contract clause
Social Cohesion Social cohesion in neighbouring communities could be adversely impacted by differential access to Project opportunities and influx of Project workers						
Poverty/vulnerability and Social exclusion Project costs and benefits could reduce or increase vulnerability of specific groups of PAPs, i.e. positive or negative impacts						Contract clause
Child and Adult Protection Project has the potential to negatively impact communities as it relates to sexual exploitation of adolescent girls and harassment of women by predominantly male workforce				CPS & WD, MHD		$1500 one off training fees and logistical support
Economic Environment						
Costs of Goods and Services Influx or Project workers may negatively impact the cost (inflation) of basic					The MOWT will take into account the socio-economic baseline context and require of its contractors,	.

goods and services.					consultations with village councils as it relates to employment	
Socio-economic Development The Project may impact the socio-economic development of local communities, wider Cayo area and the country of Belize positively and/or negatively particularly as it relates to tourism and cross-border trade.						
Employment and Labour						
Employment is a potential positive impact of the Project, directly through employment on the Project and indirectly through livelihoods. Poor governance practices and lack of skills however limit access to jobs which could be a negative impact.	Number of grievances about hiring practices % of workers hired from local PAPs communities Number of grievance about impact on livelihoods Number of grievances about compensation for land take % of affected persons reporting satisfaction with level of compensation and process	No unresolved grievances related to hiring practices No unresolved grievances related to compensation for land take 95% of affected persons reporting satisfaction with compensation/ process	Grievance database Site visits	PEU, MOWT	The MOWT and contractors will work actively to promote local access to Project employment in both the construction and the operations phases. To do this MOWT and contractors will apply transparent and fair employment policies and work with local village councils to source local labour Additionally, constant communication and due lead time will be given to vendors with support for relocation in the interim; where private land take is absolutely unavoidable, market-value compensation to owners will be employed after due consultation process managed by the MOWT	Contract clauses
Skills Project employment and training could positively impact the local skills base						515k [13 kiosks + land uptake for Roaring River crossing, Z-curve by pass and entrances to Succotz and Benque]
Development of Businesses and informal livelihood activities Businesses and livelihood activities may be indirectly positively impacted by the Project.						
Temporary/Permanent Land Take Replacement of the Roaring River crossing bridge, the widening of existing road where necessary and/ or creation of detours at the Z-curve may require land take and affect people's property. However, the upgrading of the road is expected to cause minimal adverse impact since the Project is designed in such a way that minimum private land will be affected and where absolutely unavoidable, compensation at market value will occur.						
Cultural Heritage						
Archaeological Sites, Mounds/Points of Interests and Local Cemeteries The Road Project has the potential to positively impact established sites though increased volume of visitors and enhancement as tourist destinations for increased opportunities of livelihoods	Number of grievances about destruction of cultural heritage	No unresolved grievances related to destruction of cultural heritage	Site visits Grievance	PEU, MOWT DOE, MFFSD	The proposed road works will be limited to the existing track and road width; Safety barriers will be erected to protect the existing mounds, plazuelas and patios that are within the buffer zone;	

and overall added economic benefits/development of the wider area. In similar fashion, the Project also has the potential to negatively impact archaeological mounds within extreme close proximity to the ROW as well as identified Cemeteries if the necessary precautions are not taken.			database		Preferred alternate routes were chosen to avoid direct impact to archaeological mounds and plazuelas as indicated in the Archaeological Assessment and Road Alternative Identification. To avoid potential adverse impacts on archaeological remains, it is recommended that an archaeologist undertake further investigate work prior to initial clearance. Initial investigation would include excavation of test pits along the route. Should the investigation uncover substantial archaeological deposits a more detailed investigation would be required. It is recommended that such work is undertaken in close consultation with the Department of Archaeology.	
Health						
Health impacts related to construction pollution (dust, noise …) The Road Project has the potential to positively impact pollution related health problems in the long term by reducing volume of dust from current ROW but may negatively impact during the construction phase due to pollution	Air emissions Health impacts resulting from noise or dust	Compliance with air emission standards No health impacts resulting from construction pollution	Environmental monitoring Health and grievance monitoring	DOE, MFFSD	During the construction phase, a rigorous health and safety plan will be implemented to ensure excavation and construction activities minimise dust and noise-related pollution for the workforce, neighbouring communities and schools. Mitigation Measures will be clearly communicated to the PAPs to reduce stress caused by uncertainty.	Contract clause
Communicable Disease Influx of labour force and transport workers may increase exposure to communicable diseases inclusive of HIV-AIDS	% of workers with comprehensive knowledge of HIV % of workers aware of health and safety plan	No grievances/claims in relation to injuries % of RTAs within Road Section < 5% (2013 baseline)	Grievance database Spot checks Police/MOH Administrative reports	PEU, MOWT MOH	The MOWT through the PEU and its contractors are required to implement HIV/AIDS awareness, prevention and control activities aimed at construction workers and the communities in the Project Area in line with the Environmental and Social Management Plan. Additionally good hygiene and health practices in line with the overall health and safety plan are to be observed.	Contract clause
Injury Construction, transport and operations could expose workers and local people to the risk of injuries or accidents.	Number of residents injured as a result of Project activities Number of RTAs during			PEU, MOWT Contractors	Development, communication and implementation of a robust Preparedness Plan are essential both for local communities and workers. Health care providers should be consulted in developing this plan; Develop traffic control measures to limit the risk of	Contract clause

	construction phase				construction, operational and transport accidents which could endanger the health of community members; Conduct a road safety campaign to reduce the risk of traffic accidents for community members, particularly important for children;	
OHS Worker health and safety could be compromised unless managed properly	Proportion of workers injured on the job	No workers' injuries	Contractors' records SSB Administrative reports		MOWT to require contractors to adopt strict construction and operation practices with best technology and health and safety training to ensure the safety of its workers in line with the OSH Bill. MOWT to develop and implement a Traffic Safety Monitoring Plan(see Table 8.10 for sample form) to ensure lives are protected first and foremost and to respond appropriately to any traffic related incident/accident. To this end, they will: Carryout a safety checklist of all safety equipment; Assess the daily placement of all traffic safety equipment; Manage safely the passage of traffic within the work zones; and Notify the general public on detours and alternate routes	Contract clause
Grievance Mechanism						
The effectiveness of the grievance mechanism is key to tracking performance of social impact management	% of grievances resolved Within established time frame Complainants' satisfaction with grievance resolution Community awareness of grievance mechanism	All grievances resolved within specified timeframe Majority of complainants express satisfaction with the grievance process Majority of community members aware of how they could lodge a grievance	Grievance database Performance monitoring survey	PEU, MOWT	Grievance mechanism	7k [DB design, development and deployment] 5k Training for staff and communities(PAPs) in application of GM

Table 8.10: Site Safety Checklist

Equipment	Operators	Site Work crew	Traffic Control	Technical Staff
Site Name:			Day**:**	
PPE				
Hard Hat				
Safety Vest				
Ear plugs/muffs				
Respirator				
Traffic				
Signs				
Cones				
Speed Bumps				
Flaggers				

8.4.1.2 Management of Social Risk

As discussed in Chapter 7, Section 7.2, the Project faces a number of potential social risks related to its socio-economic and political context. Social risk is also influenced by the fact that the types of consultation and application of social standards applied by the Project, in accordance with best practice, are relatively new. MOWT's social risk strategy ensures that social management activities undertaken are designed and implemented to actively reduce social risk. The following activities will make important contributions to social risk management, inclusive of but not limited to:

PPP Activities: The Participatory Public Participation Process (PPP), presents MOWT's strategy for stakeholder engagement. This PPP is a 'live' document that outlines how MOWT will communicate with a range of stakeholders and PAPs and incorporates the Grievance Mechanism for PAPs. The PPP therefore plays an essential role in reducing social risk by building relationships with stakeholders and PAPs, counteracting the spread of misinformation about the Project and ensuring that stakeholders have the means to communicate their legitimate concerns to MOWT and receive responses and fair resolution as appropriate. MOWT's Grievance Mechanism, and the work of Community Liaison Officers (CLOs) presented below, will also act as an early warning system, picking up on any relevant community discontent quickly to ensure it can be addressed by MOWT before it gives rise to social conflict or resentment against the Project.

Social Impact Management: The social impact mitigation management measures will reduce social risks by ensuring that negative Project impacts are avoided or at least mitigated, and that Project benefits are shared equitably. This will contribute to PAPs having a positive perception of the Project, thereby reducing the associated social risk.

Socio-economic Baseline Change Monitoring: It is recommended that socio-economic monitoring be on-going for the life of the Project, with periodic monitoring of the Project social context and social performance with informal assessment through the PPP and grievance processes on a rolling basis and formal monitoring Baseline Surveys at the mid- and end-points of the Road Project Cycle, at an estimated cost of BZ $24,000.

8.4.1.3 Social Management Mechanisms and Organisational Capacity

The implementation of the SMP is the direct responsibility of the MOWT; the MOWT works through the Project contractor and other key stakeholders with direct support from the GPH Road Rehabilitation PEU. The contractor will be required to apply international standard quality assurance procedures and management system.

Other key organizations responsible for ensuring the successful implementation of the SMP and RAP are the Ministry of Fisheries, Forestry and Sustainable Development: Department of the Environment; Ministry of Human Development: Department of Women and Gender Affairs; Ministry of Natural Resources: Lands Department; and the Ministry of Local Government.

The Environmental Engineer (to be contracted and housed in the PEU) will report to the Chief Engineer and the Road Project PSC. It is the recommendation, that the Ministry of Local Government, through the local village councils and municipalities of PAPs communities assist in guiding decisions with respect to local employment as well as exploring opportunities for road maintenance via service contracts during operations for added ownership, employment opportunities and greater cohesion between local and central government.

It is further recommended that MOWT establish a Community Relations Focal Point (CRFP) and contract for the life of the Project, 3 part-time Community Liaison Officers dedicated to conveying information about the Project and implementing the ESIA Mitigation Measures and Key Performance Indicators (KPIs) of the SMP, as well as the PPP targets. The CRFP will manage the Grievance Mechanism, including establishment and management of the Grievance Database at an estimated cost of BZ$7,000. The CRFP will also ensure that the Grievance Mechanism is functioning effectively within agreed resolution time frames and that there is a mechanism for applying lessons learned and that feedback to stakeholders is actually delivered. Additionally, the CFRP and the CLOs will coordinate and deliver training to PAPs on the application of the Grievance Mechanism at an estimated cost of BZ$5,000.

8.5 MOWT's Grievance Mechanism

A grievance can be defined as an actual or perceived problem giving ground for complaint; in line with international standards, projects should provide a Grievance Mechanism which should address concerns promptly, using an understandable and transparent process that is culturally appropriate and readily accessible to all segments of the affected communities, and at no cost and without retribution.

MOWT is proactively seeking to prevent grievances through managing Project impacts and through pre-emptive community liaison activities designed to anticipate and address potential issues before they become grievances.

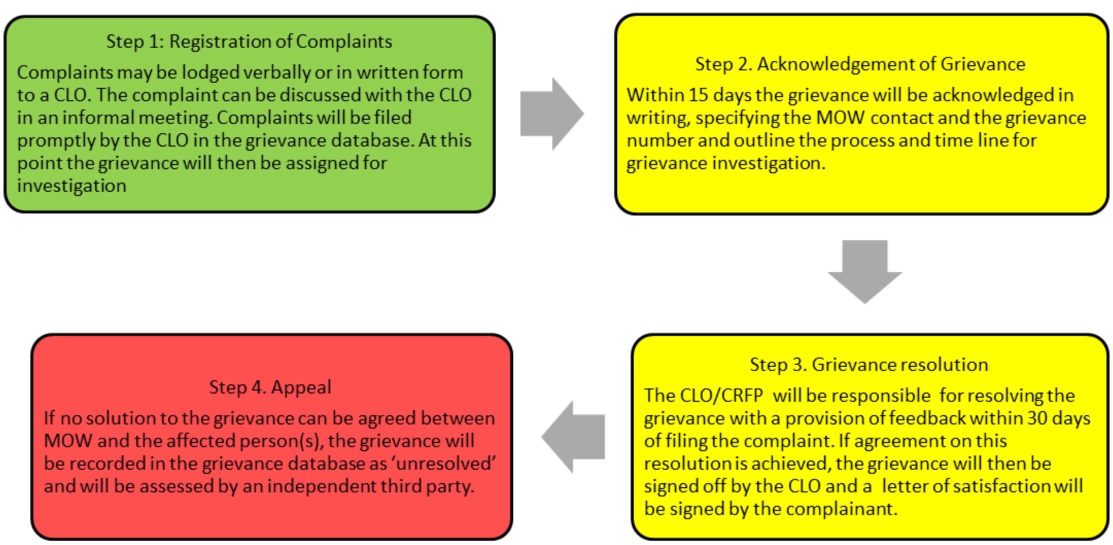


Figure 8.1: Grievance Mechanism Process Flow

Notwithstanding, the Grievance Mechanism is the official process by which people affected by the Project can bring their comments, concerns and grievances to the CLOs and the MOWT management team. The Grievance Mechanism specifies: the Purpose; Scope and Target Group; Procedure; Management Structure and Tracking; and Monitoring and Reporting, the overall process flow is outlined in figure 8.1.

Management and Tracking of Grievances: The roll out of the Grievance Mechanism to community members will be the responsibility of the CRFP/CLO; explanations of the process to community members will be led by the CLO.

Specific issues to be addressed during testing and subsequent roll out of the mechanism are:

- The Grievance Mechanism is accessible to PAPs with low levels of formal education;
- The Grievance Mechanism is publicised using culturally relevant and inclusive media;
- The Grievance Mechanism is accessible for local, national and international stakeholders;
- Community members are aware that they can use the Grievance Mechanism without retribution; and
- Grievances can be lodged without danger of retribution in practice, given that some Project affected stakeholders are reliant on informal livelihoods, and that some grievances may be lodged by workers against contractors who are their employers.

A Grievance Database System will be set up by the CSFP/CLO before construction starts. This database will be designed to make it easily possible to track individual grievances, giving each grievance a unique ID number (UIDN), trigger deadlines for progress on grievance communications and resolution as specified in the grievance process. The Grievance Database should specify where grievances have been resolved and a statement of satisfaction has been signed by the complainant. Where it has not been possible to resolve grievances to the satisfaction of both parties, this should be specified in the database, and unresolved grievances should be assessed during third party monitoring.

Monitoring and Reporting of Grievances: The implementation of the Grievance Mechanism is subject to third party monitoring (e.g. DOE, MHD, IDB …) to ensure that MOWT is performing effectively in its commitments to resolving community grievances. Third party monitors of the

Grievance Mechanism will be provided with access to the Grievance database to audit performance. MOWT through the CRFP/CLO will report on performance in closing out grievances (i.e. the number of grievances resolved within agreed time frames) as part of an annual public report. A draft Grievance Mechanism Leaflet for MOWT is presented in Figure 8.1; as well as a draft Grievance Form, Figure 8.2.

INFORMATION ON MOWT'S GRIEVANCE PROCESS

The Government of Belize through the Ministry of Works and with loan facility from the IDB is proposing to undertake rehabilitation of the GPH from its junction with the Hummingbird Highway extending to the Benque-Guatemalan border.

The purpose of this Grievance Mechanism is to ensure that anyone with a grievance or concern about the Project can communicate it to MOWT and get feedback from MOWT on how they will address this concern.

WHAT KINDS OF GRIEVANCES CAN I RAISE?

Anyone, including both community members and staff of contractors or contractors themselves can raise a grievance with MOWT if they believe that the Project is having a negative effect on their community, nation, the environment or their quality of life. Examples of grievances could include, but not limited to:

- ✓ Concerns about the environmental impact of the Project;
- ✓ Project impacts on your quality of life, such as traffic problems, dust and noise;
- ✓ Project impacts on your livelihood and employment activities;
- ✓ Health and safety problems related to the Project;
- ✓ Failure to comply with standards or legal obligations;
- ✓ Improper behaviour by Project staff;
- ✓ Financial malpractice, impropriety or fraud;

MOWT through its PEU will investigate all grievances that are submitted.

HOW TO REPORT A GRIEVANCE

MOWT has a number of ways of receiving your grievances. You can:

Complete the attached Grievance Form and send it to the address on the form or drop off at any MOWT Office;

Contact the Community Liaison Officer in person/via phone to lodge a verbal grievance; the CLO will then fill out a form for you to ensure that your grievance is tracked.

Communicate a Grievance through the MOWT website.

FOLLOW UP (Case Management)

Unless a CLO is able to deal with your grievance immediately, MOWT will go through the following steps to deal with it:

When MOWT get your grievance form or are notified verbally of your grievance, a member of staff will be assigned to investigate;

MOWT will acknowledge your grievance by letter (posted, dropped off in person by a CLO) within 15 days of receiving the grievance or by email if appropriate. This letter will acknowledge your contact person at MOWT, and give a reference number for your grievance;

MOWT will then investigate your grievance and may need to contact you in order to do this. When MOWT has completed its investigation, you will be contacted with the findings of the investigation and proposed response within 30 days of you lodging your grievance.

If you are satisfied with the investigation and the proposed response MOWT will ask you to sign a statement to this effect.

If you are unsatisfied with the investigation and/or response MOWT will discuss with you other options for dealing with the grievance and attempt to agree to a response. If parties are unable to agree to a response, the grievance will be assessed by an independent third party.

CONFIDENTIALITY AND ANONYMITY

If you ask MOWT to keep your identity confidential in relation to your grievance, we will ensure that your name and details are known only to the grievance investigator/s and are not shared with other MOWT employees/management, Contractors, or people or organisations outside MOWT. If it is not possible for MOWT to resolve the grievance without revealing your identity, MOWT will contact you to ask how you prefer to address this situation. If you wish to raise a grievance anonymously you may do so, and MOWT will investigate the grievance. However, in this case MOWT will not be able to contact you to discuss the results of our investigation and the proposed mitigation measure/s.

Figure 8.2: MOWT Grievance Mechanism Information Leaflet

Form 8.11: Sample MOWT Grievance Form

Contact Information					
Full Name:				○	○
	(first)		(last)	Male	Female
Address:					
Phone:					
e-mail:					
Road Section:	○ RS I	○ RS II	○ RS III	Other:__________________	
CTVC:					
Complainant Category:	○ Resident	○ Local Business	○Village Chairperson	○ Councillor	○ NGO/CBO
	○ Contractor	○ Contractor Employee		Other:__________________	
If with an Agency:					
	Name of Agency			Position with Agency	
Description of Grievance (when relevant, please provide specific names, dates and locations of incidents):					
Recommendation for resolving the grievance?					
Signature			Date		

8.6 Consolidated Environmental and Social Management Plan

The sub-section summarizes, the key environmental and social mitigation and mangement measures for the Road rehabilitation Road Project across the following major requirements: General Construction; Drains and Culverts Construction; Excavation and Borrow Pit; Material Storage and Handling; Workers Camp; Ecological; Archaeological; Vegetation Removal and Re-vegetation; Traffic Management; Utilities Management; Community and Worker Welfare, Safety and Healt; New Roaring Creek Bridge Construction; Z-Curve Construction; and Succotz Alternate Roadway Construction Requirements.

8.6.1 General Construction Requirements

- Use concrete surfacing where lifting of road impractical.
- Establish and adhere to construction timetables that minimize disruption to the normal activities of the construction area.
- Coordinate truck and other construction activity to minimize noise, traffic disruption and dust.
- Develop and implement appropriate human health and worker safety measures during construction.
- Post construction timetables and traffic diversion schedules at the project site.
- Where significant environmental impacts may occur, document and photograph pre-construction and post-construction conditions.
- Backfill and/or restore borrow areas and quarries before abandonment unless alternative uses for those sites are planned.
- Control runoff into borrow pits.
- Provide proper, temporary sanitation at the construction site.
- Recover and replant topsoil and plants as practicable.
- Set protocols for vehicle maintenance to control contamination by grease, oil and fuels.
- Install temporary erosion control and sediment retention measures (check dams and silt curtains) when permanent ones either are not feasible or are delayed.
- Avoid pollution of waterways with stockpiled construction materials.
- Cover stockpiled construction materials, as practicable.

- Place solvents, lubricants, oils, and other semi-hazardous and hazardous liquids over a lined area with appropriate secondary containment in order to contain spillage. Test the integrity of bulk storage tanks and drums, and secure valves on oil and fuel supplies.
- Build appropriate containment structures around bulk storage tanks and materials stores to prevent spillage entering watercourses.
- Handle, store, use and process branded materials in accordance with manufacturer's instructions and recommendations.
- Take waste materials to appropriate, designated local disposal areas.
- Minimize burning of waste materials.
- Employ techniques to minimize dust and vapor emissions as practicable (e.g., road speed limits, air extraction equipment, scaffolding covers, road spray).
- Build sedimentation ponds or other separators for silt-laden material prior to allowing significant outflow into watercourses.
- Build collection channels leading to oil and/or silt traps, particularly around areas used for vehicle washing or fuelling.
- Seal or remove abandoned drains to minimize water contamination.
- Segregate waste which can be salvaged, re-used or recycled.
- Introduce measures to control and minimize the volume of waste on site.
- Keep worksite free of litter
- Employ sensitive strategies with regard to trees, watercourses, plant or animal species or habitats, and important historical and archaeological features.
- As practicable, landscape construction sites in a way that is appropriate to local conditions.
- Minimize the disturbance of, and reduce the spread of ground contaminants.
- Do not build structures in sensitive areas such as wetlands.
- Provide for the safe disposal of gray water from bathing and washing.
- Erect noise and dust barriers near schools and sensitive areas.

8.6.2 Drains and Culverts Construction Requirements

- Design, construct and maintain drains to minimize ponding and overflow onto highway or inundate private property.

- Construct drainage along all realigned sections to avoid damming or obstruction of surface runoff on either side of road.
- Replace all culvert that are either undersize and compromised according to the recommendations resulting from the culvert assessment.
- Ensure culvert dimensions are based on assessment of projected water flows and that they meet at the very least the minimum standard.
- Ensure that the drainage improvement recommendations are implemented for the flood prone areas and that proper drainage form part of the overall road design.
- Ensure that where there sections proposed for vertical and horizontal alignments provide proper drainage designs for adjacent properties and land owners.

8.6.3 Excavation and Borrow Pit Requirements

- Ensure excavation is accompanied by well-engineered drainage to control runoff into the pit.
- Ensure that sites meet the general site criteria recommended in this study.
- Develop specific procedures for storing topsoil, and for phased closure and reshaping and restoration of the pit when extraction has been completed. Include plans for segregating gravel and quarry materials by quality and grade for possible future uses. Where appropriate, include reseeding or re-vegetation to reduce soil erosion, prevent gullying and minimize visual impacts.
- Backfill and/or restore borrow areas and quarries before abandonment if alternative uses for those sites are not planned. Areas should be restored so that they are suitable for sustainable use after extraction is completed.
- Extract material volumes from different sites to distribute the environmental impact footprint.
- Level extraction sites evenly.
- Provide for free drainage following extraction and ensure that measures are put in place to trap sediments before discharging into the receiving environment.

8.6.4 Material Storage and Handling Requirements

- Identify sites for temporary/permanent storage of excavated material and construction materials.

- Maintain proper storage facilities in all construction camps.
- Avoid pollution of waterways with stockpiled construction materials.
- Set protocols for vehicle maintenance to control contamination by grease, oil and fuels.
- Maintain spill clean-up kits and report spills to DOE.
- Build collection channels leading to oil and/or silt traps, particularly around areas used for vehicle washing or fuelling.
- Build appropriate containment structures around bulk storage tanks and materials stores to prevent spillage entering watercourses.
- Build tanks or other separators for silt-laden material prior to allowing significant outflow into watercourses.
- Cover stockpiled construction materials, as practicable.
- Minimize the disturbance of, and reduce the spread of, ground contaminants.
- Handle, store, use and process branded materials in accordance with manufacturer's instructions and recommendations.
- Take construction waste materials to appropriate, designated local disposal areas.
- Minimize burning of waste materials.

8.6.5 Workers Camp

- Ensure that workers camp is located away from schools, churches and areas frequented by community members.
- Locate camp sites away from water ways and provide amenities and proper sanitation facilities.
- Ensure workers camp is secure and prevents access to members of general public
- Ensure campground are maintained free of debris and pollution.
- Provide acceptable, sanitation facilities for workers.
- Properly containerize and dispose of domestic waste at workers camps.
- Locate Bulk storage of fuel and other hazardous substance away from workers structure and place appropriate signs (no smoking, cell-pones etc around these areas).
- Vegetate and seed disturbed areas of campsites after decommissioning sites.

8.6.6 Ecological Requirements

- Prevent siltation of Creeks and streams
- No vehicles or machinery will be washed in rivers or creeks.
- Prevent contamination of Water bodies and never completely obstruct the flow of a stream or creek.
- Minimize potential for die back of vegetation areas by regular placement and maintenance of culverts and drainage system.
- Place box culverts to provide passage of fauna under road to other side.
- Post safety signs for wildlife crossings.
- Preserve all roadside trees and shrubbery not required to be cleared.
- Vegetate and seed disturbed areas of campsites.
- Designate work areas and campsites "no hunting zones."

8.6.7 Vegetation Removal and Re-vegetation Requirements

- Where significant environmental impacts may occur, document and photograph pre-construction and post-construction conditions.
- If vegetation must be removed during wet periods, wait until just before actual construction.
- Store topsoil and preserve removed plants for later use.
- Re-vegetate with recovered plants and other appropriate local flora immediately after equipment is removed from a section of the site.
- Stabilize hillsides to avoid slippage or landslide during torrential rain events.
- Keep high vegetation cleared along GPH ROW.
- Promote sustainable land use practices among farmers to reduce siltation and damming of stream channels, making flash floods and inundations worse.
- Minimize potential for die back of vegetation areas by regular placement and maintenance of culverts and drainage system.
- Stabilize slopes by planting vegetation. Work with agronomists to identify native species with the best erosion control properties, root strength, site adaptability, and other socially useful properties. Do not use non-native plants. Use soil stabilizing chemicals or geo-textiles (fabrics) where feasible and appropriate.

8.6.8 Traffic Management Requirements

- Maintain a minimum road width open for through traffic at all times.
- Install signage to direct traffic during construction stating speed, curve, crossings and junctions must be installed.
- Use proper signage, traffic safety equipment/warning devices and speed indicators when diverting traffic either to an alternate route or reducing to one lane.
- Employ traffic wardens at schools and other sensitive areas to control the movement of both the deviated traffic and construction traffic.
- Place fencing and safety barriers to separate the construction site from the trafficable areas.
- Use adequate night illumination and warning signs and decals to alert and warn motorist and pedestrians.
- Reduce pedestrian/vehicle conflict to ensure safety, especially through the communities.
- Install pedestrian crossings at key areas including busy trafficking areas, schools and clinics.
- Requiring the contractor to manage construction activities to ensure that traffic can flow in both directions on the highway, especially at night thereby minimizing risks
- Maintain access to all properties, including those that are someway linked. Where access restrictions are required, the land owner should be notified as early as possible and such restrictions should be limited to daylight hours.
- Reduce congestion on roads through communities and villages, improving pedestrian safety (with reduced impact through traffic conflict) and other adverse social impacts associated with congestion, including traffic noise.
- Improve connectivity between residential development and the social infrastructure and services available.
- Improve vehicular movement across the road network and vehicular efficiency and provide greater access to alternative routes.
- Provide pedestrian and cycle carriageways across communities to enable better traffic safety.

8.6.9 Archaeological Requirements

- Identify and avoid areas in the project impact zone that may contain important ecological, archeological, historic, religious or cultural resources.
- Identified areas in Road Section I includes areas in Camalote, Teakettle, Ontario and Blackman Eddy which have scattered mounds and plazuelas within the existing carriageway buffer zone or road corridor as stated in the Archeological Impact Assessment.
- Identified areas in Road Section II includes areas at Lower Dover, Floral Park, Baking Pot and Esperanza which show signs of mounds, plazuelas and patios that are of archeological interest, located within the road corridor or study area.
- Identified areas in Road Section III includes the sites of Cahal Pech, Buenavista, Nohoch Ek, Actuncan and Xunantunich which are partially within the road buffer zone.
- Have construction crews and supervisors be alert for buried historic, religious, and cultural objects, and provide them with procedures to follow if such objects are discovered. Provide incentives for recovery of objects and disincentives for their destruction.
- Erect safety barriers to protect the existing mounds, plazuelas and patios that are within the buffer zone.
- Register GPS locations of mounds so future works can be undertaken to rehabilitate these sites.
- Use alternate routes to avoid direct impact to archeological mounds and plazuelas as indicated in the Archeological Assessment and Road Alternative Identification.
- If impact to sensitive areas cannot be avoided during road reconstruction, involve ecologists, archeologists and engineers in evaluating alternatives and minimizing impacts.
- Where significant environmental impacts may occur, document and photograph pre-construction and post-construction conditions.

8.6.10 Utilities Management Requirements

- Liaise with BEL prior and during construction to ensure that necessary power poles are relocated prior to road construction commencement.

- Identify water mains, both rural and governmental pipes, on the road shoulder to ensure that works do not impact these supply pipes.
- The potential impacts on water supply were considered in determining the preferred widening alternative in order to avoid potential impacts to existing water mains

8.6.11 Community and Worker Welfare, Safety and Health Requirements

- Work during daylight not exceeding 12 hrs.
- Ensure workers from local communities are hired with minimum of 30% quota for women;
- Inform communities of construction activities.
- Ensure that the contractor responds appropriately to complaints from communities.
- Ensure early discussion and negotiation between land-owners and the Ministry of Works regarding any property acquisition for the alternative routes and road alignment, including acquiring land for the alignment of the Z Curve, new Roaring Creek Bridge and alternate route for the Succotz carriageway.
- Improve road safety, especially around schools where the movement of heavy equipment and increase in vehicular movement is inevitable.
- Maintain and regularly check tools fitted with mufflers where appropriate.
- Construct noise barriers between work sites and communities.
- Maintain construction vehicles fitted with mufflers where appropriate; turn off when not in use; avoid reversing.
- Provide and ensure workers wear Personnel Protective Equipment.
- Have workers use vibration isolation and suspension systems.
- Alternate vibration work among workers.
- Use vibration isolation and suspension systems.
- Assess vibration impacts to property and discontinue where damage/injury imminent.
- Use dust suppressant measures.
- Shut off equipment when not in use and maintain in good operating condition.
- Ensure equipment has emission control devices.
- Provide proper sanitation facilities at workers camps.
- Ensure fire and medical response for the campsites.

8.6.12 New Roaring Creek Bridge Construction Requirements

- Establish and adhere to construction timetables during dry season.
- Work during daylight not exceeding 12 hrs.
- Construct abutments sequentially to allow unimpeded flow of creek.
- Employ best management practices working near waterways.
- Divert storm water from construction areas.
- Use wing dams made of sand bags or silt curtains.
- Store all stripped pavement and excavated soil away from riverbanks and streams.
- Construct approaches to bridge and the deck of bridge above the maximum flood stage.
- Avoid haulage of materials through village streets and ensure loads are covered.
- Ensure no motor vehicle washed in river or stream.
- Limit and enforce speed around construction zone.
- Shut off equipment when not in use and maintain in good operating condition.
- Ensure equipment has emission control devices.
- Fit equipment with mufflers and turn off when not in use.
- Service and maintain construction heavy-duty equipment.
- Make provisions for attaching utility services to the proposed bridge crossing.
- Reduce traffic congestion within this zone by the aforementioned construction
- Place bollards and barriers to ward off vehicles and others from accessing the old bridge after construction of new bridge is complete

8.6.13 Z-Curve Construction Requirements

- Road side slopes and cuts should have slopes of 1.5:1 ratio.
- Use of erosion control blankets or fiber-web geo-synthetics for stabilization of cut slopes; as well as to promote the growth of grass, plants and shrubbery.
- Install barriers/curtains to prevent contaminants, debris, and other pollutants entering water bodies.
- Stabilize hillsides to avoid slippage or landslide during torrential rain events.
- Halt and divert to alternate route all associated traffic and movement of residents within this area.

- Put in place with the assistance of the Police Department, all safety measures to ensure no one is in the area except for those authorized.
- Warn the general public via radio and television advertisement of such planned activities.
- Upgrade alternate roadway to temporarily accommodate traffic within this area.
- Put in place all respective dust suppression measures and signage.
- Construct drainage along the roadway to divert any water runoff away from the hillside.
- Place silt traps and silt curtains at the end of this drainage to prevent siltation and other hydrological impacts.
- Leave intact the old road or un-aligned road area to develop a Nature Walk area around this area.

8.6.14 Succotz Alternate Roadway Construction Requirements

- Pave the road to prevent dust formation which would impact the residents.
- Construct proper drainage to drain water away from the roadway and residents.
- Place traffic signs and speed bumps to control traffic within this alternate route.

8.7 Indicative Costing of Mitigation Measures

Table 8.12 provides an indicatives costing for the implementation of the recommended mitigation measures to address the environmental and social impacts associated with the rehabilitation of the George Price Highway and it accompanying activities. The costs are those primarily associated with capacity building and institutional strengthening of the executing and regulatory agencies involved in ensuring compliance monitoring of the ESMP. It also includes the estimated costs for land acquisition and compensation. It must be borne in mind that the major costs associated with mitigation measures have been included in the design features of the project and are part of the pre-feasibility and preliminary engineering design estimates provided by A. Thurton and Associates. In addition, many of the mitigation measures recommended are based on the implementation of best management practices and good industry standards which are intended to be included as conditions in the contracts that would be issued in respect to the rehabilitation of road project.

Table 8.12: BET ADVANCED PRELIMINARY COST ESTIMATES

Environmental and Social Impact Assessments for the Rehabilitation of the George Price Highway

	ITEMS/DESCRIPTION	QTTY	UNITS	RATES	COST : $US
A	**LAND ACQUISITION**				
1	Road Realignment - Roaring Creek				
a	Agricultural Show Grounds: Public Lands	1		0.00	0.00
b	SW Quadrant of Roaring Creek Bridge: Private Property				
	Land acquisition within fenced area	650.00	SY	50.00	32,500.00
c	Riviera bypass: Purchase of 100 feet wide corridor, Private Property	31,740.00	SY	7.50	238,050.00
2	Road Alignment -Roundabout Benque				
a	NE-NW and SE quadrant of Benque Viejo Bridge – boundary with Succotz				
	Land acquisition	1	LS	1000,000.00	1000,000.00
3	San Jose Succotz Village - Ferry Area				
a	Ferry Kiosk demolished and relocate across river	13	only	600.00	7,800.00
b	Construction of replacement kiosks water & sanitation facilities	13	only	3,000.00	39,000.00
4	Z-Curve				
a	John Roberson property Parcel 1, 2 and 3	1,300.00	YDS	200.00	260,000.00
d	Lease of temporary road bypass acres	10	Acre	500.00	5,000.00
5	Succotz Bypass				
a	NE and east of village				
	Alternative Route 2 Section 1 and 2	5,470.00	SY	40.00	218,800.00
	SUB-TOTAL: LAND ACQUISITION				**1801,150.00**
B	**MITIGATION & MANAGEMENT MEASURES**				
1	Mitigation Activities-Material				
a	Streams Cleaning for better flow -3 streams (Red, Garbutt and Barton Creeks)	3	only	4,000.00	12,000.00
b	Z Curve Slope stabilization material (Roll of 300 ft L 15 ft H)	6	Rolls	800.00	4,800.00
c	Culverts for wildlife 3 (Material and labour)	120	LF	450.00	54,000.00
2	Capacity Building				
a	Personnel: Environmental Technician (60% staff time for life of project)	3	yrs	9,000.00	27,000.00
b	Training				
	Risk Identification and Management in Road infrastructure Project	1	only	5,000.00	5,000.00
	Performance Monitoring Evaluation Environmental compliance monitoring	1	only	5,000.00	5,000.00
	Child Protection/Gender for project staff and contractor/workers	1	only	1,000.00	1,000.00
	Training of PEU Staff and PAPs Communities in the use of grievance mechanism	1	only	3,000.00	3,000.00
c	Evaluations				
	Performance Monitoring Evaluation Impact Mitigation Measures-Mid Point and End Point (2 evaluations)	2		6,000.00	12,000.00
d	Design, Development and Deployment of Grievance Mechanism Data Base	1	only	4,000.00	4,000.00
e	Community Liaison Officers: 3 part-time officers, 1 per road Section	3	only	9,000.00	27,000.00
	SUB-TOTAL: MITIGATION & MANAGEMENT MEASURES				**154,800.00**
	TOTAL				**$1955,950.00**

SY: Square Yards; LF: Linear Foot; YRS: Years LS: Lump Sum

Chapter 9 Participatory Public Participation

9.1 Introduction

Public participation is not only a statutory requirement, but a process that is designed to provide interested and affected parties with the necessary and sufficient opportunities to: provide local knowledge on the Project Area; raise issues of concern; identify and confirm issues requiring further investigation in the impact assessment; influence project decisions; evaluate the results of environmental and social impacts and suggest enhancement/mitigation thereof.

Interested and affected parties represent various interests and sectors of society as well as the various relevant organs of government. Through informed and transparent public participation, effective social and environmental management/ mitigation measures can be established and implemented. To this end, the PPP's design focuses on achieving the following objectives:

- Ensure that interested and affected parties are well informed about the proposed Project;
- Provide a broad range of interested and affected parties sufficient opportunity to engage and provide input and suggestions on the proposed Project;
- Verify that interested and affected parties' issues have been accurately recorded, considered and/or addressed;
- Draw on local knowledge in the process of identifying environmental and social issues associated with the proposed Project; and to involve interested and affected parties in identifying ways in which these can be addressed;
- Provide opportunities for clearing up misunderstanding about technical issues, resolving disputes and reconciling conflicting interests;
- Is an important aspect of securing transparency and accountability in decision making;
- Contributes towards maintaining a healthy, vibrant democracy; and
- Comply with legal requirements, as per the EIA regulations.

9.2 Methodology

To achieve effective public participation in the ESIA process, communities along the existing ROW in the Study Area and PAPs were engaged using various methods and techniques and their socio-economic profiles studied to ensure the use of socio-culturally appropriate participatory approaches during the consultations.

Principal among the methods and techniques are the use of key informant interviews, focus group discussions, probability and purposeful surveys, community meetings and the required public consultation as per the EIA regulations.

9.3 Initial Engagement, Information Sharing and Consultations

At the time of the Report preparation, BET had already conducted:

- Key informant interviews with a number of PAPs and general road users inclusive of:
    - ✓ Bus drivers
    - ✓ Taxi operators
    - ✓ Cyclists
- Focus Group Discussions with:
    - ✓ Women
    - ✓ Youth/Cyclists
    - ✓ Educators
    - ✓ Village Council Chairpersons/Councilors
- Socio-economic baseline survey based on:
    - ✓ Probability sample
    - ✓ Purposeful sample

For a complete listing of persons and groups consulted, see Annexes XIII – XVII.

Key to the success of the PPP and an overall underpinning strategy of the BET team in this process was engagement of the village chairpersons/councilors from the PAPs communities as first points of contact. This served not only to validate the legally established leadership in these communities, but also paved the way for the Team to better understand the socio-economic and political context of the communities, map community assets and build excellent rapport for future engagement. The Chairpersons communicated their appreciation for BET's consideration and commented on the number of times activities/projects would be undertaken in their communities without any levels of information exchange much less being consulted.

9.4 Focus Group Discussion

9.4.1 Focus Group Discussions: Village Chairpersons

The PPP included a focus group session with the Chairpersons from the villages of Camalote, Blackman Eddy, Unitedville, Georgeville and Teakettle. A shared concern of these Chairpersons is the continued flooding of certain areas of the GPH in their villages during storms and heavy and prolonged rain events. All Chairpersons identified this as a problem that needs urgent attention; as when these flooding take place, there are major social and economic disruptions, with persons not being able to get to school or work on time, or any at all. All Chairpersons believe that the construction of proper drainage, including culverts with appropriate culvert heads as a part of the Project, especially along the GPH in these areas, will substantially reduce the occurrence of these flooding events. Additionally, and high on the list of priorities was the need for the Project to hire workers from the local communities with special attention given to youth and women in a normally male dominated work force.

Another shared concern of the Chairpersons is the safety of the GPH in their villages for pedestrians and cyclists. Many if not all of these villages have recorded traffic accidents which have resulted in fatalities or serious bodily injury to villagers. Chairpersons attribute many of these traffic accidents to the lack of safety features and pedestrian infrastructure along the portions of the GPH in their villages. This safety issue is even more of a concern where the entrances and exits to schools are located immediately adjacent the GPH, placing children in dangerous proximity to unregulated traffic along these portions of the GPH.

In response to these safety concerns along the GPH in their villages, Chairpersons suggested as an inclusion in the Project, the upgrading or construction of road shoulders on the same level with the road; the construction of walkways and bicycle paths separated from the GPH by drains or other infrastructure where possible; or where land is not available for that option, the construction of elevated sidewalks. They also suggested the construction of appropriate pedestrian crossings, signage, bus stops, lighting, garbage facilities and speed bumps or other traffic calming devices in their sections of the GPH. A final concern of the Chairpersons was the possibility of the Project making arrangements with the appropriate authorities, such as the Department of Transport, to ensure that large trucks and other heavy equipment which passes through these villages and which will pass more frequently once the road is upgraded, especially late at night when villagers are asleep; have proper noise suppression devices attached to these vehicles.

9.4.2 Focus Group Discussion: Youths and Cyclists

A focus group discussion was held with youths and cyclists. The concerns raised with this group understandably reflects those raised by the Chairpersons. Youths and Cyclists first addressed the existing concerns and problems with the GPH and those possibly arising from the rehabilitation work. They identified the existing concerns and problems as:

- the highway being too narrow;
- the highway easily damaged by rain, with too much pot holes;
- a lack of drainage;
- the highway needs to be widened;
- broken edges on road or lane/shoulder drop-offs;
- too much dust in some areas;
- terrible road conditions when it rains; and
- reckless driving.

When the rehabilitation is complete, this group believes a new set of concerns will occupy the attention of villagers within the Project Area. These include:

- increased traffic and speeding;
- fast approaching traffic;
- the need for more speed bumps;
- the need for proper lighting;
- noise pollution;
- dust pollution from works; and
- better road pavement.

This group also focused however on the benefits that would accrue from the rehabilitation of the GPH in their villages. They believe the rehabilitation would lead to more job opportunities, especially during the construction phase and may quite likely lead to more economic opportunities after its completion from local and international visitors coming to experience the local attractions. Another important benefit pointed out by this group was the possibility of faster travelling time to healthcare facilities located outside these communities, in light of the fact that many of these villages are without even a basic health care post.

Finally, this group looked at the safety features to the GPH that should be a part of the Project. Once again, they mirror those put forward by the Chairpersons and include: the erection of street lights and traffic signs and the construction of pedestrian crossings, better drainage, sidewalks and more bus stops.

9.4.3 Focus Group Discussion: Women and Educators

A third focus group which participated in the PPP was that of women and educators. Once again, the concerns raised were similar to those of the previous two focus groups. In looking at the existing problems with the portion of the GPH in their villages, this group saw the road as unsafe particularly because of speeding and reckless driving; believe the road is too narrow, that the highway is easily damaged by rain because of a lack of drainage. They believe the road has too many pot holes, needs to be widened and has many broken edges. In certain areas they also complain of too much dust and terrible conditions when it rains.

Like the other two focus group before, women and educators listed the following as concerns once the GPH is rehabilitated:

- more traffic and speeding on the highway;
- fast approaching traffic;
- a need for more speed bumps;
- a need for proper lighting;
- noise pollution;
- dust from works;
- a better road pavement;
- a need for pedestrian crossings especially for school children and the elderly;
- a need for highway patrols; and

- the loss of livelihood during the construction period.

Women and educators likewise view the main benefits from the proposed road project being a more comfortable ride on the rehabilitated road, faster travelling time to healthcare facilities and work places, more job opportunities, increased visitors/tourists to area, and more attraction from local and international visitors. Notwithstanding a core issue needing address is the potentially negative impact of the work force as it relates to sexual exploitation of adolescent girls and harassment of women by the predominantly male work force. On a final note, this focus group recommended for inclusion in the Project, the following safety improvements to the sections of the GPH passing through their communities: street lights, traffic signs, pedestrian crossings, better drainage, sidewalks, and more bus stops.

9.5 Socio-Economic Baseline Survey

The Socio-Economic Baseline Survey was conducted during the month of June by BET targeting two principal audiences within the Study Area: a random sample of households drawn from the communities along the existing ROW based on sample size of 232 Household (HH), confidence level of 95% and limits of 7% with overall response rate of 97%; and a purposeful sample of HH in close proximity/within the 100 feet wide corridor. For a complete presentation of the key findings of the Survey disaggregated by the three (3) defined Road Sections along the existing ROW, see Chapter 5: Socio-Economic Setting.

Given the traditionally low participation levels and non-representativeness of participants associated with community meetings, the probability Survey method and the information generated therein offers a solid and representative insight into the existing conditions and perceptions of PAPs communities and should be viewed as a key tool of community consultation on the proposed Road Project.

9.6 Community Meetings and Public Consultations

9.6.1 The Feedback Loop: Community Meetings

As a further element of the PPP, three community meetings are planned across the Road sections as per schedule outlined in Table 9.1.

The Meetings are being coordinated with the respective village chairpersons of the communities within the Road Sections who have agreed to assist with the mobilization of their respective communities; additionally the use of flyers inviting PAPs and a radio PSA will be utilized. The overall objective of the community meetings is fourfold:

- Further share information on the proposed Road Rehabilitation Project
- Provide feedback on the FGD and SES recently conducted
- Share preliminary information on the proposed Road Project alternatives
- Facilitate dialogue and solicit recommendations from the PAPs on the above to validate the preliminary Road Project design.

For completeness and reinforcing the multidisciplinary nature of the Road Project, the Meetings are being planned jointly with the MOWT and the pre-feasibility Consulting Firm, Anthony Thurton and Associates.

Table 9.1: Schedule of Community Meetings Across Road Sections

Activity	Date	Venue	Time
Community Meeting, Road Section I: Roaring creek; Camalote; Teakettle; Ontario; Blackman Eddy and surrounding communities	Saturday August 9, 2014	Camalote	1:00 p.m.
Community Meeting, Road Section II: Central Farm, Unitedville, Georgeville, Esperanza and surrounding communities	Saturday August 9, 2014	Georgeville	4:00 p.m.
Community Meeting, Road Section III: San Jose Succotz, Benque Viejo del Carmen and surrounding communities	Sunday August 10, 2014	Succotz	3:00 p.m.

9.6.2 The Legal Requirement: Public Consultation

In tandem with the EIA Regulations Chapter 328 Section 20, Box 9.1, intended public notification is scheduled for the week ending August 3, 2014 in the major print media.

Box 9.1: EIA Regulations Chapter 328 Section 20

(1) A person who has submitted an environmental impact assessment shall, as soon as may be, publish in one or more newspapers circulating in Belize a notice:

(a) stating the name of the applicant;

(b) the location of the land or address in respect of which the environmental impact assessment relates;

(c) stating that application has been made and indicating the location and nature of the proposal to which the application relates;

(d) stating that an environmental impact assessment has been prepared in respect of the proposal;

(e) naming a place where a copy of the environmental impact assessment may be inspected free of charge;

(f) specifying the times and the period (being the prescribed period) during which the environmental impact assessment can be so inspected;

(g) stating that any person may during the prescribed period make objections and representations to the Department in relation to the effects of the proposed project activity on the environment;

(h) the date on which the environmental impact assessment shall be available to the public;

(i) the deadline and address for filing comments on the conclusions and recommendations of the environmental impact assessment.

(2) An environmental impact assessment submitted by a developer shall be accompanied by a copy of a newspaper in which there has been published a notice in accordance with sub-regulation (1).

REFERENCES

AGRA CI Power, 1999. Macal River Upstream Storage Facility Feasibility Study and Environmental Impact Assessment Report prepared for Belize Electricity Limited.

Anderson, E.R., et al., 2008. Potential Impacts of Climate Change on Biodiversity in CentralAmerica, Mexico, and the Dominican Republic. CATHALAC / USAID. Panama City,Panama, 105 pg.

Arevalo, B., Cal, R., Gentel, G., Gamez, G. & Gamez V., 2012. Vaca Hydroelectric Project Wildlife Monitoring Study: Dry and rainy season monitoring technical report (2011). Friends for Conservation and Development. San Jose Succotz, Belize. p. 54.

Arivgo, Rosita, 1992. Panti Maya Medicine Trail Field Guide. Tropical Research Foundation Ltd. San Ignacio, Cayo, Belize.

Arvigo, Rosita and Michael Ballick, 1992. Rainforest Remedies, One Hundred Healing Herbs of Belize. Lotus Press, Twin Lakes, WI.

Awe, J.J. et al., 2014. Archaeological Assessment and Impact Analysis of the George Price Highway between the Belmopan Jct. (Mile 47.9) and the Guatemalan Border (Mile 74.9). Report Prepared for Belize Environmental Technologies, Belize July, 2014.

Barlow, Virginia. 1993. The Nature of The Islands, Plants and Animals of the Eastern Caribbean. Chris Doyle Publishing and Cruising Guide Publications, Dunedin, FL.

BAS 2014. Guanacaste National Park. Retrieved July 5, 2014. http://www.belizeaudubon.org/protected_areas/guanacaste-national-park.html.

BCES, 2006. Belize Country Environmental Profile. Second edition, revised, K. Mustafa Toure Consulting Editor. Ministry of Natural Resources and the Environment. CCAD/Earth Council, Belize Audubon Society.

Beca International Consultants Ltd, 1999. Belize-Burrell Boom Road Upgrading Project: Environmental Impact Assessment and Economic Analysis, prepared for Ministry of Works and Transport, Belize 1999.

Beca International Ltd, 2001 Airport Link Road: Preliminary Design Report, prepared for Ministry of Transport, Government of Belize.

Beca International Ltd, 2002 Airport Link Road: Design Report, prepared for Ministry of Transport, Government of Belize.

Beca International Ltd, 2005. Placencia Road Upgrade Environmental Impact Assessment, prepared for Ministry of Works and Transport, Government of Belize.

Belize Audubon Society, 2001. Belize Biodiversity Information System Bird List for Guanacaste National Park. Compiled by Chris Hecker, July 4, 2001 Belize.

Belize Biodiversity Information System. Website http://fwie.fw.vt.edu, Belize Ministry of Natural Resources Land Information Centre.

Belize Electricity Company Limited (BECOL), 2001. Macal River Upstream Storage Facility Environmental Impact Assessment: Part 2 Support Documents, Volume II of IV. AMEC E&C Services Ltd.

Boles, E. and Boles, R. (2009). Mopan-Macal-Belize Watershed Atlas. Friends for Conservation and Development (FCD). San Jose Succotz, Belize.

Borenstein, S., 2013. There's More Carbon Dioxide in the Air Now Than Any Time in 3 Million Years. Associated Press, May 10, 2013. http://twitter.com/borenbears.

Bunce, Nigel J., 1993 Introduction to Environmental Chemistry. Published 1993 by Wuerz, Winnipeg, Canada.

BWS Annual Report 2008-2009.

Canter, L. W.1996. Environmental Impact Assessment 2nd Edition McGraw Hill.

Canter, L.W. 1993. The Role of Environmental Monitoring in Responsible Environmental Management, vol. 15 of 1993.

Castañeda, A. 2007. Technical Needs Assessment of Agriculture Sector in Belize. Second National Communication to the UNFCCC. Belize Climate Change. MNRE 2007. Belmopan, Belize.

Central Statistical Office, 1997. Abstract of Statistics, 1997.

Central Statistical Office, 1999. Environmental Statistics for Belize, 1999.

Chauhan, Surender Singh, 2010. Mining, Development and Environment:A Case Study of Bijolia Mining Area in Rajasthan, India. J Hum Ecol, 31(1): 65-72 (2010). "

"Corbit, D.S. 1998: Standard Handbook of Environmental Engineering, Second Edition, McGraw Hill.

Cornec, J. H., 1986, Provisional geological map of Belize at the scale of 1:250,000:Petroleum Office, Ministry of Natural Resources, Belmopan, Belize.

Cornec, J. H., 2003, Geology map of Belize,1:750,000: compiled and published lished by J. H. Cornec. Belmopan.

Cover and Land Use, Central Belize, 1998 Report.

Cure. J.D. and B. Acock, 1986. Crop responses to carbon dioxide doubling: A literature survey. Agriculture and Forest Meteorology, 38, 127-145.

Davis, M.L. and Cornwall, D.A. 1998. Introduction to Environmental Engineering, Third Edition, McGraw Hill ISBN 0-07-015918-1.

Department of Enviroment, 2014. Accessed July 16, 2014. http:///www.doe.gov.bz.

Dixon, C.G., 1956, Geology of Southern British Honduras: Belize City, Belize.

DOE, 1995. Environmental Water Quality Monitoring Program, Final Report and Annexes. GOB/USAID.

EPA Identifies Noise Levels Affecting Health and Welfare, 1974-04-02. Retrieved June 2011.

ESL Management Solutions Limited 2006. Environmental Impact Assessment: Vaca Hydroelectric Project, Cayo District Belize prepared for Belize Electric Company Limited.

Esselman P.C. & Boles E., 2001. Status and future needs of limnological research in Belize. In: Limnology in Developing Countries Volume 3. (eds R.G. Wetzel & B. Gopal), pp. 35-68. International Association for Limnology, New Delhi, India.

Esselman P.C., 2007. Draft Report - Predicted Spatial Success of African Tilapia in Rivers Draining to the Coast of Belize: Preliminary Results and Expanded Applications.

Esselman P.C., 2009. Fish communities and conservation of aquatic landscapes on Northeastern Meso-America.

Esselman P.C., Freeman M.C. & Pringle C.M., 2006. Fish assemblage variation between geologically defined regions and across a longitudinal gradient in the Monkey River Basin, Belize. Journal of the North American Benthological Society, 25, 142-156.

Fabro, I.E. and J.R. Rancharan, 2008. Environmental Audit and Review ? Old Belize Adventure Cucumber Beach Marina, Belize. December 2008.

FAO, 2013. Climate-Smart Agriculture Sourcebook. E-ISBN 978-92-5-107721-4 (PDF). Rome.

Federal Highway Administration, 2014. Noise Effect on Wildlife, Federal Highway Administration Us Department of Transport, 2014. Accessed July 2, 2014. http://www.fhwa.dot.gov/environment/noise/noise_effect_on_wildlife/effects/wild04.cfm

Franks JR, Stephenson MR, and Merry CJ. Preventing occupational hearing loss. A practical guide. DHSS (HIOSH) pub. No. 96-110. And National Institute of Deafness and Other Communicative Disorders: Noise Induced Hearing Loss.

Frutos, R. and Tzul, F. 1995. Impact of Climate Change on Maize, Dry Beans and Rice Production in Belize. Central American Climate Change Project: Agricultural Sector. National Meteorological Service and the Department of Agriculture and Fisheries, Belize.

Frutos, R. and Tzul, F. 1999. Mitigation - Adaptation: Agriculture Sector. Climate Change Project - Belize.

Frutos, Ram¢n, Central American Cold Surges: Some Effects on Citrus and Banana Production Belize, M.Sc. Dissertation, 1996, University of Reading, U.K.

Graf, Alfred Byrd. 1986. Tropica. Roehrs Company, U.S.A.

Graham, Russell et al., 2004. Science Basics for Changing Forest Structure to Modify Wildlife Behaviour and Severity. Gen. Tech. Rep. RMRS-GTR-120. Fort Collins, Co. USA. http://www.fs.fed.us/rm/pubs/rmrs.gtr120.pdf. Retrieved June 2012.

Greenfield, D.W. and J. E. Thomerson. 1997. Fishes of the Continental Waters of Belize. University Press of Florida, Gainesville, FL USA; 1st edition (May 24, 1997).

Halcrow Group Limited, 2010. Macal River Second Crossing Environmental and Social Impact Assessmentprepared for Ministry of Works and Transport, Belize July 2010.

Halcrow Group Limited, 2010. Macal River Second Crossing Environmental and Social Impact Assessmentprepared -Supplement to Final Reportfor Ministry of Works and Transport, Belize September 2010.

Hartshorn, G., et al., 1984. BELIZE Country Environmental Profile, A Field Study USAID Contract San Jose. Trejos. Hnos.Sucs. S.A. pp. XVI152.

Horwich, Robert H. and Jonathan Lyons. 1990. A Belizean Rainforest, The Community Baboon Sanctuary. Hynek Printing, Richland Center, WI.

IPCC, 2013. Summary for Policymakers. IPCC AR5 WG1, Stockholm, Sweden.

IPPCC Fourth Assessment Report, 2007

iRAP, 2012. iRAP Belize Final Technical Reportprepared by Julio Urzua and Douglas W. Harwood for the Government of Belize funded by the Caribbean Development Bank,
the FIA Foundation for the Automobile and Society and iRAP, 15 March, 2012.

Janzen, Daniel H. 1983. Costa Rica Natural History. University of Chicago Press, Chicago, IL.

Land Resource Assessment of Northern Belize Volume I.

Laws of Belize Revised Editions 2000 and 2003. Retrieved July, 2014 from http://belizelaw.org.

Lefond, S.J. and R. Foad, 1976. Belize Industrial Mineral Survey. Geology Office, Belompan.

Lennox , G.W. and S.A. Seddon. 1990. The Flowers of the Caribbean, the Bahamas and Bermuda. MacMillan Education Ltd. London and Basingstoke.

LIC (MNRE)/ UNDP/CSR/BEG University of Austin (----). Texas, Remote Sensing Analysis of land

Magana, V, O. R., 2009. Guide to Generate Regional Probabilistic Climate Change Scenarios for Decision Making. Center for Atmospheric Science, UNAM, Monterey, Mexico, July 2009. National Meteorological Service of Belize, CLICOM and HOMS Database.

Marcus, L. G. 1979: A Methodology for Post-EIS (Environmental Impact Statement) Monitoring. US Geological Survey Circular 782, US Geological Survey.

McSweeney C., M. New and G. Lizcano (2009). UNDP Climate Change Country Profiles Documentation: Draft Report: 18 p.

Meekin, T, 1985. Survey of the small scale tropical freshwater fishery at Crooked Tree Lagoon.

Meerman, J., J. McGill, M. Cayetano 2011. Belize National Land Policy for Land Resources Development. Belmopan, Belize.

Milius, S. (2007). High Volume, Low Fidelity: Birds are less faithful as sounds blare, Science News vol. 172, p. 116.

Miller, Matt (original draft). Guanacaste National Park, Tree Guide. Belize Audubon Society, Belize City, Belize.

Mitchell, TD et al, 2003. Tyndall Centre for Climate Change Research, University of East Anglia. www.cru.uea.ac/uk/~timm.

Morton, Julia. 1971. Plants Poisonous to People in Florida, and other warm areas. Fairchild Tropical Gardens. Miami, FL.

Morton, Julie. 1977. Wild Plants for Survival in South Florida. Fairchild Tropical Gardens. Miami, FL.

NARMAP (1995) Environmental Water Quality Monitoring Program Final Report. Natural Resource Management and Protection Project. USAID Project No 505-0043 Belize.

Nathanson, J.A. 1996. Basic Environmental Technology: Water Supply, Waste Management and Pollution Control. 2ND Edition.

National Adaptation Strategy to address Climate Change in the Water Sector in Belize, 2009.

NHDAC/UNDP/GOB, Taking Stock: National Human development Report 1997.

Nicolait, Robert and Associates Ltd. 1984. Belize Country Environmental Profile, A Field Study. 1984. Trejos Hnos., Sanjose, Costa Rica.

Noise Effects on Wildlife, 2014. Accessed July 2014 http://www.fhwa.dot.gov/environment/noise/noise_effect_on_wildlife/effects/wild04.cfm.

PAHO & Ministry of Health Belize, 2005. Report on the study of mercury content in fish life from three rivers in the Cayo District.

PAHO/WHO, GOB Sectoral Analysis in Water Supply and Sanitation in Belize, 1995. Sectoral Analysis Series, No. 5.

Pollution Regulations, 1996, Statutory Instrument No. 56 of 1996 Department of the Environment.

Ramirez, D. et al., 2013. Belize Effects of Climate Change on Agriculture. ECLAC/CCAD/DFID. Mexico, D.F. Printed United Nations NY, January 2013.

Rogers, H.H.; R.C. Dahlmann, 1993. Crop responses to CO2 enrichment. Vegetatio, 104/105, 117-131. Technical Cooperation Programme, FAO/ Government of Belize, Water Resources Management Policy, Planning and Organization, November 1994. Final Report.

Salinger, M.J., Stigter, C.J., Das, H.P., 2000. Agriculture and Forest Meteorology: Agrometeorological adapatation strategies to increasing climate variability and climate change. Paw, K. T., 2000 Editor Chief. Elsevier Vol 103, Nos. 1-2 June 2000.

Seddon, S.A. and G.W. Lennox. 1993. Trees of the Caribbean. The MacMillan Press Ltd., London and Basingstoke, Printed In Hong Kong.

Selvaraju R., et. al, 2013. Climate Change and Agriculture in Jamaica. Agriculture Sector Support Analysis, Environment and Natural Resources management Series 21 Monitoring & Assessment ISSN 2071-0992. IDB - FAO.

Souviron, A. 1991. Survey of Iindustrial Minierals of Belize, Geology Office , Belmopan

The Belize Forestry Department. 1946. Forty-Two Secondary Hardwood Timbers of British Honduras. Bulletin No. 1.

Trumbach, D. MSPH ENHS, 1994. : Analysis of Ground water Quality and the Monitoring Program of the Public Health Bureau of Belize. PAHO-Belize/MASICA/PROAGUA, 1994.

Tunich Nah Consultants & Engineering, 2004. Phillip S.W. Goldson International Airport Environmental Impact Assessment, Belize 2004.

Tunich-Nah Consulting and Engineering, 2010: A proposed Road Restoration and Upgrade Project for New River Enterprise, TNCE.

"TYPSA, 2010. Global Study to Propose Specific Interventions to Reduce the Belizean Road Network Vulnerability to Flooding Events-Final Report. Prepared for the Government of Belize, Belize, August 2010.

UNICEF / Central Statistical Office Belize, The Right to a Future: A Situational Analysis of Children in Belize, 1995.

University of Colorado, 2009. http://www.colorado.edu/news/releases/2009/07/23/noise-pollution-negatively-affects-woodland-bird-communities...Retrieved June 2012.

"Water Resources Assessment for Belize. US Army Corps of Engineer, US Army TEC, US Southern Command, March 1999.

Watershed-Reef Interconnectivity Scientific Study: Stann Creek Area and Southern Belize, 1997-2000, WRISCS Newsletter, Vol. 1, May 1998. www.icran.org

WMO, 2014. WMO Statement on the Climate. www.wmo.org

Woodside, G. 1951. Environmental, Safety and Health Engineering. John Wiley & Sons Inc. Diana Kocurek, May 27, 1997.

World Resources Institute (WRI), 2005. Navigating the Numbers Greenhouse Gas Data and International Climate Policy, USA.

Wright, et al. 1959. Land of British Honduras. Her Majesty's Stationary Office. York House Kingsway, London, WC2.

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