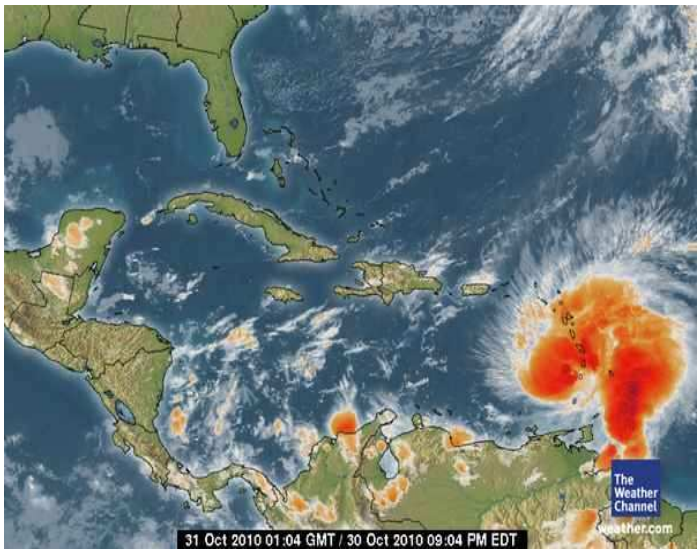
HURRICANE TOMAS

DAMAGE ASSESSMENT REPORT

With Technical Assistance by

Association of Professional Engineers of St. Lucia (APESL Inc.)



Version 1.0 - Issued December 07, 2010

Contents

Background

Saint Lucia was severely impacted by winds and heavy rains from Hurricane Tomas which was so declared at the 11:00 am Advisory of October 30, 2010. The hurricane, which arrived on St. Lucia as a category 1 system with sustained winds of 75 mph, slowed significantly from 17 mph to 9 mph forward speed, increasing to a category 2 system with winds of 100 mph before leaving the island. The All-clear was issued at 12:00 noon on October 31, 2010.

St. Lucia's Prime Minister issued a Disaster Declaration on October 31, 2010, effective up to November 14, 2010.

Context & Objective

The National Emergency Management Advisory Council (NEMAC) comprises several agencies and committees tasked with specific responsibilities towards an effective and efficiency framework for disaster planning, mitigation, response and rehabilitation / reconstruction. The National Damage and Needs Assessment (DANA) Committee of NEMAC comprises several sector agencies and others with specific competencies to assist with its mandate.

DANA's reporting framework is summarized in Appendix A and is characterized by incremental reports. To date DANA has issued the following to the national Emergency Management Organization (NEMO), based on information received, through NEMO, from District Disaster Committees and specific sector agencies:

#	**Report**	**Issue Date**
1	Initial Situation Overview – ISO No. 1, 2 & 3	30th October 2010
2	National Damage Assessment Report – 01	2nd November 2010
3	National Damage Assessment Report – 01(1)	5th November 2010
4	National Damage Assessment Report – 01(2)	7th November 2010

These reports would have provided initial 'snap shots' and information to determine immediate actions necessary to respond to the effects of the events.

The extensive impact of the hurricane warranted key agencies to focus on delivering / executing emergency actions for protection and critical response. Coupled with capacity and logistical

issues, the production and updating of detailed, timely reports from agencies (including key Government Ministries) has been very challenging.

Recognizing this challenge, the DANA chair, in consultation with the NEMO director, commissioned the assistance of the Association of Professional Engineers of St. Lucia (APESL Inc. – a member of the DANA Committee). On Tuesday 9th November 2010, a meeting was held with a team of volunteer, private Engineers, who were deployed to undertake assessments and make recommendations with respect to specific sectors, locations and impacts, as follows, based on the key "hot spots" and available competencies / expertise:

Road Infrastructure
- Christopher Wyatt
- Eglan Flavien
- Robertson Felicien

Housing and Settlements
- Arlette St. Ville
- Lyndell Gordon
- Adrian Dolcy

Geotechnical: Roads and Settlements
- Roosevelt Isaac
- Bradley Sadoo

Institutions and Public Buildings
- Adrian Dolcy
- Neil Williams
- Roland Theobalds

Rivers Management
- Eglan Flavien
- Norman St. Ville
- Arlette St. Ville
- John Peters

The objective was <u>not</u> an exhaustive coverage of every sector / location / damage, but <u>to add value</u> to the general process through specific technical assessments and recommendations related to key impacts. The assessments were conducted within 1 – 2 weeks, using / based on the form developed as in ***Appendix B***.

It was anticipated that the reports may be serve as base data / information and rapid technical expert advise for NEMO, sector agencies / Ministries, the Government of St. Lucia and relevant external agencies in the process of planning and designing the response, recovery and redevelopment exercise. To date significant portions of the report would have been transmitted to and used by the UNECLAC team commissioned by the Government of St. Lucia (in collaboration with the OECS Secretariat) to undertake a Macro Socio-Economic Assessment of Hurricane Tomas (November 17 – 24, 2010).

Compiled by
Chamberlain Emmanuel – DANA Committee Chairperson

River Management

EXECUTIVE SUMMARY

Hurricane Tomas deposited on average 24 inches of rainfall throughout the island over a twenty four hour period. This level of rainfall caused significant loss of property and some lives in the floodplains of St. Lucia. There was also tremendous impact on the hydraulic infrastructure of the island.

The river management initiatives are based on the following objectives

a. to ensure some level of immediate protection to lives and property and to ensure that in the medium term the river courses and drainage channels can accommodate the runoff in the next wet season.
b. Flood mitigation measures
c. Hydrological modelling to inform the planning process for flood proofing future development in the floodplain
d. Watershed management in key areas
e. Establishment of early flood warning systems

The team adopted a 'lessons learned' approach and revisited the response to Tropical Storm Debbie in 1994. A review was done of the World Bank Report on the implementation of projects done as a result of the Bank's intervention post Debbie. Five projects have been developed for possible funding from financial institutions.

PACKAGE 1(A): (I) IMMEDIATE REHABILITATION OF RIVERS, DRAINAGE CHANNELS AND UPSTREAM (II) SLOPE STABILIZATION AND SOIL EROSION MITIGATION MEASURES

This project will look at the critical watershed areas and de-silt the rivers to reinstate the hydraulic capacity of the river courses. The Debbie experience showed that there was no parallel attention to reducing the soil erosion that was occurring upstream, and this result in the loss in the effectiveness of the immediate response. This project is structured to allow both activities to occur in parallel.

The project also includes de-silting many of the urban drainage channels that are also severely affected.

It is the intent to create a labour intensive component to provide relief to those in these communities who are mainly into farming and have lost their source of income and employment. The soil erosion mitigation and slope stabilization that will occur upstream will be a labour intensive exercise.

ESTIMATED COST: $ 20,000,000 XCD

PACKAGE 1(B) - RIVER TRAINING: CUL DE SAC RIVER – SAROT TO L'ABAYEE

The team looked at the bank of the river that is closer to the East Coast Road and concluded that river training should be pursued in this section of the river. The East Coast road is a major arterial link to the south of the island and the works will mitigate the over flooding unto the roadway. During Hurricane Tomas the roadway was flooded over one metre in some areas.

ESTIMATED COST: $ 15,000,000 XCD

PACKAGE 2 – HYDROLOGICAL CONSULTANCY

The team is of the opinion that there needs to be some hydrological studies involving modelling in the floodplains to determine the high water mark. It is though that such data will inform the planning process and thus application for development in the floodplain will be subjected to the established high water mark. Recommendations for flood proofing buildings in the flood plain will also be a deliverable.

ESTIMATED COST: $ 1,700,000 XCD

PACKAGE 3 – EARLY FLOOD WARNING SYSTEMS

This project is a roll-over from the initiatives funded by the World Bank. It appears that this project was never implemented due to concerns on the suitability of the selected system. Such systems have been quite successful in Jamaica and have been proven to save lives. The Hydrological study will inform the establishment of the early flood warning system.

ESTIMATED COST: $ 2,000,000 XCD

PACKAGE 5 – FOND ST JACQUES WATERSHED PROGRAMME

The lands at Fond St. Jacques are important to the agricultural sector of St. Lucia. These fertile lands cannot be removed from the agricultural land bank of the nation, and the resultant dislocation of a significant farming community is of some concern. The project will look at the watershed and develop relevant farming practices for the area. The project will be informed by the geotechnical studies, and preliminary review has shown that the ground water sources have been a major cause of the slides.

There are possibilities of incorporating irrigation techniques with the ground water relief that may be proposed in reducing slides.

ESTIMATED COST: $ 3,500,000 XCD

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT FORM

DATE:	LOCATION/LANDMARKS:	SECTOR TEAM:
10-16th Nov 2010	*12 PRIORITY RIVERS (GPS Coordinates):*	**John Peters, Norman St. Ville, Arlette St. Ville**

DESCRIPTION of issue/problem (*quantify scale /dimensions*):

Riverbanks eroded, culverts were washed away, bridges damaged, channels widened, extensive silt deposition, and river channels rerouted.
Large scale flooding exacerbated by multiple major landslips upstream resulting in blocking of major access roads, destruction of property, silt and debris deposition and blocking of watercourses Of the 37 major watershed areas in St. Lucia, 12 were affected by Hurricane Tomas (population, infrastructure/transportation networks) including:

1. Cul de Sac /Marc River
2. Roseau River
3. Choc River
4. Soufriere River/Fond St. Jacques
5. Castries River
6. Canaries River
7. Dennery River
8. Anse La Raye River
9. Fond Dor River
10. Mamiku River
11. Fond River
12. Vieux Fort River

CAUSE/TRIGGER of issue/problem (*what caused it to happen*):

The main cause of the flooding issues related to Hurricane Tomas was the sheer magnitude of this event. H. Tomas would be classified as a 1 in 100 rainfall event with precipitation over 300mm in a 24 hour period (like Tropical Storm Debbie-1994).

Saturated soils from high volumes of continuous precipitation, fallen trees from high winds and debris from landslides choked gullies and watercourses, creating blockades dams that trapped enormous quantities of water before giving away, washing away bridges and flooding adjoining farmland and settlements.

According to data from the Meteorological Department this rainfall even in the 24-48 hour period resulted in 593mm/23.4 inches of rainfall in the South (Vieux Fort), 533.3mm/21.0 inches in the North (Castries), 405 mm/15.9 inches in the North West (Anse La Raye), 668 mm/26.3 inches in the East (Soufriere) and 635 mm/25.0 inches in the interior (Forestiere).

PHOTOS (*showing state of issue/problem*)**:**

FLOODING AND SILTATION BY THE CASTRIES RIVER OF CENTRAL BUSINESS DISTRICT, BRIDGE STREET

FLOODING AND SILTATION BY THE CASTRIES RIVER OF JEREMIE STREET

FLOODING AND SEDIMENTATION FROM THE CUL DE SAC RIVER AT THE SARROT GAP

SILT DEPOSITION ALONG THE MAIN RIVER CHANNELOF THE CUL DE SAC RIVER AT BEXON

SILT DEPOSITION FROM THE CUL DE SAC RIVER ALONG CASTRIES VIEUX FORT HIGHWAY-LABAYEE

RISKS related to issue/problem *(probability of harmful consequences/ losses -deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):*

Risks include loss of property, injury to residents and death (at least 2 persons died when their vehicles were swept away by flood waters).

Urban drainage systems were severely affected with communities along the Castries River impacted by flooding from Hurricane Tomas and included:

- Castries-Riverside Road 57 households/99 residents
- Castries-Jeremie Street 29 households/62 residents
- Castries-Waterworks 48 households/104 residents
- Castries-La Clery CDC 63 households/116 residents
- Castries-Faux-a-chaud 84 households/147 residents
- Castries-Georgeville 135 households/268 residents
- Castries-Almondale 7 households/16 residents
- Castries-Entrepot-61 households/161 residents
- Castries-New Village-189 households/400 residents
- Castries-Coral Street-11 households/32 residents
- Castries –Victoria Street-162 households/309 residents
- Bagatelle (lower)- 90 households/291 residents
- Marchand 130 households/374 residents
- Tro Rouge 149 households/486 residents
- Marchand Boulevard 142 households/424 residents

Rural communities impacted by the 12 rivers listed above and included:

1. Marc River: Crownlands, -75 households/172 persons
2. Cul de Sac River: Labayee, Bexon, Odsan-679 households/1358 persons/Des Glos 61 households/112 persons
3. Roseau River: Coolie Town-268 households/559 persons
4. Choc River: Almondale 7 households/16 persons
5. Soufriere River/Fond St. Jacques
6. Castries River (see above)
7. Canaries River: Village 568 households/1141 persons
8. Dennery River: Village 302 households/966 persons
9. Anse La Raye River: Village 642 households/1082
10. Fond Dor River: Grande Ravine 350 households/704 persons
11. Mamiku River: Agricultural production
12. Fond River: Agricultural production

RECOMMENDATIONS/Mitigation (*structural/non-structural measures to limit adverse impact* **):**

IMMEDIATE/short term:

PROJECT TITLE: Rehabilitation of Hydraulic Infrastructure Project, Construction and Stabilization of river walls and berms and Conservation and Stabilization of slopes of upper watersheds

ESTIMATED COST: 35,000,000 ECD

SILT DEPOSITION FROM THE CUL DE SAC RIVER IN FRONT OF THE BEXON PRIMARY SCHOOL

SILT AND DEBRIS DEPOSITION ALONG THE MAIN RIVER CHANNELOF THE MARC RIVER AT MARC BRIDGE

SILT AND DEBRIS DEPOSITION ALONG THE MAIN RIVER CHANNELOF THE MARC RIVER

REMNANTS OF REPORTED 5 FEET FLOOD WATERS AT MARC AND SILT DEPOSITION ALONG DRAINS AND ROADWAYS

FLOODING AND SILT DEPOSITION BY THE CUL DE SAC RIVER AT CUL DE SAC INDUSTRIAL ZONE

SILT DEPOSITION FROM THE ROSEAU RIVER ALONG THE CHANNEL AT VANARD

Justification/objective:

1. To undertake labour intensive conservation measures upstream to protect the productive valleys downstream
2. Identification, prioritization and design of upstream rehabilitation measures (labour-intensive) to control erosion and stabilize steep slopes.
3. Development of at least 3 pilot demonstration projects of best practice for training and capacity building in rehabilitation of rivers, construction of berms and upper watershed management.
4. Removal of river debris and obstructions (deposited there by Hurricane Tomas) as the arrival of the next wet season is a serious concern as the volume of soil and debris which the storm washed into the rivers reduced channel capacity greatly increasing the risk of flooding.
5. Immediate need to repair the damage to hydraulic infrastructure
6. Restoring and protecting priority river basins and drainage areas, with labor intensive works that provided disaster-stricken families with badly needed incomes.
7. To address the short long term requirements by immediate execution of priority river and drainage rehabilitation works, together with supervisory engineering services for their implementation and surveys to develop design criteria for improved river works
8. Identification, prioritization and design of River training measures to modify or constrain the behavior of rivers, typically including the creation of new embankments and the upgrading of existing ones,
9. Planting of certain varieties of trees and grasses to hold soil in place, stabilizing the outer edge of river bends using stones or other inorganic material to lessen erosion and to keep the river to its course.

PROJECT TITLE: Urban small drains desilting Project (towns and villages)
ESTIMATED COST: 3,000,000 ECD

Justification:

1. Removal of river debris and obstructions (deposited by Hurricane Tomas) as the arrival of the next wet
2. Season is a serious concern as reduced channel capacity greatly increasing the risk of flooding
3. In the urban areas works are required to construct and repair of stormwater drainage canals and the construction of retaining walls along rivers.
4. These works are mainly for urban areas where channels are located within high density areas within the city limits o f Castries and several other urban neighborhoods.

SILT DEPOSITED BY THE MILLET RIVER ALONG THE MAIN RIVER CHANNEL AT MILLET

FLOODING AND SILT DEPOSITED BY THE ROSEAU RIVER ON THE WEST COAST HIGHWAY AT ROSEAU

SILT DEPOSITION BY THE SOUFRIERE RIVER AT FOND ST JACQUES

SILT AND DEBRIS DEPOSITION BY THE SOUFRIERE RIVER ALONG MAIN CHANNEL AT FOND ST JACQUES

SILT DEPOSITED IN THE TOWN OF SOUFRIERE BY THE SOUFRIERE RIVER

STRATEGIC/medium-long term:

PROJECT TITLE: Early flood Warning and Risk Assessment System Project on 12 critical rivers.
ESTIMATED COST: EC$2,000,000

Justification/objective:

1. There is need to improve GOSL/NEMO understanding of flooding risk, capacity to manage and ability to respond effectively.
2. To prevent loss of life and reduce the economic damage caused by floods.
3. This is achieved through the ability to forecast likely flood conditions and provide interpretation and warnings to those at risk.
4. Development of a Flood Direct Warnings service, which will allow members of the public to register to receive direct warnings to their mobile phone.
5. Rainfall and river level monitoring across the catchment areas to generate improved information on conditions, which will then be used to provide advance warning of flooding to members of the public

PROJECT TITLE: Development of Hydrological and hydraulic models on 12 critical rivers (Technical Assistance).
ESTIMATED COST: EC$1,700,000

Justification/objective:

1. To integrates a multiple numerical weather/climate prediction system with hydrological and hydraulic models to model flood event prediction and risk analysis.
2. To should satisfy the unmet technological demands in the field of flood prediction and risk analysis.
3. To develop appropriate software to assist end-users such as planning department (to identify high water marks in critical communities to guide all future planning development), insurance companies (using flood risk maps to estimate loss values and calculate premium to be allocated to specific regions), engineers (to provide sound climate-proof design for flood defences and other hydraulic structures, public (to give timely and relevant information that can be used for flood-proofing of residences)
4. Develop data to inform the design, equipment procurement and communication activities of Early flood Warning and Risk Assessment System Project
5. To develop recommendations to inform the activities of the DCA/Planning Department in approving development and land use planning/zoning activities

SILT AND DEBRIS IN THE MAIN CHANNEL DEPOSITED BY THE SOUFRIERE RIVER NEAR NEW DEVELOPMENT

SILT DEPOSITION BY THE CANARIES RIVER NEAR MAIN BRIDGE

SILTATION AND DEBRIS DEPOSITION BY THE FOND DOR RIVER NEAR THE GRANDE RIVIERE BRIDGE

SILT DEPOSITED BY THE DENNERT RIVER NEAR MOLE ROAD

FLOODING AND SILTATION IN DENNERY OFF THE MAIN STREET

				ELEMENTS at risk *(place an **x**)*:			
				Utilities	**X**	**Institutions**	**X**
Risk SIGNIFICANCE level *(Magnitude/Frequency/Duration)**: x***				**Industry**	**X**	**Tourism**	
URGENT/INTOLERABLE	**X**	**CRITICAL/NON-ACCEPTABLE**		**Population**	**X**	**Transport System**	**X**
MINOR		**TOLERABLE**		**Natural Resources**		**-**	
-		**ADAPTABLE**		**Agriculture**	**X**	**-**	

STRATEGIC/medium-long term CONT'D:

ESTIMATED COST: EC$3,500,000

PROJECT TITLE: Fond St. Jacques Watershed Agro Forestry/Reforestation Project

Justification/objective:

1. To rehabilitate and conserve the fertile land resources of the area for the benefit of present and future generations
2. To preserve valuable watersheds.
3. To maintain and increase farmers' income and livelihood.
4. To enable the area to live up to its reputation of 'food basket' of St. Lucia.
5. To devise a long-term watershed management plan for the entire Fond St. Jacques area.
6. To identify and improve conservation farming practices on all watersheds in the area
7. To provide farmers with adequate financial and technical support in order to undertake major conservation measures.
8. To develop agronomic, marketing and production support for agroforestry diversification crops such as cocoa, and 'exotic' tree crops such as sapodilla, sugar-apple and sour-sop , etc in areas experiencing serious erosion problems, to enhance soil conservation and supplement farmers' incomes.
9. While components (1) and (2) are being completed, temporary measures will have to be adopted within the area to prevent further deterioration of the land. These activities will be as follows
10. To undertake reforestation of selected forest tree species on slopes deemed unsuitable for general agricultural purposes; planting of appropriate tree species on banks of streams to enhance the availability of water from these sources.

OTHER information:
Photos by: Ranan Emmanuel and Bill Mortley

REFERENCE material used/available on issue/problem (*include where document can be accessed***):**

1. **A Probable Maximum Loss Study of Critical Infrastructure in Three Caribbean Islands**
2. **The World Bank Report No.: 32677-LC, PROJECTPERFORMANCEASSESSMENTREPORT, ST. LUCIA, WATERSHED AND ENVIRONMENTAL MANAGEMENT PROJECT, (CREDIT 2768-SLUAND LOAN3925-SLU) AND EMERGENCY RECOVERY AND DISASTER MANAGEMENT PROGRAM (CREDIT 3151-SLUAND LOAN4419-SLU), June 27,2005**
3. **National Forestry Action Programme - http://www.fao.org/docrep/x5652e/x5652e07.htm**

Geotechnical: Roads & Settlements

Overview

Tomas was a category one hurricane on the 30th October 2010 with registered rainfall as high as 688mm in the Western section of the country. The intense rainfall during the hurricane was the trigger for the majority of landslides, subsidence and mudflows which impacted the transportation, utility, and housing infrastructure around St. Lucia.

The landslides can be categorized into two groups, major and minor, defined on the basis of their long term impact on infrastructure and livelihood of the population or sections of the population.

This report is a generalized assessment of the landslides during Tomas using a subjective approach based on the engineering backgrounds of the authors. Site visits were conducted around the island on the 11th of November 2010.

General Site Information and Observation

The intense rainfall as experienced during the Hurricane event caused landslides as a result of one or a combination of the following:

1) An increase in the pore water pressure within the soil on slopes

2) A loss of the cohesive strength of soils causing soil to become fluid along slopes.

3) A toe loss of slopes through erosion along river or ravine banks.

Minor Landslides

Minor Slides were observed throughout the island and varied in size and magnitude of debris flow.

Large, minor slides typically occurred within the forested center of the island, where there was no major loss to agricultural tree crops and infrastructure. The removal of debris flows or mitigation is of no consequence to settlements or infrastructure.

The smaller, minor slides were observed in some roadway cut sections, farms on slopes and housing developments. This type of minor slides are characterized as having no long term financial impact with costs only associated with inconvenience and removal of debris flow. In this case the stability of the affected area is not compromised.

Major Landslides

The major Landslides observed during the hurricane were located in the more mountainous sections of St. Lucia and include:

1) East and South of Castries – Residential communities between Morne, Derriere Fort, Bagatelle, Forestiere and Babonneau.

2) The Center of the island – Bare D'Isle roadway and Millet Roadway & Dam Access

3) The Soufriere Area - Columbette and Fond Se Jacques Community.

The observations made in these regions are summarized as follows:

Landslide Location/Description	Description of Failure Mechanism	Potential Hazards	Proposed Mitigation	Notes/Comments
Colombette An extensive slide which resulted in loss of life, damage to the main arterial roadway and significant mass wasting.	Very rapid debris Avalanche as a result of an increase in the pore water pressure within the subsurface soil layer.	The soil mass is likely to expand through increased sliding and creep. This could affect the integrity of the roadway and the utilities within the easement. Soil erosion is causing a major environmental impact to the surrounding area including the marine reserve.	**Short term**: Clear Roadway, provide surface drainage, flatten the slope for increase stability and build retaining walls along roadway cuts. **Long term**: Realign the roadway, use subsurface drainage, use soil reinforcement and plant trees along the exposed slopes.	The area is unsuitable for development unless a major mitigation project to improve slope stability is undertaken. The risk after development may be higher than usually accepted.
Fond St. Jacques An extensive slide which resulted in loss of life, damage to roadway infrastructure including two bridges, significant mass wasting and the destruction of residences.	Very rapid debris Avalanche as a result of an increase in the pore water pressure within the subsurface soil layer.	There is evidence of soil creep which could lead to additional slippage at the landslide site. Significant instability may occur during or after extreme rainfall of earthquakes.	**Short Term:** Evacuate area within the slide zone. Provide adequate surface drainage and implement a river training program. **Long Term:** Redesign the landscape to improve slope stability. Evaluate the area for suitability of residential settlement. Plant trees on slopes and install relief wells for springs.	Development restrictions are required to limit and control activities which could affect the stability of the area. The potential of other landslides exists for other larger slopes surrounding the area based on a similar mechanism of failure.
Barre D'Isle A series of landslide along the mountains and within the roadway cut and fill sections damaging roadway and utility infrastructure.	Slow to rapid debris flow as a result of an increase in the pore water pressure within the subsurface soil layer.	There is evidence of soil creep which could lead to additional slippage along the roadway. Significant instability may occur during or after extreme rainfall or earthquakes.	**Short Term:** Clear Roadway, provide surface drainage, bench and/or flatten the slope for increase stability and build retaining walls along roadway cuts. Use reinforced or stabilized earth in road construction. **Long Term:** Develop an alternate route to bypass area which may require highway bridges and tunnels.	Development and cultivation restrictions may be required.

Landslide Location/Description	Description of Failure Mechanism	Potential Hazards	Proposed Mitigation	Notes/Comments
Barre D'Isle ……..Continued			Develop stabilization program which would include, planting of trees on slopes, Bench and flatten slopes and control ground water in key areas.	
Millet A series of landslides along the access roadway to the main water supply of St. Lucia.	Slow to rapid debris flow as a result of an increase in the pore water pressure within the subsurface soil layer	There is evidence of soil creep which could lead to additional slippage along the roadway. Significant instability may occur during or after extreme rainfall or earthquakes.	**Short Term:** Clear Roadway and provide adequate surface drainage to control storm water. Flatten and or bench slopes to increase slope stability. **Long Term:** Improve slopes along roadway	The roadway needs to be improved to with a focus of uninterrupted access to the Dam Site.
East and South Hills of Castries A series of Landslides within residential communities impacting, roadways, utilities and residences	Slow to rapid debris flow as a result of an increase in the pore water pressure within the subsurface soil layer	There is historical evidence of creep which became extensive landslides, impacting lives and infrastructure. Significant instability may occur during or after extreme rainfall or earthquakes.	**Short Term:** Clear Roadway and provide adequate surface drainage to control storm water. Flatten and or bench slopes to increase slope stability. **Long Term**: Implement comprehensive storm water management plan. Improve slopes along roadways along with retaining structures to improve overall stability of area.	Residents need to control runoff to reduce creep. Overall strategy on storm water management needs to be implemented.

Recommendations/Conclusion

Full scale geotechnical investigations and studies are essential for the determination of the long term stability of the regions of major landslide. The Area of Fond Se Jacques and the outer residential slopes of Castries need critical attention as the potential for loss of life is high.

These studies can be used in the determination of long term land use and planning policy as it relates to the risk of landslides and corresponding impacts to settlements and infrastructure.

Highway designers and planners should use engineered slopes on future roadways and also improve the slopes and stability of existing highway cuts and fills on the main arterials and key infrastructure roadway access.

Storm drainage and control should be improved at both subdivision and residential levels and tied into a master storm water system.

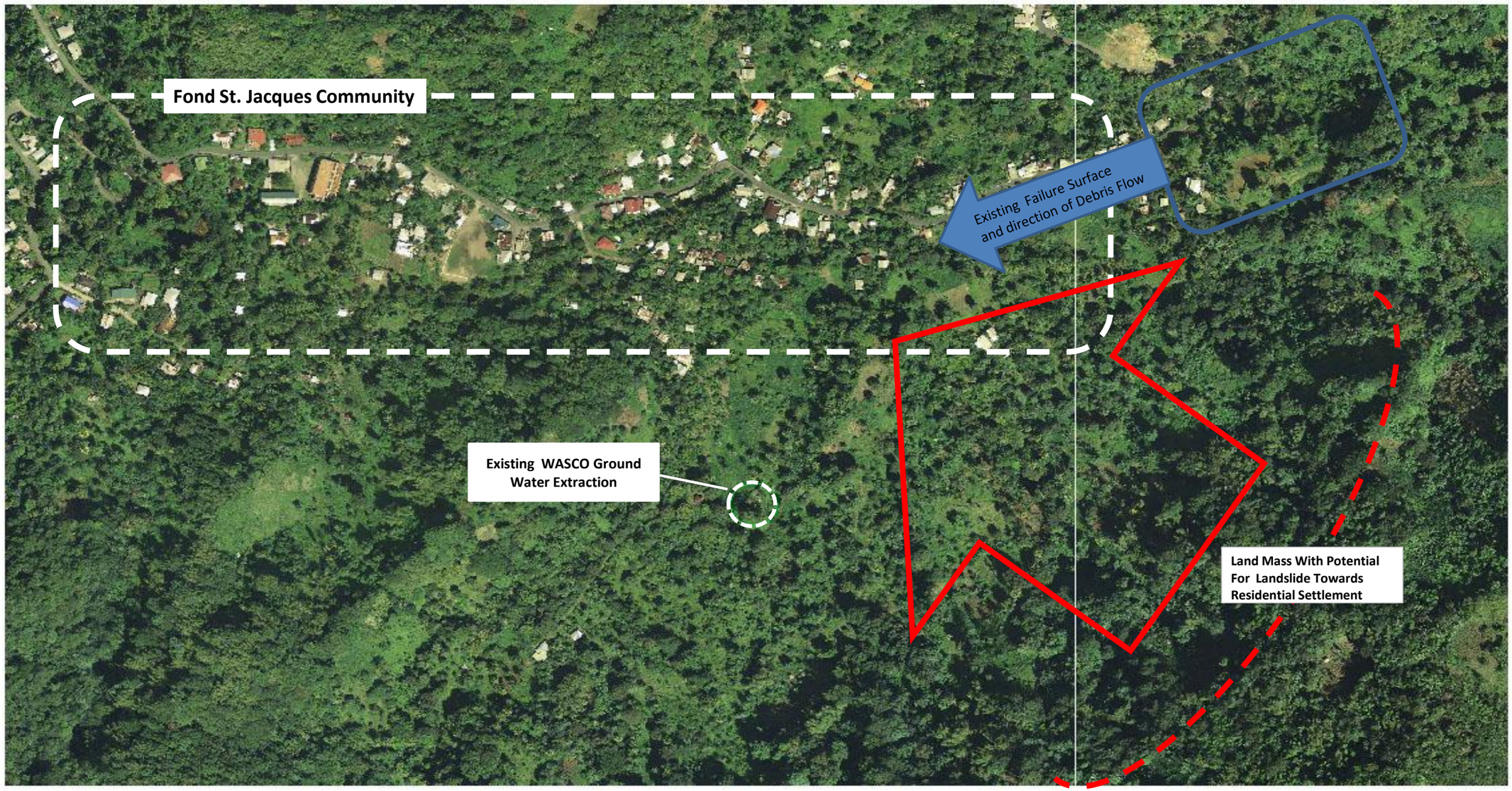


Figure 1.0 - Aerial Showing Potential Landslide Mass in Fond St. Jacques

Appendix

Photo 1.0 – Failure Surface of Fond Se Jacques Landslide

Photo 2.0 – Surrounding Hills of Fond Se Jacques with possible landslide risk to the community

Photo 3.0 – Failure Surface of Colombette Landslide

Photo 4.0 – Northern side of Colombette Landslide showing area with potential for continued debris flow

Photo 5.0 – Landslide in Barre D'Isle showing compromised roadway

Photo 6.0 Steep slopes in Barre D'Isle Roadway which have the potential to continue sliding

Road Infrastructure

Section 1: These assessments cover portions of the primary roads from Barre De L'Isle through Cul-de-Sac to Soufriere, and bridges along the John Compton Highway

Introduction

This note presents additional information including justification for recommendations made in attached forms from a reconnaissance of the performance and damage coursed to road infrastructure (including bridges and culverts) due to the passage of Hurricane Tomas 30th October 2010.

Due to the very limited time for delivery, the assessment is in no way exhaustive. Recommendations are based on a perceived worst-case scenario and so are decidedly conservative. Thorough geotechnical investigation will be necessary to achieve the most economically viable solution.

Bridges

The observed mode of failure at both the Choc and Bois orange bridges was a blockage by debris and general refuse (ranging from fridges to large trees) leading to the overtopping scour and erosion of roadway and the structure itself. Both bridges are multi-span corrugated steel arch structures.

Multi-span structures are generally not recommended from both hydraulic and environmental standpoint. Piers tend to collect debris, which impose greater loads on the structure and block the passage of water (essentially damming the river) and resulting in flood flow being diverted onto adjacent lands and roadway, overtopping the bridge deck and leading to failures as noted in the two examples given above.
Additionally greater spans will mean that the abatements are further away from the effects of erosion during a 'normal' storm event. The heavy construction methods required to build a durable mid-channel pier would also impose avoidable environmental impacts.

Our recommendation is to replace the existing structures with single/clear span structures.

This recommendation of course has cost implications. Clear spans require girders of greater depth and in general more steel or concrete tonnage to achieve the greater spans. This cost should be weighed against the cost associated with the disruption delays and replacement cost after a Debi/Tomas like storm every 15 or so years (with climate change return period is expected to get even shorter and storms more intense).

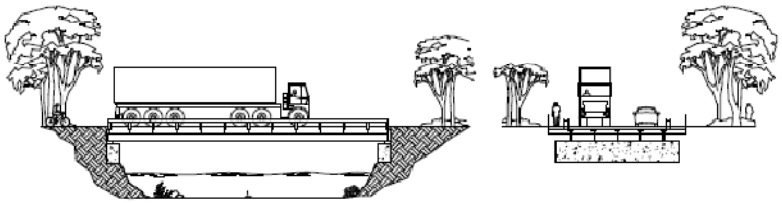
The prevailing reason for opting for a much less advantageous multi span structure when a single span structure is the most hydraulically efficient is cost. An option that may be considered to reduce cost is prefabricated composite bridges in which the steel girder structure is designed and fabricated overseas and can arrive in St.Lucia within 10 to 12 weeks of order. Local skilled personnel can then be engaged to design and construct abutments ,reinforced concrete deck and approach roadway.

A minimum savings of 20% can be realized with this method of procurement when compared with taking the regular route. A significant reduction in the design and construction period is also an obvious advantage.

COMPOSITE BEAM BRIDGES ARE GOOD FOR:

- Spans 10m to 24m (but larger spans are possible).
- Easy Widening
- Low visual impact.
- Building in situ or cantilever launch.
- Single or multiple spans.

But: become more expensive as spans get longer.



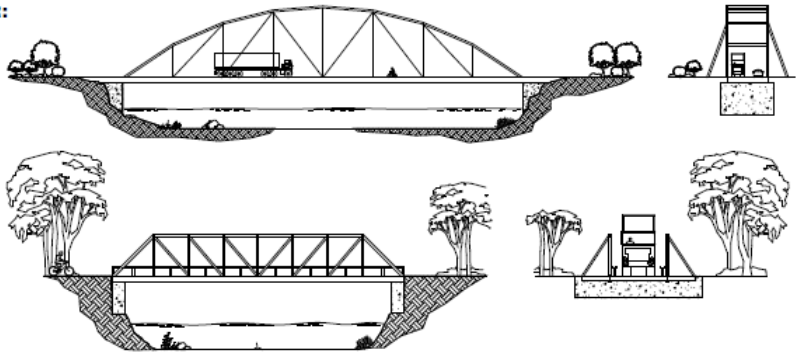
Far Left: *Composite bridge, preparing to launch in Uganda.*

Left: *Continuous composite beam bridge, Maphutsaneng Bridge, on the Mohales Hoek-Mekaling road, Lesotho - Africa.*

THROUGH TRUSS BRIDGES ARE GOOD FOR:

- Spans 15m to 100m
- Maximum clearance underneath the roadway.
- Building in situ or cantilever launch
- Single or Multiple Spans

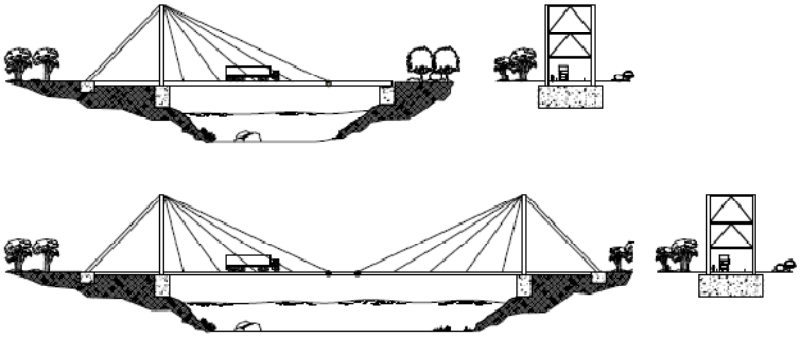
But: can only be widened by building another bridge.



STAYED BRIDGES ARE GOOD FOR:

- Long spans up to 200m.
- Where building in situ or cantilever launch is not possible.
- Where access to the far side is difficult.
- Where a big visual impact is required.

But: can only be widened by building another bridge alongside.



Retaining Structure

It was generally observed that gabion basket structures fared much better than masonry and considerably better than reinforced concrete block wall retaining structures. This may be as a result of two factors i.e. poor design and construction practices and the inherent flexibility and drainage advantages of rock filled gabion basket walls.

We recommend gabion retaining structures where space allows (gabion wall require a minimum base width of 2m) and where aphetically suitable.

Other Recommendations /Suggestions

Bio Engineering Measures.

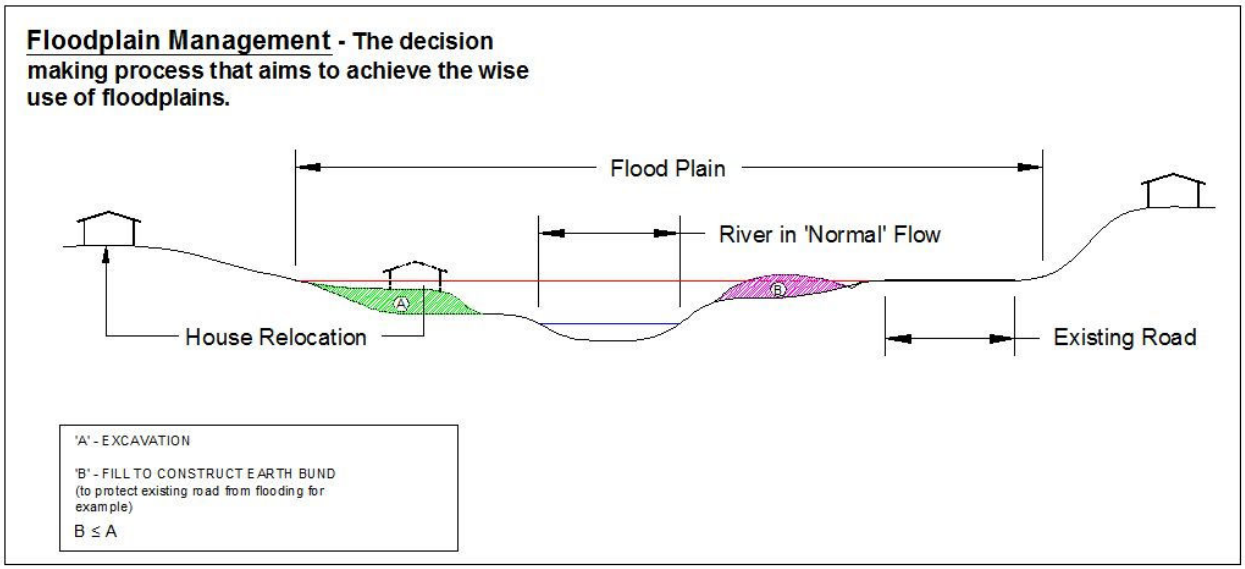
Bio Engineering in the inclusion of grasses, shrubs, trees and other types of vegetation into engineering design to improve and protect hill slopes, embankments and structures from the problems associated with shallow slope failure.

Bio-Engineering provides pratical cost-effective solutions to many of the environmental corncernc associated with infrastructure development and increased soil erosion. It should be thought of as a skill which engineers can employ to increase the effectiveness of their work.

Clark, J and Hellin,J.(1996) Bio-engineering for Effective Road Maintenance in the Caribbean.

A number of bio engineering measures have been initiated locally (the planting of vetiver grass along slopes for instance) but generally BE has not court on as an extremely viable solutions mainly due to poor supervision, monitoring and the absence of a local champion to drive the process of implementation.

Floodplain Management



OPRC

It is clear that existing system of road maintenance management is not adequate to suit the countries developing needs. This has been made quite strikingly clear post hurricane Tomas with major damage to road and other infrastructure being observably caused by badly maintained drainage and other road infrastructural items.

It is understood that CDB has put forward OPRC (Output and Performance Based Roads Contracts) to regional road authorities as a means of procuring road maintenance services but it is not clear to what point this initiative has progressed.

A properly structured and run OPRC would mean more of a focus on preventative maintenance with the inherent long-term cost saving and a reduction in severity of damage post Tomas like storm

OPRC have been noted to improve efficiency and effectiveness of road network management and savings of as much as 20% for physical work and 30% on consultancy input has been realized by road authorities.

Plastic bottles and other trash

To highlight a very much related issue 'trash' (in particular plastic bottles) in drains, rivers and eventually the sea. Not only is there the obvious environmental concerns, the resultant damage caused to infrastructure due to blockages in culverts and drains in evident.

A possible solution one that has been considered in the past by local authorities is to give value to used plastic bottles and the like via some sort of arrangement with wholesalers. This would provide the incentive to the general public to return item to some assigned deport and then be refunded for their efforts based on total weight or number and size of plastic item.

Going forward with recommendation

It is hoped that the relevant authorities seriously consider the recommendations made above. The knowledge and skills required to take these recommendations forward are available locally and the APESL and its individual members are eager to play their part in the reconstruction/rehabilitation effort.

Relevant Human causes of Landslides

a. Excavation of slope or its toe
b. Loading of slope or its crest
d. Deforestation
e. Irrigation
g. Artificial vibration
h. Water leakage from utilities

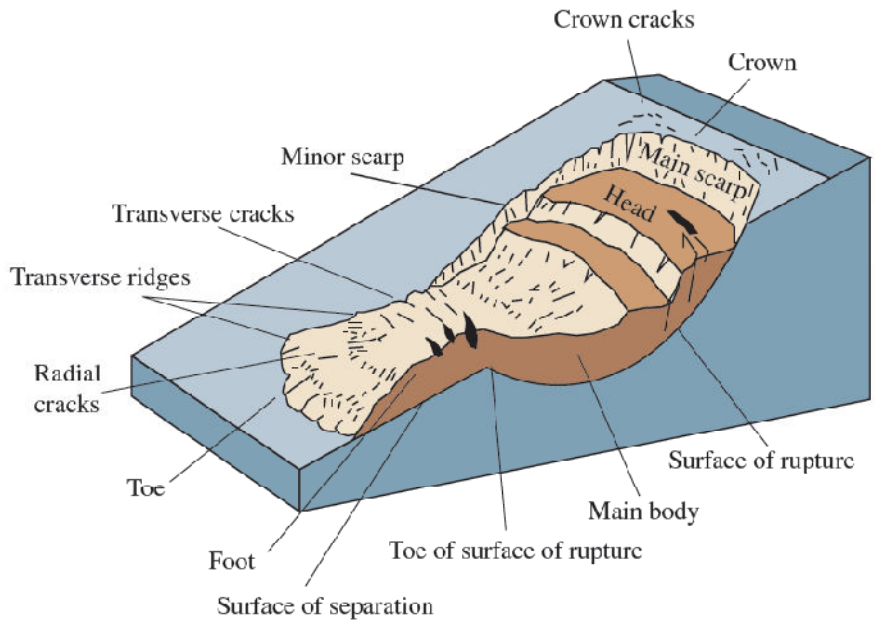


Figure 1. An idealized slump-earth flow showing commonly used nomenclature for labeling the parts of a landslide.

References

Clark J. and Hellin J. (1996) *Bio-engineering for effective Road Maintenance in the Caribbean. Chatham, UK: Natural Resources Institute.*

VETIVER SYSTEM APPLICATIONS TECHNICAL REFERENCE MANUAL SECOND EDITION
PAUL TRUONG TRAN TAN VAN ELISE PINNERS

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT

Sector: Road and Infrastructure(including bridges and culverts)

Team: Christopher Wyatt, Eglan Flavien, Robertson Felicien

Date: November 10 -15th 2010

Location: Ti Colon (along West Coast Road)

GPS_Coordinates:

N	**13.96836°**
W	**061.00296°**

Description of issue/problem:

50m wide slide along downhill slope. Carriageway directly affected. Single lane traffic through this point.

Photos:

Risks related to issue/problem (probability of harmful consequences/losses-deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):

There is some risk of continued failure, which would lead to further narrowing of carriageway and greater risk to road users.

Risk **Significance** level (Magnitude/Frequency/Duration):

Urgent/Intolerable	
Critical/Non-Acceptable	X
Tolerable	
Adaptable	
Minor	

Elements at risk:

Utilities	
Institutions	
Industry	
Tourism	X
General Population	X
Transport System	X
Natural Resources	
Agriculture	X
Other Namely:	

Recommendations/Mitigation (Structural/non-structural measures to limit adverse impact):

Rationale/overview Like many observed this slide was a result of failure of retaining wall.	
Immediate/short term: Apart from cordoning off half the carriageway to protect the general public a short-term solution may not be economically justifiable.	**Estimated COSTS**
Strategic/medium-long term: Though further investigation is required to determine the exact cause and mode of failure, based on observations the proposed long-term solution may take the form of a Gabion retaining wall systems with tie-backs. And reconstruction of road pavement.	**Estimated COSTS** **$375,000.00**

Other information:
Reference material used (include where document can be accessed): See attached note for general comments, observations, recommendations, mitigations and a list of reference material used.

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT

Sector: Road and Infrastructure(including bridges and culverts)

Team: Christopher Wyatt, Eglan Flavien, Robertson Felicien

Date: November 10 -15th 2010

Location: Barre de L'Isle ridge – South side
From N13.92829° W060.94836° downhill to Grande Rivier de Mabouya Bridge Another 4 no. slides

Description of issue/problem:

4 No. slides of similar size along the downhill slope which frighten integrity of roadway above

Risks related to issue/problem (probability of harmful consequences/losses-deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):

There is some risk of continued failure, which would lead to further narrowing of carriageway and greater risk to road users.

Risk **Significance** level (Magnitude/Frequency/Duration):

Urgent/Intolerable	
Critical/Non-Acceptable	
Tolerable	X
Adaptable	
Minor	

Elements at risk:

Utilities	
Institutions	
Industry	
Tourism	
General Population	X
Transport System	X
Natural Resources	
Agriculture	X
Other Namely:	

Recommendations/Mitigation (Structural/non-structural measures to limit adverse impact):

Rationale/overview Risk may be tolerable short-term but a long-term solution need to be implemented to protect the accet.	
Immediate/short term: Stopgap measure for safety. Including signage and reflectorised barriers.	**Estimated COSTS** **$10,000.00**
Strategic/medium-long term: Earth Retaining structure preferably gabion retaining wall. *Total cost of solution for all four (4) failures.*	**Estimated COSTS** **$1.75 million**
Other information:	
Reference material used (include where document can be accessed): See attached note for <u>general</u> comments, observations, recommendations, mitigations and a list of reference material used.	

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT

Sector: Road and Infrastructure(including bridges and culverts)

Team: Christopher Wyatt, Eglan Flavien, Robertson Felicien

Date: November 10 -15th 2010

Location: Barre de L'Isle ridge – South side

GPS_Coordinates:

N	**13.92703°**
W	**060.95316°**

Description of issue/problem:

Two slide 40, 45m long, and 25m apart along the downhill slope. Carriageway directly affected in both cases. Failed masonry retaining walls.

Photos:

Risks related to issue/problem (probability of harmful consequences/losses-deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):

Because these failures are along the inside of a bend forward visibility for approaching vehicles is poor and with the carriageway narrowed to one lane the potential for vehicular conflict is very high at this location. There is also some risk of continued failure.

Risk **Significance** level (Magnitude/Frequency/Duration):

Urgent/Intolerable	
Critical/Non-Acceptable	X
Tolerable	
Adaptable	
Minor	

Elements at risk:

Utilities	
Institutions	
Industry	X
Tourism	X
General Population	X
Transport System	X
Natural Resources	
Agriculture	X
Other Namely:	

Recommendations/Mitigation (Structural/non-structural measures to limit adverse impact):

Rationale/overview Because of its location and combined length, additional traffic management measures including automatic signals may be considered. Also suggested is the provision of reflectorised barriers and traffic cones for nighttime situation awareness	
Immediate/short term: Traffic management measures	**Estimated COSTS** **$15,000.00**

Strategic/medium-long term: Gabion retaining structure with reconstruction of pavement	**Estimated COSTS** **$800,000.00**
Other information:	
Reference material used (include where document can be accessed): See attached note for general comments, observations, recommendations, mitigations and a list of reference material used.	

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT

Sector: Road and Infrastructure(including bridges and culverts)

Team: Christopher Wyatt, Eglan Flavien, Robertson Felicien

Date: November 10 -15th 2010

Location: Barre de L'Isle ridge – South side

GPS_Coordinates:

N	**13.92829°**
W	**060.94836°**

Description of issue/problem:

Rotational type landslide resulting in loss of half of carriageway. Length approx. 50m
Only single lane traffic possible.

Photos:

Risks related to issue/problem (probability of harmful consequences/losses-deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):

Existing carriageway has been narrowed to less than half-original width. Though now widened on the uphill side by approximately 2.5m roadway is still only safe for single lane traffic. Nighttime safety will remain an issue until completely rehabilitated.

Risk **Significance** level (Magnitude/Frequency/Duration):

Urgent/Intolerable	X
Critical/Non-Acceptable	
Tolerable	
Adaptable	
Minor	

Elements at risk:

Utilities	X
Institutions	X
Industry	X
Tourism	X
General Population	X
Transport System	X
Natural Resources	X
Agriculture	X
Other Namely:	

Recommendations/Mitigation (Structural/non-structural measures to limit adverse impact):

Rationale/overview	
Immediate/short term: It has been observed that measures, which we assume are stopgap, are being implemented to facilitate motorability along failed section, improve safety at location and to prevent further deterioration.	**Estimated COSTS** **Cost unknown**

Strategic/medium-long term: A possible solution that may incorporate parts of stopgap measures is a gabion retaining structure founded on rock fill/boulder pack.	**Estimated COSTS** **$500,000.00**
Other information:	
Reference material used (include where document can be accessed): See attached note for <u>general</u> comments, observations, recommendations, mitigations and a list of reference material used.	

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT

Sector: Road and Infrastructure(including bridges and culverts)

Team: Christopher Wyatt, Eglan Flavien, Robertson Felicien

Date: November 10 -15th 2010

Location: Road to John Compton Dam

Description of issue/problem:

Blocked culvert damming water course and causing the erosion away of road embankment . Road is the only vehicular access to dam.

Photos:

Risks related to issue/problem (probability of harmful consequences/losses-deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):

Following the storm the only access to the dam was via helicopter . It is important to insure vehicular access to this vital national asset.

Risk **Significance** level (Magnitude/Frequency/Duration):

Urgent/Intolerable	
Critical/Non-Acceptable	
Tolerable	X
Adaptable	
Minor	

Elements at risk:

Utilities	X
Institutions	X
Industry	
Tourism	
General Population	
Transport System	
Natural Resources	X
Agriculture	
Other Namely:	

Recommendations/Mitigation (Structural/non-structural measures to limit adverse impact):

Rationale/overview Though access has been restored via a temporary solution longer-term…	
Immediate/short term: Short-term measure to reestablish access is in place. Cost unknown	**Estimated COSTS**
Strategic/medium-long term: Replace failed culvert with a more hydraulically efficient structure	**Estimated COSTS** **$80,000.00**

Other information:
Reference material used (include where document can be accessed): See attached note for general comments, observations, recommendations, mitigations and a list of reference material used.

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT

Sector: Road and Infrastructure(including bridges and culverts)

Team: Christopher Wyatt, Eglan Flavien, Robertson Felicien

Date: November 10 -15th 2010

Location: Near Anse la Verdure

GPS_Coordinates:

N	**13.91345°**
W	**061.04607°**

Description of issue/problem:

Inadequate and blocked culverts resulting in erosion on downhill slope and undermining of gabion retaining structure and roadway.

Photos:

Risks related to issue/problem (probability of harmful consequences/losses-deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):

Direct and eminent freight to carriageway if not addressed short-term.

Risk **Significance** level (Magnitude/Frequency/Duration):

Urgent/Intolerable	
Critical/Non-Acceptable	X
Tolerable	
Adaptable	
Minor	

Elements at risk:

Utilities	
Institutions	
Industry	
Tourism	X
General Population	X
Transport System	X
Natural Resources	
Agriculture	
Other Namely:	

Recommendations/Mitigation (Structural/non-structural measures to limit adverse impact):

Rationale/overview West coast Road is still motor able at through this point however situation has to be addressed short-term	
Immediate/short term: Clearing existing culvert if possible. If not possible construction of new culvert to prevent further damage.	**Estimated COSTS** **$50,000.00**
Strategic/medium-long term: Along with the replacing existing culvert significant earth retaining works will be necessary to protect integrity of carriageway.	**Estimated COSTS** **$500,000.00**

Other information:
Reference material used (include where document can be accessed): See attached note for general comments, observations, recommendations, mitigations and a list of reference material used.

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT

Sector: Road and Infrastructure(including bridges and culverts)

Team: Christopher Wyatt, Eglan Flavien, Robertson Felicien

Date: November 10 -15th 2010

Location: Colombette (along the West Coast Road)

GPS_Coordinates:

N	**13.87052°**
W	**061.04403°**

Description of issue/problem:

Major landslide resulting in multiple loss of life and initially making 120m (approx.) of the West Coast Road impassable.
Crown of slide approx. 200m above roadway. Finale position of toe approx. 300m below.

Photos:

Risks related to issue/problem (probability of harmful consequences/losses-deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):

As of 10th November it was observed that roadway had been cleared for single lane traffic. Significant risk to road users still exist, loose slide material on slope above road has now been made more unstable again with the removal of material to clear road.

Risk **Significance** level (Magnitude/Frequency/Duration):

Urgent/Intolerable	X
Critical/Non-Acceptable	
Tolerable	
Adaptable	
Minor	

Elements at risk:

Utilities	X
Institutions	X
Industry	
Tourism	X
General Population	X
Transport System	X
Natural Resources	X
Agriculture	X
Other Namely:	

Recommendations/Mitigation (Structural/non-structural measures to limit adverse impact):

Rationale/overview Suitable medium term to long-term design solution would require geotechnical investigation.	
Immediate/short term:	**Estimated COSTS**

Strategic/medium-long term: Possible design solution is a gabion retaining structure with tiebacks	**Estimated COSTS** **$2milion**
Other information:	
Reference material used (include where document can be accessed): See attached note for general comments, observations, recommendations, mitigations and a list of reference material used.	

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT

Sector: Road and Infrastructure(including bridges and culverts)

Team: Christopher Wyatt, Eglan Flavien, Robertson Felicien

Date: November 10 -15th 2010

Location/Item: Grande Rivier de Mabouya Bridge

Description of issue/problem:

Blocked low lying bridge forming a dam and inundating surrounding land including households.

Risks related to issue/problem (probability of harmful consequences/losses-deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):

Risk to property, livelihood and economic activity due to the built-up location of the failure and the direct impact on homes and agricultural amenities

Risk **Significance** level (Magnitude/Frequency/Duration):

Urgent/Intolerable	
Critical/Non-Acceptable	
Tolerable	X
Adaptable	
Minor	

Elements at risk:

Utilities	X
Institutions	
Industry	
Tourism	X
General Population	X
Transport System	X
Natural Resources	
Agriculture	X
Other Namely:	

Recommendations/Mitigation (Structural/non-structural measures to limit adverse impact):

Rationale/overview	
Immediate/short term: Clearing river and bridge invert of debris and silt	**Estimated COSTS** **$50,000.00**
Strategic/medium-long term: Replacing existing structure with a more hydraulically efficient structure. Associated roadworks to raise approaches	**Estimated COSTS** **$2.5 million**
Other information:	
Reference material used (include where document can be accessed): See attached note for general comments, observations, recommendations, mitigations and a list of reference material used.	

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT

Sector: Road and Infrastructure(including bridges and culverts)

Team: Christopher Wyatt, Eglan Flavien, Robertson Felicien

Date: November 10 -15th 2010

Location: Patience / Morne Repos (along the East Coast Road)

GPS_Coordinates:

N	**13.85238°**
W	**060.90933°**

Description of issue/problem:

Culvert blockage leading to damming of watercourse and erosion of road embankment.
Existing failed structure is corrugated steel pipe approx. diameter 2m.

Photos:

Risks related to issue/problem (probability of harmful consequences/losses-deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):

With this failure and others along major arterial roads travel time and wear and tear on vehicles is significantly increased with the consequent impact on economic activity and vehicle operating cost.

Risk **Significance** level (Magnitude/Frequency/Duration):

Urgent/Intolerable	
Critical/Non-Acceptable	X
Tolerable	
Adaptable	
Minor	

Elements at risk:

Utilities	X
Institutions	X
Industry	X
Tourism	X
General Population	X
Transport System	X
Natural Resources	
Agriculture	X
Other Namely:	

Recommendations/Mitigation (Structural/non-structural measures to limit adverse impact):

Rationale/overview	
Immediate/short term: Short term measure (diversion route around failure) already in place. Cost unknown	**Estimated COSTS**
Strategic/medium-long term: Replace with box culvert structure of suitable hydraulic capacity. Should also incorporate features to minimize the likelihood of blockage due to debris.	**Estimated COSTS** **$400,000.00**

Other information:
Reference material used (include where document can be accessed): See attached note for general comments, observations, recommendations, mitigations and a list of reference material used.

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT

Sector: Road and Infrastructure(including bridges and culverts)

Team: Christopher Wyatt, Eglan Flavien, Robertson Felicien

Date: November 10 -15th 2010

Location/Item: Choc Bridge

Description of issue/problem:

Damaged roadway/bridge structure due to the blockage corrugated steel barrels and consequent damming of river overtopping roadway. Scour and erosion of fill material between barrels is evident voids may be present in structure.

Photos:

Risks related to issue/problem (probability of harmful consequences/losses-deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):

Economic activity disruption on this very heavily traffics route, which links the commercial centre of Castries to the rapidly developing and highly touristic north. Interim measure put in place

Risk **Significance** level (Magnitude/Frequency/Duration):

Urgent/Intolerable	
Critical/Non-Acceptable	X
Tolerable	
Adaptable	
Minor	

Elements at risk:

Utilities	X
Institutions	X
Industry	
Tourism	X
General Population	X
Transport System	X
Natural Resources	
Agriculture	
Other Namely:	

Recommendations/Mitigation (Structural/non-structural measures to limit adverse impact):

Rationale/overview Inadequate freeboard between the design flood level and the bridge deck/top of barrel. This increases the likelihood of floating debris blockage and does not allow for any uncertainties in the hydrological and hydraulic design calculations. From the photos is clear that this is a major design shortcoming for this particular structure and since the frequency and intensity of storms are likely to increase with climate change it is strongly advised that bridge be replaced.	
Immediate/short term: MCWT&PU have already implemented a short-term measure. Cost unknown.	**Estimated COSTS**

Strategic/medium-long term: Replacing the existing structure with a clear span bridge (approx. 40m) with river retraining works upstream.	**Estimated COSTS** **$3.4 million**

Other information:

The prevailing reason for opting for a much less advantageous multi span structure when a single span structure is the most hydraulically efficient is cost. An option that may be considered to reduce cost is prefabricated composite bridges in which the steel girder structure is designed and fabricated overseas and can arrive in St.Lucia within 10 to 12 weeks of order. Local skilled personnel can then be engaged to design and construct abutments, reinforced concrete deck and approach roadway.

A minimum savings of 20% can be realized with this method of procurement when compared with taking the regular route. A significant reduction in the design and construction period is also an advantage.

Reference material used (include where document can be accessed):

See attached note for general comments, observations, recommendations, mitigations and a list of reference material used.

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT

Sector: Road and Infrastructure(including bridges and culverts)

Team: Christopher Wyatt, Eglan Flavien, Robertson Felicien

Date: November 10 -15th 2010

Location/Item: Bois D'Orange Bridge (along the Castries Gros-Islet highway) Multiple barrel structure.

Description of issue/problem:

Damage caused to roadway/bridge structure due to blockage of three (3) corrugated steel barrels and consequent damming of river at that point. One of the barrels collapsed and now filled with boulders. Remaining two (2) barrels partially collapsed on downstream side.

Photos:

Risks related to issue/problem (probability of harmful consequences/losses-deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):

The existing condition of barrels means that the hydraulic capacity of structure in severely reduced. Although an interim measure has been put in place (i.e.RC pavement slab) a significant risk of collapse and additional traffic disruption remain. Economic activity would be further hindered on this already very heavily traffics route which links the commercial centre of Castries to the rapidly developing and highly touristic north.

Risk **Significance** level (Magnitude/Frequency/Duration):

Urgent/Intolerable	
Critical/Non-Acceptable	X
Tolerable	
Adaptable	
Minor	

Elements at risk:

Utilities	X
Institutions	X
Industry	X
Tourism	X
General Population	X
Transport System	X
Natural Resources	
Agriculture	
Other Namely:	

Recommendations/Mitigation (Structural/non-structural measures to limit adverse impact):

Rationale/overview It was observed that the damming of bridges and culverts by debris was the most prevalent mode of failure. Most of these structures are multiple span multiple barrel structures and or with hydraulically inadequate cross sections and other substandard features. Piers also reduce the existing channel cross section and as a result may increase in-channel velocities and turbulence resulting in increased probability of scour and undermining of structure.	
Immediate/short term: MCWT&PU have already implemented a short-term measure. Cost unknown.	**Estimated COSTS**

Strategic/medium-long term: Replacing the existing structure with a clear span bridge (approx. 35m span) with river retraining works upstream.	**Estimated COSTS** **$3.1million**

Other information:

The prevailing reason for opting for a much less advantageous multi span structure when a single span structure is the most hydraulically efficient is cost. An option that may be considered to reduce cost is prefabricated composite bridges in which the steel girder structure is designed and fabricated overseas and can arrive in St.Lucia within 10 to 12 weeks of order. Local skilled personnel can then be engaged to design and construct abutments ,reinforced concrete deck and approach roadway.

A minimum savings of 20% can be realized with this method of procurement when compared with taking the regular route. A significant reduction in the design and construction period is also an advantage.

Reference material used (include where document can be accessed):

See attached note for general comments, observations, recommendations, mitigations and a list of reference material used.

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT

Sector: Road and Infrastructure(including bridges and culverts)

Team: Christopher Wyatt, Eglan Flavien, Robertson Felicien

Date: November 10 -15th 2010

Location: Anse Galet (West Coast Road)

GPS_Coordinates:

N	**13.93221°**
W	**061.04591°**

Description of issue/problem:

Corrugated steel single barrel culvert blocked by debris damming river resulting in roadway being overtopped damaging via scour downstream side of carriageway and drainage structure itself. River coarse diverted and continues to overtop carriageway as of 14 Oct.

Photos:

Water from river on carriageway

Risks related to issue/problem (probability of harmful consequences/losses-deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):

Risk of further damage in the interim if short measures are note put in place. No now viable bypasses exist at this location along the West Coast Road. WCR critical in regards to touristic activity.

Risk **Significance** level (Magnitude/Frequency/Duration):

Urgent/Intolerable	
Critical/Non-Acceptable	
Tolerable	X
Adaptable	
Minor	

Elements at risk:

Utilities	
Institutions	
Industry	
Tourism	X
General Population	X
Transport System	X
Natural Resources	
Agriculture	X
Other Namely:	

Recommendations/Mitigation (Structural/non-structural measures to limit adverse impact):

Rationale/overview Though situation may be tolerable in the short-term failure needs to be addressed to preserve the long-term integrity of the roadway.	
Immediate/short term: Clearing of roadway and removal of debris upstream of river and at culvert inlet	**Estimated COSTS** **$50,000.00**
Strategic/medium-long term: Design solution may include a new bridge/box culvert structure with more hydraulically efficient features. May also include raising approach road levels.	**Estimated COSTS** **$1.75 million**

Other information:
Reference material used (include where document can be accessed): See attached note for general comments, observations, recommendations, mitigations and a list of reference material used.

Section 2: These assessments cover critical areas within the sub-urban & rural Castries ('North-Central' section of the island)

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
Forestierre	1	N13.97550	W060.95670	Tolerable	Landslide on property next to roadway	Slope Monitoring	$6,000.00	**$66,000.00**
	2	N13.98665	W060.96050	Minor	Slide alond slope supporting roadway	Slope retainment	$60,000.00	
Guesneau	3	N13.98927	W060.96163	Urgent	Slide along slope blocking roadway	Debris removal andSloping embankment	100,000.00	**$11,915,000.00**
	4	N13.98979	W060.96278	Tolarable	Landslippage onto roadway	Control water from dwelling houme; debris removal and immediate retainment of slope upon removal	$815,000.00	
	5	N13.99076	W060.96290	Critical/Urgent	Land slippage resulting in loss of section of roadway	Initial tempory access to allow trafic flow; vegetate expose slope; reallignment of roadway section and creation of a new link to connect roadway	$11,000,000.00	
Ti-Rocher Castries	6	N13.99883	W060.96921	Urgent	Slope failure along road edge	Retainment and recostruction of road edge	$1,500,000.00	**$4,000,000.00**
	7	N13.99423	W060.97026	Urgent	Slope failure along road edge	Retainment and recostruction of road edge	$2,500,000.00	
T-Rocher Castries-Bocage link	8	N13.9942	W060.97065	Urgent	Slope failure along road edge	Retainment and recostruction of road edge	$800,000.00	**$815,000.00**
	9	N13.99778	W060.96816	Urgent	Slope failure supporting road	Vegetate slope; clear debris from roadside drains along entire road section	$15,000.00	
Bocage	10	N14.00283	W060.97033	Minor	Landslide on property next to roadway	Initial vegetation of slope; future retainment of slope with retaining wall	$205,000.00	**$380,000.00**
	11	N14.00448	W060.97172	Urgent	Headwall failure, blocked culvert	Replace culvert and headwall	$175,000.00	

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
Ravine Chabot	12	N14.00195	W060.97642	Urgent	Landslippage causing unsafe road edge	Culvert repair, construction of headwall	$30,000.00	**$2,530,000.00**
	13	N14.000243	W060.97687	Urgent	Slope failure, compramising roadway; homes at risk	Clear roadway; evacuate homes; control water into slide; allow slide to remain until retainment is to be constructed	$2,500,000.00	
Ti-Rocher Castries -Dier Fort link	14	N13.99389	W060.97277	Urgent	Slope failure depositing debris along side of roadway; homes at risk	Evacuate homes; allow slide to remain in short term; clear slide and immediate construction of retaining wall	$350,000.00	**$350,000.00**
Trois Piton Road	15	N13.99174	W060.97389	Urgent	Slope failure on either side of roadway; road unsafe due to continued failures	Drainage control; slope retainment; vegetation of slope	$2,500,000.00	**$2,800,000.00**
	16	N13d58.957'	W060d58.400'	Urgent	Undemining of roaway; loss of roadsection	Retain road edge, underpin culvert, construct spillway	$300,000.00	
Bagatelle	17	N13.99622	W060.98051	Urgent	Slope failure on either side of roadway	Retain slope with grid/mat reinforcement; construct catchpits for drains; retainment of road edge	$1,000,000.00	**$8,950,000.00**
	18	N13.99613	W060.97956	Urgent	Slope failure and erosion	Clearing slide; retain slope; vegetation slope	$1,500,000.00	
	19	N13.99558	W060.97930	Urgent	Landslippage resulting in loss of road section	Retain both upper and lower slope; reinstate road section; demolish house at apex of slide	$5,000,000.00	
	20	N13.99436	W060.97845	Urgent	Slope failure with lots of vegetation deposited onto roadway	Evacuate house; clear debris; retain road edge	$250,000.00	
	21	N13.99440	W060.97839	Urgent	Slope failure on upper side; retaining wall failure on lower side	Clear debris; retain slopes; repair retaining wall	$600,000.00	

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	22	N13.99362	W060.977443	Urgent	Slope failure on lower side of roadway; road edge failure	Retainment of road edges	$600,000.00	
Estimated Total Cost							**$31,806,000.00**	**$31,806,000.00**
Contingency Sum (15%)								**$4,770,900.00**
Total Budget Cost								**$36,576,900.00**

Section 2: These assessments cover an extensive area of the road network from Praslin to Choiseul (East – South/West)

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
Mamiku Gardens Road	99	1533008	518819	Tolerable	River flooding with the deposition of silt and debris onto the roadway, drains and banana plantation	Adequate, structured desilting annual exercises to maintain the channel capacity of the river. Replacement of bridge with a structure of adequate capacity		$ -
	100	1532856	518769	Minor	River flooding with the deposition of silt and debris onto the roadway, drains and banana plantation	Adequate, structured desilting annual exercises to maintain the channel capacity of the river. Replacement of bridge with a structure of adequate capacity		
Mamiku Gardens Road	101							$ -
	102	1532783	518623	Tolarable	1. Damaged culvert system and roadway (gravel over the culvert) on tributary to the main river 2. At Pt 105 – landslip and debris at 600mm dia. culvert 3. At pt 106 to 107 – small landslip	1. replace culvert with new culvert and repair roadway 2. clear landslip and cut slope back to stable angle and clear debris from culvert 3. clear landslip and cut slope back to stable angle		
	103	1532677	518443	Tolarable	1. Damaged culvert system and roadway (gravel over the culvert) on tributary to the main river 2. At Pt 105 – landslip and debris at 600mm dia. culvert 3. At pt 106 to 107 – small landslip	1. replace culvert with new culvert and repair roadway 2. clear landslip and cut slope back to stable angle and clear debris from culvert 3. clear landslip and cut slope back to stable angle		

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
East Coast Road	108	1531415	518094	CRITICAL/NON-ACCEPTABLE	Landslip at outlet to 600mm dia. culvert at LHS of roadway. The roadway is under increasing threat for further erosion	Complete reconstruction of the culvert or reconstruction of the outlet depending on the size of culvert determined that is required from the hydraulic analysis.		**$ -**
	109	1531409	518092	CRITICAL/NON-ACCEPTABLE	Landslip at outlet to 600mm dia. culvert at LHS of roadway. The roadway is under increasing threat for further erosion	Complete reconstruction of the culvert or reconstruction of the outlet depending on the size of culvert determined that is required from the hydraulic analysis.		
East Coast Road	110	1531206	517928	URGENT/INTOLERABLE	Major landslip across the entire width of the east coast road.	Construct an adequately sized bridge structure with an innovative wingwall system to reduce likelihood of undermining of the bridge system and another collapse.	$ -	**$ -**
	111	1531215	517908	URGENT/INTOLERABLE	Major landslip across the entire width of the east coast road.	Construct an adequately sized bridge structure with an innovative wingwall system to reduce likelihood of undermining of the bridge system and another collapse.	$ -	
Sub-Total							**$5,165,000.00**	
East Coast Road	115	N13.99622	W060.98051	Urgent	Slope failure on either side of roadway	Retain slope with grid/mat reinforcement; construct catchpits for drains; retainment of road edge	$1,000,000.00	**$ -**

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	116	1530041	518177	URGENT/INTOLERABLE	1. erosion (causing major landslips and felling of trees) and then deposition of large volumes of silt, gravel, debris and large uprooted trees within along miles of river channel and the adjacent farmlands within floodplain levels. Silt deposited up to four (4) feet deep. Tree trunks and logs measure up to 1.5m in diameter	Adequate, structured desilting annual exercises to maintain the channel capacity of the river and outfall into the sea.	$ -	
	117	1530795	517778	CRITICAL/NON-ACCEPTABLE	Malgretoute Bridge (pt 120-123): minor repairs, bridge seemed of adequate capacity; no overtopping.	Cut loose trees, clear landslip and debris, and cut slope back to stable angle		
	118	1530770	517791	CRITICAL/NON-ACCEPTABLE	Landslip on LHS above road level on the east coast road.	Cut loose trees, clear landslip and debris, and cut slope back to stable angle		
	126	1528252	518480	TOLERABLE	1. Flooding across the east coast road from the Volet River 2. Uplift and erosion of sections of asphalt on the east coast road from the floodwaters.	1. Conduct analysis of hydraulic capacity of existing culvert and determine the need for increased dimensions not necessarily to accommodate a greater flow volume but possibly to allow the culvert to maintain capacity by allowing the volumes of transport trees and debris to not clog the cross sections 2. Cut out section of the roadway in area of asphalt uplift and erosion, reregulate and recompact the base, and repave		

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
						ensuring adequate tack coating.		
	127	1528234	518470	TOLERABLE	1. Flooding across the east coast road from the Volet River 2. Uplift and erosion of sections of asphalt on the east coast road from the floodwaters.	1. Conduct analysis of hydraulic capacity of existing culvert and determine the need for increased dimensions not necessarily to accommodate a greater flow volume but possibly to allow the culvert to maintain capacity by allowing the volumes of transport trees and debris to not clog the cross sections 2. Cut out section of the roadway in area of asphalt uplift and erosion, reregulate and recompact the base, and repave ensuring adequate tack coating.		

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	132	1529166	514693	URGENT/INTOLERABLE	Major catastrophic failure of road embankment removing the roadway completely. Failures further along roadway are highly likely. However, this was not ascertained as travelling beyond the first collapse of the embankment was near impossible and highly dangerous, even on foot.	Reconstruct the road embankment or provide an alternative route.		
	133							
TROUMASSEE BRIDGE AND RIVER	134	1527172	518799	CRITICAL/NON-ACCEPTABLE	1. erosion (causing major landslips and felling of trees) and then deposition of large volumes of silt, gravel, debris and large uprooted trees along miles of river channel and the adjacent farmlands within floodplain levels. Silt deposited up to six (6) feet deep in places. Tree trunks and logs measure up to 1.5m in diameter 2. Bridge (pt 120-123): minor repairs (including railing), bridge (abutments and wingwalls) seemed of adequate capacity; no overtopping.	Adequate, structured desilting annual exercises to maintain the channel capacity of the river and outfall into the sea.		
	135	1527175	518791					
	136	1527213	518801					
	137	1526775	518723					

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
EAST COAST ROAD	138	1526729	518710	CRITICAL/NON-ACCEPTABLE	Erosion of road embankment and failure of retaining rubble wall (outfall to culvert) on LHS	Reconstruction of the culvert outlets and inlets (as a minimum) properly incorporating the roadside drains.		
	139	1526723	518710		Erosion of road embankment and failure of outfall to culvert and inlet to culvert up to half road width			
	140	1526707	518709					
	141	1526705	518709		Erosion of road embankment and failure of retaining rubble wall (outfall to culvert) on LHS			
	142	1526483	518703		Damage to culvert and half width of road from the inlet side.			
DESRUISSEAUX TO BELLE VUE	143	1525053	514499	CRITICAL/NON-ACCEPTABLE	Landslip on LHS above road level on the Desruisseaux to Belle Vue road.	Cut loose trees, clear landslip and debris, and cut slope back to stable angle		
	144	1525070	514500					
DESRUISSEAUX TO BELLE VUE	147	1525121	513964	TOLERABLE	Low-level causeway crossing approx 3.4m wide. Functions such that rivers floods over during heavy rains River flooding with the deposition of silt and debris onto the roadway, drains and adjacent banana plantations.	River training upstream to ensure the containment of soil from landslides entering the river, and an adequate, structured desilting annual exercises to maintain the channel capacity of the river. Replacement of causeway with with a structure of adequate hydraulic capacity is an option.		
	148	1525122	513942					

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
DESRUISSEAUX TO BELLE VUE ROAD	149	1525018	513509	TOLERABLE	Failure of half width of roadway on the inlet side of the culvert with massive collapse, exposing what seems to be the original road embankment. The roadway is under increasing threat for further erosion	Complete reconstruction of the culvert and road embankment depending on the size of culvert determined that is required from the hydraulic analysis.		
	150	1525024	513497					
BELLE VUE TO GRACE ROAD	151	1525091	513503	TOLERABLE	30ft high Landslide of soil and vegetation above RHS of roadway	clear landslips and cut slope back to stable angle and clear debris from drains		
	152	1524610	513005					
	153	1524274	512743	TOLERABLE	Landslide across roadway			
	154	1524260	512701					
	155	1524022	512268	TOLERABLE	landslide above RHS of roadway	clear landslips and cut slope back to stable angle and clear debris from drains		
	156	1524007	512266					
	157	1524003	512262					
	158	1523987	512255					

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	159	1523864	512286					
	160	1523849	512309	TOLERABLE	landslide above RHS of roadway (60ft wide x 10ft high x 5ft deep)landslide above LHS of roadway (25ft wide x 20ft high x 5ft deep)	clear landslips and cut slope back to stable angle and clear debris from drains		
	161	1523754	512420	TOLERABLE	low level causeway, overtopped by river, leaving roadway impassable with deposition of debris	clear landslips and cut slope back to stable angle and clear debris from drains		
	162	1523472	512422					
BELLE VUE TO GRACE ROAD	165							
	166	1523514	512436		25ft high Landslide of soil and vegetation above RHS of roadway			
	167	1523505	512437					
GRACE TO BEASEJOUR ROAD	168	1520585	512156	TOLERABLE	Hydraulic capacity of small bridge to tributary of VF River exceeded (with some blockage by floating debris) causing damage to railings and minor damage to leading edge of deck slab on inlet side. Beams, wingwalls and abutments intact.	Clear the river channel of silt and remove upstream 'precarious' vulnerable trees and vegetation prior to the rainy season.		
	169	1520573	512159					

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
BANSE / LA GRACE	188	1523922	508626	TOLERABLE	20ft high Landslide of soil and vegetation above LHS of roadway	Clear landslips and cut slope back to stable angle and clear debris from drains		
	189	1523932	508631					
	190	1523623	508630		40ft high road embankment slide (below road) at RHS of roadway			
	191	1523945	508642					
	192	1524000	508663		30ft landslide above RHS of roadway			
	193	1524041	508633					
	194	1524085	508637		slip at RHS of road, section of the road is in threat of major collapse with utility line presently exposed.			
	195	1525185	508727		landslide (over 50ft) above RHS of roadway forcing stream of water onto road. This includes over 100m of debris filled RHS drains of soil and trees. Road extensively eroded and damaged.			
	196	1525171	508731					
	197	1525138	508732					

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	198	1525301	508786		landslide above RHS of roadway (40ft wide x 60ft high x 10ft deep)			
	199	1525330	508798					
	200	1525347	508795		landslide above RHS of roadway (40ft wide x 60ft high x 10ft deep). Soil and debris a quarter way onto the road.			
BANSE and DARBAN	206	1525964	508665	TOLERABLE	1. Pt 206-232 (Banse) - major series of landslides measuring up to 40m in height of soil and vegetation above roadway, rendering the road completely impassable to vehicles. 2. Darban - major series of landslides measuring up to 50m in height of soil and vegetation above roadway, rendering the road completely impassable to vehicles.	clear landslips and cut slope back to stable angle and clear debris from drains, re-stabilize using appropriate, cost effective methods		
SALTIBUS	225	1526145	506663	CRITICAL/NON -ACCEPTABLE	40ft high Landslide of soil and vegetation above LHS of roadway	clear landslips and cut slope back to stable angle and clear debris from drains. Toe , full retaining walls or a combination of realignment of roadway and retaining structures are		
	226	1526222	506743					

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	227	1526310	506810		40ft high road embankment slide (below road) at RHS of roadway, reducing roadway width with the high probability of further potential collapse.	recommended for the more aggressive slips		
	228	1526318	506813					
	229	1526462	506877		22ft high landslide above LHS of roadway			
	230	1526496	506886					
	231	1526623	507009		25ft high landslide above LHS of roadway			
	232	1526640	506998					
	233	1526776	506998		Greater than 100ft high slip at LHS of road embankment. Slip likely to progress with section of the road in threat of major collapse with the next heavy rain event.			
	234	1526783	506994					
	235	1527026	507060		landslide above LHS of roadway (10ft wide x 10ft high x 3ft deep).			
	236	1527029	507078		30m long, 8ft high, shallow landslide above LHS of roadway			

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	237	1527017	507099					
	238	1526995	507148		landslide above LHS of roadway (10ft wide x 90ft high x 5ft deep)			
	239	1526943	507161		long LHS slip 15ft high x 10ft deep at the toe. Will continue to move with rains. Blocked drains will lead to erosion of the roadway and compromise slope stability on other side of roadway.			
	240	1526934	507165					
	241	1526924	507169					
	242	1526917	507180					
	243	1526880	507239		minor landslide above LHS of roadway (10ft wide x 25ft high x 8ft deep). Though cleared likely to slip further.			
	244	1526899	507237					
SALTIBUS	245	1526917	507249	CRITICAL/NON-ACCEPTABLE	1. minor landslide above LHS of roadway (10ft high x 4ft deep). Not expected to slip extensively with next heavy rains but should be monitored.	clear landslips and cut slope back to stable angle and clear debris from drains. Construction of retaining gabion basket walls or a combination of realignment of roadway and retaining structures are recommended for the more aggressive slips		
	246	1526929	507244					
	247	1526940	507235					

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	248	1527006	507197		slip which threatens the road on its RHS (at a 0.6m diameter cross culvert), approx 20ft wide and has reduced road width by 3ft. slope eroded by water outfall from the culvert			
	250	1527037	507209	CRITICAL/NON-ACCEPTABLE	3. Pt 250-251 – 40ft high landslide above LHS of roadway 4. Pt 250-252 – 20ft high landslide (10ft wide x 2ft deep) above RHS of roadway. LHS drain severely compromised and will cause to flow into road			
	251	1527052	507225					
	252	1527063	507230					
	253	1527136	507239	CRITICAL/NON-ACCEPTABLE	20ft high, shallow landslide above LHS of roadway			
	254	1527166	507238					
	257	1527263	507363	CRITICAL/NON-ACCEPTABLE	start of major impassable slide (mud, land and vegetation) – 40m wide x 30ft deep and fully across roadway			
	258	1527272	507343		60ft high (30ft deep) mudslide across from LHS of roadway			
	259	1527273	507283					

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	260							
DARBAN	261			CRITICAL/NON-ACCEPTABLE	landslide above LHS of roadway (50ft high x average 10ft deep). Substrate seems stable with only minor slippage from top 5ft of slide face likely during next heavy rains	clear landslips and cut slope back to stable angle and clear debris from drains. Construction of retaining gabion basket walls recommended for the more aggressive slipsreplace low level causeway with bridge or culvert structure		
	262							
	263				single lane, low level causeway overtopped during storm with deposition of large amounts of tree debris making it impassable during and immediately after hurricane			
	264							
	265				RHS slip above road (20ft high at it tallest point, 10ft at its shortest point, 5ft deep), compromising the RHS drains			
	266							
	267				LHS slip above road (20ft high, 8ft deep). Though slope is relatively stable at this point, tree at top of slope likely to fall across road with the next moderate to severe rains.			
	268							

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	269							
	270							
	271				LHS slip above road			
	272							
	273							
	274				RHS lower (embankment slip) road, which is in imminent danger of catastrophic failure especially if drainage not controlled.			
	275							
	276				LHS above road slip (35ft high x 8ft deep). Relatively stable with only a moderate level of slippage expected with next heavy rains			
	277							
	278				LHS above road slip (15-25ft high x 5ft deep).			
	279							

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
THOMAZO	280			URGENT/INTOLERABLE		conduct adequate, structured desilting annual exercises to maintain the channel capacity of the river and outfall into the sea; designed river training and flood protection works; replace existing bridge structure with a structure of adequate hydraulic capacity to accommodate storm flows and therefore maintain transport link during storm events		
	281							
	284				LHS above road slip (20ft high x 3ft deep).			
	285							
	286				LHS above road slip (15ft high x 4-5ft deep). Slope material is not stable and is likely to move with next heavy rains.			
	287							
	289	1540253	515043		The spread of the river over acres and acres of land caused the depositing of large volumes of silt, up to 4ft in places. At the point of the bridge, the road was impassable with the overtopping of the bridge and the deposition of logs, trees and debris, until this was cleared after the end of the hurricane.			
	290	1540246	515046					
	291	1540250	515058					
	292	1540256	515054					
GRANDE RIVIERE	293	1539992	515554	URGENT/INTOLERABLE	The spread of the river over acres and acres of land caused the depositing	conduct adequate, structured desilting annual exercises to maintain the channel capacity of		

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	294	1539986	515558		of large volumes of silt, up to 4ft in places. At the point of the bridge and surrounding area, the road was impassable with floodwaters, the overtopping of the bridge and the deposition of logs, trees and debris, until this was cleared after the end of the hurricane.	the river and outfall into the sea; design and construct river training and flood protection works; replace existing bridge structure with a structure of adequate hydraulic capacity to accommodate storm flows and therefore maintain transport link during storm events		
	295	1539992	515569					
	296	1520721	505944					
CHOISEUL – LAMAZE & MYERS BRIDGE	299	1525724	505639	CRITICAL/NON-ACCEPTABLE	15ft high (15ft wide x 5ft deep) landslide of soil and vegetation above RHS of roadway into road and drains	clear landslips and cut slope back to stable angle and clear debris from drains		
	300	1525725	505634		road narrowed to 2m with a 40ft high (20ft wide) road embankment slide (below road) at RHS of roadway			
	301	1525732	505641					
	302	1527689	504971		20ft high (50ft wide x 10ft deep) landslide of soil and vegetation above LHS of roadway			
	303	1527683	504954					
	304	152672	504920		15ft high (60ft wide x 20ft deep) landslide of soil and vegetation above LHS of roadway and across			
	305	1527672	504901					

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	306	1527567	504615		erosion of section of roadway (RHS) due to stormwater flow over surface (20ft long x 2ftwide x 2ft deep trench). Pavement to be reconstructed fully and adequate drainage put in.			
CHOISEUL – VIEUX-FORT/SOUFRIERE H'WAY	307	1527423	503764	URGENT/INTOLERABLE	25ft high (30m wide x 5ft deep) landslide of soil and vegetation above RHS of roadway into road and drains	clear landslips and cut slope back to stable angle and clear debris from drains, re-stabilize using appropriate methods (not necessarily methods used previously)		
	308	1527399	503752					
	309	1527410	504229		25ft high (25ft wide x 28ft deep) landslide of soil and vegetation above RHS of roadway across the road and drains			
	310	1527391	504223					
	311	1527340	504190		major landslide (behind RHS gabions basket wall) measuring 85ft high (70ft wide x 70ft deep) landslide of soil and vegetation above RHS of roadway across the road and drains			
	312	1527320	504184					
	313	1527200	504095		major landslide (behind RHS gabions basket wall) measuring 90ft high (60ft wide x 40ft deep) landslide of soil and vegetation above RHS of roadway, partially across the road			
	314	1527076	503999					

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
CHOISEUL – MORNE JACQUES & ENVIRONS				CRITICAL/NON-ACCEPTABLE	and drains	clear landslips and cut slope back to stable angle and clear debris from drains, re-stabilize using appropriate, cost effective methods		
	315	1527026	503954		major landslide (behind RHS gabions basket wall) measuring 40m high (70m wide x 30m deep) landslide of soil and vegetation above RHS of roadway, partially across the road and drains			
	316	1527027	503955					
	317	1526295	503896		rock (sizes up to 0.75m diameter) fall from RHS road of volume 10m3			
	318	1526307	503906					
	320	1526403	504044		major landslide upslope of RHS of roadway across the entire width of road measuring 80m wide x 75m high (one half of slide) and 20m high (second half of slide) x 40m			
	321	1526343	504068					
	323	1526598	504648		15ft high (20ft wide x 8ft deep) landslide of soil and vegetation above LHS of roadway into road and drains			
	324	1526598	504648		60ft high (10ft wide x 30ft deep) mudslide above LHS of roadway across the road and drains			

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	325	15216608	504784		25ft high (15ft wide x 18ft deep) mud and rock slide above LHS of roadway across the road and drains			
	326	1526562	504815		minor slip of mud and rock 15ft high (10ft wide x 5ft deep) slide above LHS of roadway across the road and drains			
	327	1526488	504877		10ft high (30ft wide x 8ft deep) vegetation and debris slide above roadway LHS across the road			
	328	1526400	504886		slide of weather rock with suspended trees 12ft high (30ft wide x 3ft deep) above roadway LHS			
	329	1526384	504880					
	330	1525919	504968		slide of topsoil and heavy vegetation 10ft high (55ft wide x 20ft deep) above roadway LHS			
	331	1525896	504955					
	332	1522772	504581		bridge overtopped with large amounts of soil, debris, logs and other vegetative matter			
	333	1522766	504584		major landslide measuring up to 80ft high (60m wide x 7m deep) landslide of soil			

Area	Item #	Coordinates		Repair Status	Damages	Repair Required	Estimated Cost	Area Cost
		Northern	Eastern					
	334	1522751	504577		and vegetation above LHS of roadway. Covered roadway with 30ft of vegetation and soil.			
	335	1522743	504564					
	336	1522740	504554					
	337	1522747	504548					
	338	1522815	504502		major landslide measuring up to 35ft high (over 65m wide x 10m deep) landslide of soil and vegetation above RHS of roadway.			
	339	1523494	517375					
	340							
Estimated Total Cost							**$ 10,765,000.00**	**$ 7,965,000.00**
Contingency Sum (15%)								**$ 1,194,750.00**
Total Budget Cost								**$ 9,159,750.00**

Institutions and Public Buildings

- ***Victoria Hospital Paedriatric Ward***
- ***St. Joseph's Convent***
- ***Babonneau School Retaining Wall***
- ***Augier Combined School***
- ***Belle Vue Combined School***

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT FORM

DATE:	LOCATION/LANDMARKS:	SECTOR TEAM:
16 Nov. 2010	*Victoria Hospital Paedriatric Ward Building (GPS Coordinates):*	**Public Institutions**

DESCRIPTION of issue/problem (*quantify scale /dimensions*):

Leaking roof of the building is posing severe problems for all the floors below. The Paedriatic Ward patients have been transferred elswhere and the water poses a problem for the X-Ray Room and equipment and also reaches the Laundry Room in the basement. Building Footprint: 3660ft^2 (340m^2)

CAUSE/TRIGGER of issue/problem (*what caused it to happen*):

The roof of the building is clearly inadequate as this problem has been a recurring one. There is corrugated sheeting over a flat concrete roof and there appears to be problems with this concrete roof thus permitting rain water through.

RISKS related to issue/problem *(probability of harmful consequences/ losses -deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):*

The structural condition of the concrete roof was not assessed in this brief review but any failure would be catastrophic.

PHOTOS *(showing state of issue/problem)***:**

Risk SIGNIFICANCE level *(Magnitude/Frequency/Duration)**: x***

URGENT/INTOLERABLE		**CRITICAL/NON-ACCEPTABLE**	**X**
MINOR		**TOLERABLE**	
-		**ADAPTABLE**	

ELEMENTS at risk *(place an **x**):*

Utilities		**Institutions**	**X**
Industry		**Tourism**	
Population		**Transport System**	
Natural Resources		**-**	
Agriculture		**-**	

RECOMMENDATIONS/Mitigation (*structural/non-structural measures to limit adverse impact* **):**

RATIONALE/overview: Replacement of the concrete roof is clearly desirable

Estimated COSTS

EC$250,000.00

IMMEDIATE/short term:
Undertake a detailed engineering review of the building to determine structural integrity. The concrete roof is a major cause of concern as the continual leaking problem could be indicative of a wider problem. However roof replacement will depend on the residuual strength of the buldings other beams and columns and their ability to carry a new possibly heavier roof structure.

STRATEGIC/medium-long term:

After detailed review of structure follow up action to correct problem to be immediately persued

OTHER information:

REFERENCE material used/available on issue/problem (*include where document can be accessed***):**

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT FORM

DATE:	LOCATION/LANDMARKS:	SECTOR TEAM:
16 Nov 2010	*St. Joseph's Convent* *(GPS Coordinates):*	**Public Institution**

DESCRIPTION of issue/problem (*quantify scale /dimensions*):

Small landslide to th back of the school approx 50ft (15m) long

PHOTOS *(showing state of issue/problem)***:**

CAUSE/TRIGGER of issue/problem (*what caused it to happen*):

Landslide triggered by excessive haevy rain

RISKS related to issue/problem *(probability of harmful consequences/ losses -deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):*

No great risk to th school but will continue to be a nuisance requiring claen-ups

Risk SIGNIFICANCE level *(Magnitude/Frequency/Duration)**: x***

URGENT/INTOLERABLE		**CRITICAL/NON-ACCEPTABLE**	
MINOR	**X**	**TOLERABLE**	
-		**ADAPTABLE**	

ELEMENTS at risk *(place an **x**):*

Utilities		**Institutions**	**X**
Industry		**Tourism**	
Population		**Transport System**	
Natural Resources		**-**	
Agriculture		**-**	

RECOMMENDATIONS/Mitigation (*structural/non-structural measures to limit adverse impact* **):**

RATIONALE/overview:

Estimated COSTS

EC$25,000.00

IMMEDIATE/short term:

STRATEGIC/medium-long term:

Construction of an approximately 50ft (15m) long retaining wall

OTHER information:

REFERENCE material used/available on issue/problem (*include where document can be accessed***):**

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT FORM

DATE:	**LOCATION/LANDMARKS:**	**SECTOR TEAM:**
16 Nov. 2010	*Babonneau Secondary School (GPS Coordinates):*	**Public Institution**

DESCRIPTION of issue/problem (*quantify scale /dimensions*):

A Landslide close to the school buildings is a future threat to the institution.

PHOTOS *(showing state of issue/problem)***:**

CAUSE/TRIGGER of issue/problem (*what caused it to happen*): **Ground movement on a slope caused by persistent heavy rain.**

RISKS related to issue/problem *(probability of harmful consequences/ losses -deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):*

Future movement could pose problems for several school buildings.

ELEMENTS at risk *(place an **x**):*

Utilities		**Institutions**	**X**		
Industry		**Tourism**			
Population		**Transport System**			
Natural Resources		**-**			
Agriculture		**-**			

Risk SIGNIFICANCE level *(Magnitude/Frequency/Duration)**: x***

URGENT/INTOLERABLE	**X**	**CRITICAL/NON-ACCEPTABLE**	
MINOR		**TOLERABLE**	
-		**ADAPTABLE**	

RECOMMENDATIONS/Mitigation (*structural/non-structural measures to limit adverse impact* **):**

RATIONALE/overview: Construction of an approximately 130ft (40m) long retaining wall to arrest further ground movement

Estimated COSTS

EC$150,000.00

IMMEDIATE/short term:

Construction of retaining wall

STRATEGIC/medium-long term:

OTHER information:

REFERENCE material used/available on issue/problem (*include where document can be accessed***):**

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT FORM

DATE:	LOCATION/LANDMARKS:	SECTOR TEAM:
Nov 16, 2010	Augier Combined School	Institutions

DESCRIPTION of issue/problem (*quantify scale /dimensions*):

1. **Roof damage Stairwell (10'x20')**
2. **Roof damage to administrative block (12'x20')**
3. **Roof damage to classroom block (21'x25') including external wall (12'x25')**
4. **Damage to ceilings and electrical (72'x19')**

PHOTOS *(showing state of issue/problem)***:**

See attached

CAUSE/TRIGGER of issue/problem (*what caused it to happen*):

Wind and water.

RISKS related to issue/problem *(probability of harmful consequences/ losses -deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):*

1. **Water ingress to electrical system. High risk of injury.**
2. **Severe mould growth. High risk for persons with respiratory issues**
3. **Ceilings exposed to rain may collapse. High risk.**
4. **Buildings not weather tight**

ELEMENTS at risk *(place an **x**):*

Utilities		**Institutions**	***x***		
Industry		**Tourism**			
Population		**Transport System**			
Natural Resources		**-**			
Agriculture		**-**			

Risk SIGNIFICANCE level *(Magnitude/Frequency/Duration)**: x***

URGENT/INTOLERABLE	***x***	**CRITICAL/NON-ACCEPTABLE**	***x***
MINOR		**TOLERABLE**	
-		**ADAPTABLE**	

RECOMMENDATIONS/Mitigation (*structural/non-structural measures to limit adverse impact* **):**

RATIONALE/overview: Reinstate elements listed above

Estimated COSTS

EC$115,000.00

IMMEDIATE/short term:

1. **Reinstate elements listed above**

STRATEGIC/medium-long term:

OTHER information:

REFERENCE material used/available on issue/problem (*include where document can be accessed***):**

Housing & Settlements

- *No separate report produced to date - the team members focused initially on their other sectors (River management and Institutions)*

Appendix A: Types of Assessment Reports for Emergency Relief and Short-term Restoration

Type of assessment	Time Period	Purpose	Responsibility
Initial Situation Overview [ISO]	4 – 8 hours after the disaster has occurred and/or the *All Clear* given	To provide a "snap shot" of the situation.	District Committee
Initial Damage Assessment [IDA]	12 - 24 hours after the disaster has occurred	To provide information on overall damages and causalities and needs to permit allocation of critical supplies in the first 24 hours after a disaster.	District Committee
Detailed Sector Report [DSR]	24 - 36 hours after disaster occurs	To summarize data on overall damages and causalities by Sector.	Sector Agencies
National Damage Assessment Report #1	48 hours after disaster	Summary of Information provided over time in the ISO, IDA and the DSR. It also provides more details on damages in order to continue the allocation of emergency resources.	DANA Committee
National Damage Assessment Report #2	7 days after disaster	Revision and update on the First DANA Report	DANA Committee
National Damage Assessment Report #3	14 days after disaster	Revision and update on the Second DANA Report. This process can be repeated as needed.	DANA Committee
Macro Socio Economic Report	From 21 days after the disaster has occurred.	Starting with the DANA Reports a sector-by-sector analysis of the impact of the event is produced. Sectors are grouped into four categories: • Social • Productive • Infrastructural and • Environment.	OECS Secretariat with DANA Committee

Appendix B: APESL Inc. Post Hurricane Tomas Technical Assessment Form

ST. LUCIA POST HURRICANE TOMAS RAPID TECHNICAL ASSESSMENT FORM

DATE:	**LOCATION/LANDMARKS:** *(GPS Coordinates):*	**SECTOR TEAM:**

DESCRIPTION of issue/problem (*quantify scale /dimensions*):

CAUSE/TRIGGER of issue/problem (*what caused it to happen*):

RISKS related to issue/problem *(probability of harmful consequences/ losses -deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged):*

PHOTOS *(showing state of issue/problem)***:**

ELEMENTS at risk *(place an **x**):*

Utilities		**Institutions**	
Industry		**Tourism**	
Population		**Transport System**	
Natural Resources		**-**	
Agriculture		**-**	

Risk SIGNIFICANCE level *(Magnitude/Frequency/Duration)**: x***

URGENT/INTOLERABLE		**CRITICAL/NON-ACCEPTABLE**	
MINOR		**TOLERABLE**	
-		**ADAPTABLE**	

RECOMMENDATIONS/Mitigation (*structural/non-structural measures to limit adverse impact* **):** **RATIONALE/overview:**	**Estimated COSTS**
IMMEDIATE/short term:	
STRATEGIC/medium-long term:	

OTHER information:

REFERENCE material used/available on issue/problem (*include where document can be accessed***):**