Saint Lucia
Ministry of Infrastructure,
Ports, Energy and Labour

Preparatory Survey Report
on
The Project for Reconstruction of Bridges in Cul-De-Sac Basin
in
Saint Lucia

June 2017

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., Ltd.

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Preface

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to NIPPON KOEI Co.,Ltd.

JICA Survey Team held a series of discussions with the officials concerned of the Government of Saint Lucia, and conducted field investigations. As a result of further studies in Japan, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Saint Lucia for their close cooperation extended to JICA Survey Team.

June 2017

Itsu Adachi
Director General,
Infrastructure and Peacebuilding Department
Japan International Cooperation Agency

SUMMERY

1. Background of the Project

(1) Background

Saint Lucia, ranked as the 14th most at risk among 160 countries in the world by the impacts of climate changes according to Global Climate Risk Index 2015: Germanwatch, is vulnerable to damages caused by hurricane, floods and other natural disasters. Hurricane Tomas in October 2010 resulted in economic losses of infrastructure over US$ 145 million (11.7% of GDP), and Christmas floods in December 2013 resulted in losses over US $ 70.6 million (5.3% of GDP). As such, Saint Lucia experienced huge amount of economic losses of infrastructure damages by natural disasters. The Government of Saint Lucia (hereinafter referred to as the GOSL) has developed "the National Hazard Mitigation Policy" as a strategic instrument for hazard mitigation, of which policy is intended to facilitate the more effective use of scarce technical and financial resources in a comprehensive approach to disaster management. It is a very urgent need to maintain the traffics in Saint Lucia to reduce the risks of economical losses of traffic disruption at the time of natural disaster.

Among the major roads in the island the East Coast Road (hereinafter referred as the Road), which carries approximately 15,000 vehicles/day between Hewanorra International Airport on the south of East Coast and the national capital Castries on the north of West Coast, is the most important primary road running through the central highland. The Road is vulnerable to the natural disaster risks like floods and landslides, and paralyzes the flow/movement of traffics between the north and south of the island for approximately 8 days/year to force long-distance vehicles detour. From the viewpoint of the disaster risk mitigation of the Road, the GOSL requested the Government of Japan (hereinafter referred to as the GOJ) a grant aid to reconstruct three (3) high priority bridges, viz. Cal de Sac Bridge, Ferrands Bridge and Ravine Poisson Bridge, in the Cal de Sac basin (hereinafter referred to as the Project).

(2) Implication of National Plan of Saint Lucia

National Vision Plan, which is a long term plan covering all areas of the country and aiming at enlargement of future investment, was published in 2008.

"MEDIUM TERM DEVELOPMENT STRATEGY, 2012-2016, Sectoral Action Plan" was published in September 2012. "Goal 18: Economic Infrastructure" deals with the concerned matters of the Project. The objectives of Goal 18 consists of the following 3 activities, in which the first one is closely related to the Project.

18.1 To rehabilitate and upgrade the network of roads and bridges damaged by Hurricane Tomas

18.2 To rehabilitate and upgrade the water system

18.3 To rehabilitate and secure other infrastructure

PDM of the above 18.1 in the Medium Term Development Strategy is re-produced in Table 1.

Table 1 PDM of Object 18.1 in MEDIUM TERM DEVELOPMENT STRATEGY

Objective 18.1	**Indicators**	**Means of Verification**	**Assumptions/Risks**
Outcome	A safer and more reliable system of roads & bridges		Universal commitment to enhanced standards in construction of roads and bridges – CUBiC and beyond
Outputs	■ Critical links between North and South restored in Year 1 ■ Roads damaged by Hurricane Tomas reconstructed & upgraded during Years 1 – 3 ■ Bridge structures for major rivers are designed to accommodate a 1 in 50 year flood event ■ Existing bridges are replaced by open span structures during Years 1 – 5	■ Survey ■ Survey ■ Guidelines of the Ministry of Communications & Works ■ Survey	Need for urgency in coordination by authorities well appreciated by them

Source: "MEDIUM TERM DEVELOPMENT STRATEGY, 2012-2016, Sectoral Action Plan", September 2012.

Related matters to the Cul-De-Sac Bridge and Ravine Poisson Bridge are in the 2nd and 3rd paragraph of Outputs in the table; "Roads damaged by Hurricane Tomas reconstructed & upgraded during Years 1 – 3", and "Bridge structures for major rivers are designed to accommodate a 1 in 50 year flood event".

(3) Necessity and Project Goal

Almost 100% of Domestic transportation of Saint Lucia depends on road transportation. The total population is 182,300 (WB 2013) in the total land area of 610 km^2.

The Cul-De-Sac Bridge is located on the West Coast Road and the Ravine Poisson Bridge is on the East Coast Road. Road links to connect the Capital City Castries in the north and Hewanowa International Airport in the south depend on both of the East Coast Road and the West Coast Road.

Major economic activities are concentrated in the north region and south region which includes Hewanowa and Vieux Fort. Road transportation between north and south regions should use Cul-De-Sac Bridge or Ravine Poisson Bridge, both of which are likely affected by natural disaster of floods. To build these 2 bridge can decrease the potential risks of road closure due to natural disaster and obtain stable transport networks.

The Project aims at reconstruction of the existing bridges which are located in the high risk areas of floods from the natural disasters such as hurricanes and tropical storms taking into consideration the design requirement of probable floods for 50 year return periods. As such, transport risks from the natural hazards of the major roads of the East Coast Road and the West Coast Road would decrease being resulted in stable traffics.

By implementing the Project, recipients are regarded widely spreading to all the areas of the country and strengthening the opportunities of tourism industry development and increasing the potential investment.

2. Outcomes of the Survey and Contents of the Project

(1) Survey Team Deployment to Saint Lucia

JICA deployed JICA Survey Team three (3) times to Saint Lucia for surveying and exchanging the views on the requested three (3) sites: June 1 to July 9, 2016 (confirmation of the Saint Lusia's request of the project components), October 24 to November 10, 2016 (basic approach for concept design of the Project), and February 27 to March 9, 2017 (contents of the Project and undertakings by Saint Lucia and Japan). The Survey includes mainly the bridge location study and road geometry design, natural condition survey (topography and subsoil) and traffic survey, design high water levels by hydrological and river engineering studies, span length and width compositions of bridges and approach roads, comparative studies on bridge type options, structural designs on bridges (superstructures, substructures and foundations) and approach roads, planning on construction methods and temporary bridge layout/ temporary cofferdams, surveys on construction equipment and materials/labours, capacity development of maintenance organization after the Project, etc.

(2) Saint Lucia's Request and Feature of Project Contents

Saint Lusia's Request: Reconstruction of three (3) specific bridges (Cul de Sac, Ferands, Ravine Poisson) in the Cul de Sac Basin, approach roads and protection of piers and abutments

Project Situation: The Project aims at reconstruction of the existing bridges, which are located in the high risk areas of floods from the natural disasters, on the major road of the country. The GOJ stated the Japan's CARICOM policies in July 2014, in which is "Cooperation towards sustainable development, including overcoming the vulnerabilities particular to small island states". Strengthening the major roads in the island by the Project is regarded as relevant from the view point of "disaster risk reduction and environment problem support" of the foreign policy of the GOJ.

Criteria and Grade of Facility Design of the Project: Bridges, approach roads and river protection works of piers and abutments will be on the prevailing design standards in Japan, except for the seismic proof design standards in Saint Lucia. Vertical clearance above the high water level up to the bridge soffit will be on the 50-year probable flood level (as per Medium Term Development Strategy of Saint Lucia). The required lane number was decided at two (2) for dual (both directions) carriageway taking into consideration traffic volumes forecasted for 20 years after the bridge reconstruction.

Development Levels and Design Approach of Bridge Reconstruction: Reconstructed bridges should be structurally safe against the design floods. As for bridge design, structural elements should be on the river structure design codes specified in Japan.

Scope of the Specific Bridges under the Japan's Grant: JICA Survey Team examined the possible scope of the specific bridge combination scenarios as summarized in Table 2-2: viz. 1 bridge implementation case (Cul-de-Sac bridge only), 2 bridge implementation case (Cul-de-Sac and Ravine Poisson bridges) and 3 bridge implementation case (Cul-de-Sac, Ravine Poisson and Ferrand's bridges). As per the results shown in the table, the river improvement plan should be made prior to the implementation of the Ferrands bridge reconstruction. As concluded in the minutes of discussions in March 2017 between GOSL and JICA

Survey Team, the implementation plan in the Survey deals with two (2) bridge reconstruction of Cul de Sac and Ravine Poisson bridges although the Survey produces three (3) bridge designs including Ferrands Bridge.

Table 2 Present River Conditions in the Vicinity of Specific Bridge Sites and Effects of the Project

Specific Sites	Adjacent River Channel and Flooding Condition	Project Effects and Risks	Evaluation
Cul-de-Sac Bridge	As the river improvement works on the downstream side of this bridge has been completed, a new bridge can be effectively built by implicating the river improvement plan.	The existing bridge is located in a narrow section of the river, of which discharge capacity can be augmented through the bridge building works. Accordingly, effects of the Project is significantly high.	Good
Ferrand's Bridge	There is no river improvement plan both on downstream and upstream sides. Any river channel dredging and riverbund development have not been done, and the existing river channel largely meanders. The narrow section of the river is regarded as the main cause of floods and inundation in the area.	The existing structure is located at the narrow section of the river, which continues downwords up to the existing Cul-de-Sac Bridge. Significant effects are not expected even if a new bridge is built because of continuation of long distance of narrow river section. A new bridge construction without river improvement plan migh be in vain when the future river channel is realighned.	Not Recommended
Ravine Poisson Bridge	As the main river and tributary meet together just downstream of the existing bridge, water level is affected by the river confluence and severe damages from over-topping likely took place.	Taking into consideration that overtopping induced at the confluent of the main river and tributary, the bridge should be built by way of maintaining the adequate discharge capacity of the river. If to do so, the effects of the Project would be significantly high.	Good

Source: JICA Survey Team

Additional Survey requested by GOSL during the Survey: The following two (2) items were requested during JICA Survey Team stay in Saint Lucia.

- ✓ Conceptual plan of river improvement from upstream banks of Cul de Sac Bridge up to Ferrands Bridge: As a result of the river engineering studies on the Cul de Sac River, it was revealed that the river improvement plan should be made prior to the implementation of the Ferrands bridge reconstruction. JICA Survey Team produced a conceptual plan as indicative one.
- ✓ Road Raising of West Coast Road Connection: Road raising works of south connection of West Coast Road approach road has been regarded as undertakings by GOSL. GOSL has requested JICA Survey Team to produce a design/drawings on the road raising works of this south connection to maintain an uniform design as a continuation from the approach road under the Japan's grant.

(3) Feature of Outline Design

Bridge types and structural requirements anticipated in the request time by GOSL and those updated by GOSL and JICA Survey Team are in Table 3.

Table 3 Summary of Bridge Types and Structural Requirements Anticipated in GOSL Request and Updated by the Survey

SL No.	Request by GOSL			Update by the Survey	
	Bridge Name	Structural Requirements	Bridge Type	Bridge Type, Structural Requirements	Remarks
1	Cul-De-Sac Bridge	Simple Span Span Length 25m Width 10.5m, Height 6m	Hollow Slab	3 Span PC Hollow Slab Bridge Length 81m, Width 11.5m	
2	Ferrands Bridge	Simple Span Span Length 25m Width 10.5m, Height 6m	Concrete Girder	3 Span PC Hollow Slab Bridge Length 81m, Width 10.5m	Design is included but excluded in the scope of the Project
3	Ravine Poisson Bridge	Simple Span Span Length 25m Width 10.5m, Height 6m	Hollow Slab	Simple Span PC Hollow Slab 18m, Width10.5m	

Source: JICA Survey Team

Finally, the features of the respective bridges are shown in Figure 4 to 6.

Table 4 Facility Feature of Cul de Sac Bridge

Item		Types, Size & Dimensions, etc.
Bridge Location		Immediate Downstream (West) Side of Existing Bridge
Width	Bridge = 11.3m	Breakdown: Railing 0.4m + Sidewalk 1.5m + Carriageway 2x3.75m + Sidewalk 1.5m + Railing 0.4m
	Approach=11.5m	Breakdown: Guardrail 0.5m + Sidewalk 1.5m + Carriageway 2x3.75m + Sidewalk 1.5m + Guardrail 0.5m
Bridge Type		3 Span Continuous PC Hollow Slab Bridge
Span Arrangement Bridge Length		Span Arrangement: 20m + 30m + 29.9m Bridge Length = 81.0m
Bridge Surface Pavement		Asphaltic Concrete, Thickness: Carriageway =80mm, Sidewalk =40mm
A1 Abutment	Type	RC Invert-T
	Str. Height	6.8m
	Foundation	1.2m dia. RC Cast-in-place Piles
	Abutment Protect	Low Water Channel Slope: Dumped Stone High Water Channel & Bank Slope: Mortar Riprap
A2 Abutment	Type	RC Invert-T
	Str. Height	6.8m
	Foundation	1.2m dia. RC Cast-in-place Piles
	Abutment Protect	Low Water Channel Slope: Dumped Stone High Water Channel & Bank Slope: Mortar Riprap
P1 Pier	Type	RC Invert-T
	Str. Height	8.1m

	Foundation	1.2m dia. RC Cast-in-place Piles
	Pier Protect	Dumped Stone
P2 Pier	Type	RC Invert-T
	Str. Height	8.1m
	Foundation	1.2m dia. RC Cast-in-place Piles
	Pier Protect	Dumped Stone
Approach Road	Total Length	North (inc. Millennium Highway): 375m South: 240m Total = 615m
	Pavement	Type: Asphaltic Concrete Thickness: Carriageway 140mm=60mm (surface) + 80mm (binder), Sidewalk as unpaved shoulder
Junction	North	3 legs with East Coast Rd & West Coast Rd
	Midway	3 legs with Millennium Highway & West Coast Rd
	South	3 legs with West Coast Rd & Farmer's Rd

Source: JICA Survey Team

Table 5 Facility Feature of Ferrands Bridge

Note: This bridge is excluded in the scope of the project implementation.

Item			Types, Size & Dimensions, etc.
Bridge Location			Downstream side (to be finalized after river improvement plan)
Width	Bridge= 11.3m		Breakdown: Railing 0.4m + Sidewalk 1.5m + Carriageway 2x3.75m + Sidewalk 1.5m + Railing 0.4m
	Approach=11.5m		Breakdown: Guardrail 0.5m + Sidewalk 1.5m + Carriageway 2x3.75m + Sidewalk 1.5m + Guardrail 0.5m
Bridge Type			3 Span Continuous PC Hollow Slab Bridge
Span Arrangement Bridge Length			Span Arrangement: 25.4m + 30m + 25.4m Bridge Length = 81.0m
Bridge Surface Pavement			Asphaltic Concrete, Thickness: Carriageway =80mm, Sidewalk =40mm
A1 Abutment		Type	RC Invert-T
		Str. Height	7.4m
		Foundation	1.2m dia. RC Cast-in-place Piles
		Abutment Protect	Low Water Channel Slope: Dumped Stone High Water Channel & Bank Slope: Mortar Riprap
A2 Abutment		Type	RC Invert-T
		Str. Height	7.4m
		Foundation	1.2m dia. RC Cast-in-place Piles
		Abutment Protect	Low Water Channel Slope: Dumped Stone High Water Channel & Bank Slope: Mortar Riprap
P1 Pier		Type	RC Invert-T
		Str. Height	8.6m
		Foundation	1.2m dia. RC Cast-in-place Piles

	Pier Protect	Dumped Stone
P2 Pier	Type	RC Invert-T
	Str. Height	8.6m
	Foundation	1.2m dia. RC Cast-in-place Piles
	Pier Protect	Dumped Stone
Approach Road	Total Length	512m
	Pavement	Type: Asphaltic Concrete Thickness: Carriageway 140mm=60mm (surface) + 80mm (binder), Sidewalk as unpaved shoulder
West Junction		3 legs with West Coast Rd & Feeder Rd

Source: JICA Survey Team

Table 6 Facility Feature of Ravine Poisson Bridge

Item		Types, Size & Dimensions, etc.
Bridge Location		Same as Existing Bridge
Width	Bridge = 11.3m	Breakdown: Railing 0.4m + Sidewalk 1.5m + Carriageway 2x3.75m + Sidewalk 1.5m + Railing 0.4m
	Approach=11.5m	Breakdown: Guardrail 0.5m + Sidewalk 1.5m + Carriageway 2x3.75m + Sidewalk 1.5m + Guardrail 0.5m
Bridge Type		Simple Span PC Hollow Slab Bridge
Span Length Bridge Length		=17.8m =18m
Bridge Surface Pavement		Asphaltic Concrete, Thickness: Carriageway =80mm, Sidewalk =40mm
A1 Abutment	Type	RC Invert-T
	Str. Height	7.4m
	Foundation	Spread Footing (Direct Foundation)
	Abutment Protect	River Channel: Dumped Stone Bank：Mortar Riprap
A2 Abutment	Type	RC Invert-T
	Str. Height	7.4m
	Foundation	Spread Footing (Direct Foundation)
	Abutment Protect	River Channel: Dumped Stone Bank：Mortar Riprap
Approach Road	Total Length	West Side (Beginning Point): 20m East Side (End Point): 24m
	Pavement	Type: Asphaltic Concrete Thickness: Carriageway 140mm=60mm (surface) + 80mm (binder), Sidewalk as unpaved shoulder
West Side Junction		4 legs with East Coast Rd and Community Rd

Source: JICA Survey Team

3. Required Periods for Detailed Engineering Design and Construction and Preliminary Undertaking Costs of GOSL

Implementation periods required for the detailed engineering designs and subsequent construction are approximately 8.0 months and 24.0 months, respectively. As for costs of the Project, costs to be born as the undertakings by the Saint Lucia side are estimated at approximately EC$ 100,000.

4. Project Evaluation

(1) Relevance

Recipient Population of the Project**:** Major economic activities are concentrated in the north region and south region which includes Hewanowa and Vieux Fort. Road transportation between north and south regions should use Cul-De-Sac Bridge or Ravine Poisson Bridge, both of which are likely affected by natural disaster of floods. To build these 2 bridge can decrease the potential risks of road closure due to natural disaster and obtain stable transport networks.

Although Saint Lucia Government requested to reconstruct 3 bridges but the implementation of the Project consists of 2 excluding the Ferrands Bridge, some feeder roads can have role of detour road of the Ferrands Bridge and accordingly the East Coast Road will function as the road link between the north and south regions.

Accordingly recipient population is regarded as total population of the country（182,300 (WB 2013)）.

Implication of National Plan of Saint Lucia: As already discussed in "1 Background of the Project" of this SUMMARY, reconstruction of Cul de Sac Bridge and Ravine Poisson Bridge as well as Ferrands Bridge has been included in the national development plan "MEDIUM TERM DEVELOPMENT STRATEGY, 2012-2016, Sectoral Action Plan", September 2012.

Related Japanese Policy of Foreign Assistance: Priority sectors of Japanese Foreign Assistance are mainly in the following 2 sectors.

[Priority Sector 1: Disaster Risk Reduction and Environment] As Saint Lucia is located in the disaster affected area by Hurricane and floods, the assistance for urgent issues of the country such as climate change measures and disaster prevention measures to the country would be continued taking into consideration the bio-diversity aspect. As for the present conditions that Saint Lusia largely depends on electricity energy generation by using fossil fuel, assistance to diversify the energy generation system from fossil to re-newable energy system and saving energy system.

[Priority Sector 2: Fisheries] Saint Lucia intends to industrial diversification and employment creation, the fishery industry has been contributing Saint Lucia nationals to supply high qualified protein and increasing job opportunity. Sustainable use of marine resources is just same as Japanese target, and therefore continuous assistance to the fishery industry of Saint Lucia.

The Project is to reconstruct the Cul-De-Sac Bridge and the Ravine Poisson Bridge in the high risk area of flooding by hurricane and tropical storm, and therefore the objective of the Project satisfies the Priority Sector 1 in the above. Moreover, both bridges are located along the transportation corridors of industrial products between markets mostly in the capital Castries region and fisheries harbours. In this

regard, the Project also satisfy the Priority Policy Sector 2 in the above.

(2) Effectiveness

Quantitative Indicators: As indicated in Table 7.

Table 7 Quantitative Indicators

Effect		Base Value (2016)	Target Value (2023)
Impassable car due to road blocked*1 (number/year)	the Cul-De-Sac bridge	64,000	0 *3
	the Ravine Poisson bridge	2,000	0 *3
Number of days of Road closed due to overtopping*2	the Cul-De-Sac bridge	8 days/year	0 *3
	the Ravine Poisson bridge	2 days/five years	0 *3
Average daily passenger (number /year)	the Cul-De-Sac bridge	9.90 mil	10.00 mil (11.70 mil)*5
	the Ravine Poisson bridge	6.50 mil	6.55 mil (7.50 mil) *5
Average cargo weight(ton/year) *4	the Cul-De-Sac bridge	1.90 mil	2.00 mil (2.30 mil) *5
	the Ravine Poisson bridge	1.40 mil	1.42 mil (1.60 mil) *5

*1 Due to occurrence of flood
*2 Overtopping is defined as the circumstances of which the river water level is higher than 5.3 m at the Cul-De-Sac Bridge and higher than 3.0 m at the Ravine Poisson bridge.
*3 In case rainfall does not exceed the values of 50-year return period in the term
*4 Transport volume is on the basis of actual value by traffic survey results and anticipated value by future demand forcast (See also Appendix5-4)
*5 The indicators in parentheses are calculated based on the predicted future average daily traffic volume.

Intangible Benefits: As described below.

[Reconstruction of Cul-De-Sac Bridge]

- After completion of the bridge reconstruction, the high risks of flood disaster of CPJ Distribution Center, of which location is immediately downstream on the south bank, reduces then being resulted in enabling the smooth and stable transport of food products from the factory to the major market of the north region including the national capital Castries. It should be noted that this factory has been most severely affected by flood disaster of the Cul-De-Sac River.
- On upstream side of the north bank, OB Sado Engineering Services Limited is operating his business including construction equipment storage yard which is likely affected by over-topping of water floods of the river. After completion of the bridge reconstruction, disaster risks of floods will slightly reduce around the equipment storage yard. If an extension of riverbund is implemented on the upstream side in the future, disaster risks will greatly reduce.
- Near the river mouth of the Cul-De-Sac River, an oil storage company, Buckeye Terminal

Saint Lucia, has a number of oil storage tanks on the south bank side. As location of the company's storage tanks is very close to the river mouth, the disaster risks of floods is not significant even at present.

- A little bit apart from the Cul-De-Sac River, there are several companies on the south, viz. Massy Store Supermarket Saint Lucia, West Indies Shipping & Trading Co., Ltd., hardware supplier company WIZO, gas station and automobile accessory shop RUBIS Total Auto, and so on. As the locations of them are a little bit away from the river, the experience of disaster damage by them seems little and the damages in the past are not significant.
- In fact, JICA Survey Team conducted interview survey to 10 companies in the vicinity of the site including the abovementioned companies, and only 3 companies responded. Desire to the bridge reconstruction is high and none of negative opinions was given to JICA Survey Team.

[Reconstruction of Ravine Poisson Bridge]

- There are residents, Zion SDA Church, George Charles Secondary School and South Casteries Secondary School in the west (Cul-De-Sac Br. And Ferrands Br. side) of the bridge. Very close to the bridge, also on the west bank side, WASCO operates a pump house, which is very important for local people life. Now water main is accommodated on the bridge structure. After completion of the bridge reconstruction along with the water main being accommodated on new bridge structure, water supply will be maintained safely and inhabitants' life improve significantly.
- Existing structures of the Ravine Poisson Bridge is much aged and repair works were conducted very often. Once the bridge reconstruction is completed, inhabitants' mental fear of old Ravine Poisson Bridge will cease.
- If the bridge reconstruction is completed under the disaster risk reduction aspect as well as better car driving condition on new bridge is provided, users of vehicles will enjoy alleviation from the bridge damage.

Contents

APPENDICES

Country Information

Population	182,300 (World Bank, 2013)
Area	620 km^2 (World Bank)
Capital	Castries
Largest City	Castries
Gross Domestic Product (GDP)	
	1,336 Million US Dollar (World Bank,2013)
	Per Capita:7,328 US Dollar (World Bank,2013)
Gross National Income (Atlas Method)	
	1,310 Million US Dollar (World Bank,2013)
	Per Capita:7,060 US Dollar (World Bank,2013)
GDP Growth Rate	−0.43 % (World Bank, 2013)
Gross Fixed Capital Formation (GFCF, %-GDP)	26.2 (UNISDR, GAR, 2015)
Current Account Balance	−183 Million US Dollar (Balance of Payments Manual, 2013)
Total Assistance Received	27 Million US Dollar (World Bank, 2012)
Economic Classification	High-Middle Income Country
Independence	February 22, 1979
Currency	East Caribbean-Dollars (EC $)
Climate	Tropical Rainforest Climate
Administrative Distinction	11 Districts
Language	English (Official Language)
Religion	Christian 64.9 % others
Major Industries	Agriculture, Tourism

Reference : World Bank, UNDP,CIA, World Fact Book, Ministry of Foreigh Affairs of Japan(Government Development Assistance Country Inventory), UNISDR

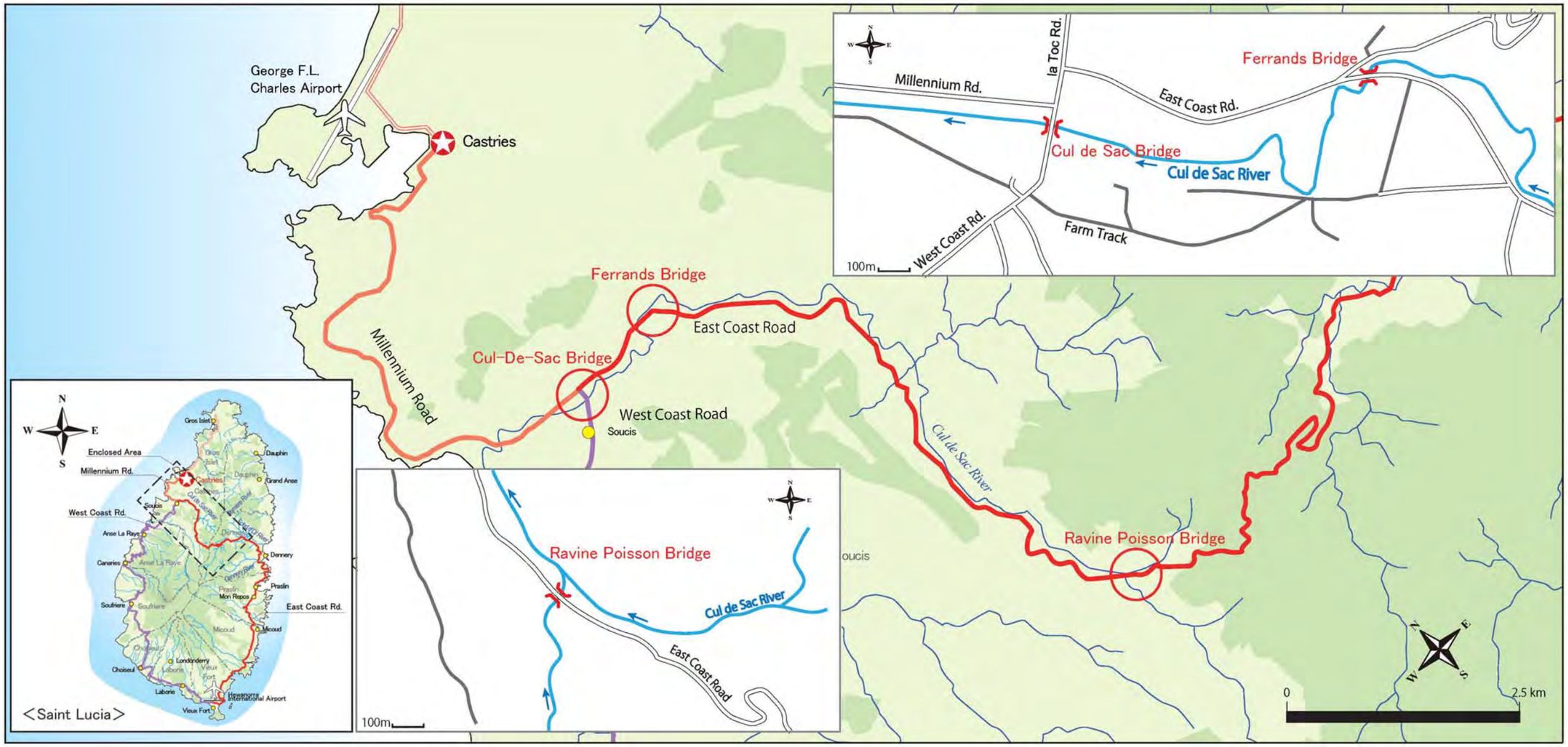
Legend

- Administrative Sector
- Capital
- Main City
- Main Road
- Millennuium Road
- West Coast Road
- East Coast Road
- Main River
- Airport

Source:JICA Survey Team

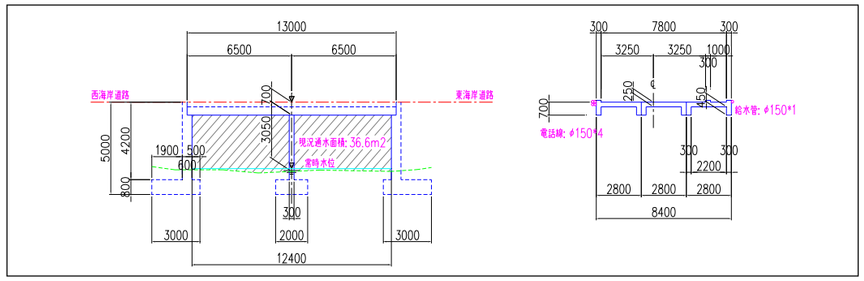
L O C A T I O N M A P

Project Location MAP

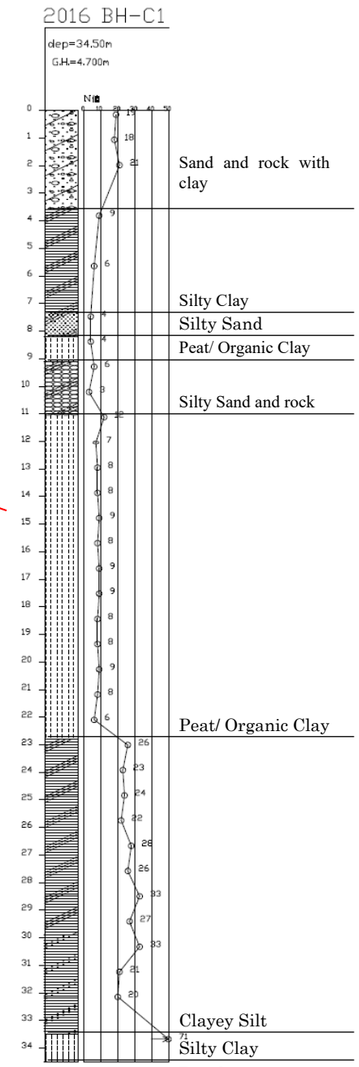


Cul De Sac Bridge

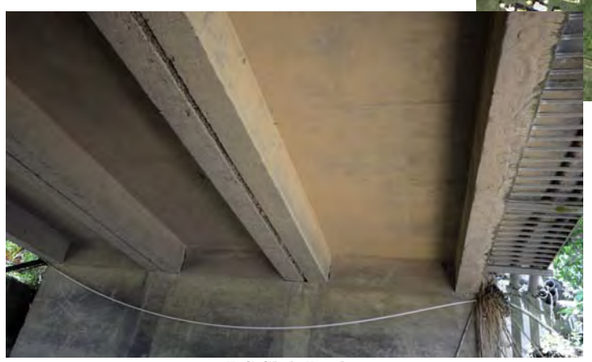
2 lanes with side walk on upperstream side
AADT 8,000 vehicles/day



View from Downstream



Center Pier



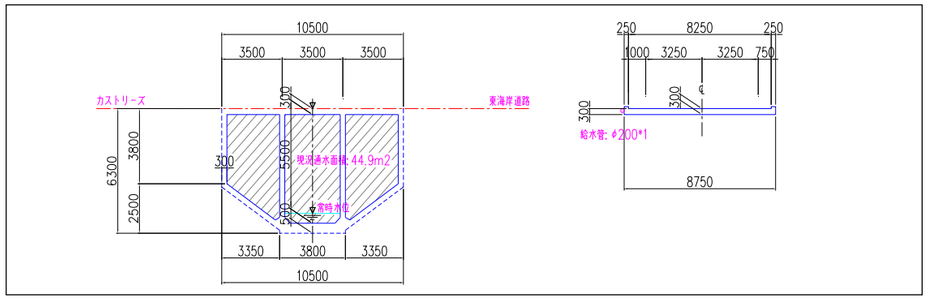
RC Slab Bridge

Floating Debris at upperstream side

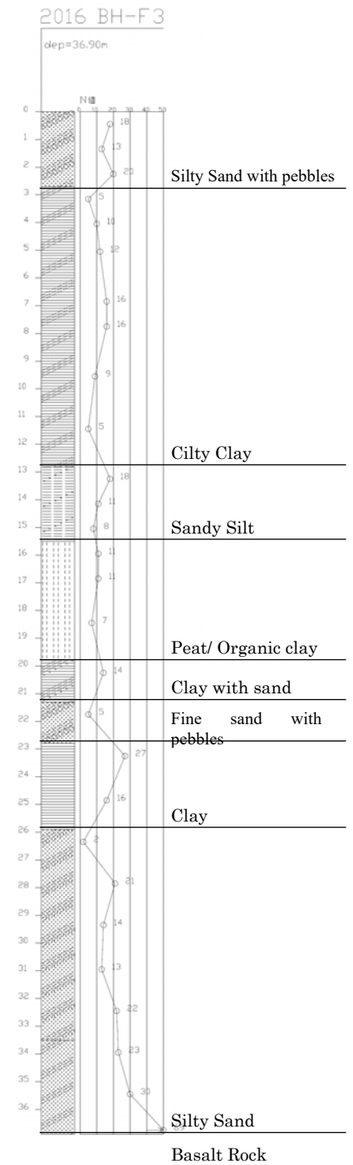
Utilities (Electric line, water line, etc)

Ferrands Bridge

View from Upperstream



West View from the bridg
AADT 8,700 Vehicles/day



Upperstream View from the bridge

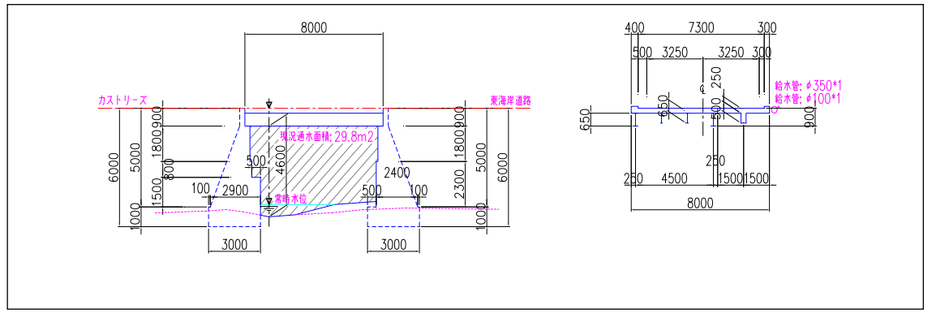
View from downstream

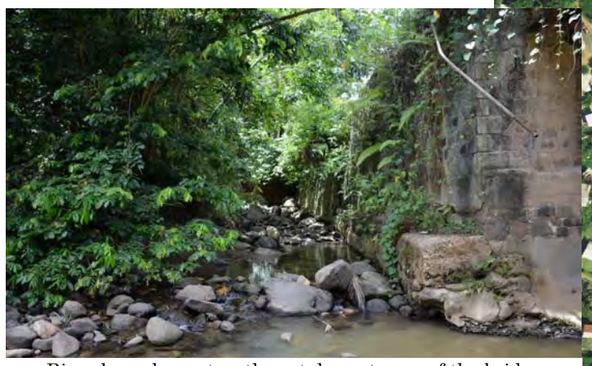
Handhole near the bridge

View from East side

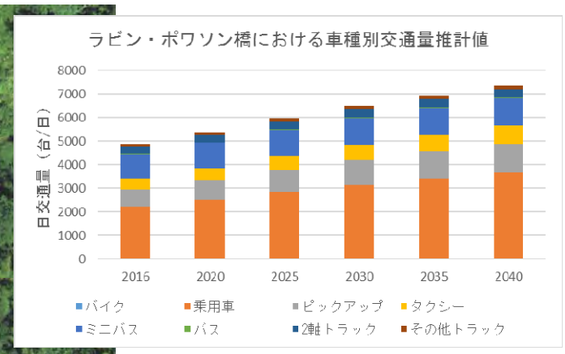
Ravin Poisson Bridge

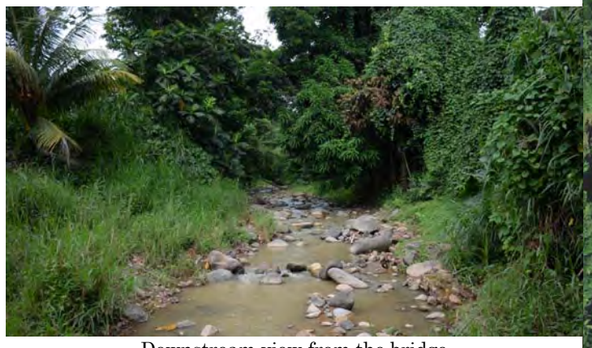
View from downstream



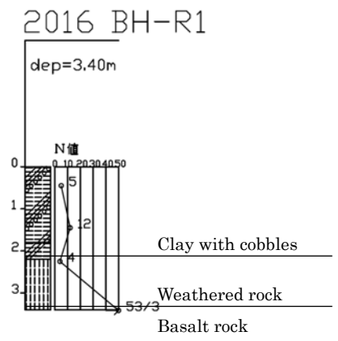


River branch run together at downstream of the bridge





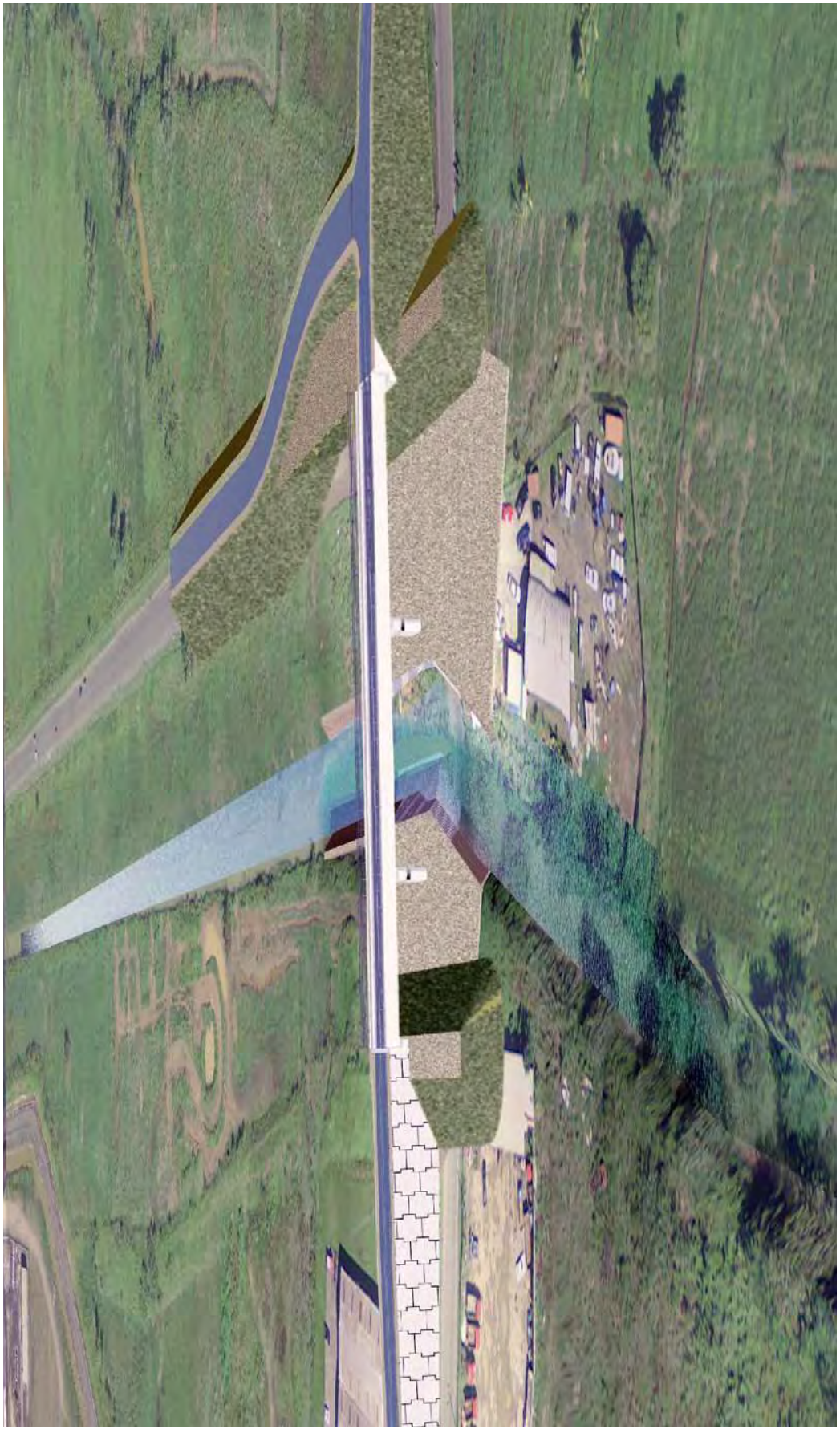
Downstream view from the bridge



Steel H girder and expanded by T girder, Substructure is Stone Masonry

View from the west side
AADT 4,800Vehicles/day

Steel handrail are damaged/inclined



Perspective

New Cul De Sac Bridge

Perspective

New Ravine Poisson Bridge

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ABBREVIATIONS

AADT	:	Annual average daily traffic
AASHTO	:	American Association of State Highway and Transportation Officials
ARAP	:	Abbreviated Resettlement Action Plan
CARICOM	:	Caribbean Community
CBR	:	Unit, California Bearing Ratio
CDO	:	Community Development Officer
CIA	:	Central Intelligence Agency
CSC	:	Environment, Construction Supervision Consultant
DCA	:	Development Control Authority
DHWL	:	Design High Water Level
DPS	:	Deputy Permanent Secretary
d/s	:	River engineering, downstream
DVRP	:	Disaster Vulnerability Reduction Project
EC$	:	East Caribbean Dollar
EIA	:	Environment, Environmental Impact Assessment
E/N	:	Exchange of Notes
EMP	:	Environment, Environment Management Plan
F (%)	:	River engineering, frequency (%)
FY	:	Financial (Fiscal) Year
GDP	:	Gross National Products
GFCF	:	Gross Fixed Capital Formation
GOJ, GoJ	:	Government of Japan
GOSL, GoSL	:	Government of Saint Lucia
HWL	:	High Water Level
IEE	:	Environment, Initial Environmental Examination
JICA	:	Japan International Cooperation Agency
JICA GL	:	Environment, JICA Guide Line
M.A.S.L	:	Meters above sea level
MIPE&L	:	Minister for Infrastructure, Ports, Energy and Labour
PAPs	:	Environment, Project Affected Persons
PC	:	Pre-stressed Concrete

PCE	:	Passenger Car Equivalent
PCU	:	Unit, Passenger Car Unit
PM	:	Latin, post meridian
PS	:	Permanent Secretary
RAP	:	Resettlement Action Plan
RC	:	Reinforced Concrete
ROW	:	Right of Way
SCS	:	Soil Conservation Service, the United States Department of Agriculture (USDA)
SPU	:	Special Project Unit, MIPE&L
St. Lucia, SL	:	Saint Lucia
UNDP	:	United Nations Development Programme
UNISDR	:	The United Nations Secretariat for International Strategy for Disaster Reduction
u/s	:	River engineering, upstream
Veh/day	:	vehicles per day
WB	:	The World Bank
WB OP	:	Environment, World Bank Operation Manual
WRMA	:	Water Resource Management Agency, Saint Lucia

Chapter 1 Background of the Project

1-1 Background of the project

Saint Lucia, ranked as the 16th most at risk among 160 countries in the world by the impacts of climate changes according to Global Climate Risk Index 2015: Germanwatch, is vulnerable to damages caused by hurricane, floods and other natural disasters. Hurricane Tomas in October 2010 resulted in economic losses of infrastructure over US$ 145 million (11.7% of GDP), and Christmas floods in December 2013 resulted in losses over US $ 70.6 million (5.3% of GDP). As such, Saint Lucia experienced huge amount of economic losses of infrastructure damages by natural disasters. The Government of Saint Lucia (hereinafter referred to as the GOSL) has developed "the National Hazard Mitigation Policy" as a strategic instrument for hazard mitigation, of which policy is intended to facilitate the more effective use of scarce technical and financial resources in a comprehensive approach to disaster management. It is a very urgent need to maintain the traffics in Saint Lucia to reduce the risks of economical losses of traffic disruption at the time of natural disaster.

Among the major roads in the island the East Coast Road (hereinafter referred as the Road) , which carries approximately 15,000 vehicles/day between Hewanorra International Airport on the south of East Coast and the national capital Castries on the north of West Coast, is the most important primary road running through the central highland. The Road is vulnerable to the natural disaster risks like floods and landslides, and paralyzes the flow/movement of traffics between the north and south of the island for approximately 8 days/year to force long-distance vehicles detour. From the viewpoint of the disaster risk mitigation of the Road, the GOSL requested the Government of Japan (hereinafter referred to as the GOJ) a grant aid to reconstruct three (3) high priority bridges in the Cal de Sac basin (hereinafter referred to as the Project).

The GOJ stated three (3) pillars of Japan's CARICOM policies in July 2014, first of which is "Cooperation towards sustainable development, including overcoming the vulnerabilities particular to small island states". Strengthening the major roads in the island by the Project is regarded as relevant from the view point of "disaster risk reduction and environment problem support" of the foreign policy of the GOJ. If the Project is implemented, it would provide commodity transport and evacuation route at the time of disaster and accordingly satisfy the Japan's CARICOM policies and the foreign policy of the GOJ.

Japan International Cooperation Agency (hereinafter referred to as JICA) is the executing agency of the Grant Aid for General Projects, for Fisheries and for Cultural Cooperation, etc. JICA will conduct a preparatory survey for the Project (hereinafter referred to as the Survey) in order to confirm the necessity and relevance of the Project requested by the GOSL. The Survey includes an outline design which accords with appropriateness as a Japan's Grant Aid scheme, implementation plan and cost estimate of the Project.

1-2 Project Site

1-2-1-1 Current status of existing bridges

(1) Existing Bridges

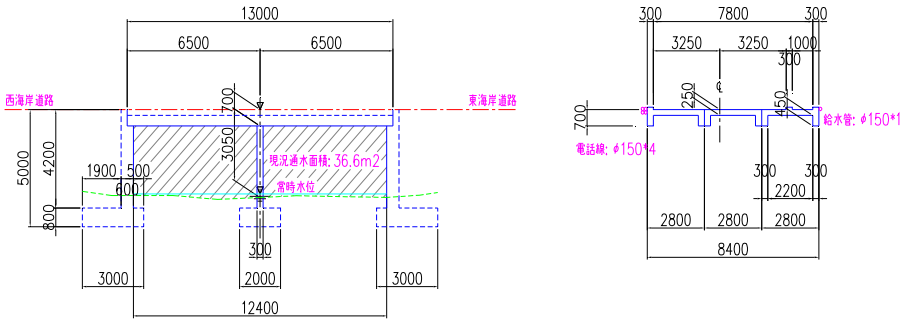
Current status of existing bridges is summarized from field ovservation in Table 1-1 and also shown in frontispiece. The Cul-De-Sac and Ferrands bridge maintain structural soundness. However, the Ravine Poisson bridge is deteriorated and the steel girder is currently damaged with corrosion.

Table 1-1 Current status of existing bridges

Name	Cul De Sac Bridge	Ferrands Bridge	Ravine Poisson Bridge
Year of completion	1980's	1980's	1970's
Client	Ministry of infrastructure	ditto	ditto
Contractor	Unidentified	ditto	ditto
Design Document	Missing	ditto	ditto
Type of structure	RC 2span slab	RC 3span boxculbert	H Type Steel gerder widening with RC T girder, Single span
Bridge length/ width	Approx.13.0m/8.4m	Approx.10.5m/8.75m	Approx.8.0m/8.0m

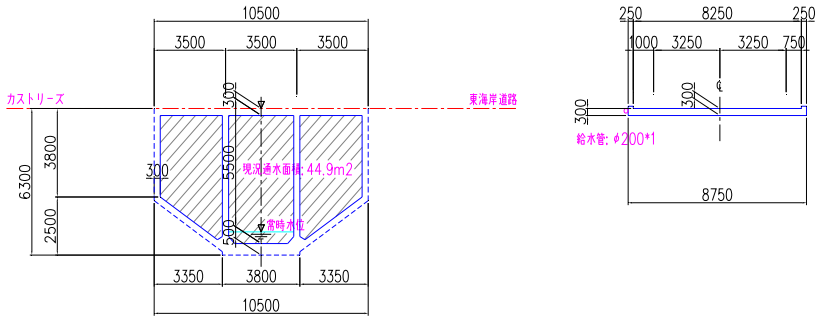
Source: JICA Survey Team

Demension of the bridges estimated from visual observation are shown approximately in Figure 1-1~Figure1-3. Lanewidth is 3.25m and the number of lanes is 2 on each bridges with sholder (0-1m). Cul-De-Sac Bridge have Sidewalk with 1m width on one side.



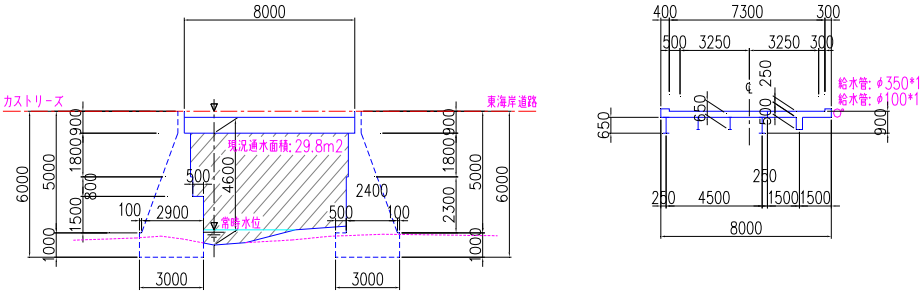
Source: JICA Survey Team

Figure 1-1 Existing Cul-De-Sac Bridge



Source: JICA Survey Team

Figure 1-2 Existing Ferrands Bridge



Source: JICA Survey Team

Figure1-3 Existing Ravine Poisson Bridge

Evaluation results of flow capacity at each bridges are shown in Table 1-2. Accoding to the results, it can be determined that the current flow capacity is insufficient of the predicted flood flow. Thus the reconstruction of bridges shold be executed with securing necessary flow area.

Table 1-2 Evaluation results of flow capacity at each bridges

Name	Cul De Sac Bridge	Ferrands Bridge	Ravine Poisson Bridge
Flood flow※	Approx.. 720m^3/s	Approx.. 690m^3/s	Approx.. 192m^3/s
Flow speed	3.0m/s	3.3m/s	4.6m/s
Necessary flow area	240.0m^2	209.1m^2	41.8m^2
Existing flow area	36.6m^2 (15.3%)	44.9m^2 (21.5%)	29.8m^2 (71.3%)
Evaluation	Insufficient Capacity	ditto	ditto

Source: JICA Survey Team

Photos of the bridges are summarized below;

1) Cul De Sac Bridge

The bridge

Side view

Undersurface of the superstructure

River protection

Source: JICA Survey Team

Figure 1-4 Photos of existing Cul-De-Sac bridge

2) Ferrands Bridge

Bridge Surface

Side View from upstream

Side View from downstream

Area aroud downstream of the bridge

Source: JICA Survey Team

Figure 1-5 Photos of existing Ferrands bridge

3) Ravine Poisson Bridge

Current Bridge

Under survace of the bridge

Side view from downstream

Branch stream of Cul-De-Sac river

Source:JICA Survey Team

Figure 1-6 photos of existing Ravine Poisson bridge

(2) Public Utilities

Public utilities at the bridges are shown in Table 1-3. The relocation of these bridges shall be undertaken by GOSL at appropriate timing during construction.

Table 1-3 Public Utilities at the bridges

Name	Cul De Sac Bridge	Ferrands Bridge	Ravine Poisson Bridge
Upstream side	Water supply (φ150)	Water supply (φ200)	Water supply (φ350) Water supply (φ100)
Downstream side	Telecom line (φ150) Electric line (φ 80)*2	Telecom line	-
Others	Electric wire	-	Underground water pipe

Source: JICA Survey Team

1-2-1-2 River Structures

Site reconnaissance was conducted in the downstream stretch of the Cal de Sac River from the river mouth to the Cal de Sac Bridge to inspect the site conditions of the objective bridges and existing river structure in the surrounding area.

(1) Downstream of the Cul de Sac Bridge

1) River mouth

Tide level: No tidal gauge is installed in the Cul de Sac Bay. At left bank of the bay, there is an oil storage facility (Buck eyes), but no tidal water level is observed.

Bay area: The bay area of the Cul de Sac River is a low lying area. There are a few houses which the floor level is elevated by about 1-2 m from the ground level. Flood and tidal water rises up to the floor level, and are widely spreading in this low lying area at the time of flood and high tide.

River improvement works: River improvement works have been carried out in the stretch from the river mouth to the downstream of the Cu de Sac Bridge. In 1980's, the low water channel of the river was straightened. After Hurricane Debby attacked in the area in 1994, a study for the river improvement works was carried out. In 1998, the construction of the right levee which is used as levee-road as a part of the Millennium Highway was completed. The left levee was also constructed along the boundary of

land of the oil storage facility and private warehouse.

The design scale of the levee was assessed at 100 year of the return period ($Q=346m^3/s$). The design was prepared for the upstream of the Cul de Sac Bridge, however actually construction work was completed until the 100 m downstream of the Cul de Sac Bridge.

Box culvert: A box culvert (2 barrels x 2 m wide) is constructed at the intersection between the highway of the right levee and old river channel to drain the local inland water. Because no gate is attached in the culvert, back water from the river would be restored into the backside of the levee through the culvert when flood occurs. The area becomes a natural retarding basin at the flood events.

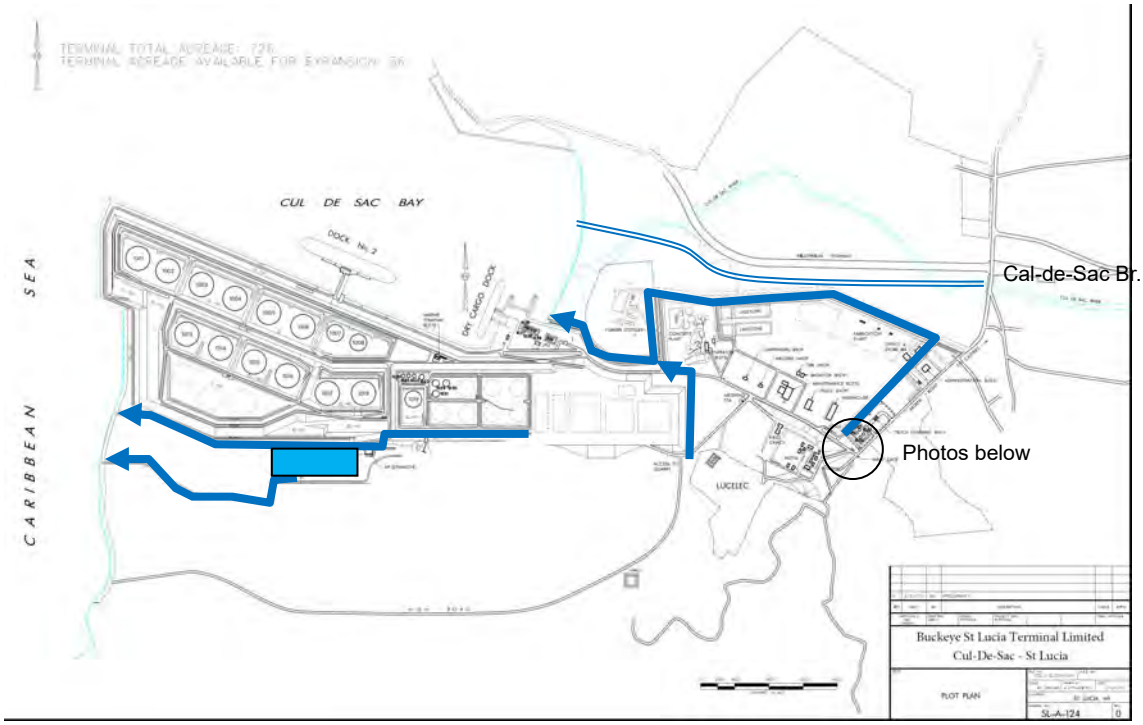
(2) Left side of river mouth (Buckeye)

History of Development: In 1982, the oil storage facility was developed in the area left downstream stretch of the Cul de Sac River. The US company owns it and is operating the facilities. There are a mooring facility, oil tanks and pipe networks in the area. The left levee is constructed along the boundary of their lot.

Flood situation: According to the Operation Manager of Buckeye, the flood water in this area comes from hilly area but not from the Cul de Sac River. Since the ground level is elevated and drainage network are constructed in the facility, no serious flood inundation damages were reported. Only at the entrance//exist gates, local flood is occurred. Figure 1-8 show the timeline photos of flood conditions at the gate on November 6, 2015.

The sea walls of their facility has the crest elevation of 20 ft above the mean sea level. According to the Operation Manager of Buckeye, tidal water have been never overtopped even at the time of Hurricane Tomas while only sea wave overflowed the crest at that time.

Drainage facility: The drainage system of the facility is designed well. The drainage channels (with 5 m in width and 2 m in depth) are constructed along the outer area of their land. All rainwater coming from the hilly area is flowed into the drainage channels, and directly discharged out to the sea though the drainage channel network. The drainage is designed considering that rainwater coming into the their area will not go out to the Cul de Sac River as well as that no river water will not affect into their land during floods. In addition, on the elevated area in the southern part where may oil tanks are located, a large settling basin with area of approximately 1 ha is constructed so that oily water can be temporary stored there, and only surface water can be spilled out from the overflow weir attached at the end of the settling basin. The spilled water is also directly discharged into the sea.



Source: Buckeyes

Figure 1-7 General Plan of Oil Storage Facility (Buckeyes) along the left downstream of the Cul de Sac River

11:30

12:30

12:00

15:00

Source: Buckeyes

Figure 1-8 Photos of Flood Inundation at Gate of Oil Storage Facility (Buckeyes) in November 2015

(3) Surrounding area of Cul de Sac Bridge

River area: Figure 1-9 shows the plan of Cul de Sac River at the Cul de Sac Bridge site. The river channel alignment is almost straight with river width of 10 m at the bridge. The downstream of the bridge, the river cross section is a compound section with a low water channel of 5 m in width and 2 m in depth without lining.

Drainage structure: There are four drainage outlets at upstream and downstream, and left and right bank of the bridge. The drainage outlet at the left downstream is the bigger one.

River bank protection: No river bank protection is constructed at bridge abutment. Gabion boxes are installed recently at upstream of the bridge abutment.

Riverbed: There are big stones in the riverbed at upstream and downstream of the bridge. No visible sediment deposits and riverbed degradation is observed. At the time of site inspection, drifted woods with diameter of 0.5m are trapped at upstream of the culvert which making opening section of the culvert narrower.

(4) Ferrand's Bridge site

River area: Figure 1-10 shows the plan of surrounding area of the Ferrand's bridge. The river width at the bridge is around 10 m locating at the bend section. The river channel is curved to left with about 90 degree in the upstream of the channel.

Drainage structure: There is no drainage structure. Rain water is naturally drained into the river channel from surface ground.

River bank protection: There is a river bank protection of boulders pitching with 1-2 m in diameter at the outer bend in the upstream of the bridge (upstream right bank). The bank protection is around 5 m in height and 20 m in length,

Riverbed: No visible sediment deposition is observed. Local scouring is seen at the downstream of the bridge where bottom of the culver slab is appeared above the riverbed. The scouring is limited in this portion. Riverbed degradation is not seen in this area.

(5) Ravine Poisson Bridge site

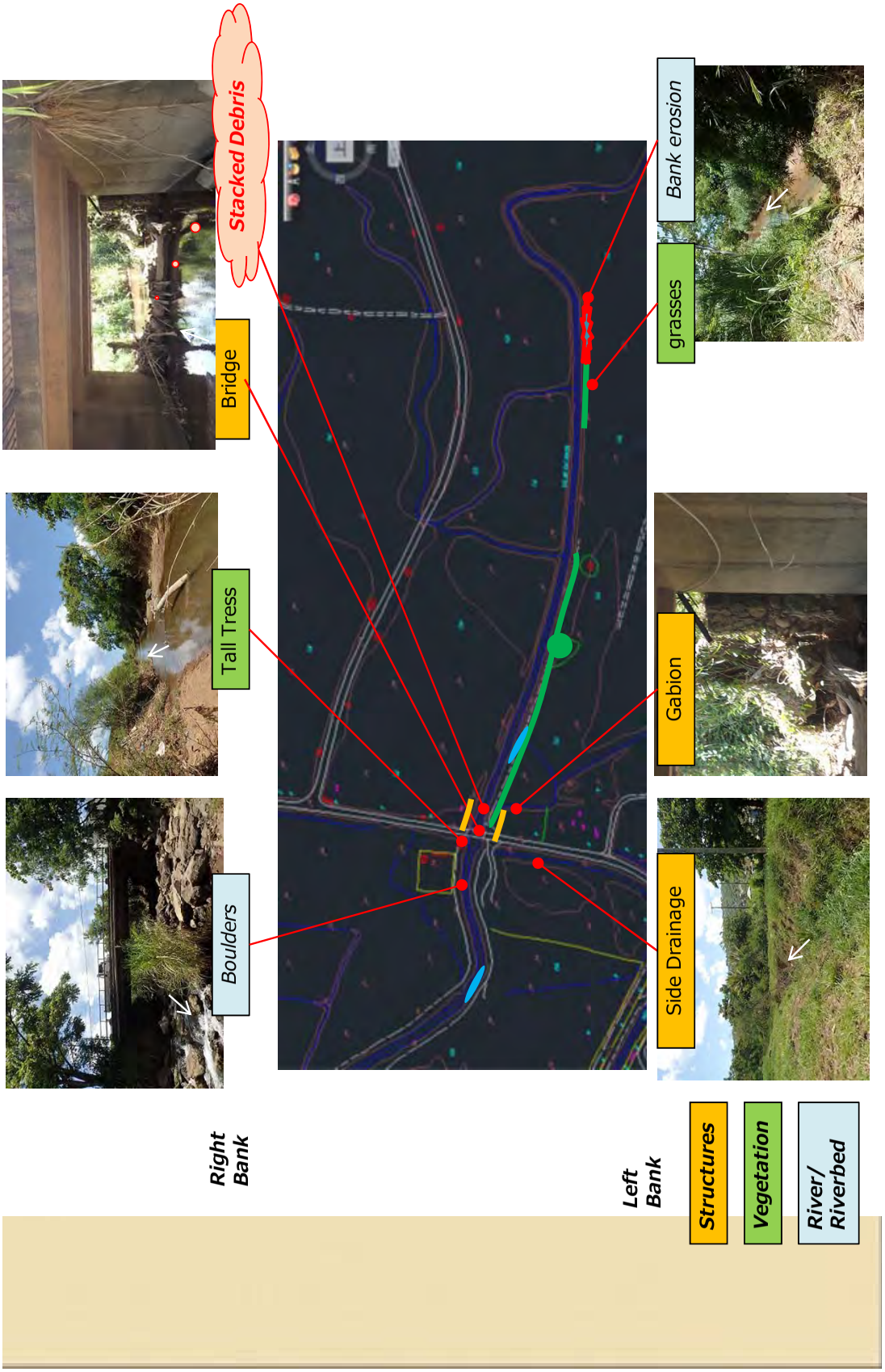
River area: Figure 1-11 shows the plan of surrounding area of the Ravine Posisson bridge. The river width at the bridge is around 10 m locating at the bend section. The river channel is curved to right with about 90 degree in the upstream of the channel.

Drainage structure: There is no drainage structure. A tributary joins from right bank immediately downstream of the bridge. The right abutment wall of the bridge is utilized as a part of the channel outlet of the tributary. The tributary is around 3 m in width and the riverbed profile is deemed steeper than that of the main stream.

River bank protection: There is a river bank protection of wet masonry along the outer bend in the upstream of the bridge (upstream left bank). The bank protection is around 5 m in height and 5 m in length,

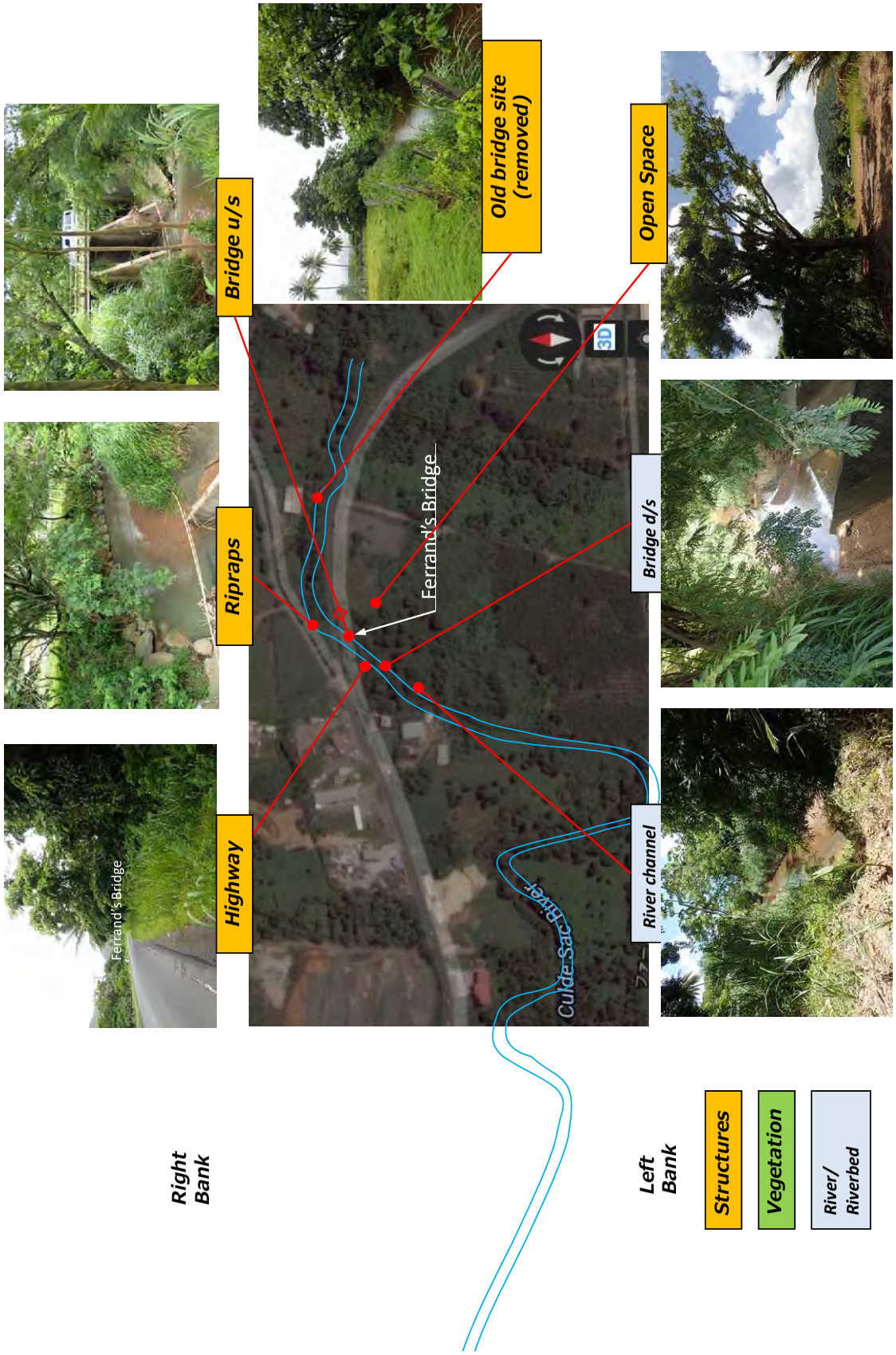
Riverbed: The bridge is located steep riverbed profile section. Outcrops are appeared on the riverbed. The riverbed materials are gravels and rocks. Local scouring is seen at the downstream of the bridge where bottom of the abutment foundation is appeared above the riverbed. At the confluence with the tributary, foundation of the approach road and right abutment are also affected by local scouring. There is a trend of riverbed degradation in this area.

Intake weir: At around 500 m upstream of the bridge, there is an intake weir owned by WASCO. The weir is old one with concrete overflow section with about 3 m in height and 5 m in overflow width. The downstream apron was already washed away where the riverbed is lowered by around 1 m. Water is taken at the intake on the left bank of the weir and distributed through underground pope to the water tank located at the left bank of the Ravine Poisson Bridge.



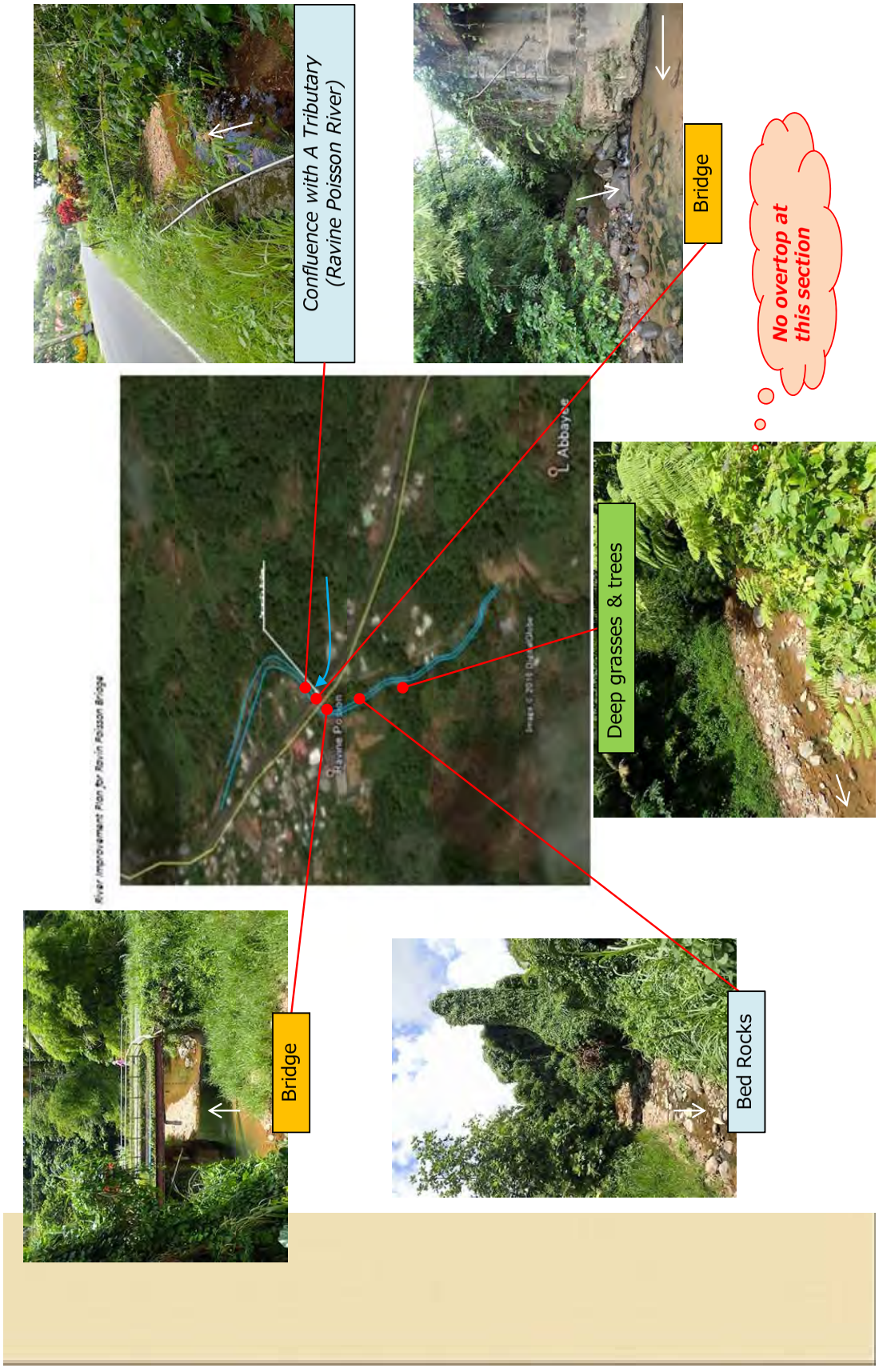
Source: JICA Survey Team

Figure 1-9 River Plan at Cul de Sac Bridge



Source: JICA Survey Team

Figure 1-10 River Plan at Ferrand's Bridge



Source: JICA Survey Team

Figure 1-11 River Plan at Ravine Poisson Bride

1-2-2 Traffic volume at the project sites

1-2-2-1 Results of traffic surveys

(1) Outline of traffic surveys

Traffic surveys were carried out to grasp the traffic situation at the project sites. The outline of the surveys is presented in Table 1-4.

Table 1-4 Outline of traffic surveys

Item	Methodology	Date
Manual classified count	Count by surveyors classified by vehicle type and direction. 16 hours.	5 July 2016 (Tuesday) 6AM – 10PM
Automatic traffic count	Automatic count using pneumatic road tubes by direction	2–8 (Sat.-Fri.) and 15–21 (Fri.-Thu.) July 2016
Travel speed survey	Automatic measurement using pneumatic road tubes by direction	2–8 (Sat.-Fri.) and 15–21 (Fri.-Thu.) July 2016
Axle load survey	Weighing using portable axle scales at a parking lot to where the police ushered the trucks	10 August 2016 (Thursday) 8AM – 6PM

Note 1: Axle load survey was conducted near Ferrands Bridge. The others were conducted at all three bridges.

Note 2: Automatic traffic count was carried out with the initial setting of simplified vehicle classification, but the accuracy was turned out to be not sufficient from the comparison with the result of manual classified count. The total traffic volume had been correctly measured (3% difference with manual count), accordingly the data of total traffic volume were used for the analysis. For the reason of failure of data, the survey was conducted for two weeks.

Source: JICA Survey Team

Source: JICA Survey Team

Figure 1-12 Implementation of traffic surveys

(2) Conversion factors for counted traffic volume

The traffic surveys in this Project was carried out only in limited period. In order to grasp the annual average daily traffic (AADT), the counted traffic volume data in the survey period were

multiplied by the seasonal conversion factor provided by the MIPE&L. The factor for July is 1.02.

Passenger Car Unit (PCU) or Passenger Car Equivalent (PCE) is a concept to consider heavy vehicles as multiple passenger cars, in order to calculate their impact on road capacity. There is no defined PCU factor in Saint Lucia, accordingly the factors defined in Highway Capacity Manual 2010 were used. The factors are presented in Table 1-5. From its definitions, the factor for level terrain was adapted for Cul-de-Sac Bridge and Ferrands Bridge, and the factor for rolling terrain was adapted for Ravine Poisson Bridge.

Table 1-5 PCU factors

	PCU factors by Type of Terrain		
	Level	Rolling	Mountainous
Trucks and buses	1.5	2.5	4.5

Source: Highway Capacity Manual 2010

(3) Traffic flow at Cul-de-Sac Bridge

Average daily traffic at Cul-de-Sac Bridge during the survey period was 7,926 vehicles. Multiplied by factors, its AADT is calculated as 8088 vehicles, or 8,409 PCUs. The average travel speed was 24.7 km/hour, and proportion of heavy traffic was 7.9 %. The peak hour with the most traffic from both directions was from 8AM to 9AM, where 6.4% of the daily traffic passed and the directional distribution factor “D” was 55.9% with dominant direction from south to north (toward Castries). More traffic was observed for the direction from south to north during morning, and the opposite direction during afternoon. Furthermore, 888 pedestrians and 13 bicycles were counted during 16-hours’ manual count.

(4) Traffic flow at Ferrands Bridge

Average daily traffic at Ferrands Bridge during the survey period was 8,560 vehicles. Multiplied by factors, its AADT is calculated as 8,735 vehicles, or 8,409 PCUs. The average travel speed was 34.8 km/hour, and proportion of heavy traffic was 10.5 %. The peak hour with the most traffic from both directions was from 4PM to 5PM, where 7.3% of the daily traffic passed and the directional distribution factor “D” was 51.4% with dominant direction from west to east (from Castries). More traffic was observed for the direction from east to west during morning, and the opposite direction during afternoon. Higher travel speed was observed for the direction from east to west. Furthermore, 15 pedestrians and 13 bicycles were counted during 16-hours’ manual count.

(5) Traffic flow at Ravine Pisson Bridge

Average daily traffic at Ravine Poisson Bridge during the survey period was 4,776 vehicles. Multiplied by factors, its AADT is calculated as 4,873 vehicles, or 5,581 PCUs. The average travel speed was 35.1 km/hour, and proportion of heavy traffic was 9.7 %. The peak hour with the most traffic from both directions was from 4PM to 5PM, where 8.4% of the daily traffic passed and the

directional distribution factor "D" was 51.2% with dominant direction from west to east (from Castries). More traffic was observed for the direction from east to west during morning, and the opposite direction during afternoon. Furthermore, 73 pedestrians and 6 bicycles were counted during 16-hours' manual count.

(6) Summary of results of traffic surveys (except axle load survey)

Results of traffic surveys except axle load survey are summarized in Table 1-6.

Table 1-6 Summary of results of traffic surveys (except axle load survey)

Item	Unit	Cul-de-Sac Bridge	Ferrands Bridge	Ravine Poisson Bridge
AADT	vehicles/day	8,088	8,735	4,873
AADT in PCU	PCU/day	8,409	9,193	5,581
Average travel speed	km/h	24.7	34.8	35.1
% of hervy vehicles	%	7.9%	10.5%	9.7%
Peak hour	(time)	8-9AM	4-5PM	4-5PM
Peak ratio	%	6.4%	7.3%	8.4%
Peak hour D factor	%	55.9%	51.4%	51.2%
Pedestrian (16hours)	persons/16h	888	15	73
Bicycle (16hours)	vehicles/16h	13	13	6

Source: JICA Survey Team

(7) Result of axle load survey

Axle load survey was carried out near Ferrands Bridge with support by polices who ushered the trucks to a parking space. By 10-hours' sample survey, axle loads of 97 were measured. Given the annual average daily truck volume as 917 vehicles at Ferrands Bridge, the sample rate was about 11%. The survey result is presented in Table 1-7.

Table 1-7 Result of axle load survey

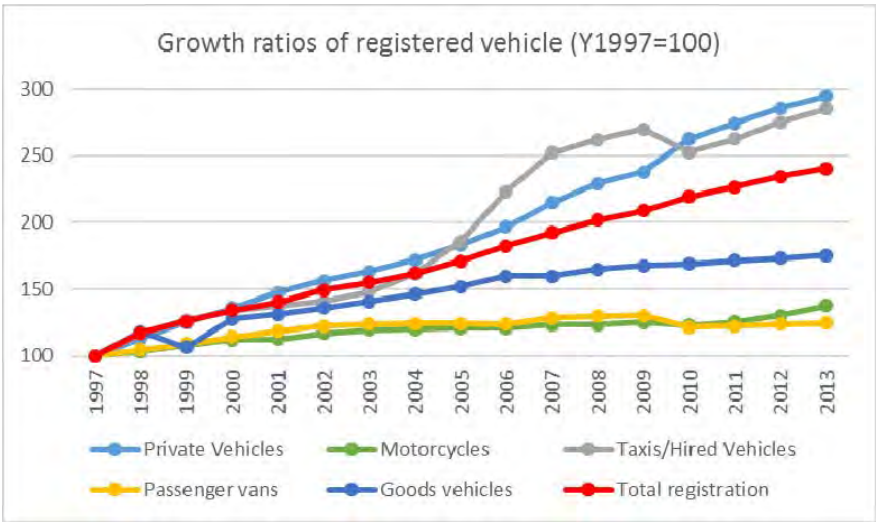
Vehicle	Sample size	Load (ton)						
		1st axle	2nd axle	3rd axle	4th axle	5th axle	6th axle	Total
2-axle truck	69	3.1	3.9					7.0
3-axle truck	15	8.0	9.0	8.7				25.8
4-axle truck	8	7.6	7.3	5.4	6.0			26.4
5-axle truck	4	7.8	10.2	12.9	12.7	12.0		55.7
6-axle truck	1	12.6	13.6	8.4	10.7	11.2	8.6	65.0

Source: JICA Survey Team

1-2-2-2 Traffic demand forecast

Vehicle registration in Saint Lucia is constantly increasing since late 1990s. The

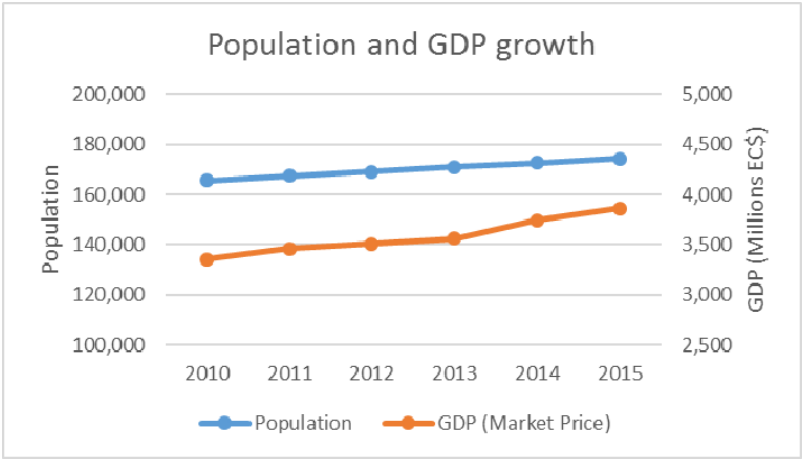
historical growth ratios of registered vehicles by type are presented in Figure 1-13, taking the values of the year 1997 as 100.



Source: JICA Survey Team

Figure 1-13 Growth ratios of vehicle registration

As shown in Figure 1-14, the population and the GDP of Saint Lucia are also stably growing. Long term projection for these indices is not published, but the Global Economic Prospects for the next 3 years published in 2016 by the World Bank predict a continuation of the stable growth of this nation's economy.

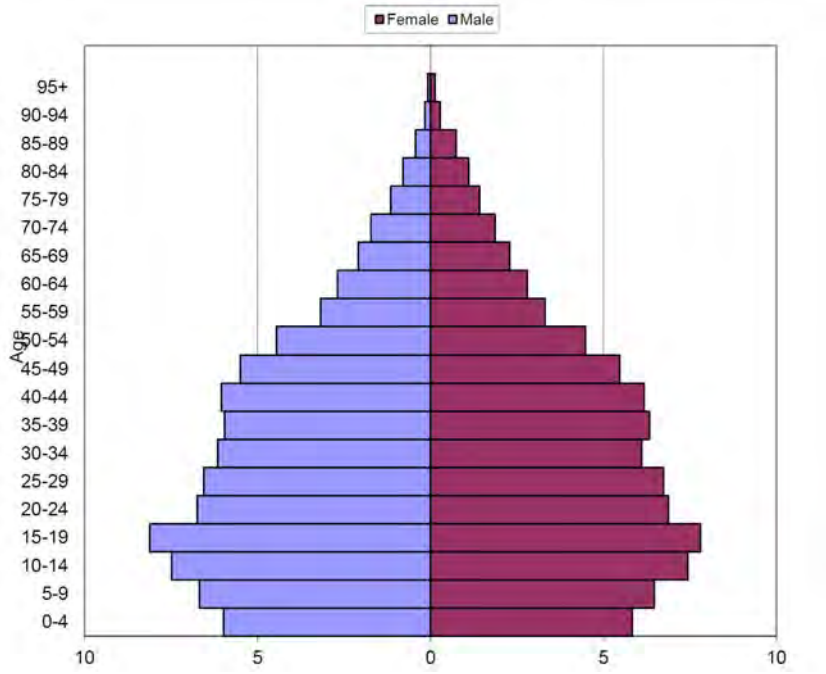


Source: Review of Economy 2015

Figure 1-14 Population and GDP growth

On the other hand, the population structure indicates that the twenties born in late 1990s are forming the biggest generation, and the birth rate is decreasing afterwards, as presented in Figure 1-15. Decrease of birth rate along with economic growth is a general trend observed in most countries in the world, and it is probable that Saint

Lucia is also taking gradually the same tendency.



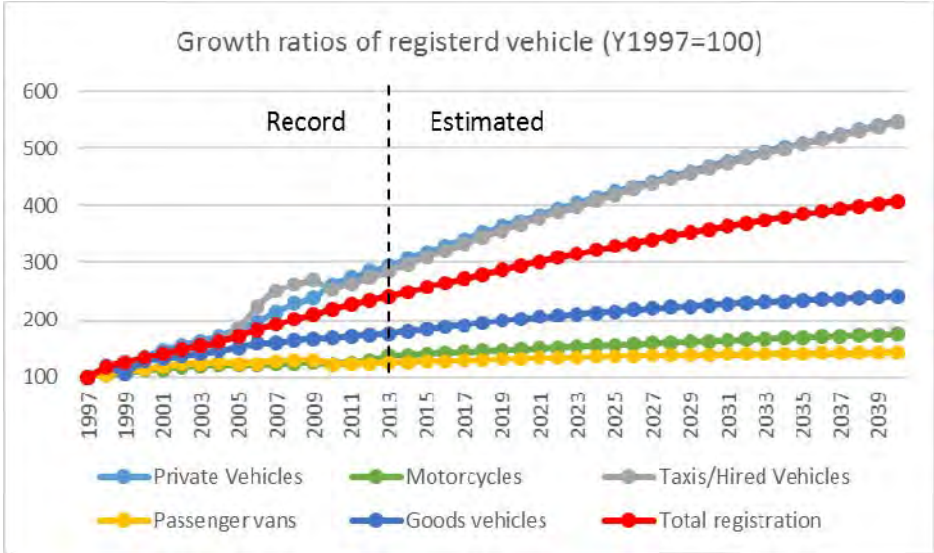
Source: Population and Housing Census 2010

Figure 1-15 Population structure in 2010

In this Project, the traffic volumes at project sites were measured, but the other data such as origin and destination of these vehicles were not captured. Accordingly, for the traffic demand forecast, the future trend of national vehicle registration was forecasted based on past trends of vehicle registration, population and economic indices, then this estimated future trend was applied to the traffic volumes at the project sites. The presumed completion year of bridge reconstructions was set as 2020, and the traffic volumes for initial 20 years until 2040 were forecasted.

From the past trends, the stable growing trends for private car, motorcycle and taxi are estimated to continue. Taking the population structure into consideration, the yearly increments were assumed to decrease 2% each year. For minibus and truck which are already showing relatively low growth rates, the yearly increments were assumed to decrease 5% each year.

The past and forecasted growth ratios of registered vehicles by type are presented in Figure 1-16, taking the values of the year 1997 as 100.



Source: Past data from Ministry of Infrastructure, Port Services and Transport, Transport Department, and estimation by JICA Survey Team

Figure 1-16 Past and estimated growth ratios of vehicle registration

Applying these ratios, the estimated future traffic volume at the three bridges are presented below.

Table 1-8 Estimated future traffic volume

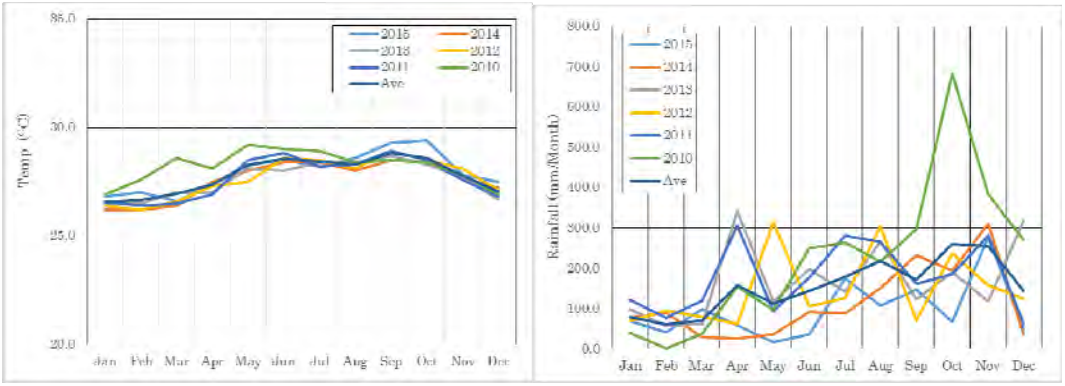
	AADT (vehicles/day)					
	2016 (present)	2020	2025	2030	2035	2040
Cul-de-Sac Bridge	8,088	8,993	10,012	10,921	11,736	12,468
Ferrands Bridge	8,735	9,635	10,643	11,541	12,342	13,054
Ravine Poisson Bridge	4,873	5,391	5,971	6,490	6,953	7,364

Source: JICA Survey Team

1-2-3 Natural Conditions

1-2-3-1 Meteorological condition

Saint Lucia has a marine tropical climate, and it located on the trade wind climate zones. The record of average temperature and monthly rainfall are summarized with reference to the data provided by Metrological Department in Figure 1-17. These data have been measured at the ovservation point (Soucis) near the project site. It shows the average temperature is about 26 to 30 degree, almost flat in a year. And regarding the rainfall data, there is a trend that the rainfall in dryseason is almost lower than 150mm/Month from December to May, and that in rainy season from June to November is about 150 to 300mm/Month. However, actual rainfall data vary in size by each year.



Source: Made from the date provided by Metrological Department, MIPE&L

Figure 1-17 Average temperature and rainfall

1-2-3-2 Topographical condition

Topogaraphical survey were carried out in order to obtain the basemap for the design and information for the hydrological analysis. Survey items and quantity are shown in Table 1-9.

Table 1-9 Topographical survey

Item		Quantity
For Hydrological analysis	Vertical Profile	Ferrands bridge ~ Cul De Sac bridge: 1,000m Cul De Sac bridge ~ river mouth: 1,500m 2,500m in total
	Cross Section	Ferrands bridge ~ Cul De Sac bridge: 1,100m (11nos×100m) Cul De Sac bridge ~ river mouth: 3,200m (16nos×200m) 計：4,300m
For the Design	Topographic Map	Ravine Poisson bridge: 9,000m^2 (150 m×60 m) Ferrands bridge: 27,000m^2 (300 m×90 m) Cul De Sac bridge: 18,000m^2 (300 m×60 m)
	Vertical profile	Ravine Poisson bridge: 150m Ferrands bridge:500m Cul De Sac bridge: 300m
	Cross section	Ravine Poisson bridge: Bridge design: 420m (7nos.×60m), River structure:1,050m Ferrands bridge: Bridge design: 2,250m (25nos×90m), River structure 2,100m Cul De Sac bridge:

		Bridge design: 900m (15nos×60m), River structure 2,100m
	Public Utilities	Identify the location of public utilities (electrical, telecom, gas, water supply, drainage) with information collection

Source: JICA Survey Team

1-2-3-3 Geological Survey Results

(1) Outline of geological condition

Saint Lucia is situated at Lat.13°59' N. and long.61° E, and island country in eastern Carribbean sea. The island began its life as a series of submarine volcanoes, and the geographically characterized by rough terrain including Mt.Gimie (950m), Gros Piton (771m), Petit Piton (739m). Geology in the island mainly consists of Andesite, Basalt rock, volcanic sediments and flood plane deposits.

(2) Geological survey results

Geological survey was conducted in order to obtain the necessary information for the design of bridge and road structure. Survey Items are shown in Table 1-10.

Some items in laboratory tests are currently on going. The survey results already completed are briefly summarized below;

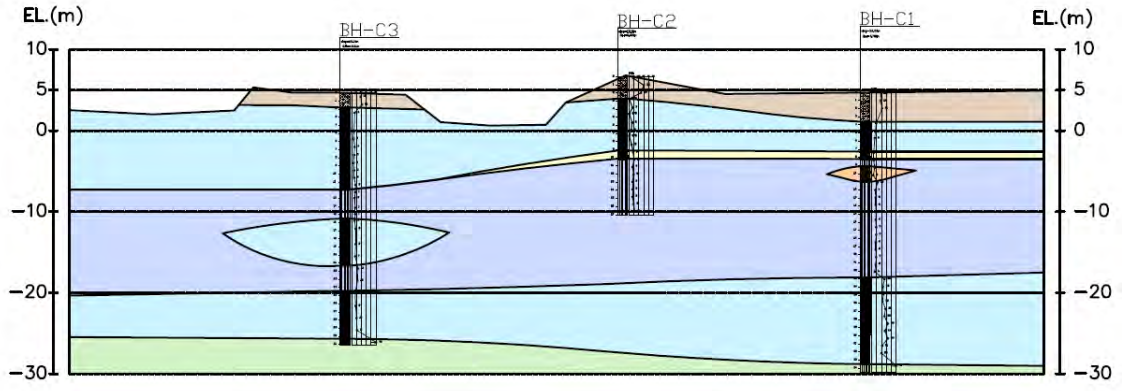
Table 1-10 Geological survey items

Survey Item		
Bridge Foundation	Borehole Survey	Ravin Poisson Bridge: 13m in total, 4 points Ferrands Bridge: 88.1m in total, 3 points Cul De Sac Bridge: 82.3m in total, 3 points
	Standard Penetration Test	159 nos in total
	Undisturbed Sampling	23 samples
	Water level monitoring	6 nos
	Laboratory Tests	Physical tests (Specific gravity, Natural moisture content, Particle size distribution, Atterberg limit) 42 nos, Direct Shear 24 nos, Consolidation 12 nos
Pavement Material	Subgrade material	Test pit 12 nos x 1m depth
		Physical tests (Specific gravity, Natural moisture content, Particle size distribution, Atterberg limit) 12 nos, CBR 12 nos
	Embankment Material	Borrow pit 3 sites x 3 samples
		Physical tests (Specific gravity, Natural moisture content, Particle size distribution, Atterberg limit) 9 nos, Proctor Test 9 nos, CBR 9 nos
	Aggregates	Fine Aggregates 2 pits x 3 samples Coarse Aggregates 2 pits x 3 samples
		Physical tests (Particle size distribution, Specific gravity & water absorption, Soundness) 15 nos
River bed	Sampling	3 Bridges x 3 samples
	Particle size distribution	9 nos

Source: JICA Survey Team

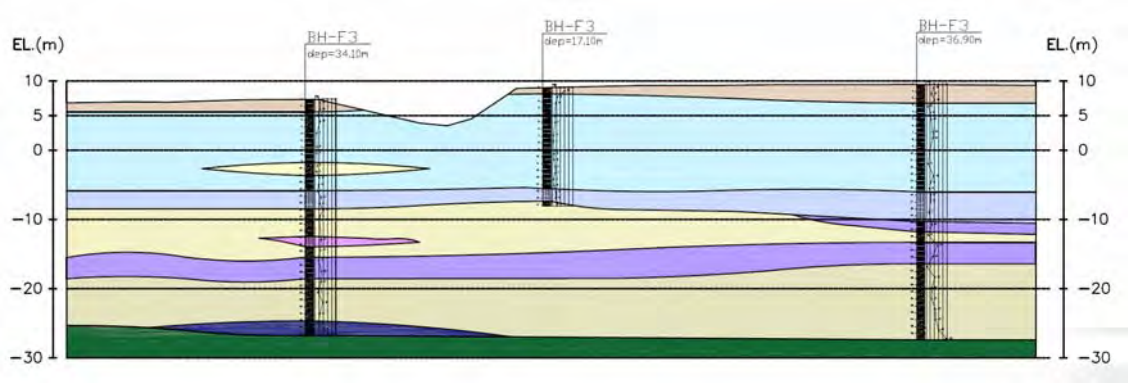
The geological profile was made from the borehole survey results. It of Cul-De-Sac bridge are shown in Figure 1-18 and Ferrands in Figure 1-19. Geological conditions of both bridge site are

similar, flood plane sediment deposit with 30m thickness on the basalt rock layer. This sediment consists of silt, clay, peat or organic clay and fine sand layer which N values are almost less than 20, and the strength is not sufficient as the supporting layer for bridge foundation. Thus, it can be determined that pile foundation is necessary for the substructures in the area. Regarding the condition at Ravin Poisson bridge, river deposit is coverd on the hard basalt layer with the thickness of 2 to 5m. Thus, the spread foundation can be adopted for the substructure.



Source: JICA Survey Team

Figure 1-18 Geological profile at Cul De Sac bridge



Source: JICA Survey Team

Figure 1-19 Geological profile at Ferrands bridge

The photos of the test pit survey are shown in Figure 1-20. According to ovservation results of test pit, road bed at Cul-De-Sac bridge and Ferrands bridge consist of sand layer, and have not enough density. Thus compaction should be carried out carefully during the construction to ensure the enough CBR (bearing capacity). It at Ravine Poisson bridge consist of sand and rock layer and have enough bearing capacity. Expected CBR for the pavement design can be determined as 15 referring the laboratory test results.

Source: JICA Survey Team

Figure 1-20 Photos of test pit survey at Cul-De-Sac bridge

Material tests are conducted to check the quality as the embankment fill or aggregates. Quarry sites where the sample obtained are shown in Table 1-11.

Table 1-11 Quarry site for embankment material and aggregates

Name	Sample Material
CIE Quarry	Coarse aggregate, Fine aggregate, Fill material
C.O. Williams Quarry	Coarse aggregate, Fine aggregate
Wilrock Quarry	Coarse aggregate, Fine aggregate
MilleQuarry	Fill material
Union Quarry	Fill material

Source: JICA Survey Team

1-2-4 Hydrological Survey Results

1-2-4-1 Basic Approach of Hydrological and Hydraulic Study

Hydrological and hydraulic data and information are collected through review of relevant documents, site reconnaissance of the river, and flood mark survey. The Cul de Sac River basin located in a tropical island has hydrological characteristics such as high intensity rainfall and rapid run-off of rainfall. In this study, methodology of hydrological and hydraulic analysis is conducted taking into account applicability for such characteristics while existing hydrological and hydraulic documents and data are verified its reliability.

Based on the analysis result, the design conditions required for the bridge design are established.

1-2-4-2 Principal Feature of Cul de Sac River

Principal feature of the Cul de Sac River is shown in Table 1-12

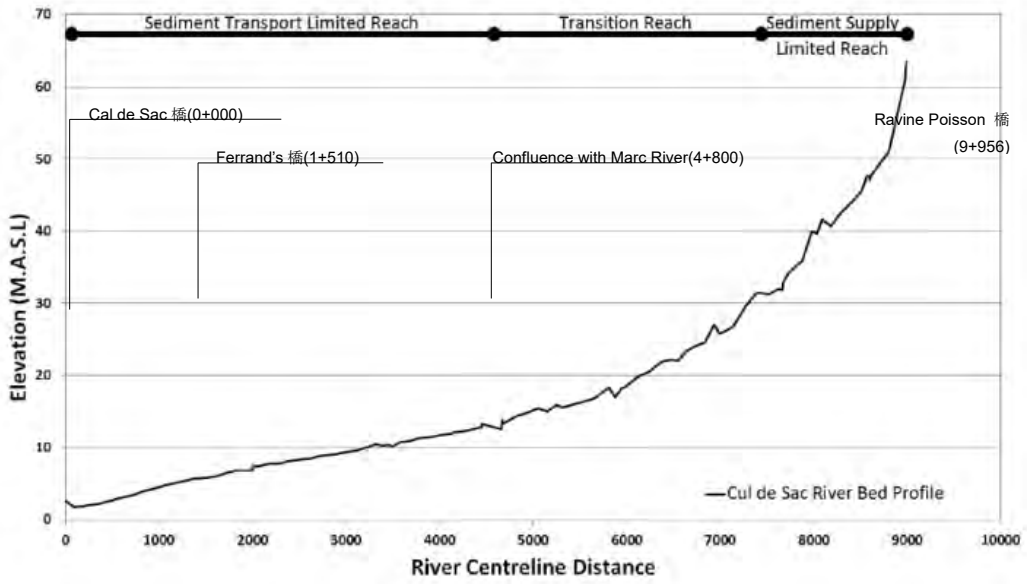
The Cul de Sac River originates from Mt. Millet located at middle west of the St.Lucia island, starts flowing down from south to north, crossing with the East Coast Highway at the Ravine Poisson Bridge at Sta.10+000 (origin of Sta.0+000 is at the Cul de Sac Bridge), and joining with a tributary of the Ravine Poisson River at immediately downstream of the bridge. After that, the river flows in parallel with the highway at west side, joining with the biggest tributary of the Mark River at Crown Land at Sta.4+800. After the confluence, the river flows changing its direction to north-west, crossing with the East Coast Highway again at Ferrand's bridge at Sta. 1+600. In the downstream of the bridge, the river starts meandering with large bends over a flood plain, crossing with the West Coast Highway at Cul de Sac Bridge (Sta.0+000). After the bridge, the river improvement works had been completed where the Millennium Highway is used as right dike of the river channel. The river eventually discharges into the Cul de Sac Bay passing through the 1.5 km of river improvement section.

Table 1-12 Principal Feature of Cul de Sac River

No.	Item	Basic Conditions of River Basin
1.	Location	Lat N13°59'08" – N13°54'25" Lon W61°00'39" – W60°58'26"
2	Name of River	Cul-De-Sac River
3	Major Tributaries	Ravine Poisson River at Sta.9+956 Marc River at Sta.4+800
4	River Length	L=13km
5	Catchment Area	Total 32.2 km^2 Ravine Poisson River 1.74 km^2 Marc River 7.80 km^2

6	Longitudinal Profile	i) 0+000 – 6+000 1/384 ii) 6+000 – 7+700 1/166 iii) 7+700 – 8+800 1/61 iv) 8+800 – 9+000 1/15
7	Rainfall	Rainfall 2,000 – 2,800mm/year Peak of rainfall is seen at Mt.Millet, gradually smaller to the downstream. Millet

Source: JICA Survey Team



Source： DILLON(2014)

Figure 1-21 Longitudinal Profile of Cul de Sac River

1-2-4-3 Collection of Hydrological/Hydraulic Data

(1) Observation Data

Following data and information relating to the hydrology and hydraulics are collected in the course of the study.

1) Rainfall

Rainfall observation in Saint Lucia are managed by two agencies, one is Meteorological Service in MIPE&L, and another is Water Resources Management Agency in Ministry of Sustainable Development. There are 7 rainfall stations in and adjacent of the basin. The condition of rainfall station is presented in table below:

In addition, the annual rainfall distribution in Saint Lucia is shown in the figure below. Annual rainfall is 2,900 m in the upper basin and 2,000m in lower basin.

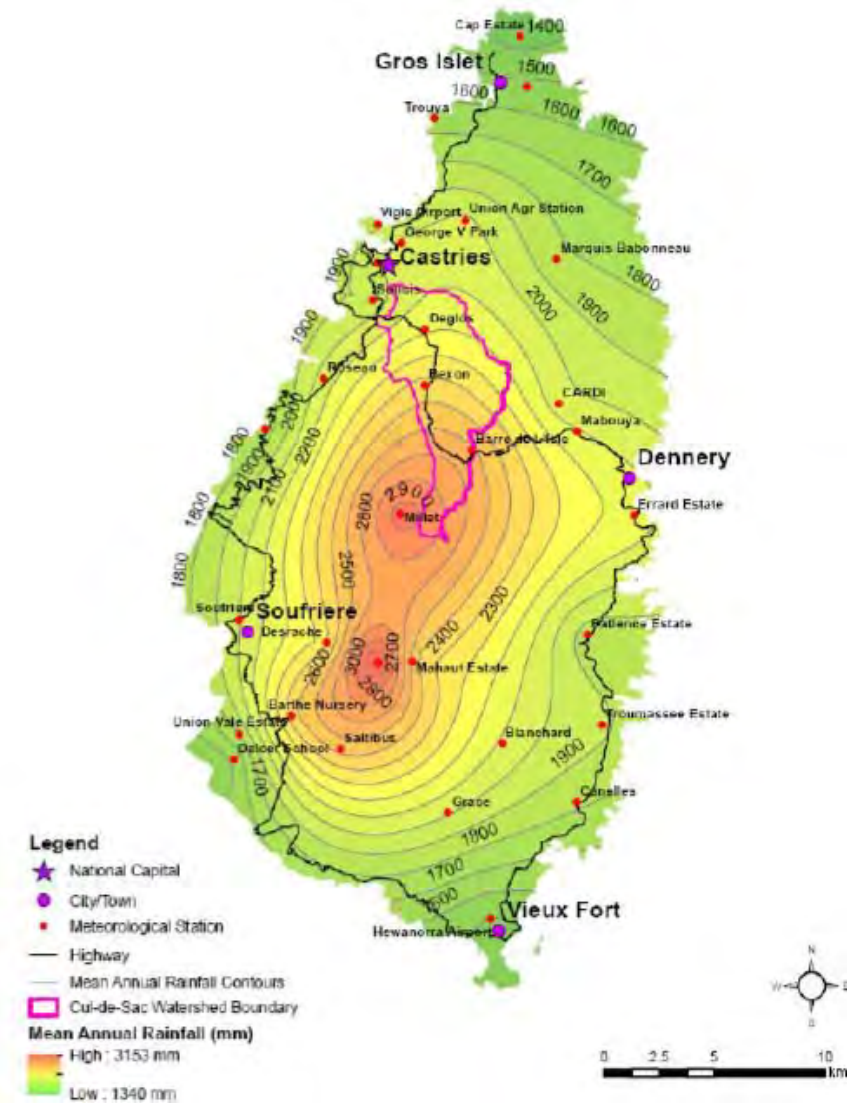
Table 1-13 Rainfall Stations in Cul de Sac River Basin

Name of Station	River Basin	Frequency	Observation Period	Source
1. Soucis	Cul de Sac R.	daily	1986/01/01 - 2015/06/30	WRMA

		hourly	2003/04/03 - 2014/11/04	WRMA
2. Bexon	Cul de Sac R.	daily	1986/01/01 - 2013/12/31	WRMA
		hourly	2003/04/04 - 2014/01/03	WRMA
3. Deglos	Cul de Sac R.	5min	2012/03/09 - 2014/01/06	WRMA
4. Government House	Castlies R.	daily	1986/01/01 - 2016/04/30	WRMA
5. Millet	Roseau R.	daily/realtime	1986/01/01 - 2016/04/30	WRMA
6. Barre D'Isle	Cul de Sac R.	daily	1986/01/01 - 2016/04/30	WRMA
7. Daglos Sanitary Landfill	Cul de Sac R.	daily	2001/08/18 - 2008/05/08	WRMA
8. Roseau	Roseau R.	daily		WRMA

Source: WRMA

Figure 1-22 Location Map of Rainfall Station in Cul de Sac River Basin



Source: WRMA

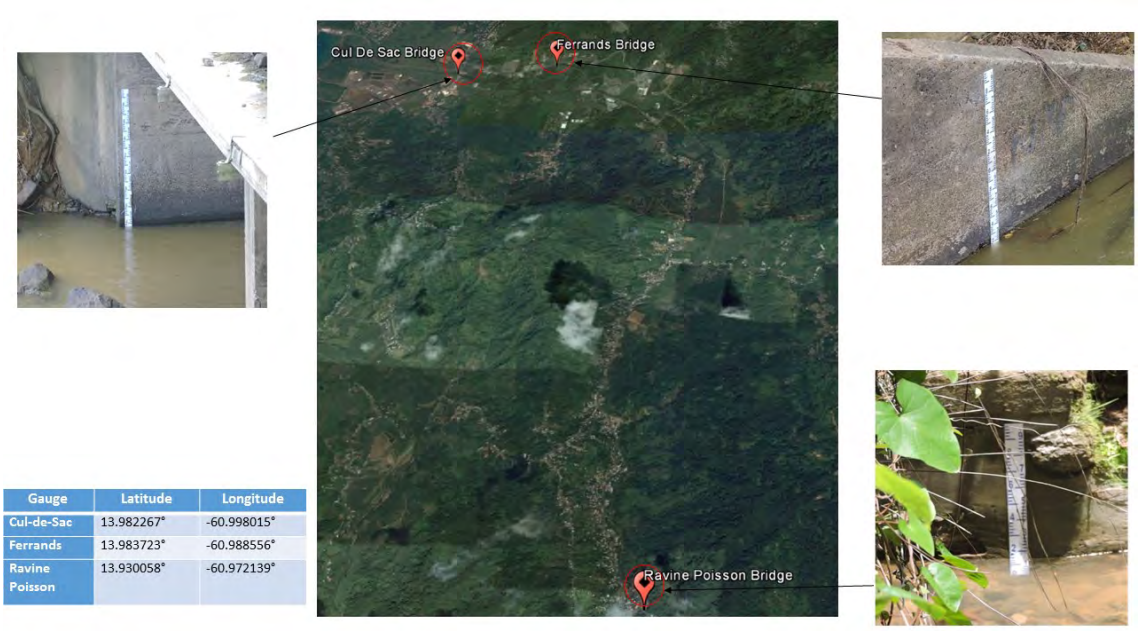
Figure 1-23 Annual Rainfall in Saint Lucia

2) Water Level and Discharge

There was a water level gauge installed at the Ferrand's bridge, but it was washed away due to the flood in 2010 Hurricane Tomas. Since then, it is not rehabilitated yet and no water level observation is conducted in the Cul de Sac River basin. Aside from this, WRMA carries out the periodical monthly water level monitoring and discharge measurement. This is aiming at monitoring low water flow, but not targeting for flood events. No flood discharge record remains in the past.

In cooperation with WRMA, three (3) water level gauges were installed at objective bridge sites in this Study. Using these gauges, water level is observed once or twice in a day by local gauge-reader by manual reading since July 15, 2016. The location map and result of water level observation are shown in figures below. On July 20, August 11,

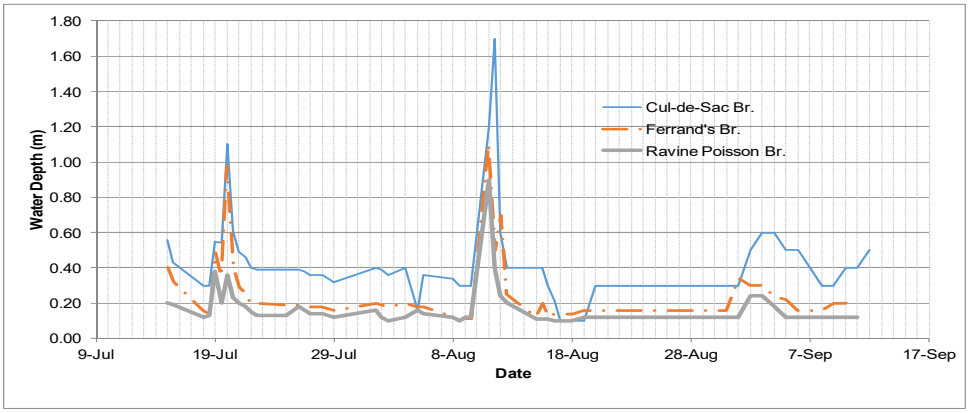
small scale floods with more than 1 m in water level were observed at the Cul de Sac Bridge site.



Gauge	Latitude	Longitude
Cul-de-Sac	13.982267°	-60.998015°
Ferrands	13.983723°	-60.988556°
Ravine Poisson	13.930058°	-60.972139°

Source: JICA Survey Team

Figure 1-24 Location Map and Photo of Water Level Gauges



Source: JICA Survey Team

Figure 1-25 Variation of Observed Water Level at Each Bridge Site

3) Tide Level

In St.Lucia, there is no tidal level observation station. In the past, a tidal gauge was installed at the bay in Canalies City, but it is not working now. There is a plan to reinstall a new gauge in the future

1-2-4-4 Review of Existing Documents

(1) Review of Existing Documents for Hydrology and Hydraulics

The existing technical documents relating to hydrology and hydraulics are collected through the hydrological survey in this study. Information of collected documents is shown in table below:

Table 1-14 Existing Technical Documents for Hydrology and Hydraulics

No.	Title of Documents / Source	Year	Contents
1	"Preliminary Feasibility Report for Cul-de-Sac Valley Development Flood Risk Study /Halcrow	July 1996"	A study conducted after 1994 hurricane Debby. Flood risk study was carried out and a river improvement plan was formulated in the downstream of Cul de Sac River.
2	Report on Proposed Flood Protection Measures to DuBoulay Warehouse Area	Sep. 1988	Local drainage plan was formulated for the private lot located at left bank downstream of the Cul de Sac Bridge.
3	Tender Drawings New Cul-de-Sac River Bridge associated Road Works (incomplete) /Halcrow	Aug. 1999	Draft Tender drawing for replacement of the Cul de Sac bridge in association with proposed river improvement works (This tender was incomplete)
4	"Flood Risk Reduction for the Watershed Communities of Marc and Bexon, /DILLON	2014	A study conducted after 2010 hurricane Tomas. Flood risk study was carried out and a river improvement plan was formulated in the upstream stretch of the Ferrand's bridge in Cul de Sac River.

Source: JICA Survey Team

(2) Past Flood Record

Past flood records with rainfall, river discharge inundation depth are listed in the table below:

Table 1-15 Past Flood Records in Cul de Sac River

Flood Damage	Rainfall (return period)	River Discharge(Ferrand Br. – River Mouth)	Inundation Depth (Ferrand Br.)
Sep. 1994: TS Debbie	360mm/day at Bexon (100-year)	525～806 m3/s	1.3 m
Oct. 1996: Tropical Wave Event	207 mm/day at Bexon (20-year)	292～366 m3/s	overtopped
Oct. 2010: Hurricane Tomas	405～668mm/day (100～375-year)	292～366 m3/s	overtopped
Dec. 2013 Christmas Eve trough			overtopped

Source: DILLON (2014), Damage Assessment

Cul de Sac River basin has been frequently suffered from serious floods. In the oldest flood record, on November 21, 1938, a large land slide occurred in the Ravine Poisson area due to a flood in the Cul de Sac River basin with 99 persons of death. In September 1994, Tropical Storm Debbie brought recorded maximum rainfall with flood damage cost of EC230 M. In 1996, tidal storm and heavy rainfall caused the damages of 230M.

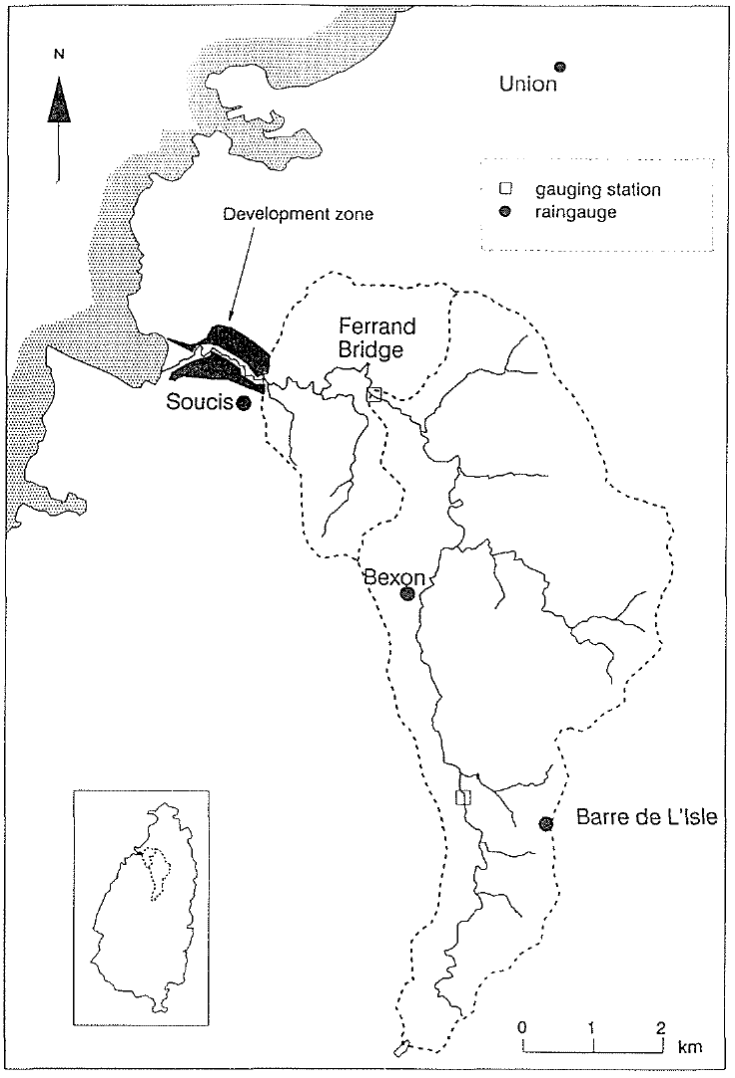
Recently, a large scale of floods had been brought by October 2010 Hurricane Tomas, December 2013 Christmas Trough.

(3) Pervious River Improvement Plan and Works

1) River improvement works:

In the river stretch of 2 km from river mouth to the Cul de Sac Bridge, river improvement works have been conducted. The history of the works is shown below:

i. In 1980's, a development plan in the western area of the west coast highway along the downstream of the Cul de Sac River was formulated. This plan was aiming at implementation of flood control works to increase safety level in the development zone and to eliminate traffic impending due to flood damage. At this time, alignment of the low water channel was straightened.



Source: Vulnerability Assessment of the Restoration Works (1993)

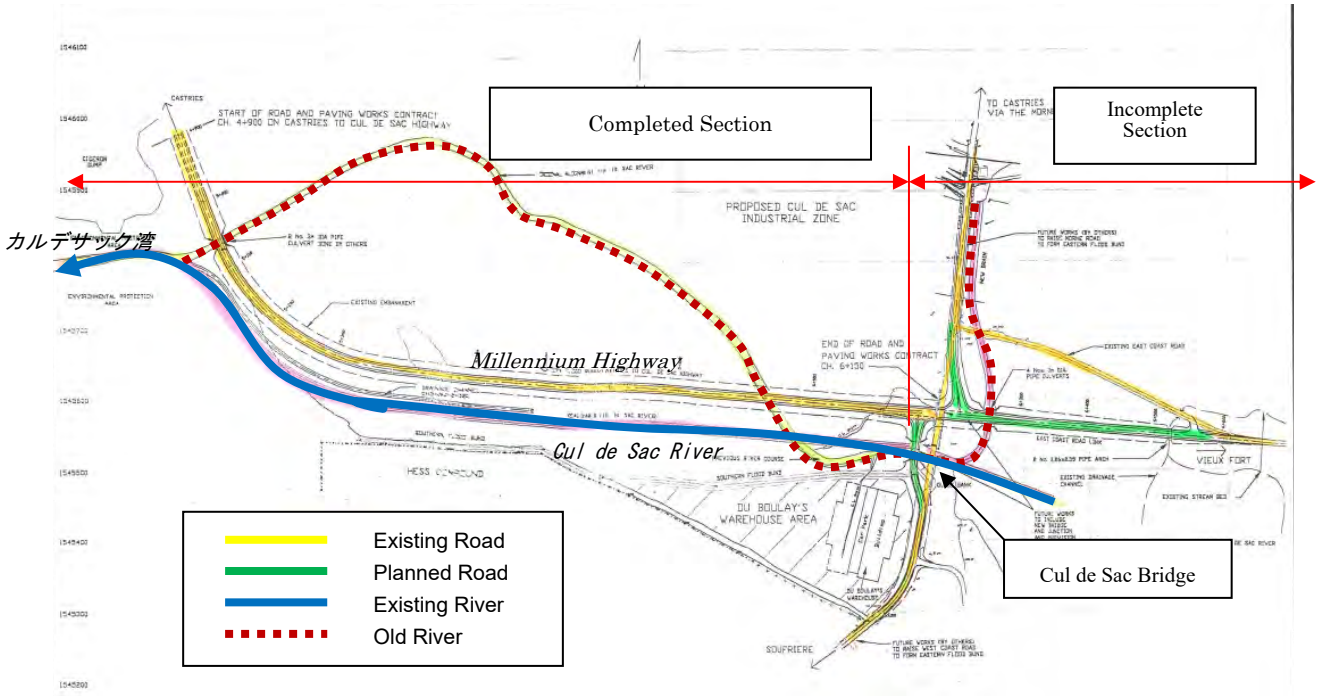
Figure 1-26 Location Map of Development Zone in downstream of Cul de Sac River

ii. After that, in the beginning of 1990's, reclamation and site preparation in the development

zone was started. At this time, construction of the Millennium Highway was planned.

iii. However, in 1994 a hurricane Debbie hit the area causing serious flood damages in the proposed development zone. With this as turning point, the river improvement plan should have been revised. As the result, an integrated flood control plan including construction of flood dike rod using excess soil materials from the Millennium Highway construction works and construction of wide compound river section was proposed as shown in Figure x.12.

iv. In March 1997, the river improvement works in the downstream of the Cul de Sac River was completed. At present, the river channel has a compound section with around 80 m in width. The right dike (north flood bund) is used as a part of the Millennium Highway, and the left dike (south flood bund) has been constructed along the property boundaries of the Buckeye (oil storage) facilities and private warehouse. The flood bunds were designed at flood discharge of 100-year return period (346 m^3/s) based on the hydrological assessment using rainfall data at that time. The proposed river improvement area was included the replacement of the Cul de Sac Bridge, but actually the river improvement works had been conducted up to 100 m downstream of the Cul de Sac Bridge, and no bridge replacement was carried out.



Source: Cul de Sac Valley Flood Protection Works (1998)

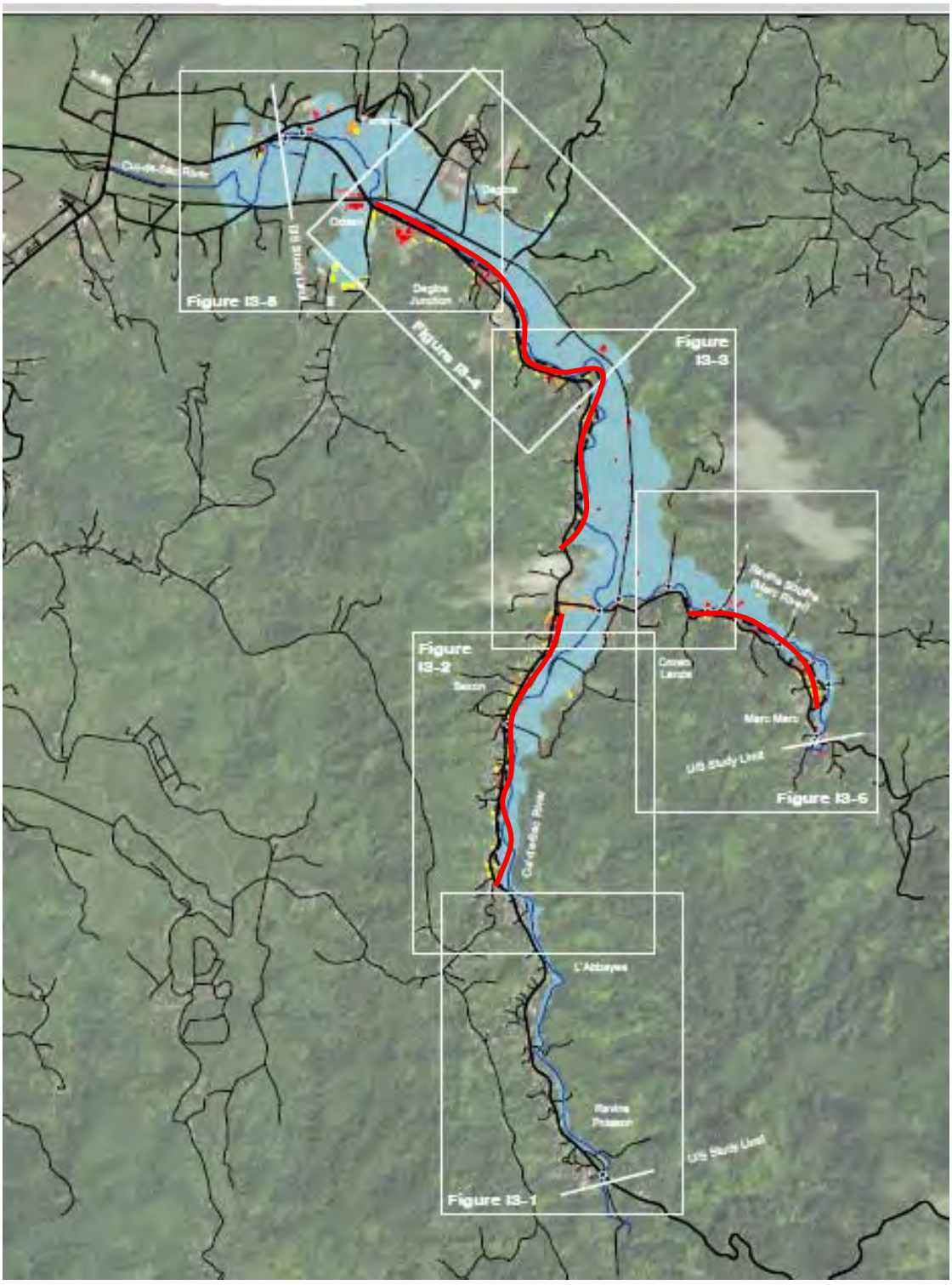
Figure 1-27 General Plan of River Improvement Works in downstream of The Cul de Sac River

2) River Improvement Plan

In the flood risk study by DILLON in 2014, a river improvement plan in the upstream of the Ferrand's Bridge was proposed as shown in Figure x.13. As the result of

comparative study of various flood protection measures, construction of flood dike was evaluated as most effective measure. The flood dike is planned to be constructed from 1 km upstream of the Ferrand's Bridge to the 3km downstream of the Ravine Poisson Bridge along the one side of the river only (western side) so that the main highway (East Coast Highway) could be protected from flooding damage.

The existing river improvement works is completed from the river mouth to the downstream of the Cul de Sac Bridge while the 2014 plan is targeting from upstream of the Ferrand's Bridge to the upstream area. There is a gap between Cul de Sac Bridge and Ferrand's bidge where no river improvement plan is formulated.



Source: DILLON (2014)

Figure 1-28 General Plan of River Improvement Works in Upstream of The Cul de Sac River

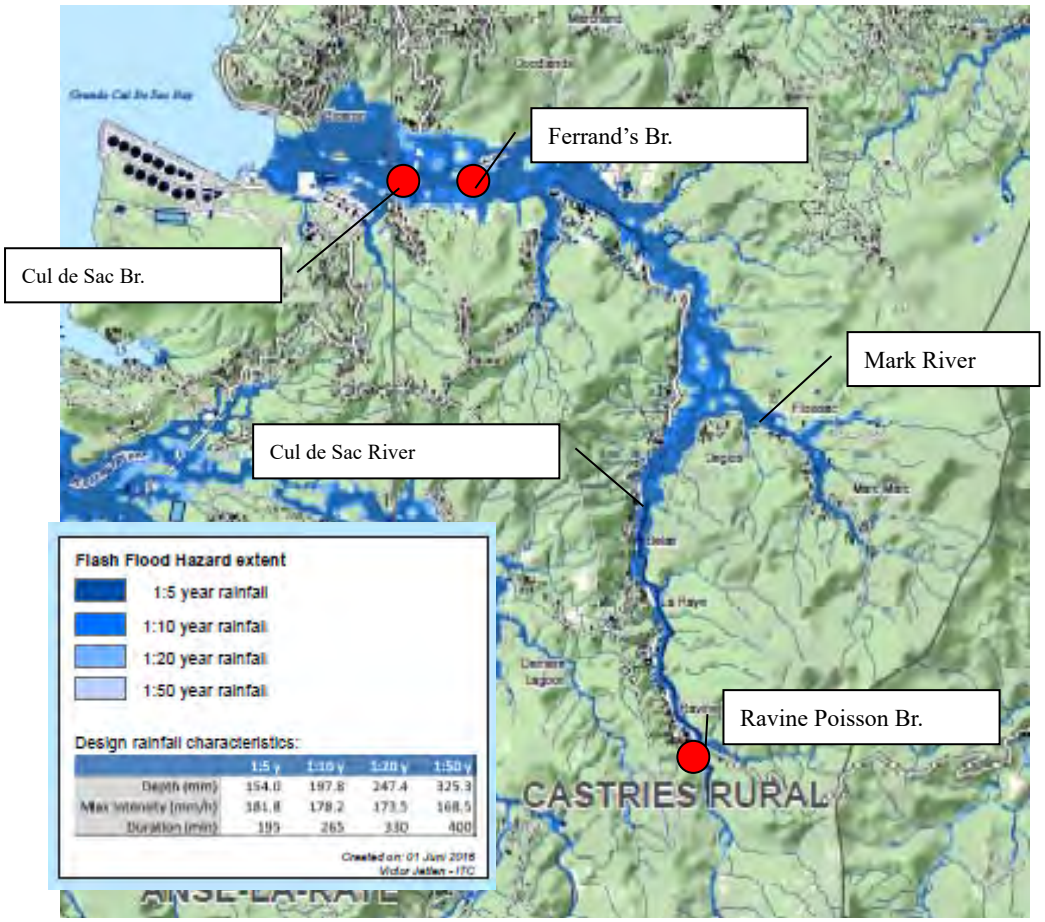
1-2-4-5 Study for Flood Mechanism

(1) Characteristics of Flood in River Basin

The Cul de Sac River basin is basically categorized into the steep topographic area. The annual rainfall amount is bigger in the internal mountain area. The river system in the basin is that the main river flows in the middle of river basin joining with some tributaries from surrounding areas. Because of these topographic and hydrological conditions, flood has characteristics of "flush flood" such that rainfall water from the basin running off into the river channel very fast, and higher peak flood discharge and shorter flood duration.

As shown in the figure of riverbed longitudinal profile, there is a changing point of the profile at the Mark River confluence. In the western part of the confluence, the riverbed profile becomes gentle, thereby flow capacity of the river channel is reduced. Aside from this condition, the water from the Mark River joints thereby the downstream of the confluence shows the topographic conditions with wider inundation area.

Inundation analysis had been conducted by some of previous studies. As a reference the example of inundation map prepared by Charim in 2016 is presented in figure below:

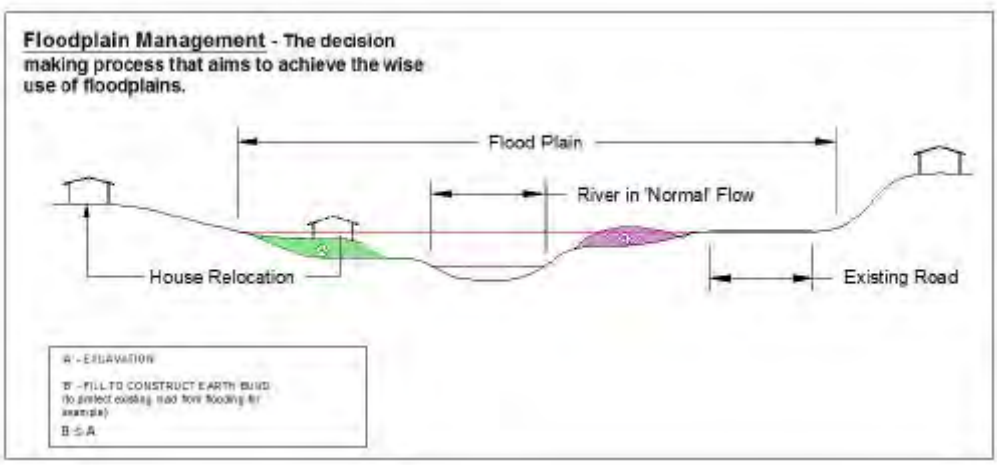


Source: CHaRIM Project、Saint Lucia National Flood Hazard Map、Methodology and Validation Report , Faculty of Geoinformation Science and Earth Observation (ITC), University of Twente, The Netherlands (2016)

Figure 1-29 Inundation Map in Cul de Sac River Basin

(2) Mechanism of Flood at Objective Bridges

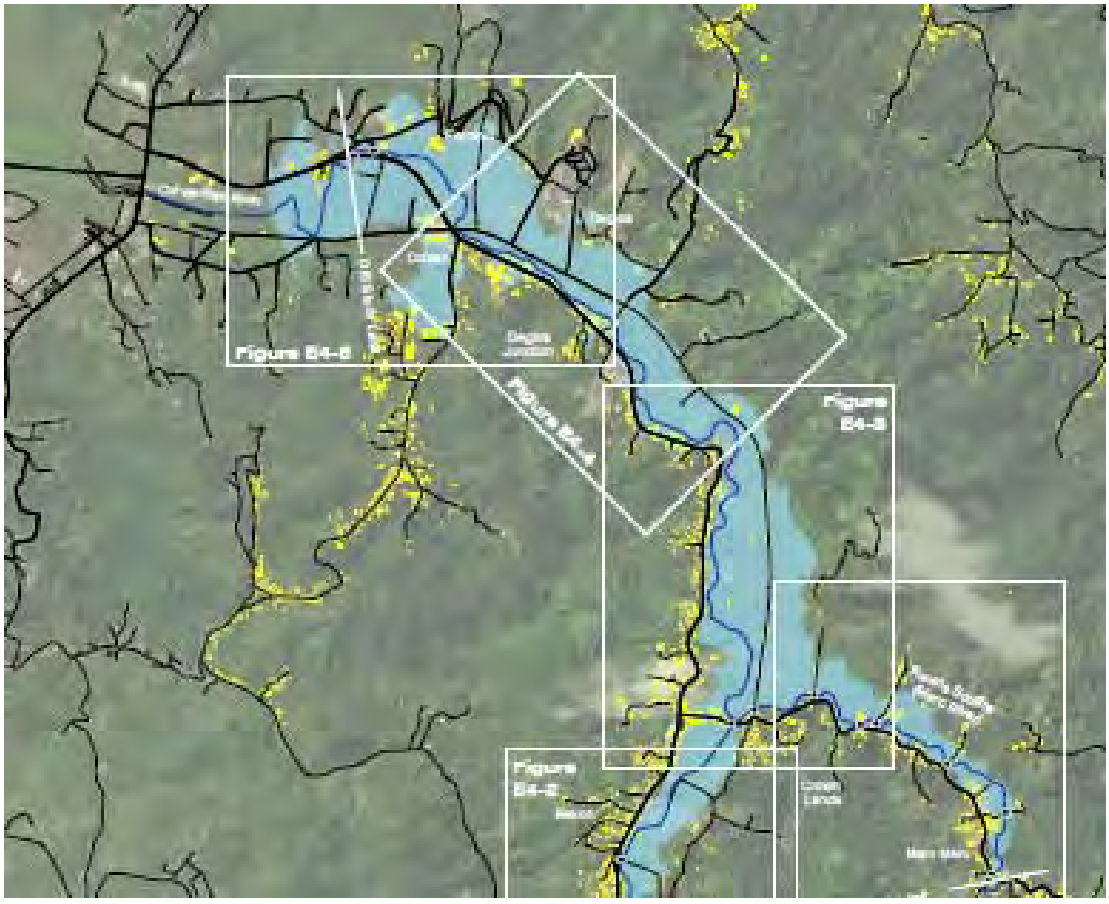
Figure x. 14 shows the flood inundation map of the 50-year flood. Focusing on the areas of the road and bridge along the Cul de Sac River, flood inundated water is spreading in wider area in the downstream of the confluence of the Mark River, causing the road and bridge are subsidized under water. Cul de Sac Bridge and Ferrand's Bridge are located within the inundation area. Once large magnitude of flood occurs surrounding area of the bridge and roads are subsided under water. Almost every year, traffic congestion due to such a heavy rainfall occurs in these areas. It is reported that maximum congested dates were eight (8) days in the past. The conceptual cross section showing the relating between road and river channel with flood plain is illustrated as shown in the figure below:



Source: Hurricane Tomas Damage Assessment Report (2010)

Figure 1-30 Conceptual Cross Section in downstream of Cul de Sac River Basin

On the other hand, in the surrounding area of the Ravine Poisson Bridge, the road is located outer of the inundation areas. As confirmed in the result of the flood mark survey, no over topping in the surrounding area have been occurred at the Ravine Poisson Bridge. At the time of site reconnaissance, it was seen that that bridge handrail was bended to the direction of downstream of the river. As per the interview to the local residents, it was said that that flood water level was temporary risen due to narrow section at the bridge where many debris and drafting woods were trapped and hit the handrail.



Source: DILLON (2014)

Figure 1-31 Relation of Layout between Objective Bridges and Highways, and Flood Inundation Area in Cul de Sac River

1-2-4-6 Study for Conceptual Plan of River Improvement Works

(1) Need of River Improvement Plan

The flood inundation areas in the downstream of the river spread out not only bridge sites but also surrounding low-lying areas and roads. In order to achieve the main objective of the Project "to secure smooth and stabilized traffic in the objective area overall a year", only single measure as replacement of the bridges could not achieve this object. To protect bridges as well as surrounding areas and roads from flood inundation, establishment of the river improvement plan in the objective area is needed.

(2) Basic Approach to Establishment of Conceptual Plan of River Improvement Works

Flood in the Cul de Sac River basin is characterized that having shorter flood duration with higher peek discharge. In such conditions, constructions of flood retarding/regulating facilities in the basin are considered effective for flood protection. However, as the result of the site inspection, it was found that there was less proper

construction site for dams and retarding basin in the upstream area. So far, no construction plan of these facilities is planned in the basin. Accordingly , the succeeding study will be made applying the basic approach that a conceptual plan of the river improvement works is formulated without consideration of any flood regulating facilities in the upstream,

As aforementioned, construction of flood bunds are proposed in the upstream of the Ferrand's Bridge based on the past flood risk study. However, in the downstream river section between Cul de Sac Bridge and Ferrand's Bridge, no river improvement plan exists at present. It is necessary that to study river improvement plan for this stretch including the Cul de Sac Bridge and Ferrand's bridge sections.

(3) Conceptual Plan of River Improvement Works at Cul de Sac Bridge

In the downstream of the Cul de Sac Bridge, river improvement works have been completed. Along the right downstream bank of the bridge, a north flood bund that is working as a part of the Millennium Highway is already constructed, Taking into continuation of the river improvement works, the plan of replacement of the bridge has to be corresponding to the geometric feature of the existing river cross section. Required bridge length is estimated at around 80 m.

In addition, at the end of the Millennium Highway, the road profile is going down by around 3 m to the Cul de Sac Bridge, thereby the elevation of this area including adjacent of the bridge site and West Coast Highway are lower than the flood level. To cope with this situation, following supporting works in addition to the replacement of the bridge are needed to secure traffic and to make river water level lower during flood.

i) Road raising at the end of Millennium Highway (approx. 30 m)

ii) Road raising of West Coast Highway (approx. 1,000m)

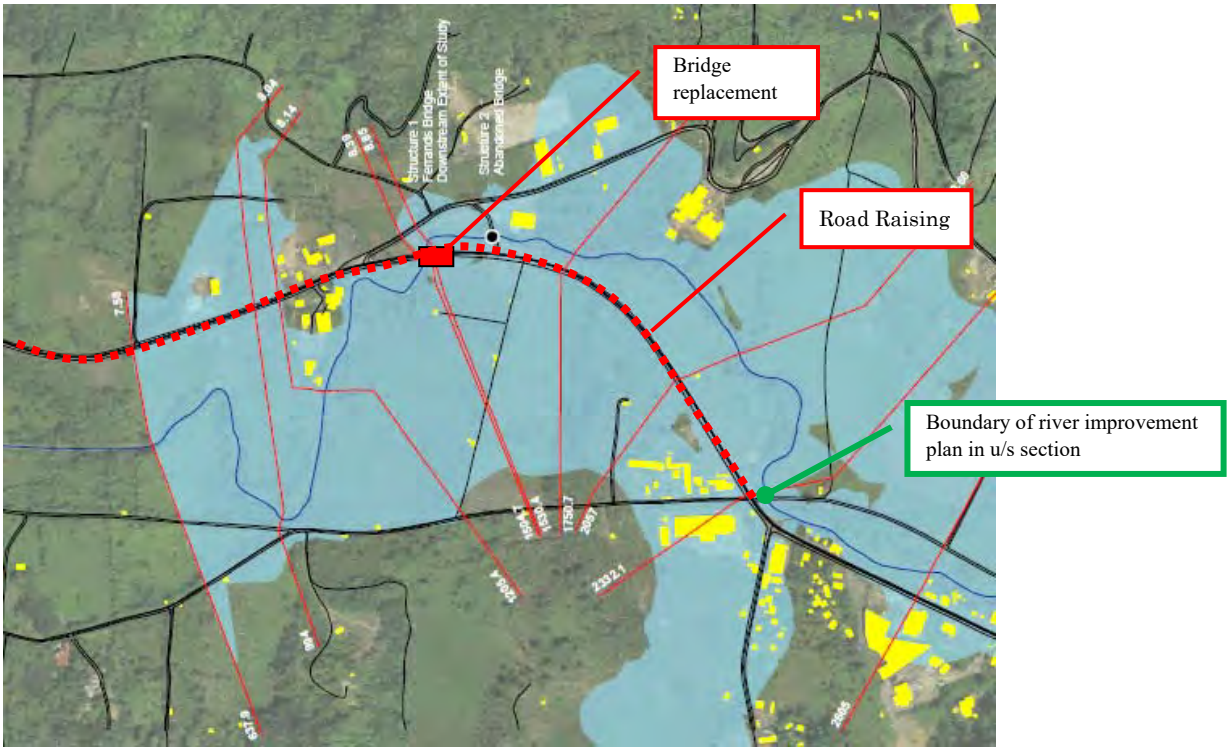
Aside from this, sediments are deposited in the low water channel in the downstream of the bridge. It is required to remove sediment in the downstream channel.

(4) Conceptual Plan of River Improvement Works at Ferrand' s Bridge

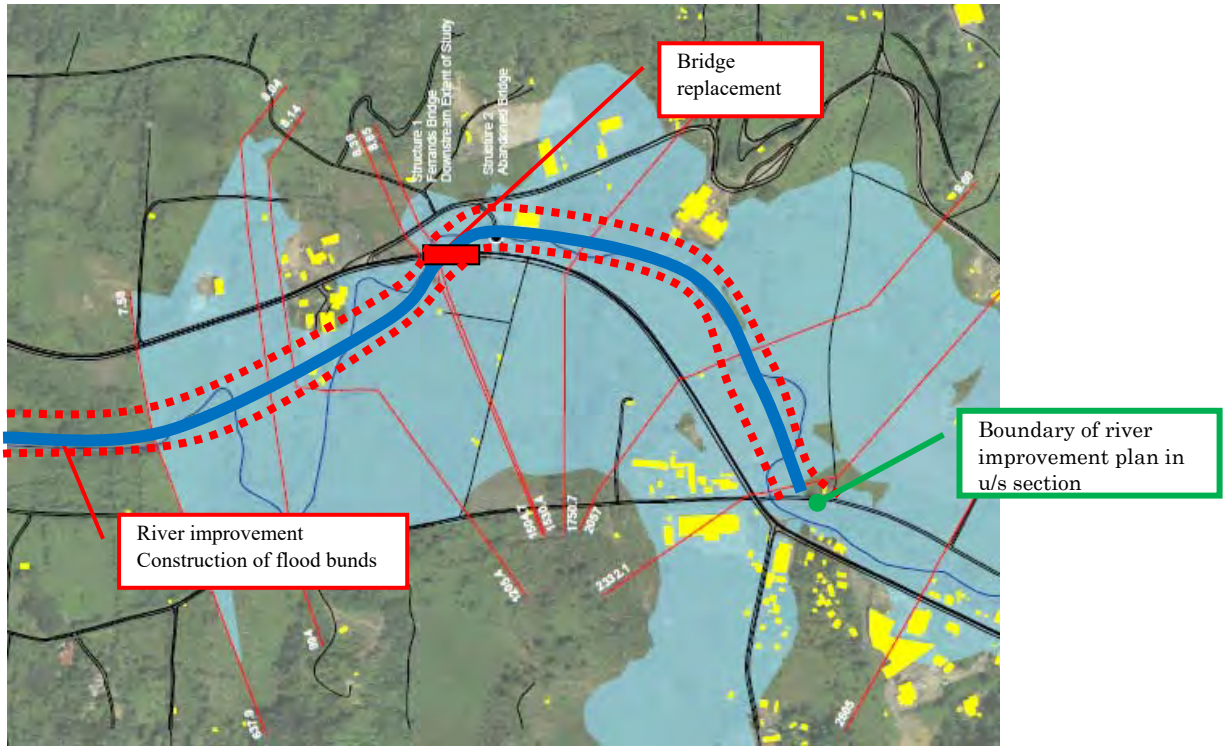
For the river improvement works in association with the replacement of the Ferrand's Bridge, following three alternatives can be considered taking into account the Project Objective:

Layout plan of each alternative is presented below.

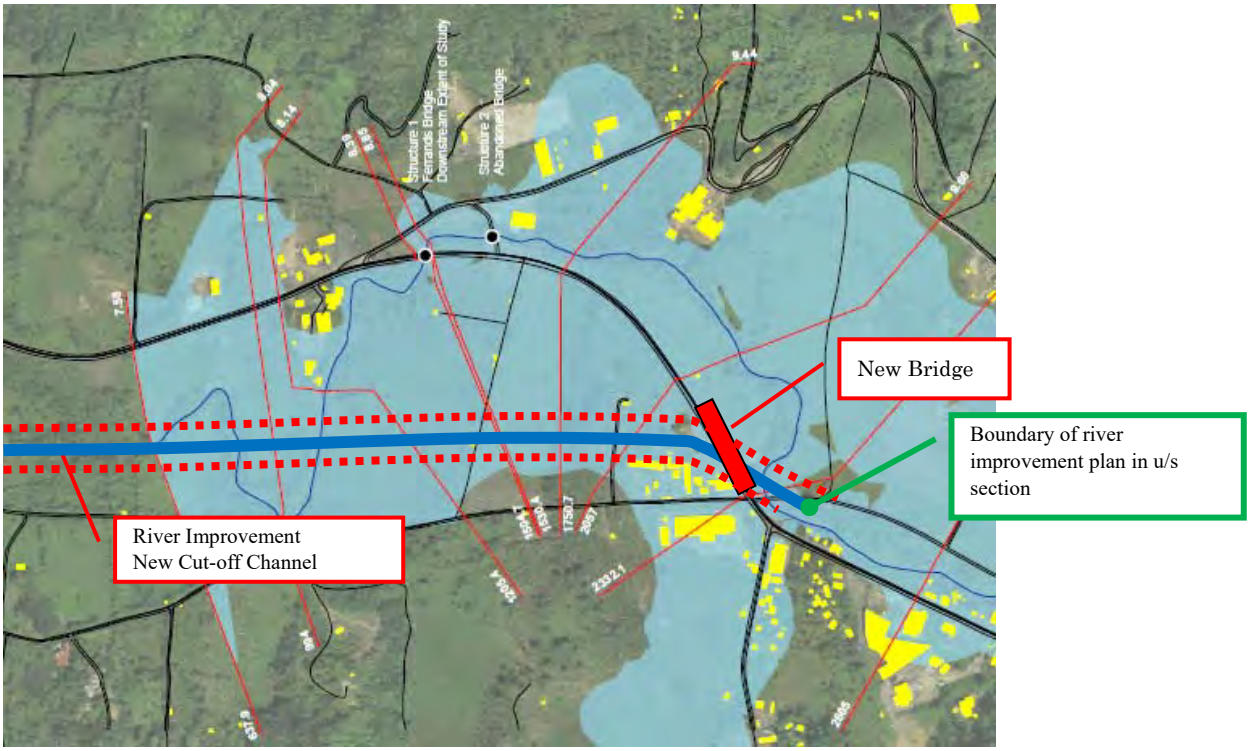
(Alternative 1) Replacement of bridge at existing site with road raising



(Alternative 2) Replacement of bridge at existing site with river improvement



(Alternative 3) Construction of new cut-off channel with a new bridge



The outline, main quantity of works and layout plan of each alternative is presented below:

Table 1-16 Comparison table of Alternatives

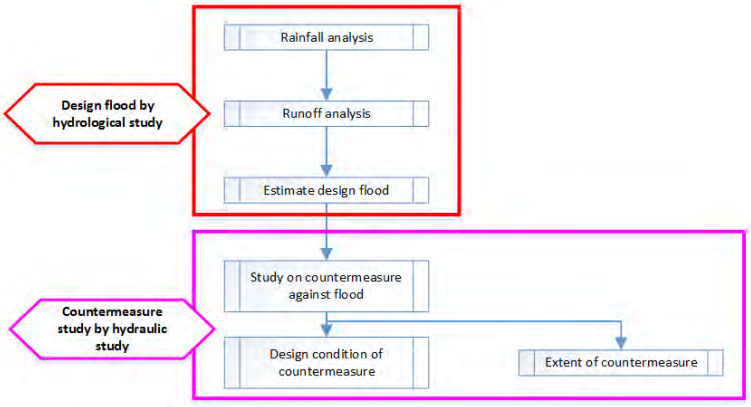
Alternative	Alternative 1	Alternative 2	Alternative 3
Outline	・Replacement of bridge at existing site with road raising	・Replacement of bridge at existing site with river improvement	・Construction of new cut-off channel with a new bridge
Basic Dimension	・Bridge Replacement: 80m ・Road Raising: 2,330 m	・Bridge Replacement: 80m ・River Improvement: 2,330 m	・New Bridge: 80m ・River Improvement: 600 m ・New Cut-off Channel :600m
ROW Acquisition	・Small: ・Limited in the surrounding area of bridge due to existing road raising	・Medium : ・ROW acquisition required for construction of flood bunds	・Large: ・ROW acquisition required for new Cut-off Channel and new Bridge
Merit	・Securing traffic at Ferrand's Bridge as well as surrounding area in case of floods ・Smaller ROW acquisition ・Lower bridge raising comparing with other alternatives	・Solving traffic constrain at Ferrand's Bridge as well as surrounding area in case of floods ・Mitigation of flood inundation area	・Solving traffic constrain at Ferrand's Bridge as well as surrounding area in case of floods ・Mitigation of flood inundation area
Demerit	・Flood inundation damage is not solved. Less contribution to regional development	・Necessity of medium scale ROW acquisition for construction of flood bund along existing river	・Necessity of large scale ROW acquisition for construction of new Cut-off Channel
Premise of JICA Grant Project	・Implementation of road raising (plan formulation, budgetary allocation, ROW acquisition) by GoST	・Implementation of river improvement works (plan formulation, budgetary allocation, ROW acquisition) by GoST	・Implementation of river improvement works and new Cut-off Channel (plan formulation, budgetary allocation, ROW acquisition) by GoST
Evaluation	Negative	Reccomend	Fair
	Alternative 1 has a merit of less ROW acquisition, however, it focuses on prioritizing for securing traffic condition, and it would not contribute on mitigation of flood damage in surrounding area. It is not recommended to apply Alternative 1 since this option will make difficult to make consistent with future flood mitigation project. Between Alternatives 2 and 3, the evaluation result is depending on the policy of GoST from the view point of flood mitigation project and regional development in future. In this Study so far, Alternative 2 is consider more feasible than Alternative 3 because of less ROW acquisition. The basic design of the Ferrand's Bridge will be made based on the Alternative 2. In case to apply Alternative 3, it is necessary to carry out large scale of ROW acquisition, and thereby it is required to formulate a integrated flood control plan in the basin including long term countermeasures.		

Source: JICA Survey Team

1-2-4-7 Hydrological and hydraulic study

(1) Study procedure

In order to estimate the design discharge, flood water level at cross-section of bridge and inundation area for design of bridge replacement, the hydrological and hydraulic study are carried out. Study procedure is described in Figure 1-32.

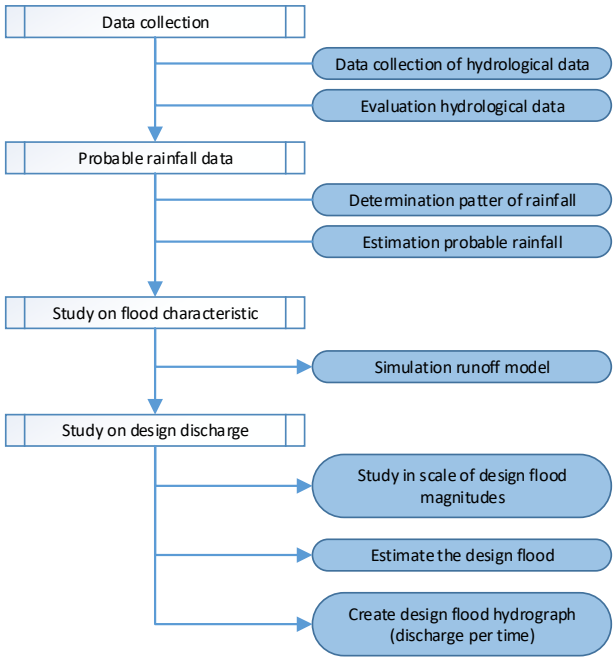


Source: JICA Survey Team

Figure 1-32 Study Procedure for Hydrology and Hydraulic Study

(2) Hydrological study for design discharge

Design discharge based on hydrological study is carried out with the following procedure as described Figure 1-33.



Source: JICA Survey Team

Figure 1-33 Study Procedure for Flood Discharge

(3) Data collection of hydrological data

There are several rain-gauge stations inside and outside of Cul-de-Sac river basin area. These rainfall data are collected and evaluated for probable rainfall estimation. Considering with the data available and the previous study, the data for use for rainfall analysis is selected. In this study, four rain-gauge stations are used as described in Figure 1-34. Vigie Airport rainfall gaging station where is 8 km far from Bexon rain-gauge station, is used only practical period as described latter.

	Name of rain-gauge station	Available data period (year)
1	Barre de L'isle	1955-2015
2	Bexon	1985-2013
3	Millet	1979-2015
4	Vigie Airport	1985-2015

Source: JICA Survey Team based on WEB Site of WRMA(http://water.gov.lc/app/db/index.php) and field survey

Source： DILLON（ Red text and line is added by JICA Survey Team）

Figure 1-34 Basin boundary and Rain-gauge Station in Saint Lucia Basin

For this study, Bexon rain-gauge station is applied for the representative station stands for the basin area since this station is center of basin area and the area of this basin area is relatively small, about 40 km^2 (Generally, one rain-gauge station can be representative is within 50 km^2). Bexon rain-gauge station is evaluated. The missing data is interpolated by the following procedure with the near rain-gauge station.

1. If the data of Barre de L'isle and Goernment house gauging station is available, the missing data is interpolated using the interpolation coefficient.
2. Period of November 2004, form January 2009 to April 2009, and from June 2010 to May 2011, the data of Bexon, Barre de L'lsle and Goernment house is not available, Vigie (George FL Charles) Airport where is located 8 km far from Bexon rain-gauge station, is used for interpolation.

Interpolation coefficient is applied the value which applied in the previous study as below.

Rain-gauge station	Interpolation coefficient
Barre de L'lsle	1.157
Goernment house	1.232
Vigie	1.279

Table 1-17 and Table 1-18 is summarized the monthly and annual depth of total and maximum rainfall data from 1955 to 2015 as based on the above evaluation.

Table 1-17 Total Depth of Monthly and Annual Rainfall Data

(unit: mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1955	87	102	64	47	126	415	430	396	435	546	661	244	3,552
1956	600	377	178	225	249	502	418	519	372	648	431	519	5,039
1957	409	110	88	243	92	380	833	604	259	840	368	287	4,515
1958	102	65	26	76	654	670	838	559	549	461	412	724	5,135
1959	195	284	182	268	631	196	360	205	198	519	230	260	3,527
1960	120	135	144	158	191	302	610	400	364	442	235	208	3,308
1961	176	204	126	62	113	240	491	353	189	540	316	311	3,122
1962	365	152	98	136	201	316	384	313	378	345	206	133	3,028
1963	370	217	91	105	157	142	216	180	221	165	137	112	2,113
1964	59	129	81	206	95	246	213	258	261	330	254	151	2,284
1965	168	173	259	231	190	237	286	252	555	247	204	379	3,180
1966	120	232	139	163	293	323	843	362	290	497	435	223	3,919
1967	279	258	161	302	225	119	257	376	678	350	407	234	3,646
1968	130	74	216	115	461	394	101	0	0	456	177	470	2,594
1969	278	74	37	155	159	411	354	541	0	425	381	334	3,151
1970	100	170	88	54	98	537	399	257	294	747	508	265	3,518
1971	235	130	58	232	0	59	128	410	206	295	180	312	2,245
1972	219	200	163	174	140	86	255	238	228	469	283	242	2,697
1973	113	105	38	116	98	272	129	275	217	278	102	117	1,860
1974	213	177	150	113	125	189	151	166	365	476	221	139	2,485
1975	214	123	0	61	82	104	87	411	268	505	576	310	2,740
1976	163	151	122	90	152	158	304	227	310	435	384	287	2,785
1977	45	70	58	190	173	71	189	510	326	0	293	157	2,083
1978	281	30	211	0	190	235	421	373	323	311	409	202	2,987
1979	151	96	256	165	169	486	0	297	505	495	541	165	3,325
1980	167	91	117	94	128	234	217	346	309	274	0	301	2,278
1981	196	274	114	480	584	206	388	196	175	175	216	249	3,252
1982	274	192	103	87	174	134	361	469	199	0	0	0	1,993
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	245	98	0	0	0	0	0	0	0	0	582	144	1,068
1985	162	101	134	200	0	0	240	244	180	391	310	151	2,113
1986	213	48	180	92	149	175	196	318	485	204	583	168	2,810
1987	68	33	42	4	363	284	253	455	293	333	522	172	2,821
1988	112	152	94	36	93	267	300	281	320	466	242	103	2,467
1989	163	157	312	171	38	68	325	303	511	220	334	255	2,858

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1990	241	107	118	62	200	180	300	219	475	570	166	174	2,813
1991	200	87	130	110	119	135	149	194	272	135	630	198	2,359
1992	108	146	72	97	168	302	211	346	616	134	551	200	2,950
1993	290	98	232	62	217	144	252	221	275	306	226	78	2,401
1994	188	107	101	72	94	153	189	330	617	272	183	139	2,445
1995	53	84	242	184	46	167	195	466	382	216	184	131	2,349
1996	114	97	104	146	83	212	313	236	326	836	342	109	2,918
1997	179	95	84	33	102	196	279	208	320	249	297	151	2,193
1998	189	34	73	33	144	307	304	255	259	473	284	378	2,732
1999	175	74	100	78	18	78	235	295	287	248	293	257	2,139
2000	146	308	172	65	177	106	237	332	287	274	235	271	2,610
2001	65	95	23	126	50	108	216	249	176	350	129	293	1,881
2002	183	240	106	185	118	143	275	201	279	303	207	51	2,289
2003	133	166	77	65	55	239	264	189	214	281	239	89	2,011
2004	88	87	175	131	348	303	272	233	190	311	106	243	2,487
2005	367	116	48	32	287	424	249	219	111	329	368	145	2,693
2006	179	83	92	58	117	422	264	212	221	289	251	188	2,376
2007	168	106	142	101	36	137	234	519	327	451	175	164	2,561
2008	188	174	156	198	97	270	352	268	345	632	312	168	3,162
2009	77	93	95	75	376	296	301	213	190	260	283	149	2,408
2010	117	5	88	311	201	320	337	277	379	872	490	347	3,745
2011	156	100	153	391	119	184	366	363	252	256	360	120	2,821
2012	108	194	94	141	327	108	220	98	123	323	164	202	2,103
2013	179	89	70	395	179	192	177	320	159	317	182	519	2,777
2014	140	157	66	31	41	120	135	242	221	224	425	56	1,857
2015	96	56	93	98	25	107	193	121	209	173	305	65	1,540
Min	45	5	23	4	18	59	87	98	111	134	102	51	1,068
Max	600	377	312	480	654	670	843	604	678	872	661	724	3,745
Ave.	156	113	118	122	141	198	253	272	300	345	303	185	2,506

Source: JICA Survey Team based on Data provide WRMA

Table 1-18 Maximum Depth of Monthly and Annual Rainfall Data

(unit: mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Max
1955	16	28	24	10	17	51	94	58	111	74	111	55	111
1956	117	111	35	41	25	95	111	111	111	175	80	111	175
1957	111	18	22	47	21	68	111	111	49	111	46	48	111
1958	25	25	13	19	103	111	111	86	111	111	75	111	111
1959	36	54	18	111	111	34	111	38	24	111	59	29	111
1960	23	58	29	20	23	31	206	88	88	73	44	38	206
1961	17	44	24	12	15	29	132	56	44	103	59	35	132
1962	36	35	35	29	100	47	68	59	90	96	29	27	100
1963	29	31	15	15	15	15	15	26	15	26	23	15	31[*1]
1964	15	21	18	23	17	26	21	23	15	15	21	15	26[*1]
1965	15	26	26	23	23	26	26	66	106	88	40	118	118
1966	29	88	21	59	67	36	126	59	44	79	94	26	126
1967	53	59	19	59	41	19	60	38	285	59	106	88	285
1968	15	15	65	23	183	103	12	0	0	165	47	59	183
1969	55	15	15	25	29	88	59	188	0	74	53	153	188
1970	31	41	21	8	15	162	138	44	73	282	65	59	282
1971	29	18	9	32	0	15	22	67	26	43	32	28	67
1972	28	26	55	23	26	12	27	15	41	73	42	32	73
1973	17	52	9	20	22	85	20	87	19	25	9	28	87
1974	20	20	28	29	38	48	27	51	60	110	50	29	110
1975	48	33	0	14	20	13	22	71	65	78	113	58	113
1976	26	31	15	19	44	44	59	71	52	61	59	26	71

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Max
1977	6	22	27	55	28	10	23	66	132	0	32	19	132
1978	88	6	54	0	22	63	88	76	46	50	73	41	88
1979	53	15	30	78	31	118	0	31	79	84	84	28	118
1980	44	15	16	29	27	29	25	59	34	26	0	59	59
1981	28	61	25	110	250	37	121	38	38	36	32	31	250
1982	71	53	21	23	37	19	38	71	37	0	0	0	71*2
1983	0	0	0	0	0	0	0	0	0	0	0	0	0*1
1984	87	48	0	0	0	0	0	0	0	0	110	42	110*2
1985	33	15	41	67	0	0	33	49	55	75	64	35	75
1986	30	17	52	22	38	48	41	75	122	64	134	27	134
1987	16	6	17	2	176	82	51	99	45	82	85	45	176
1988	19	18	29	9	18	47	48	50	138	115	51	14	138
1989	19	27	101	28	11	28	89	135	53	38	71	146	146
1990	68	17	17	14	41	30	83	40	61	83	20	32	83
1991	38	14	39	22	23	40	19	77	115	26	224	77	224
1992	56	89	12	37	62	72	69	112	159	33	79	25	159
1993	60	22	68	28	46	42	54	37	69	105	36	21	105
1994	25	20	18	25	30	42	65	117	360	33	42	48	360
1995	21	28	67	61	18	32	25	76	92	97	35	23	97
1996	21	28	45	29	16	49	128	84	211	207	71	22	211
1997	20	16	10	7	36	60	45	37	55	57	67	20	67
1998	45	9	20	4	28	40	80	83	50	89	51	50	89
1999	39	18	17	15	4	9	29	50	46	38	66	61	66
2000	21	115	42	9	67	21	50	40	40	37	31	69	115
2001	22	16	6	82	17	40	35	45	24	55	49	36	82
2002	21	128	16	76	18	26	44	48	68	55	36	6	128
2003	22	40	17	14	12	50	45	49	28	44	77	12	77
2004	10	25	30	22	90	72	45	33	32	56	23	61	90
2005	67	23	16	9	45	93	59	24	22	55	55	26	93
2006	33	17	28	15	22	99	38	33	61	59	67	52	99
2007	36	27	24	35	13	41	43	104	67	142	20	38	142
2008	26	34	34	37	24	53	48	46	53	91	62	56	91
2009	9	17	12	15	69	59	64	35	32	67	36	17	69
2010	16	4	46	56	41	52	58	56	70	682	119	85	682
2011	19	20	44	71	19	25	67	103	53	47	53	13	103
2012	16	57	38	43	57	26	50	39	29	67	41	50	67
2013	23	19	14	94	23	20	32	65	29	32	41	290	290
2014	29	35	13	6	7	33	31	28	84	41	73	10	84
2015	17	11	23	30	7	43	65	24	57	23	105	15	105
Min	6	4	6	2	4	9	12	15	15	15	9	6	26
Max	117	128	101	111	250	162	206	188	360	682	224	290	682
Ave.	29	30	31	32	35	44	53	61	77	87	64	48	143

Note）*1： The data is not used for probable rainfall analysis since figure is missing and data is extreme low
*2： The data is not used for probable rainfall analysis since there is a missing period more than three months of the rainy season.

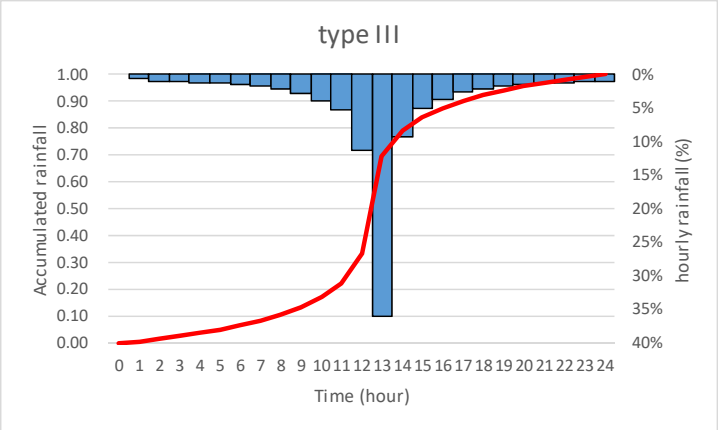
Source: JICA Survey Team based on Data provide WRMA

(4) Probable rainfall analysis

i) Pattern and duration time of rainfall

In study area, during flood, since there is not sufficient hourly rainfall data, the pattern of rainfall is applied SCS type III and duration time of rain is applied for 24 hours. The rainfall pattern and time is common in Caribbean surrounding area.

The rainfall pattern is shown in Figure 1-4. Red line in the figure is accumulated rainfall and black line is the ration of rainfall per hour (e.g. total volume for l day rainfall is 400 mm, peak houry rainfall is 140 mm hour (= 400 x 0.35))



Source: JICA Survey Team

Figure 1-35 Design Rainfall

（Accumulated Curve and hyetograph (rainfall depth per times)

ii) Probable rainfall

Stochastic hydrological study was carried out by using the maximum daily rainfall data for the represented rainfall stations. The probable curve whose SLSC[1]is under 0.04, is applied. The previous study applied for the probable curve of Log Peason III and this study also applied. The calculation summary is shown in Table 1-19.

The values of 50-year return period of rainfall is almost same as the previous study. The probable rainfall data which is more and less than 50-year return period is different and gradually wide gap. The calculated data which compared with the previous study, in 100-year and 200-year return period, it is larger and in 25-year and 10-year it is smaller.

Table 1-19 Probable Rainfall at Bexon Rain-gauge Station

Unit：(mm)

Flood of year frequency	This Study (1955-2015)	Previous Study (1955-2012)
200-year	776.0	651.1
100-year	593.2	543.9
50-year	452.0	451.2
25-year	342.8	371.0
10-year	234.9	280.6
5-year	173.5	221.6

Source: JICA Survey Team (Previous Study result is prepared by DILLON)

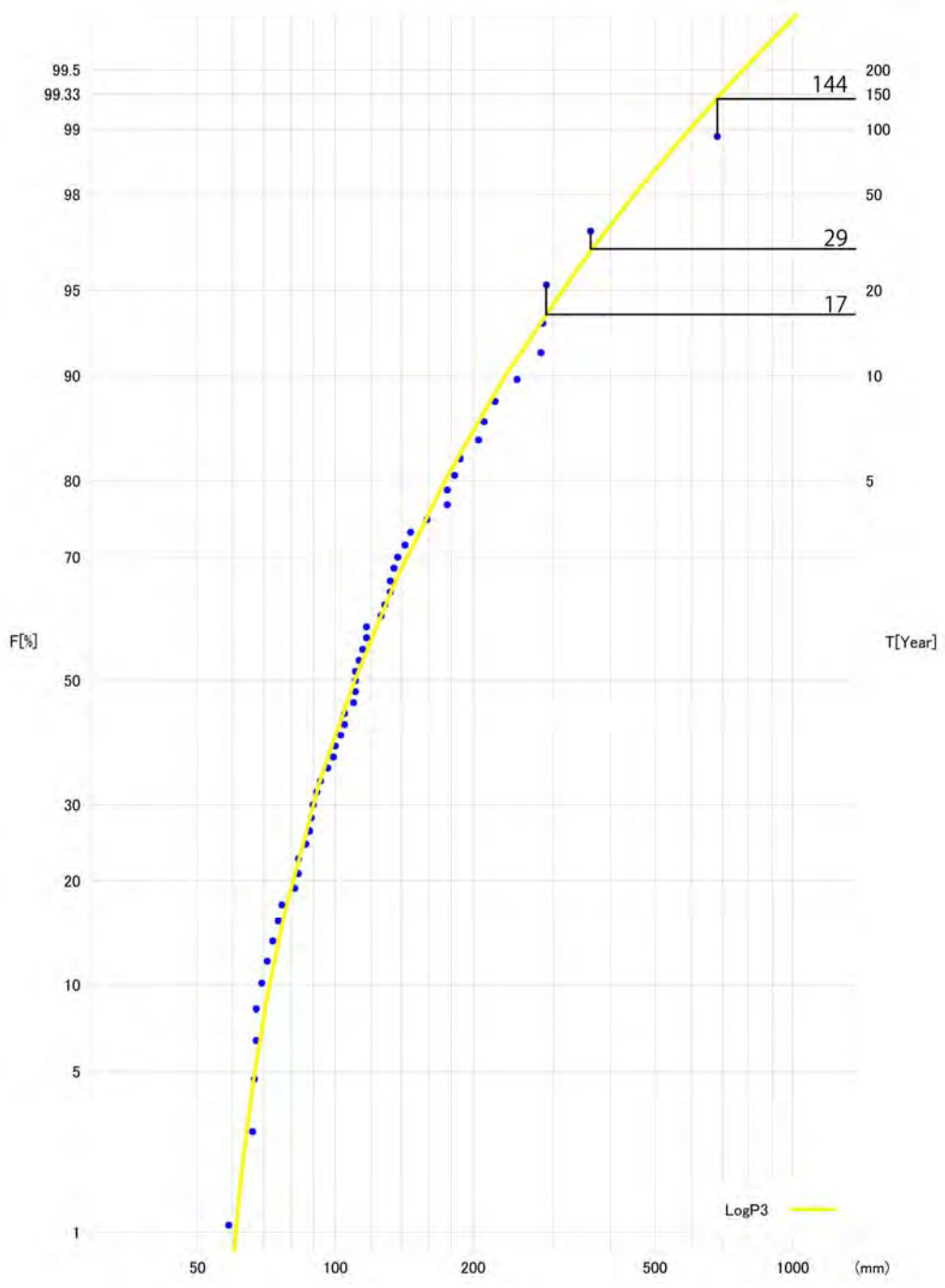
iii) Flood history

In this basin area, they have the flood history in past. The frequency of the rainfall data is estimated by using Table 1-19. The frequency of flood history in terms of rainfall is as below referring to Figure 1-36.

[1] SLSC: Standard least-square criterion: Indicator of the difference between the value in the case of estimating the observations from the plotting position formula and the value from probability distribution

Date	Daily rainfall (mm)	Return Period
September, 1994	360	29- year
October, 2010	682	144 - year
December, 2013	290	17 - year

Source: JICA Survey Team



Source: JICA Survey Team

Figure 1-36 Probability Distribution curve and Flood Record

(5) Runoff Characteristics

The previous study prepared by DILLON carried out the runoff model. In this study, the same

method is applied. The runoff analysis is carried out with the additional data from 2013 to 2015.

The basin area of this study is less than 40 km^2 and this basin area is divided to 29 basins considering the soils and infiltration. 15 river model is applied for this study. The division of basin area and the schematic model is shown in Figure 1-37 and Figure 1-38.

Flood analysis is consisted of four models. Each condition is applied for the previous study. Runoff condition and the principle parameter is shown in Table 1-20.

Runoff process	Model	Remarks
Runoff volume model	SCS curve number	
Direct runoff model	SCS unit hydrograph	
Base flow model	Exponential recession	
Routing models	Muskingum-Cunge Standard Section	Trapezoidal Section

In this study, Soil Conservation Service (SVS) Curve Number (CN) model is used for estimation. SCS model estimate's precipitation excess as a function of cumulative precipitin soil cover, land use and antecedent moisture using the following equation. In case of limited input data, this method is applicable. The basic equation is as below;

$$Q = \frac{(P - Ia)^2}{(P - Ia) + S}$$

Where Q : Runoff flow, P : Precipitation (rainfall), Ia : Initial abstractions, S : Potential maximum soil moisture retention (mm)

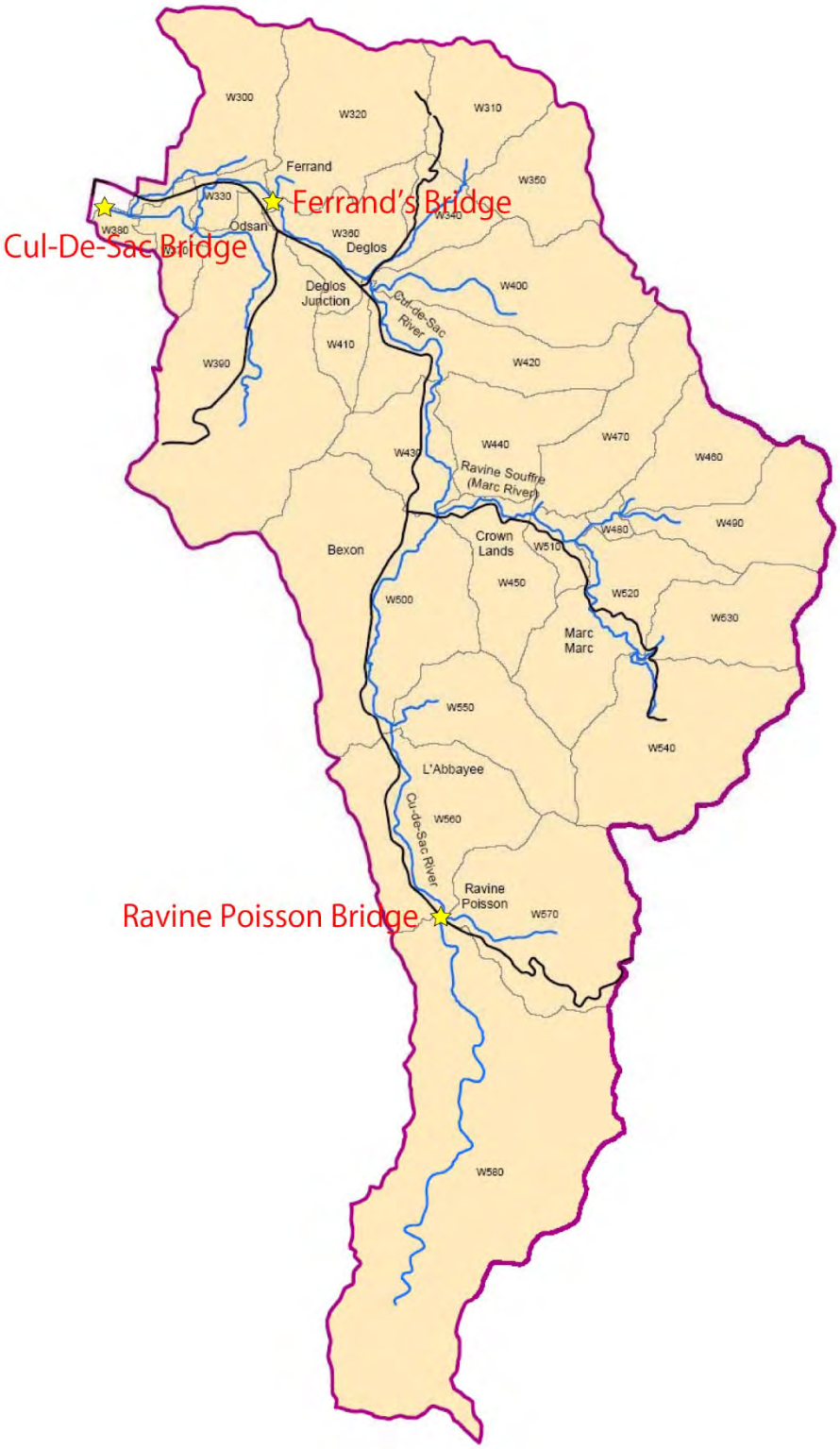
Initial abstractions (Ia) and potential maximum soil moisture retention (S) are calculated by the empirical formulation as below.

$$Ia = 0.2 \times S$$

$$S = \frac{25{,}400}{CN} - 254$$

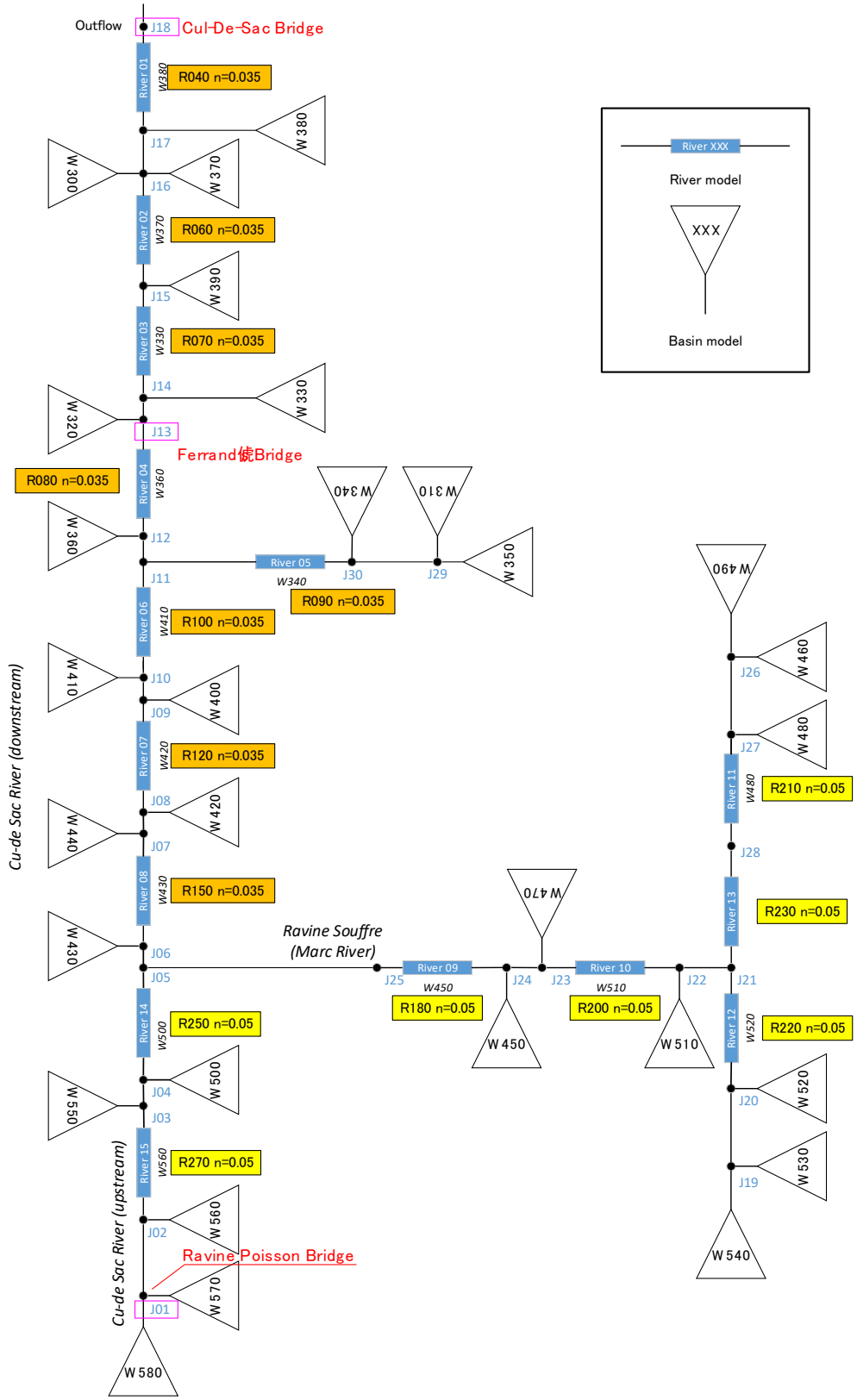
This model is used Curve Number (CN) which is considered with the land use cover and dry condition.

Potential maximum soil moisture retention is calculated by CN, and if CN is higher, S is lower and if CN is lower, S is higher (Figure 1-39). CN is determined by classification of land use, hydrological condition and soil condition as shown in Table 1-21. In this study, CN is determined based on the previous study which consider the condition of land use by each basin area. The range of CN is from 52 to 62. The other input parameter is shown in Table 1-22 Input Parameter for Runoff Analysis(Routing mode).



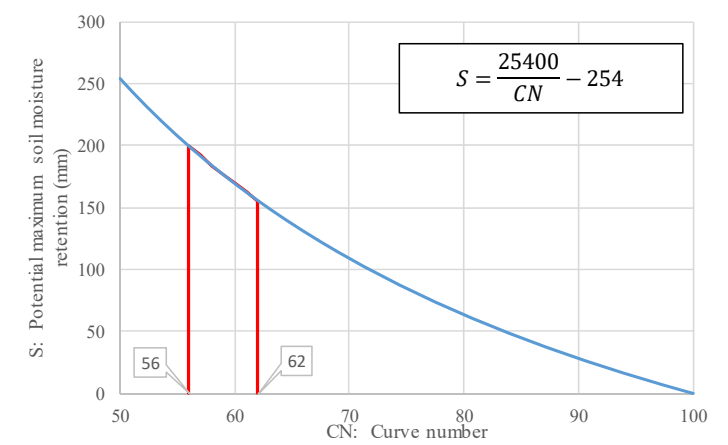
Source：DILLION (2014)

Figure 1-37　Cul-De-Sac Basin Area



Source: JICA Survey Team

Figure 1-38 Schematic of runoff model in Cul-De-Sac Basin



Note: Range between Red lines are applied in this study
Source: JICA Survey Team

Figure 1-39 Relationship between CN and Potential Maximum Soil Moisture

Table 1-20 Matrix of Curve number by land use and Hydrologic Condition

Land use or cover	Treatment or practice	Hydrologic condition	Hydrologic soil group			
			A	B	C	D
Fallow	Straight row	Poor	77	86	91	94
Row crops	Straight row	Poor	72	81	88	91
	Straight row	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Contoured and t erraced	Poor	66	74	80	82
	Contoured and terraced	Good	62	71	78	81
Small grain	St raight row	Poor	65	76	84	88
	Straight row	Good	63	75	83	87
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	73	81	84
	Contoured and terraced	Poor	61	72	79	82
	Contoured and, terraced	Good	59	70	78	81
Close-seeded legumes *1 or rota-	Straight row	Poor	66	77	85	89
tion meadow	Straight row	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	Contoured and terraced	Poor	63	73	80	83
	Contoured and terraced	Good	51	67	76	80
Past.ure or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow (permanent)		Good	30	58	71	78
Woodlands (farm woodlots)		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads			59	74	82	86
Roads, dirt *2			72	82	87	89
Roads, hard-surface *2			74	84	90	92

*1 Close-drilled or broadcast.
*2 Including right-of-way.

Source：U.S. Soil Conservation Service

Table 1-21 Input Parameter for Runoff Analysis(Direct runoff mode)

	Basin Name	km2	Initial Abstraction	Curve Number	Initial Abstraction	Imperviousness (%)	Lag time (min)
1	W300	1.1093	36.3	58	36.3	12.4	76.7
2	W310	0.80414	37.8	57	37.8	9.9	36.2
3	W320	1.4703	35.2	59	35.2	13.5	62.5
4	W330	0.22559	31.8	62	31.8	18.8	144.1
5	W340	0.4324	37.8	57	37.8	8.5	39.4
6	W350	0.75705	38.7	57	38.7	6.4	31.9
7	W360	0.73819	31.3	62	31.3	22.9	49.5
8	W370	0.33664	33.2	60	33.2	11.5	44.8
9	W380	0.11239	30.8	62	30.8	10.9	93.7
10	W390	2.9874	36.5	58	36.5	10.3	98.5
11	W400	1.4107	37	58	37.0	9	62.8
12	W410	0.27057	35	59	35.0	16	29.4
13	W420	1.1701	36.4	58	36.4	8.9	70.9
14	W430	0.65082	36.2	58	36.2	11.1	65.3
15	W440	0.84967	36.1	58	36.1	4.6	43.6
16	W450	0.77173	38.1	57	38.1	7.6	62.4
17	W460	0.78494	39.3	56	39.3	4.3	30.6
18	W470	0.98699	38.1	57	38.1	5.9	48.5
19	W480	0.0823	38	57	38.0	9.5	18.2
20	W490	0.90852	40.2	56	40.2	1.7	34.9
21	W500	2.5789	36.2	58	36.2	10	93.3
22	W510	0.22779	34	60	34.0	19.1	36.5
23	W520	1.322	38.4	57	38.4	6.6	52.4
24	W530	0.87796	38.8	57	38.8	4.8	37.3
25	W540	1.8378	38.6	57	38.6	5.1	42.9
26	W550	1.0081	38.6	57	38.6	6	45.3
27	W560	1.5799	36.4	58	36.4	11.7	49
28	W570	1.7414	38.1	57	38.1	4.9	51.9
29	W580	5.1918	39	57	39.0	3.4	169.4

Source： DILLON

Table 1-22 Input Parameter for Runoff Analysis(Routing mode)

River	Length (m)	Slope	Manning n	Shape	Width (m)	Side slope (xH;1V)
River 01	231.2	0.0015	0.035	Trapezoid	6.7	1.4
River 02	1,083.6	0.0045	0.035	Trapezoid	7.1	1.3
River 03	722.1	0.0015	0.035	Trapezoid	9.8	2.1
River 04	1,140.5	0.0025	0.035	Trapezoid	7.4	1.6
River 05	1,238.6	0.0119	0.035	Trapezoid	5.0	1.5
River 06	121.6	0.0191	0.035	Trapezoid	7.9	2.6
River 07	1,380.6	0.0018	0.035	Trapezoid	8.2	2.1
River 08	1,369.4	0.0019	0.035	Trapezoid	7.7	2.1
River 09	972.1	0.0038	0.050	Trapezoid	6.6	1.5
River 10	479.3	0.0409	0.050	Trapezoid	5.0	1.5
River 11	502.7	0.0075	0.050	Trapezoid	9.6	2.8
River 12	1,484.5	0.0151	0.050	Trapezoid	8	1.8
River 13	57.5	0.0051	0.050	Trapezoid	9	1.7
River 14	2,253.0	0.0044	0.050	Trapezoid	9	1.7
River 15	1,924.0	0.0116	0.035	Trapezoid	13.9	3.1

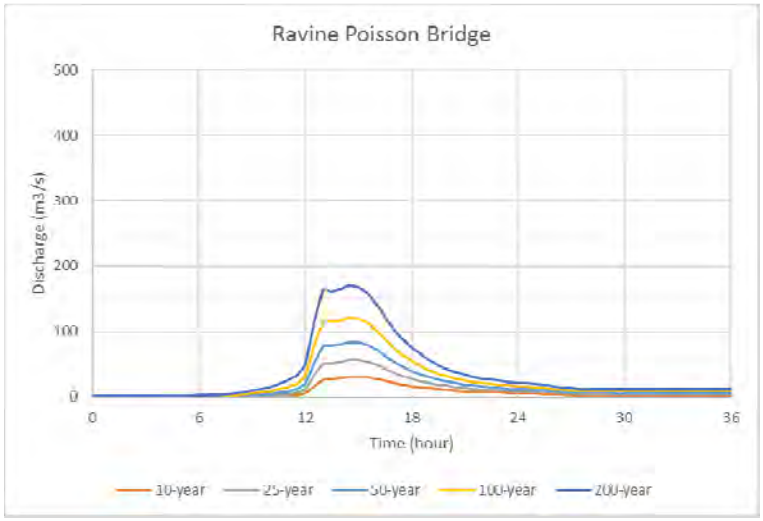
Source： DILLON

(6) Design Discharge

As mentioned above, probable rainfall and runoff model, runoff analysis is carried out. The discharge at cross-section of three bridges are calculated as below. The hydrograph calculated by each probable flood is shown in Figure 1-40, Figure 1-41 and Figure 1-42.

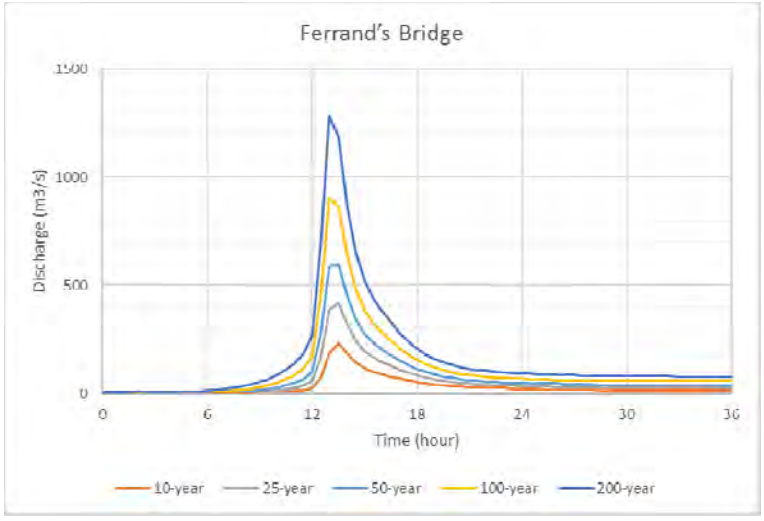
(unit m^3/s)

Location	10 year	25 year	50 year	100 year	200 year	Remarks
Ravine Poisson Bridge	30.9	56.6	84.5	121.6	170.4	Junction-01
Ferrand's Bridge	233.9	434.7	632.8	942.1	1,320.8	Junction-13
Cul-De-Sac Bridge	266.8	492.9	718.6	1,061.3	1,483.8	Junction-18



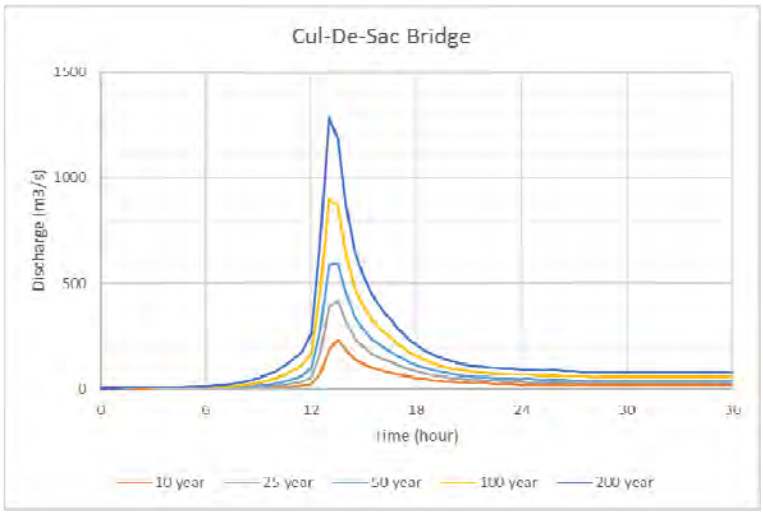
Source: JICA Survey Team

Figure 1-40 Hydrograph at Cross-section of Ravine Poisson Bridge



Source: JICA Survey Team

Figure 1-41 Hydrograph at Cross-section of Ferrand's Bridge



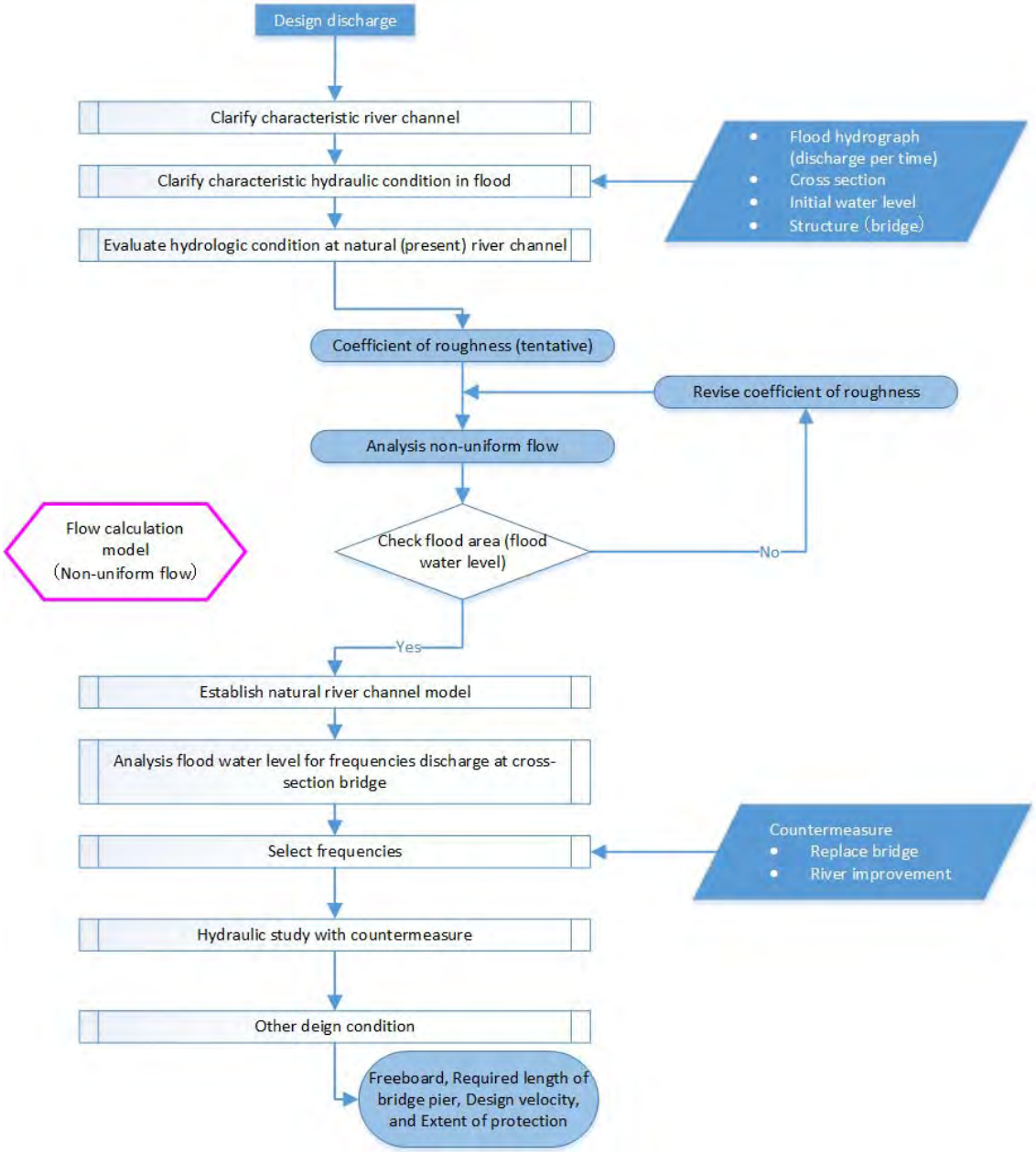
Source: JICA Survey Team

Figure 1-42 Hydrograph at Cross-section of Cul-De-Sac Bridge

Flooding period when the discharge excesses the existing flow capacity is estimated in case of 50-year return period. At Ravine Poisson Bridge, peak flood discharge is under the existing flow capacity. At Ferrand's Bridge and Cul-De-Sac Bridge, the calculation flood excesses the existing capacity, and the time period is 6 hours and 30 minutes and 7 hours and :20 minutes, respectively.

(7) Hydraulic study for countermeasures

The following step-by-step procedure is for hydraulic study for countermeasures as described in Figure 1-43. At this moment, the river cross section survey is carrying out. After the finished the cross-section survey, hydraulic study will be commenced immediately.



Source: JICA Survey Team

Figure 1-43 Study Procedure for Hydraulic Study

(8) Design Criteria (River Structure)

Based on the result of discussion with relative agency, design conditions of river structure is set as presented below:

Table 1-23 Design Conditions for River Structure

Item	Design Condition	Remarks
1) Design Scale	50-year probable flood	
2) Design Discharge	Ravine Poisson 100 m^3/s Ferrand's 640m^3/s Cul de Sac 720m^3/s	For preliminary study only
3) Design Water Level	Ravine Poisson +3.10m Ferrand's +5.50m Cul de Sac +4.80m	Reference height from existing riverbed level computed based on uniform flow
4) Free board	Ravine Poisson 0.8m Ferrand's 1.0m Cul de Sac 1.0m	
5) Design Longitudinal Profile	Ravine Poisson 1/56 Ferrand's 1/400 Cul de Sac 1/400	Based on 1/2,500 topographic map

Source: JICA Survey Team

1) Design Scale

Design scale of the replacement of the bridge is set at 50-year probable flood considering the present site conditions and hydrological conditions.

- At present, in St.Lucia, there is no definitive standard to determine the design scale of bridge construction and river improvement works. The appropriate design scale is adopted to each work/project independently based on the river characteristics and economical viability.
- Previous study identified the design discharge for construction of the food bund at downstream of the Cul de Sac Bridge is 346 m3/s. . This was evaluated as 100-year probability based on the hydrological data as of 1996.
- On the other hand, in case of the latest hydrological study using the updated rainfall data until 2014as mentioned in the previous sub-section, the discharge of 346 m3/s is assessed at around 10-25 year flood, the assessed probability becomes lower than ever. This is because of accumulated rainfall data after 1994, especially a large amount of rainfalls recorded in 2010 Hurricane Tomas and 2013 X'mas trough.
- The future river improvement works in the Cul de Sac Bain shall be implemented corresponding to the design scale of existing river improvement works in the most downstream stretch. In this study, the design scale is set at 50-year flood taking into account that i) the present design scale of the existing flood bund is around 10-25 year probable flood, ii) importance of the objective bridges, and iii) staged improvements of flood safety level in the river basin in the future.

2) Design Discharge

As the result of hydrological analysis including the rainfall data after 2012 as mentioned in the previous section, design discharge of each objective bridge is set as shown in Table 1-24:

In addition, the design discharge in case of future climate change condition is estimated referring to the previous assessment report as shown in Table 1-25:

Table 1-24 Design Discharge at Objective Bridges

Station	Location	Peak Flow (m^3/s)				
		10-yr	25-yr	50-yr	100-yr	200-yr
9+929.8	D/S of Ravine Poisson	40	60	90	130	180
0+994.0	D/S of Ferrand's Bridge	240	440	640	950	1330
0+000.0	U/S of Cul-de-Sac Bridge	270	500	720	1070	1490

Reference: Design Discharge at Objective Bridges under Climate Change Condition

Station	Location	Peak Flow (m^3/s)				
		10-yr	25-yr	50-yr	100-yr	200-yr
9+929.8	D/S of Ravine Poisson	55.6	84.7	120.0	145.9	186.0
0+994.0	D/S of Ferrand's Bridge	404.4	616.8	800.0	1056.8	1331.0
0+000.0	U/S of Cul-de-San Bridge	462.2	697.0	890.0	1177.0	1483.0

Source: DILLON(2014)

Climate Change Prediction is referring to UNDP Report (McSweeney, et al., 2010) on the basis of SRES-A.

① Increase of Design Discharge at Ravine Poisson Bridge

The design discharge at the Ravine Poisson Bridge is need to increase considering following:

i) Increase of discharge due to confluence with a tributary at immediately downstream of the bridge

ii) 10% increase of design discharge due to possibility of high sediment concentration flow at flood events in mountainous river

Based on the above, the design discharge of the Ravine Poisson Bridge is set at 100 m^3/s.

Q_{d50}= 50 m^3/s at Ravine Poisson

i) Q_{d50}= 55 m^3/s by 10% increase due to sediment flow

ii) Q_{d50}= 100 m^3/s by increase due to confluence with a tributary

Based on the above, the design discharge of the Ravine Poisson Bridge is set at 100 m^3/s.

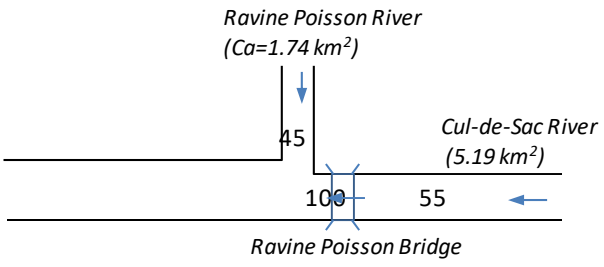


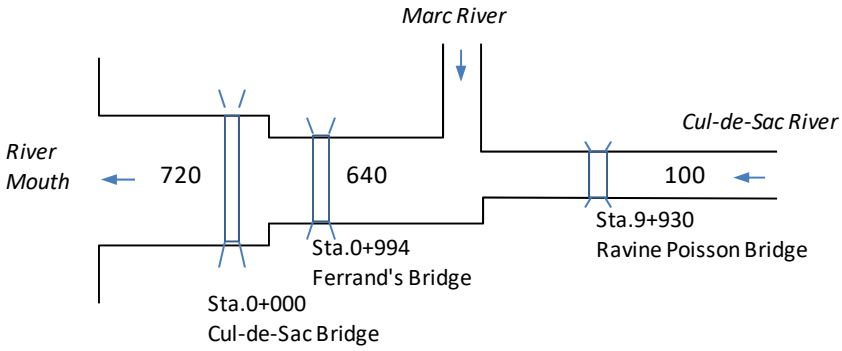
Photo: Confluence with a tributary at d/s of Raviine Poisson Bridge

Source: JICA Survey Team

Figure 1-44 Increase of Design Discharge at Ravine Poisson Bridge

② Design Discharge Distribution

Figure below shows the design discharge distribution for the basic design.



Source: JICA Survey Team

Figure 1-45 Design Discharge Distribution in Cul de Sac River (50-year probable flood)

3) Design of River Channel

Basic Layout

① Ravine Poisson Bridge

Because of existing road alignment and site conditions, the bridge replacement will be done at the same location. Riverbank protection is designed based on the said design discharge.

Particularly in the upstream of the bridge, the river alignment is turned by around 90 degree. This makes water level high and velocity fast at outer of the river bend. It is necessary to design more durable bank protection there. In addition, at the confluence with the tributary, turbulence flow would be occurred, the river bank protection area shall be extended considering this condition.

③ Ferrand's Bridge

Ferrand's Brigde is planned to be relocated to immediately downstream of the existing bridge.

River section is designed based on the premise of connection to the downstream improved river section. In addition, the river channel at bridge site is located at bend section as same as the Ravine Poisson Bridge. It is necessary for the design to consider the river alignment at wather hit points and installation of durable river bank protection.

② Cul de Sac Bridge

Cul de Sac Bridge is planned to be relocated to immediately downstream of the existing bridge.

River section is designed to keep a cross section as same as the downstream improved river section.

The table below shows the design conditions for bridge and river bank protections. In the study, after the final outputs of the topographic survey is collected, these conditions will be reviewed and updated.

Table 1-25 Design Conditions for Bridge and River Bank Protection (for Interim Report)

Item	Ravine Poisson Bridge	Ferrand's Bridge	Cul de Sac Bridge
Design Discharge	100 m^3/s	640m^3/s	720m^3/s
Design Longitudinal Profile	1/56	1/400	1/400
Design River Width*	16.0m	60.0m	80.0m
Design Side Slope of Low Water Channel	1:0.5	1:2.0	1:2.0
Roughness Parameter	n=0.045	n=0.035	n=0.035
Design Water Level*	+3.10m	+5.50m	+4.80m
Freeboard	0.80m	1.00m	1.00m
Design Velocity*	4.6 m/s	3.3 m/s	3.0 m/s

* After the final outputs of the topographic survey is collected, the design value will be reviewed and updated.

Source: JICA Survey Team

1-2-5 Environmental and Social considerations

1-2-5-1 Project components

Table 1-26 and Table 1-27 summarize the Project component and planned activities targeted for evaluation of environmental and social impact. Figure 1-46~Figure 1-49 shows the Project design, boundary and number of registered land, and surrounding environment.

Table 1-26 Project Component Summary

Project area	Target roads and bridges	Project component summary
Watershed of Cul de Sac River	West coast road Cul de Sac Bridge East coast road Ravine Poisson Bridge	1. Replacement of existing 2 road bridges 2. Embankment (flood protection works) of the river on the section near to the bridges 3. Construction of access road to the bridges

Source: JICA Survey Team

Table 1-27 Project Components and Typically Expected Environmental and Social Impacts

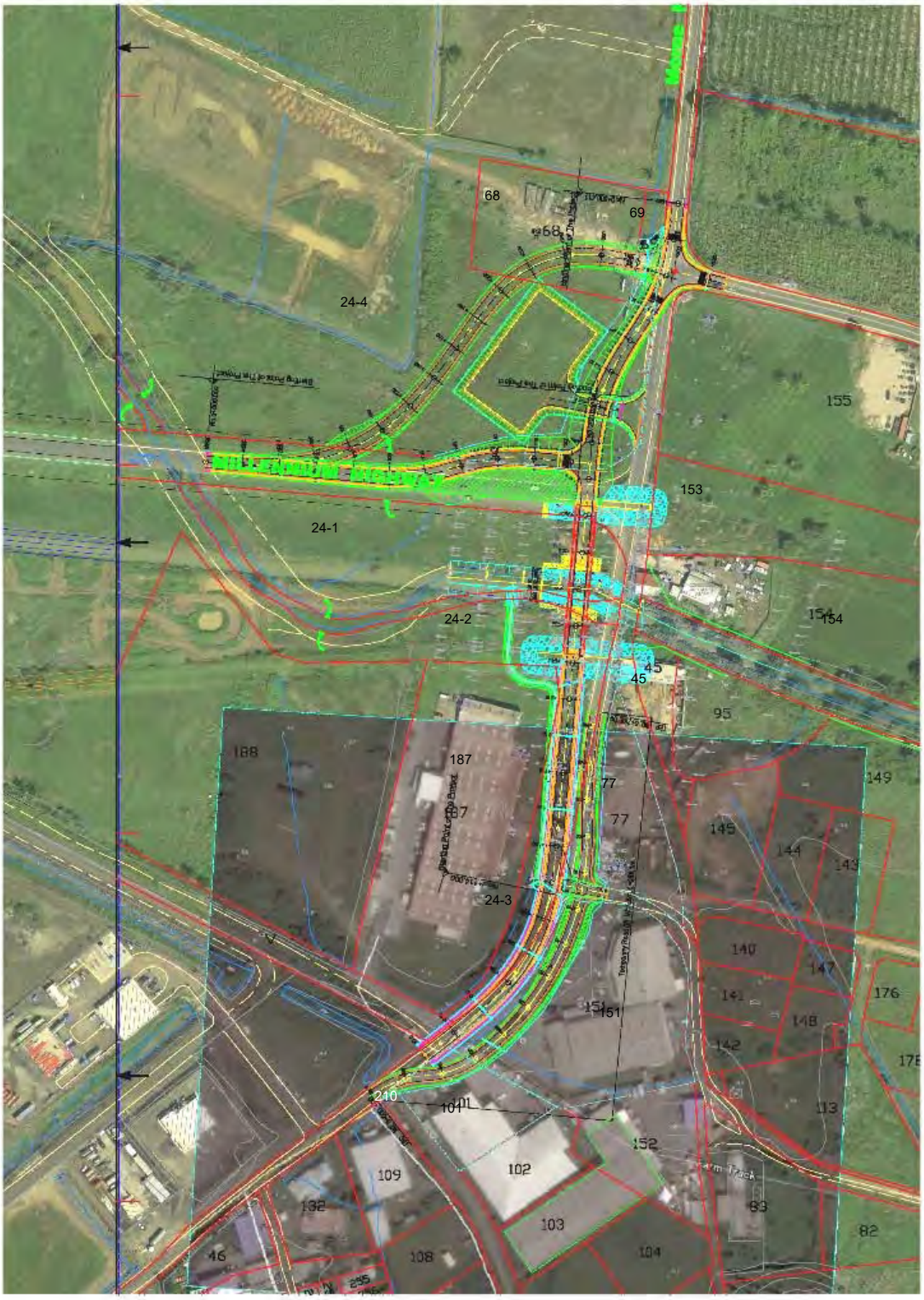
Phase	Project components and activities		Typical impacts from project components and activities
Planning phase	Demarcation of work area outside of river buffer	● Notification of the Project and restriction of land use ● Land acquisition ● Staking and construction of border fence	● Notification of stoppage and relocation of existing land use and trespassing (vendor shack, utilities (electric poles, underground utilities, utilities attached to the existing bridge structure), road and foot path, foot path to the river, etc.) ● Notification of loss of private properties
	Demarcation of work area inside of river buffer	● Decision of work area and trees to be felled	● Notification of loss of private properties (flower bed, fences, trees, etc.) ● Stoppage of using the river section (entrance to the Work Area)
Construction phase	Preparation		
	Set up of stock yard	● Storage of oils and chemicals ● Machine repair, re-fueling	● Risk of oil and chemical spill (soil contamination)
		● Storage of other materials and tools	● Risk of robbery (crime)
	Set up of office	● Existence of engineers and office staff	● Water demand ● Generation of waste water ● Generation of sewer ● Generation of wastes
	Set up of work area	● Existence of work crew	● Water demand

Phase	Project components and activities		Typical impacts from project components and activities
			● Generation of waste water ● Generation of sewer ● Generation of wastes ● The Project shall not set up workers' camps
		● Generation of transportation traffic (mainly fill material and excavated soil disposal)	● Generation of exhaust gas(off-site) ● Generation of noise (off-site) ● Generation of traffic jam (off-site) ● Increased risk of accidents (off-site)
	Removal works (existing bridge, road, etc.)	● Removal of existing structures ● Removal of trees and vegetation	● Generation of construction waste
	Set up and removal of temporal structures (Detour road, temporal bridge, access road to river bed, etc.)	● Slow speed at the detour road and temporal bridge	● Increased risk of local occurrence of traffic jam ● Increased risk of occurrence of traffic accidents
	Earth works (Excavation and refill of river bed, bank construction)	● Alteration of land form (cut, fill, excavation) ● Storage, reuse and disposal of earth, excavated soil	● (Work area or yard) Storage for reuse ● (In and out of work area or yard) Erosion (generation of muddy water)
	Bridge construction Bank protection construction Road construction	● Generation of transportation vehicle (mainly to remove excavated earth at Ferrands Bridge)	● Emission of exhaust and noise (Outside of work area) ● Increased risk of traffic congestion and accidents (Outside of work area)
	Construction general	● Operation of construction machinery and vehicles ● Use of generators	● Emission of exhaust ● Emission of noise
		● Disposal of construction wastes	● Disposal of construction wastes
		● Generation of employment ● Procurement of materials, etc.	● Direct and indirect positive impact to local economy
Maintenance phase	Opening of new bridges and road sections Existence of upgraded bridge and road		● Reduced risk of flood impact on road transportation ● Increased physical resiliency of transportation network against flood risk ● Necessity of continuous bridge maintenance such as removal of debris

Source: JICA Survey Team

Source: Land Registration Office, JICA Survey Team

Figure 1-46 Cadastral map at Cul de Sac Bridge area

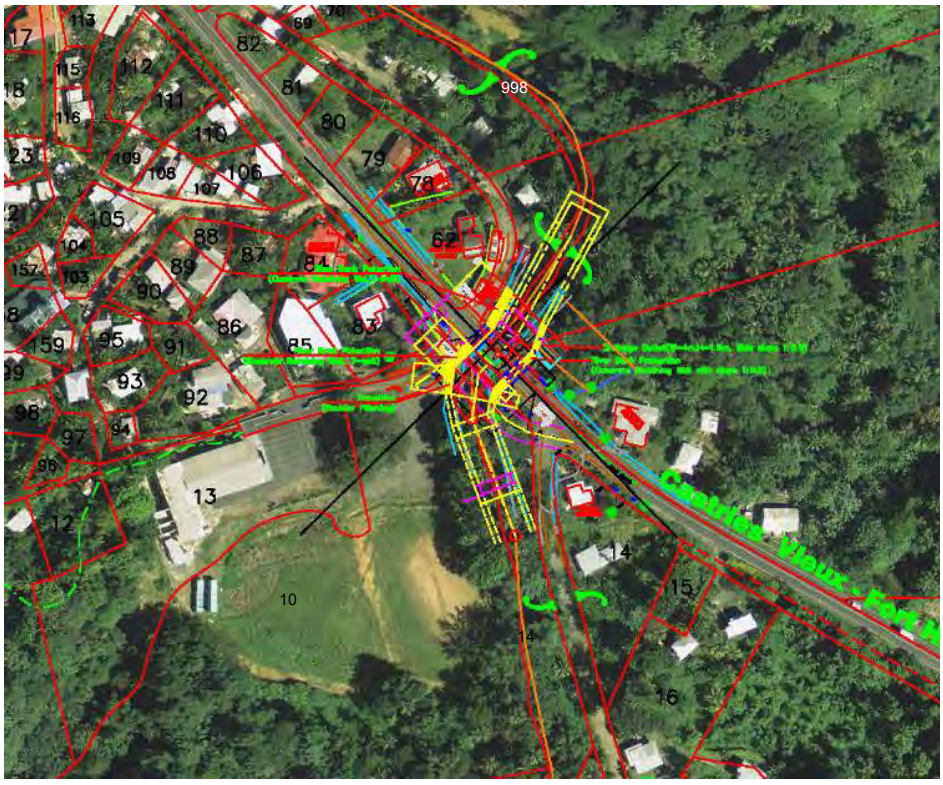


Source: Land Registration Office, JICA Survey Team

Figure 1-47 The Project design at Cul de Sac Bridge area

Source: Land Registration Office, JICA Survey Team

Figure 1-48 Cadastral map at Ravine Poisson Bridge area



Source: Land Registration Office, JICA Survey Team

Figure 1-49 The Project design at Ravine Poisson Bridge area

1-2-5-2 Comparison of Alternative Ideas

Alternatives of bridge location, including no-project option and alternative ideas of river training works were compared and priority plan was selected in 2-2 Outline Design of the Japanese Assistance.

1-2-5-3 Screening for Necessity of Environmental Impact Assessment

(1) JICA Guideline

The project components were compared with description of the JICA guidelines. It was found that the Project falls in Category B that is required to conduct Initial Environmental Evaluation survey.

Table 1-28 Categorization criteria of JICA Guideline

Category	Categorization Criteria
Category B	The project may have adverse impacts on the environment or society, but these impacts are less significant than those of Category A projects. These impacts are site-specific; few, if any, of them are irreversible; in most cases, they can be mitigated more readily than Category A projects. Responsibilities of the project proponents include the planning and monitoring of necessary ESC activities. ESC procedures such as Initial Environmental Examination and stakeholder participation may be required, depending on the scale and nature of the adverse impacts.

Source: JICA Guideline 2010

(2) Saint Lucian Systems

The review system of development projects in Saint Lucia is defined by the Physical Planning and Development Act, Chapter 5.12.

Schedule 3 of the Act lists projects that are not required for the review, and Schedule 4 lists projects that are mandated an EIA Report to be submitted. Those Schedules are listed as Appendix 5-3-1.

In the interview on November 2, 2016 with Mr. Hildreth Lewis, Deputy PS (Development Control Authority), Department of Physical Planning and Development, the Project is not required an EIA survey for following reasons. The Department may receive and review the report of JICA Survey Team as part of the Project information from MIPE&L, but is not in position of issuing approval of the IEE study in the report.

- Although the Schedule 4 demands projects that generate emissions and effluents, such character is meant for the operation phase. The Project may generate emissions and effluents during the Construction Phase, but shall not be required an EIA study for the reason.
- Repairs to roads and bridges are listed as (d) in the Schedule 3. Other road and bridge projects, especially a new alignment of road construction may be required an EIA study and report.
- In the Project, Ravine Poisson Bridge shall be replaced at the existing location. Cul de Sac Bridge shall be moved downstream but the distance is small. Both sub-project, therefore, can

be categorized as 'Improvements of roads and bridges at the same location,' and not 'new alignments of road construction.'

- With above reasons, the Project is not required an EIA study and report. As a public work, however, it is desirable that MIPE&L to send the Project information to DCA before commencement of the construction works.

1-2-5-4 Other Laws and Standards on Environmental and Social Safeguards

Other Laws and Standards on Environmental and Social Safeguards, relevant agencies in Saint Lucia are described in Appendix 5-3-2.

The Project sites and surrounding areas are not located in or near any protected areas designated in Saint Lucia.

1-2-5-5 Conformity of the Project with Policy Requirements of JICA Guidelines

The objectives, design process, site location, and the Project design were checked with policy requirements described in Annex 1 of JICA Guidelines. It was found that the Project is in conformity with the policies without any significant deficiency.

Just one point the Project is not strictly following the policy is the timing of negotiation for agreement of project implementation. JICA Guidelines require information disclosure to stakeholders including local residents at early timing such as alternative design study so that the opinions and suggestions obtained from the stakeholders are reflected in the final design.

In the Project, however, took the course to follow the customary procedure and timing of Saint Lucia, which will disclose the project information later timing compared to the JICA requirement.

MIPE&L and other stakeholder agencies expressed their commitment in communication and negotiation through community meetings and individual interviews so that the Project shall be accepted by locals.

1-2-5-6 Conditions of the Project Area and Scoping of Potential Impacts

The results of the preliminary survey of the Project area and the scoping of potential impacts based on the local condition and the Project components are summarized in Appendix 5-3-3.

1-2-5-7 Study Plan and Results

Environmental and social items that are expected to be affected, and items the impacts are unknown were selected and further study was conducted. The study plan and results are summarized in Appendix 5-3-4.

1-2-5-8 Summary of Impact Assessment

Table 1-29 summarizes the impact assessment based on the study results.

The Project shall cause typical impacts for road and bridge construction mainly during the Construction Phase. The scale of the construction works, however, is relatively small and no significant social and environmental resources are located at or near the Project site. Therefore, there is little possibility that significant negative impacts are anticipated.

Table 1-29 Summary of Impact Assessment

	Item	Planning Phase	Construction Phase	Maintenance Phase	Reason for the assessment
	Environmental pollution				
1	Air quality		B-		Emission from the vehicles and construction machines, dust from work areas and transportation of excavated soil shall be generated.
2	Water quality		B-		Muddy water shall be generated by works such as excavation of the river floor.
3	Waste		B-		Wastes such as excavated soil, used pavement and iron beams, fuel containers shall be generated and disposed.
4	Soil contamination		B-		Fuels, chemicals, lubricants may spill on bare ground at work areas and stock yards.
5	Noise and vibration		B-		Noise and vibration shall be generated from construction machineries and generators.
6	Ground subsidence				The Project does not implement works that may cause ground subsidence
7	Odour				The Project does not use materials or implement works that may cause offensive odour
8	Contamination of bottom Sediment				The Project does not use materials or implement works that may cause contamination of river bottom sediment such as heavy metals or dioxin
	Natural environment				
9	Protected areas				The Project does not affect protected areas
10	Ecosystem				The Project does not affect important ecosystem
11	Hydrology, water regime				The Project does not affect water level or flow speed of Cul de Sac River
12	Topography and geology				The Project does not affect significant topography or geology
	Social and economic environment				
13	Involuntary resettlement, loss of land and asset, business relocation	B-	B-		Private land shall be acquired in the Planning Phase. Temporal lease contract shall be made in the Construction Phase.
14	The poor				The Project does not cause any specific negative impacts on the poor
15	Ethnic minorities, indigenous peoples				The Project does not cause any specific negative impacts on ethnic minorities or indigenous peoples
16	Local economy, employment and living, livelihood				The Project does not cause any specific negative impacts on local economy, employment and livelihood
17	Land use, local resource use				The Project does not cause any specific negative impacts on land use or local resource use
18	Water use, water rights				The Project does not cause any specific negative impacts on water use or water rights
19	Existing public facilities, road and transportation facilities, social infrastructure, social services		B-		By guiding the traffic to temporal access road and bridge, there shall be higher possibility of occurrence of traffic jam.
20	Social capitals, local decision making systems, social organizations				The Project does not cause any specific negative impacts on social capitals
21	Uneven distribution of project impact and benefit				The Project does not cause any specific uneven distribution of project impact and benefit
22	Local conflicts of interest				The Project does not cause any specific local conflicts of interest

	Item	Planning Phase	Construction Phase	Maintenance Phase	Reason for the assessment
23	Split of community				The Project does not cause any specific split of community
24	Historical heritage, cultural resources				The Project does not cause any specific negative impacts on historical heritage, cultural resources
25	Landscape				The Project does not cause any specific negative impacts on landscape
26	Gender				The Project does not cause any specific negative impacts on gender
27	Children's rights		B-		By passing or crossing the temporal access road and bridge, there shall be higher possibility for pupils of the school nearby of occurrence of traffic accidents.
28	Sanitation, public health, transmittable diseases including HIV/AIDS		B-		Stagnant or still water at work areas and storage yards may be a source of infectious diseases.
29	Work environment, occupational safety and health		B-		There will be risk of work accidents.
	Other				
30	Accidents, crime		B-		By guiding the traffic to temporal access road and bridge, there shall be higher possibility of occurrence of traffic accidents.
31	Climate change, cross-border impacts				The Project does not cause any specific negative impacts on climate change or cross-border impacts

A+/-: Remarkable Positive/Serious Negative Impact is predicted.
B+/-: Positive/Negative Impact is expected to some extent
C: Extent of Impact is unknown
D (Blank cell): Impact is very small or nil and further survey is not required
Source: JICA Survey Team

1-2-5-9 Environmental Management Plan

The purpose of the EMP is to list minimum requirements of social and environmental impact mitigation, management, and monitoring activities to be implemented during the Planning, Construction, and early Maintenance Phase.

The EMP is prepared based on the the IEE study done by the JICA Survey Team. When implementing the EMP, the implementing body shall also integrate the Environmental Management Framework for the World Bank Disaster Vulnerability Reduction Project (SFG1909).

(1) Implementation Structure of EMP

Mitigation measures and monitoring activities shall be implemented by institutions listed inTable 1-30. MIPE&L shall report the monitoring results 4 times a year (every 3 months).

Necessary budget to implement the mitigation measures shall be included in the Project cost and secured by MIPE&L.

Table 1-30 Implementation Structure of EMP

	Implementation of Mitigation Measures	Monitoring	Report to JICA
Planning Phase	MIPE&L	Consultant	MIPE&L
Construction Phase	Contractor	Construction Supervision Consultant	MIPE&L
Maintenance Phase	Police MIPE&L	MIPE&L	MIPE&L

Source: JICA Survey Team

According to the due process in Saint Lucia, the Contractor shall prepare the EMP (final), by integrating the relevant items required by Environmental Management Framework for the World Bank Disaster Vulnerability Reduction Project (SFG1909). The EMP must be reviewed and approved by MIPE&L. The Contractor shall take overall responsibility of works on the implementation of mitigation measures stipulated in the EMP during the Construction Phase.

The EMP shall be reviewed during the Construction Phase among stakeholders to verify that mitigation measures in the EMP are duly targeted to minimize the negative impact in the Project Areas and then revised as appropriate. This iterative process shall continue throughout the Construction Period.

(2) Mitigation and Management Plan

1) Planning phase

Action	Environmental item	Mitigation and management measures	Responsible institution
1 Approval of development plan	—	1 Design document and other necessary papers shall be prepared and submitted without delay	MIPE&L
2 Land acquisition	Involuntary resettlement	1 According to the laws and regulations of St. Lucia and JICA Guideline, the process of land acquisition, lease contract, compensation shall be started at suitable timing, so that the process shall be finished before the planned timing of the commencement of the construction works.	MIPE&L
3 Temporal removal and recovery of utilities	Involuntary resettlement	1 According to the laws, regulations and normal operation of St. Lucia, the negotiation with the owners and managers of existing utilities shall be started at suitable timing, so that the agreement shall be reached before the planned timing of the commencement of the construction works.	MIPE&L
4 Safety Plan for the school access and the church parking lot at Ravine Poisson Bridge during the construction phase	Children's right	1 Minimize the impact on the school yard function 2 Secure the safety of school access and around the stock yard, that may be set up at the lower parking lot	MIPE&L
5 Impacts on the water intake facility	Water use, water rights	1 Confirm that the design of structure and construction works shall not change water level and run off speed at the water intake upstream from Ravine Poisson Bridge 2 Provide sufficient information on the construction plan to Water & Sewerage Company of Saint Lucia (WASCO) at suitable timing	MIPE&L

2) Construction phase

Contents of the final EMP to be prepared by the Contractor shall include following actions and measures based on the JICA Guideline, as well as the requirement of Environmental Management Framework for the World Bank Disaster Vulnerability Reduction Project (SFG1909). When necessary and appropriate, following actions and measures may be modified for better results or for

avoidance of duplication between the two (2) frameworks.

(a) Before commencement of construction works

Action	Environmental item	Mitigation measures	Responsible institution
1 Approval of environmental management plan	—	1 Develop sufficient and implementable environmental management plan, and obtain approval from MIPE&L	Contractor
2 Submission of waste plan	Waste	1 Develop sufficient and implementable waste management plan, and obtain approval from Solid Waste Management Authority	Contractor
3 Agreement of excavated soil disposal at the Deglos Sanitary Landfill	Waste Air quality	1 Negotiate and obtain approval from Solid Waste Management Authority and any other related institutions about the disposal of 14,500 m3 excavated soil from the Project, and reuse of the excavated soil for sanitary purpose 2 To minimize impacts from dust, take measures such as covering the excavated soil, spraying water on the excavated soil, and washing tires of the trucks	Contractor
4 Negotiations on existing utilities to be affected	Involuntary resettlement	1 Following up the activities of MIPE&L in the Planning Phase, start negotiation with the owners and managers of existing utilities, and reach agreement on temporal relocation and recovery without causing delay of construction works	Contractor

(b) During construction works

Action	Environmental item	Mitigation measures	Responsible institution
1 Operation of transportation vehicles	Air quality Noise and vibration	1 Always use well-maintained transportation vehicles 2 Comply to the design load of each vehicles	Contractor
2 Existence of construction activities	1 Air quality	1 Always use well-maintained vehicles and construction machines 2 To minimize impacts from dust, take other measures such as cleaning of tires and spraying water on road surface 3 Cover the excavated soil on the dump truck	Contractor
Operation of construction machineries Traffic regulation and control Use of alternate routes etc.	2 Noise and vibration	1 Use generators and construction machines that generate lower level of noise 2 Works that generate loud noise and vibration must be limited to day-time, but at the same time, should not obstruct the school-hours 3 Conduct information dissemination meetings with schools, churches and other public facilities and local residents prior to the commencement of works that generate loud noise and significant vibration, and explain the schedule of the works as well as the contact information that receives complaints	Contractor

Action	Environmental item	Mitigation measures	Responsible institution
	3 Water quality	1 Minimize the days of works that dig the river bed 2 Implement mitigation measures to avoid generation and run-off of mud water	Contractor
	4 Waste	1 Handle, store and dispose wastes such as excavated soil, pavement, iron beam and fuel containers properly as planned in the submitted Waste Management Plan	Contractor
	5 Soil contamination	1 Use indoor storage, oil pan, etc. to avoid direct spill of fuel, lubricants, and other chemicals at work areas and yards	Contractor
	6 Existing public facilities, road and transportation facilities, social infrastructure, social services Children's right Accidents, crime	1 Plan temporal detour road and bridges to minimize accidents 2 In case traffic restriction such as alternate passage is necessary, provide sufficient number of traffic guard and communication tools to avoid and minimize congestion and accidents 3 If alternate roads are available, use mass media and other tools to encourage public to detour to alternate roads 4 Instruct the traffic guards to give first priority to pupils and mass attendants during school hours and mass hours	Contractor
	7 Work environment, occupational safety and health	1 Comply to the safety standards of St. Lucia 2 Mandate use of safety tools 3 Conduct periodical meetings with workers and make sure that full knowledge of work safety and health is well understood by every workers	Contractor
	8 Sanitation, public health, transmittable diseases including HIV/AIDS	1 Standing or stagnant water at work areas and yards must be drained everyday or treated by pesticide 2 Provide prevention method/tools to avoid infection of pathogens in the river water to the workers 3 Periodically monitor the occurrence of transmittable diseases among the workers and near the work areas and yards	Contractor

3) Maintenance phase

Action	Environmental item	Mitigation measures	Responsible institution
1 Existence of upgraded road and bridges (Cul de Sac Bridge) Opening of new route Closure of the existing road	Existing public facilities, road and transportation facilities, social infrastructure, social services Accidents, crime	1 After the opening of the new road section, control and navigate the traffic right after the completion of works to minimize occurrence of traffic accidents for up to 3 months	Police

(3) Monitoring Plan of Social and Environmental Impact and Implementation and Effectiveness of Mitigation and Management

Following monitoring activities shall be implemented to assure that the mitigation and management

plan is duly implemented and they are achieving expected results. Forms to be used for the monitoring are shown in Appendix 5-3-5.

1) Planning Phase

Item/issue	What to monitor	How to monitor	Frequency	Location	Who does the monitoring
1 Approval of development plan	1 Progress of preparation and submission of design document and project approval papers	Oral interview	Every month	—	Consultant
2 Land acquisition	1 Progress of land acquisition, lease, and compensation negotiation and legal process	Oral interview	Every month	—	Consultant
	2 Progress of negotiations with owners and managers of existing utilities	Oral interview	Every month	—	Consultant
3 Children's rights	1 Extent/significance of impact of construction works for the school yard and church parking lot at Ravine Poisson Bridge 2 Safety measures in the Construction Phase for school access and around the stock yard 3 Progress of information dissemination and negotiations with the school and church	Oral interview	Every month	—	Consultant
4 Water use, water rights	1 Engineering review of the construction plan on existence of impact on water level and run off speed at the water intake upstream from Ravine Poisson Bridge 2 Progress of information dissemination and negotiations with WASCO	Oral interview	Every month	—	Consultant

2) Construction phase

Contents of the final EMP to be prepared by the Contractor shall include following actions and measures based on the JICA Guideline, as well as the requirement of Environmental Management Framework for the World Bank Disaster Vulnerability Reduction Project (SFG1909). When necessary and appropriate, following actions and measures may be modified for better results or for avoidance of duplication between the two (2) frameworks.

(a) Before commencement of construction works

Item/issue	What to monitor	How to monitor	Frequency	Location	Who does the monitoring
1 Approval of environmental management plan	1 Preparation, submission, and approval of Environmental Management Plan	Oral interview	Every month	—	CSC (construction supervision consultant)
2 Wastes	1 Preparation, submission, and approval of Waste Management Plan	Oral interview	Every month	—	CSC
3 Excavated soil disposal	1 Progress of negotiation for excavated soil disposal at Deglos Sanitary Landfill 2 Operation plan of the excavated soil transportation to minimize impacts of dust generation	Oral interview	Every month	—	CSC

Item/issue	What to monitor	How to monitor	Frequency	Location	Who does the monitoring
4 Utilities	1 Progress of negotiations with owners and managers of existing utilities	Oral interview	Every month	—	CSC

(b) During construction works

	Item/issue	What to monitor	How to monitor	Frequency	Location	Who does the monitoring
1. Transportation vehicles						
1	Air Noise, vibration	・Impacts caused by transportation vehicles ・Safe loading behaviors	Observation while patrol Responding to complaints and other reports	Everyday - twice a month (Increased frequency in the phases that require more transportation vehicles)	・Near the public facilities along the transportation routes that are susceptible to negative impacts	CSC
2. Works at the site and yard						
1	Air	・Maintenance condition of vehicles and construction machineries ・Occurrence of dust pollution ・Implementation of preventive measures such as tire wash, spraying road surface, covering excavated soil on dump trucks, etc..	Observation while patrol Responding to complaints and other reports	Everyday - every week (Increase frequency during the works that may cause air pollution)	At the work areas and the yards	CSC
2	Noise, vibration	・Occurrence of noise from generator and construction machineries ・Noise condition during night works ・Information dissemination meetings for the school, church, other public facilities and local residents on work schedule (start and end dates) and potential impacts	Observation while patrol Responding to complaints and other reports	Everyday - every week (Increase frequency during the works that may cause noise and vibration) Record every meetings for information dissemination	At the work areas School, church, and other public facilities near the work areas	CSC
3	Water quality	・Muddy water flow in the downstream ・Implementation and effectiveness of preventive measures	Observation while patrol Responding to complaints and other reports	Everyday - every week, during and after rain fall (Increase frequency during rain season)	At the work areas and down stream	CSC
4	Wastes	・Condition of segregation and storage of wastes, excavated soil, used containers, recyclables, etc.. ・Appropriate waste	Observation while patrol Confirmation of the manifesto or records of waste disposal	Twice a month	At the work areas and the yards	CSC

	Item/issue	What to monitor	How to monitor	Frequency	Location	Who does the monitoring
		disposal	company			
5	Soil contamination	・Safe storage of fuels, lubricants, chemicals, etc.. ・Implementation of preventive measures of direct spills on the ground ・Occurrence of direct spills on the ground	Observation while patrol	Twice a month	At the work areas and the yards	CSC
6	Existing traffic facilities, public facilities, social infrastructure, social services Children's rights Accidents, crime	・Occurrence of traffic congestion ・Securing safety for pedestrians and private cars during hours of commuting for school and masses ・Employment of traffic guards and use of media for detour encouragement	Observation while patrol Record every traffic accidents Record of safety measures	Twice a week - twice a month (work day and week end) (Increase frequency after the change of drive course) Record traffic accidents at every occurrence	Areas around the work areas and the yards	CSC
7	Work environment, work safety	・Compliance to safety standards ・Implementation of safety tools ・Holding meetings on safety and sanitation	Observation while patrol	Twice a month	At the work areas and the yards	CSC
8	Transmittable diseases	・Existence of stagnant water ・Occurrence of transmittable diseases among workers ・Occurrence of transmittable diseases in the areas around the construction works and yards	Observation while patrol Interview	Every day - every week, after rainfall (Increase frequency during rain season) Interview once a month	At the work areas and the yards Areas around the work areas and the yards	CSC

3) Maintenance Phase

	Item/issue	What to monitor	How to monitor	Frequency	Location	Who does the monitoring
1	Existing traffic facilities, public facilities, social infrastructure, social services Accidents, crime	1 Implementation of planned traffic control and other safety measures 2 Occurrence of traffic accidents near the new bridges (up to 3 months after the completion of works)	Field observation Interview with police, business and residents nearby	Every month	Around the new bridges and access roads	MIPE&L

1-2-5-10 Land Acquisition and Resettlement

(1) Rationale of land acquisition and resettlement

The Project aims to renovate bridges on existing road. As of September 2016, two patterns of renovation are under consideration: 1) construction of new bridge parallel to the existing one, while continuing the use of the existing bridge; 2) diversion of the traffic to temporal bridge and access road during the renovation of the existing bridge.

The ROW of the existing road is basically equal to the width of the pavement and shoulders. Therefore, in case 1) land acquisition for the access road shall be necessary, and in case 2) temporal lease of the land for access road shall be necessary to implement the Project.

Figure 1-46 and Figure 1-48 shows the Project design, boundary and number of registered land, and surrounding environment. Expected land acquisition, lease and loss of private assets are summarized in Table 1-31. No resettlement of residents are expected.

Table 1-31 Expected land acquisition, lease and loss of private assets

	Land acquisition		Land lease during Construction Phase	
	Land acquisition	Loss of private assets	Land lease	Loss of private assets
Cul de Sac Bridge area	Land for access road (Millennium Highway) (West Coast Road)	* Private assets on Crown Land (trees, movable structures) * Street trees (public) * Utilities * Grazing activities (part of large grazing land (Crown Land) shall be lost)	Land for temporal access road Land for temporal office, storage, yard	* Private assets on Crown Land (movable structure) * Grazing activities (part of large grazing land (Crown Land) shall be temporally lost)
	(Eastern access road of West Coast Road)	* Improvements (commercial)		
	Land for embankment Land for waterway	* Structure, improvements (commercial) * Movable structures		
Ravine Poisson Bridge area	None	None	Land for temporal access road and bridge Land for temporal office, storage, yard	* Flower nursery (commercial) * Trees, fences * Secondary parking lot (Church) * Utilities (temporal relocation)

Source: JICA Survey Team

(2) Legal framework for land acquisition and resettlement

1) Land acquisition procedure for public projects

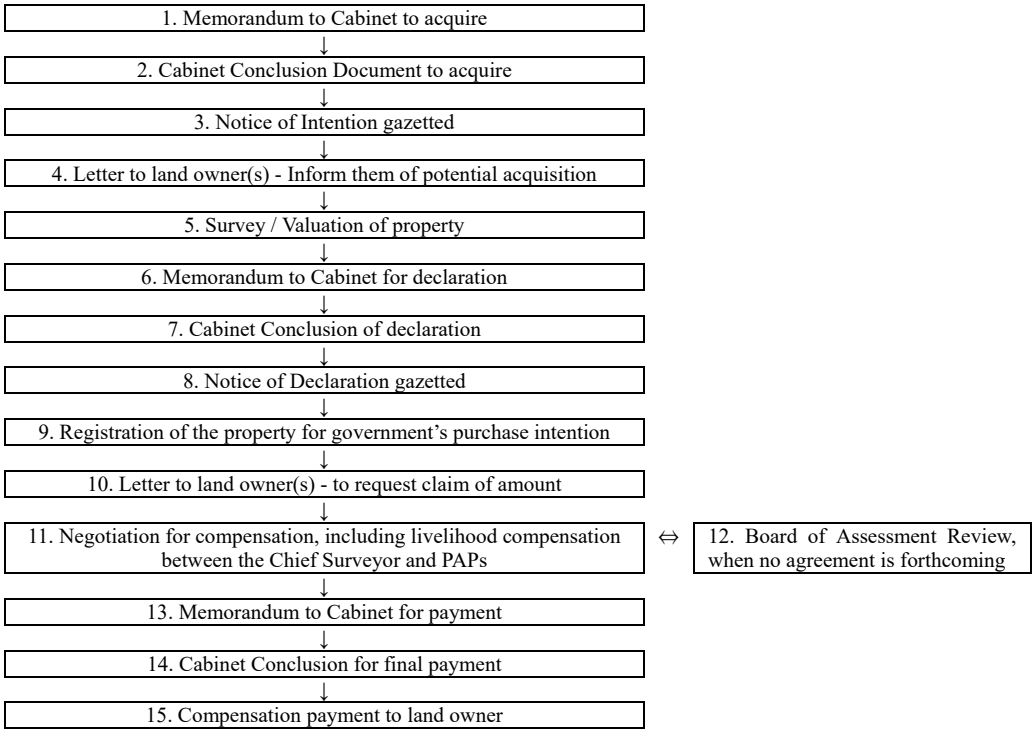
The Land Acquisition Act Chapter 5.04 defines procedure for land acquisition for public projects in St. Lucia. The flow chart is shown in Figure 1-50.

Prior to the commencement of survey work at Step 5, information shall be disseminated to the land owners at Step 4. The compensation amount, including both the land price and livelihood

assistances, shall be negotiated at Step 10 and after.

The steps through the whole process require approval and decisions of the Cabinet. The Board of Assessment, a third party consisted of persons recommended by the project owner, land owners, the Governor General, and the Chief Attorney, shall supervise the asset and livelihood assessment based on Section 12 of the Act.

During the meeting with MIPE&L in the first field survey, MIPE&L confirmed its responsibility and intention to finalize the land acquisition procedure before the commencement of the project when the acquisition was found necessary for the implementation.



Source : Land Acquisition Act Chapter 5.04, JICA Survey Team

Figure 1-50 Procedure for Land Acquisition for Public Projects in St. Lucia

2) Transfer of Crown Lands

In Saint Lucia, Crown Land is governed by Ministry of Agriculture, Fisheries, Physical Planning, Natural Resources and Co-operatives, Department of Physical Planning, Crown Lands Section (Commissioner of Crown Lands, Crown Lands Commission).

When a public work project needed to occupy Crown Land permanently, the project owner agency shall make a request to the Commissioner of Crown Lands. The demarcation of land can be done either by a staff surveyor of Land and Survey Section, Dept. of Physical Planning or a privately practicing surveyor commissioned by the project owner. With such procedure, the defined land shall be transferred to the project owner agency without land cost.

Also, a private party may make a lease contract with Commissioner of Crown Lands which has renewable contract period. Commissioner of Crown Lands can stop the renewal of the contract in case a public project is proposed and the land parcel is required for the project. In such case, the lessee is responsible for removal of all structures and improvements on the particular parcel. Commissioner of Crown Lands will remove and dispose all remaining assets after the termination of the contract.

3) Legal framework for resettlement

St. Lucian legal system does not require preparation of resettlement action plan. In March 2016, Ministry of Finance, Economic Affairs and Social Security published the Resettlement Policy Framework as a result of sub-project under the World Bank assisted Disaster Vulnerability Reduction Project. It seems, however, as of November 2016, each project owner agency conduct case-by-case resettlement, and there is no public housing program or preparation of lands for alternative housing to accept the resettlers.

4) Gap between JICA Guidelines & Laws of St. Lucia and Plan to bridge the gap

Table 1-32shows gaps between JICA Guidelines & Laws of St. Lucia and Plan to bridge the gap.

Main differences are the points below:

No. 7 : Timing of direct consultation with the affected people and their communities

No. 11 : Timing of identification of affected people, and decision of eligibility cut-off date

There is a Saint Lucian legal system that makes both of the difference unavoidable. Land Acquisition Act is implemented in such way that the issuance of Notice of Intention prohibits the land owner or anybody interested in the parcel to change existing conditions. Therefore, information on the Project can not be disseminated to the potentially affected people or their communities before the date of the issuance. The date of the issuance is not named so in the Act but definitely works as the cut-off date.

Direct consultation with the affected people and their communities, as well as the census and asset survey including valuation are duly conducted after the issuance of Notice of Intention.

Table 1-32 Gaps between JICA Guidelines & Laws of St. Lucia and Plan to Bridge the Gap

No.	JICA Guidelines	Laws of St. Lucia Land Acquisition Act, etc.	Gap between JICA Guidelines & Laws of St. Lucia	Policies in the Project Plan to bridge the gap
1.	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	MIPE&L tries to minimize purchase of private lands.	No significant gap.	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.
2.	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	MIPE&L obeys to the compensation policy described in the Land Acquisition Act.	No significant gap.	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken.
3.	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	The Board of Assessment shall be constituted of a) a chairperson, a barrister, nominated by the Chief Justice, b) a qualified person in property valuation appointed by the Governor General, c) a member to be nominated by the owner of the land to be acquired, d) a member who shall be nominated by the Minister responsible for planning. (Act Sec. 12) Assessment of compensation includes injuriously affected property, earnings, disturbance or any other matter. (Act Sec. 19a)	No significant gap.	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.
4.	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	There is no specification. (Act) Resettlement Policy Framework for WB - assisted Disaster Vulnerability Reduction Project states that 'should the laws of Saint Lucia not be in keeping with the compensation for full replacement cost, then compensation under domestic law would be supplemented by additional measures.'	Local system may not provide full replacement cost.	MIPE&L represented in the Board shall consult the valuator member in the Board so that compensation to be based on the full replacement cost as much as possible.
5.	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	There is no specification. (Act) There have been cases when the land owner did not agree on the compensation amount, the negotiation continued during the construction phase (MIPE&L)	Local system may not assure the payment prior to the displacement or commencement of construction.	Since the Construction Phase extends for about 2 years, MIPE&L and the Contractor shall communicate well with the PAP and confirm that the payment be provided prior to displacement, which may be well after the commencement of the construction works.
6.	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	There is no specification. (Act)	The Project does not cause large-scale involuntary resettlement.	Not applicable.
7.	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient	The land owners shall be contacted by an authorized officer, the Chief Surveyor at Dept. of Physical Planning, about the planned land	MIPE&L, the Project owner, can not directly handle the compensation process.	MIPE&L shall provide sufficient information of the Project to the PAPs and their community. MIPE&L, as a member of

No.	JICA Guidelines	Laws of St. Lucia Land Acquisition Act, etc.	Gap between JICA Guidelines & Laws of St. Lucia	Policies in the Project Plan to bridge the gap
	information made available to them in advance. (JICA GL)	acquisition and procedure of assessment. (Act Sec.6) Community meeting shall be held for the Project during the Detailed Design phase to share the information of the Project and obtain advices and opinions. (MIPE&L)	The timing of information dissemination directly to the PAPs by MIPE&L will be when the draft design and the draft construction plan are approved by MIPE&L.	the Board of Assessment, shall confirm that the PAPs are well consulted by responsible officer regarding compensation assessment.
8.	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. (JICA GL)	There is no specification. (Act)	In Saint Lucia, literacy rate is very high, and English is read and spoken by general public. No significant difficulty is foreseen.	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.
9.	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	Although action plan document shall not be prepared, PAPs are represented in the Board of Assessment in planning, implementation, and monitoring phase of compensation payment. (Act)	No significant gap.	PAPs shall be represented in the Board of Assessment in planning, implementation, and monitoring phase of compensation payment.
10.	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	All questions and claims relating to the payment of compensation shall be submitted to the Board of Assessment. (Act Sec. 11)	No significant gap.	The Board of Assessment shall work as the appropriate and accessible grievance mechanisms must be established for the affected people and their communities.
11.	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers or others who wish to take advance of such benefits. (WB OP4.12 Para.6)	To prevent a subsequent influx of encroachers or others who wish to take advance of such benefits, direct official contact with the potentially affected land owners must start after the Declaration of the governmental interest on the land parcel for full or partial acquisition. The date of the Declaration, which will be after the design and construction plan is examined and approved by MIPE&L, shall work as the cut-off date and no modification of the land and other properties on it shall be allowed. (MIPE&L)	Although the purpose is common between the policies, the timings of identification and recording of PAPs are different. JICA: preferably at the project identification stage Saint Lucia: after the design and construction plan is examined and approved by MIPE&L	Preliminary survey of the site and potential PAPs shall/had been be conducted at the project identification stage to avoid and minimize negative impacts of the Project. Affected people and businesses shall be identified and recorded in order to establish their eligibility through a baseline survey (including population census, asset inventory, and socioeconomic survey), after the design and construction plan is examined and approved by MIPE&L. Cut-off date shall be the date the Declaration of land is Gazetted and published.
12.	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	The compensation shall be paid not only for the legal land purchase, but for other persons interested in the land, including owners of any building, trees, or crops. (Act Sec. 13(2)) The land registration system in Saint Lucia was established in 1985 with GIS data, but not much update since then has been done. During the Detailed Design, further study of ownership and lot boundary location shall be necessary with assistance of Chief Surveyor of Physical Development Department.	No significant gap.	Eligibility of benefits shall include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.

No.	JICA Guidelines	Laws of St. Lucia Land Acquisition Act, etc.	Gap between JICA Guidelines & Laws of St. Lucia	Policies in the Project Plan to bridge the gap
13.	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP4.12 Para.11)	There is no specification. (Act)	The land to be acquired does not include farming land. Therefore, this policy is not applicable to the Project.	This policy is not applicable to the Project.
14.	Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para.6)	The assessment of compensation shall take negative impact on properties other than land, earnings, disturbances or any other matter recognized. (Act Sec. 19(a))	No significant gap.	Support shall be provided for the transition period (between displacement and livelihood restoration).
15.	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP4.12 Para.8)	There is no specification. (Act)	Detailed census of potential PAPs shall be conducted after the issuance of the Declaration of the governmental interest on the land parcel.	In the decision of the compensation and assistance by the Board of Assistance, MIPE&L shall confirm that particular attention shall be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.
16.	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	There is no specification. (Act) A few ARAPs have been prepared for the subprojects of the WB- assisted Disaster Vulnerability Reduction Project in Saint Lucia. At least one is for a road project.	Since no legal procedure exists in Saint Lucia for the review, approval and use of ARAP, the handling of ARAP for the WB- assisted subproject shall be followed for the Project as well.	ARAP shall be prepared by the Consultant, reviewed by MIPE&L, and be approved by the donor agency. The ARAP shall be referred by MIPE&L at the Board of Assessment. Social Development Specialist assigned in the Project Coordination Unit shall implement the ARAP.

Source: JICA Survey Team

(3) Area and Size of Land Acquisition

1) Cadastral map and the Project design

Figure 1-46 ~ Figure 1-49 shows the Project design, boundary and number of registered land, and surrounding environment.

2) Lands and assets planned to be affected

Table 1-33 summarizes natural and legal persons who are related to the land planned to be acquired by the Project.

The cut-off date for the listing of persons or assets related to the land shall be determined following the Land Acquisition Act, Chapter 5.04. as the date of issuance of first Notice of Intention, not the date of the starting date of the preliminary census, which was November 11, 2016.

Table 1-33 Number of Project Affected Units (PAUs) and Affected Persons (APs)

Type of loss		No of PAUs				No of APs		
		Legal	Illegal	Unknown	Total	Legal	Illegal	Total
Required for displacement								
1	HH (Structure owner on Gov. land)	0	0	0	0	0	0	0
2	HH (Structure on Private land)	0	0	0	0	0	0	0
3	HH (Tenants)	0	0	0	0	0	0	0
4	CBEs (Structure owner on Gov. land)	0	0	0	0	0	0	0
5	CBEs (Structure owner on Private land)	0	0	0	0	0	0	0
6	CBEs (Tenants)	0	0	0	0	0	0	0
7	Community owned structures including physical cultural resources	0	0	0	0	0	0	0
Not required for displacement								
8	Land owners (#69, 187, 154, 45, and Crown (#24, 153). All owners lose part of the lot)	5	0	0	5	-	-	-
9	CBEs (Structure owner on Private land) which will lose road access (#154)	1	0	0	1	-	-	-
10	CBEs (Structure owner on Private land) which will relocate an immovable structure to the remaining land (#45)	1	0	0	1	-	-	-
11	CBEs (Structure owner on Private land) which will relocate a movable structure to the remaining land (#69)	0	0	1	1	-	-	-
12	CBEs (Structure owner on Private land) which will lose sign boards, gates, and fences (#187, 154, 45)	3	0	0	3	-	-	-
13	Wage earners of relocating CBEs	0	0	0	0	-	-	-

HH: House Hold, CBEs: Commercial and Business Enterprises
Source: JICA Survey Team

Table 1-34 and Table 1-35 summarizes lands and assets planned to be affected by the Project. The stoppage of lease of Crown Lands and any related matters (#153) and clearance of occupation of Crown Lands without formal contract (#24) shall be handled by the Commissioner of Crown Lands, as regular management operation of Crown Lands. Such activities, therefore, were separated from the action necessary for the Project.

Table 1-36 and Table 1-37 lists information of the owners of the land parcels and assets on the land.

Figure 1-51 and Figure 1-52 shows existing condition of the land and assets as of June to November 2016.

Table 1-34 Lands and assets planned to be affected by the Project (Acquisition)

Acquisition (Cul de Sac)	Lot #	Ownership	Necessary area m2	Remaining area m2	Total area m2	% affected	Assets	#
Access roads								
Millennium Highway	69	Private	300	510	810	37%	Semi-mobile canteen Planting	1 1
	24-4	Crown	3,850				Grazing Semi-mobile canteen	- 1
West coast road relocation	187	Private	498	13,419	13,917	4%	Signboard	1
	24-3	Crown	3,550				Street trees	5
Embankment Waterway	154	Private	228	8,060	8,288	3%	Net fence and gate Signboard	1 1
	45	Private	277	1,113	1,390	20%	Commercial structure (with concrete founding)(Partially affected) Net fence	1
	153	Crown (1-yr. lease contract)	288	11,633	11,921	2%	Net fence and gate Signboard	1 1
	24-1	Crown	4,150				Grazing Semi-mobile canteens Fruit and ornamental trees	- 3 10
	24-2	Crown	1,900				Semi-mobile canteen	1
Private land m2 Total			1,303					
Crown land m2 Total			13,738					
Grand total m2			15,041					

Source: JICA Survey Team

Table 1-35 Lands and assets planned to be affected by the Project

(Lease during construction phase)

Lease	Use	Lot #	Ownership	Necessary area m2	Remaining area m2	Total area m2	% affected	Assets	#
Cul de Sac	Temporal detour road (Millennium Highway)	69	Private	165	645 (Includes 300 m2 for acquisition)	810	20%	Listed in previous table	
	Temporal detour road (West coast road, eastern access road)	77	Private	480	3,115	3,595	13%	Commercial structure (without concrete founding)	1
		151	Private	2,090	7,660	9,750	21%	Boundary wall Parking pavement Signboards	1 1 2
		101	Private	550	2,400	2,950	19%	Boundary wall Signboard	1 1
		210	Crown (road)	25					
	Temporal office, storage and yard	68	Crown (Application of lease under review)	1,622	3,860	5,482	30%	None	
		24-4	Crown	10,750				Listed in previous table	
Ravine Poisson	Temporal detour road and bridge	14	Private	290	2,150	2,440	12%	Commercial flower nursery	1
		999*	Crown	150				Net fence Tree Ornamental planting	1 1 1
		998*	Crown (River)	90				None	
		83	Private	5	1,020	1,025	0.5%	None	
		10-1	Private	65	38,085	39,500	4%	Ornamental planting	1
	Temporal office, storage and yard	10-2	Private	1,350				Chain gate Parking for events	1 1
Private land m2 Total				4,995					
Crown land m2 Total				12,637					

*: Lot # 999, 998 are under survey for factual numbers.

Source: JICA Survey Team

Table 1-36 Owners of lands and businesses to be affected by the Project (Acquisition)

Location	Land Owner (Acquisition)	Tenant/ Business/ Structure Owner
Cul de Sac Map #0845B	69	
	154	
	45	
	187	
	153	
	24	

Source: JICA Survey Team

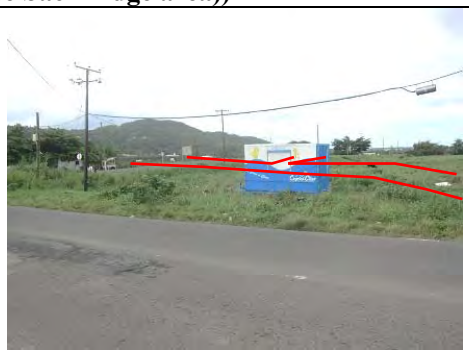
Table 1-37 Owners of lands and businesses to be affected by the Project (Lease during construction phase)

Location	Land Owner (Lease)	Business/ Structure Owner	School	Church, Community facility	Resident
Cul de Sac Map #0845B	69				
	77				
	151				
	101				
	68				
	24				
	210				
Ravine Poisson Map #1039B	14				
	10				
	83				
	999				
	998				

Source: JICA Survey Team

Figure 1-51 Photos of lands and assets to be affected
(Land acquisition (All in the Cul de Sac Bridge area))

69



24-4

187

24-3

154

45

153

24-2

24-1

24-1

Source: JICA Survey Team

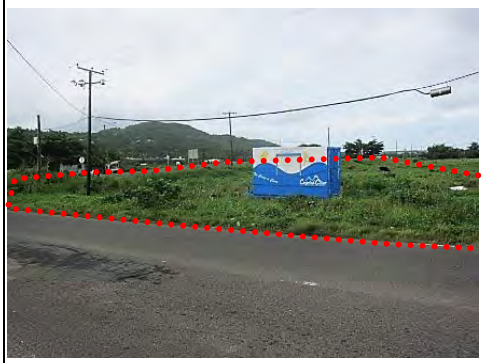
Figure 1-52 Photos of lands and assets to be affected

(Lease during the Construction Phase)

Cul de Sac Bridge

69

68



24-4

77

151

101

Ravine Poisson Bridge

14

10-1 (Detour road and temporal bridge)


10-2 (Temporal office, storage, yard)



999/83

Source: JICA Survey Team

(4) Preliminary Compensation Packages According to JICA Guideline

Table 1-38 and Table 1-39 list the types of impact and compensation and assistances related to the impact rationalized based on WB OP 4.12 and JICA guidelines.

The compensation package shall be finalized after official valuation of assets, individual negotiation with the PAP by Chief Surveyor at Department of Physical Planning, and when no agreement is forthcoming, by decision of the Board of Assessment.

Table 1-38 Preliminary Compensation Packages According to JICA Guideline (Acquisition)

Type of impact	Eligible PAP	Compensation and assistance	Implementation guideline	Responsible institution
Land acquisition	Land owner (4) #69, 187, 154, 45 All lose part of the parcels Total 1,303m2 (Crown Lands Commission is excluded from the counting here)	Cash payment for the land price rationally decided based on market value	Agreement shall be reached by following the due process defined in the Land Acquisition Act	Budget: MIPE&L Determination of the acquisition boundary and payment : Dept. of Physical Planning Determination of the volume of compensation/ assistance: Negotiation between the land owner and the authorized officer (CS).
Loss of road access to the remaining land	Land owner (1) #154	Provision of access road as a part of the Project, through #153, Crown Land	The design of the access road shall accommodate the heavy vehicles so that the auto repair business on #154 can continue as before	Budgeting and construction of the access road : MIPE&L Designation of land: Crown Lands Commission
Loss of private property	Owner of permanent structure (1) #45	Cash compensation * Demolition cost of whole structure, and * Re-construction of same function on remaining land	In determining the replacement cost, depreciation of the asset and the value of salvage materials are not taken into account.	Budgeting and construction of the access road : MIPE&L Governmental valuation and payment of compensation : Dept. of Physical Planning Determination of the compensation : Negotiation between the land owner and the authorized officer (CS).
	Owner of non-permanent structure (1) #69	Select either option: * Voluntary relocation on remaining land (when land owner agrees so) * Assistance to relocate to other places (provision of tow-vehicle and fuel)	In case of relocation to other place, the owner shall be responsible for selection of the destination (possible relocation on Crown)	Negotiation and provision of assistance: MIPE&L
	Owner of the sign board and other improvements Signboard (2) #187, 154 Fence, wall (2) #154, 45	Cash compensation for reconstruction	In determining the replacement cost, depreciation of the asset and the value of salvage materials are not taken into account.	Budgeting : MIPE&L Governmental valuation and payment of compensation : Dept. of Physical Planning Determination of the compensation : Negotiation between the land owner and

Type of impact	Eligible PAP	Compensation and assistance	Implementation guideline	Responsible institution
				the authorized officer (CS).
Negative impact on income caused by land acquisition	Above PAPs	Cash compensation decided by Board of Assessment	Board of Assessment shall conduct hearing with PAPs and decide on rational volume of income loss	Budget : MIPE&L Determination of the compensation : Board of Assessment

Following preparations shall be necessary separated from the Project.				
Type of impact	Eligible PAP	Compensation and assistance	Implementation guideline	Responsible institution
Stoppage of renewal of lease contract of public land	Owner of lease contract (1) #153	Select either option: *Provision of new lease contract of other location on public land * Provision of lease for annexing land and keep operation	Structures and other assets on public land shall be voluntarily removed by the lessee	Crown Lands Commission
Removal of private assets on public land	Owner of Semi-mobile canteens (5) #24- 4, 24-1, 24-2	Select either option: * Assistance to relocate to other places (provision of tow-vehicle and fuel) * Governmental removal and disposal, coordinating with MIPE&L	In case of relocation to other place, the owner shall be responsible for selection of the destination	Crown Lands Commission
	Owner of ornamental trees and planting (1) #24-1	Select either option: * Voluntary removal * Compensatory exchange with saplings, with assistance from Agriculture Department	In case of removal, the owner shall be responsible for selection of the destination and transportation	Crown Lands Commission
Owner of the 5 street trees on #24-3 is MIPE&L and no process or compensation is necessary for felling.				

Source: JICA Survey Team

Table 1-39 Preliminary Compensation Packages According to JICA Guideline (Lease)

No.	Type of impact	Eligible PAP	Compensation and assistance	Implementation guideline	Responsible institution
1	Temporal termination of land use	Land owner (7) C : #69, 77, 151, 101 R : #14, 83, 10 Total 4,995 m2	Cash payment for the land lease rationally decided based on market value	Contractor shall reach agreement with the owner by following the customary process in Saint Lucia. MIPE&L shall assist the negotiation	Determination of the land boundary : Contractor Assistance in negotiation and payment : MIPE&L
2	Temporal termination of economic activity	Flower cultivator (1) R : #14 (owner shall lose part of the flower nursery)	Income compensation for the months between the stoppage of production to the re-start of the market delivery	Compensation shall be the same value produced from the lost area of the flower nursery. The owner shall provide estimated price and the	Determination of the land boundary : Contractor Assistance in negotiation and payment : MIPE&L Assistance in verification of the

No.	Type of impact	Eligible PAP	Compensation and assistance	Implementation guideline	Responsible institution
				Contractor shall consult with the Agricultural Division for the rationality of the asking	price : Agricultural Division, Ministry of Agriculture, Fisheries, Physical Planning, Natural Resources and Co-operatives
3	Loss of private asset	Land owner (ornamental planting, chain gate) (1) R : #10	Recovery of the same condition by the Project budget	The Contractor, together with the owner, shall take photo and descriptive record of existing asset prior to their removal	Record and reconstruction: Contractor Assistance in negotiation : MIPE&L
		Owner of non-permanent structure (1) C: #77	Select either option: * Cash compensation * Voluntary relocation on remaining land (when land owner agrees so) * Assistance to relocate to other places (provision of tow-vehicle and fuel)	In case of relocation to other place, the owner shall be responsible for selection of the destination	Negotiation and provision of assistance: MIPE&L Technical assistance for valuation : Department of Physical Planning
		Owner of the sign board and other improvements Signboard (4) C: #77, 151 (2), 101 Fence, wall (2) C: #151, 101	Select either option: * Cash compensation for reconstruction * Reconstruction as part of the Project * Relocate to places not affected by the Project	In determining the replacement cost, depreciation of the asset and the value of salvage materials are not taken into account.	Budgeting and construction of the access road : MIPE&L Governmental valuation and payment of compensation : Dept. of Physical Planning Determination of the compensation : Negotiation between the land owner and the authorized officer (CS).

C: Cul de Sac Bridge area, R: Ravine Poisson Bridge area

Further study is necessary about the factual location of the boundary between #83 (private) and #999 (Crown, number under survey), and clarify the ownership of the following assets that are located on #999 on the cadastral map #1039B.					
No.	Type of impact	Eligible PAP	Compensation and assistance	Implementation guideline	Responsible institution
4	Loss of assets on Crown Land	Owner (Fence, tree, ornamental plants) (1) R : #999	Recovery of the same condition by the Project budget (If found that the assets are on private land, or are on Crown Land with permission)	The Contractor, together with the owner, shall take photo and descriptive record of existing asset prior to their removal	Record and reconstruction: Contractor Assistance in negotiation : MIPE&L

Source: JICA Survey Team

(5) Procedures for Grievance Redress

A grievance redress mechanism is necessary for addressing eligible concerns of affected individuals and groups who may consider themselves deprived of appropriate treatment under the project.

The mechanism includes:

(i) a recording and reporting system, including grievances filed both verbally and in writing,

(ii) designated staff with responsibility for addressing grievances at various levels of Government, and

(iii) a time frame to address the filed grievances.

The functioning of the grievance redress mechanism for this ARAP shall be monitored and evaluated by the Chief Surveyor (CS) at Department of Physical PlanningS during its implementation in the Planning Phase of the Project.

The Remedial Abbreviated Resettlement Action Plan for Dennery Infant School (2016) followed the steps of grievance redress as shown in Table 1-40. Similar staff, institutions and steps are expected to work for the Project as well.

Table 1-40 Grievance Redress Procedures in the Remedial Abbreviated Resettlement Action Plan for Dennery Infant School

Grievances from affected parties	* Grievances made verbally to the Social Safeguards Officer
Access Point	* The Project Coordination Unit (PCU) serves as the access point for grievances
Grievance Log	* Grievances received verbally are documented, verified and signed by both parties. * Grievances will be copied to the relevant authority as defined in the Land Acquisition Act.
Assessment	* Grievances categorized by type. Determination of eligibility of grievance. * The first assessment of the grievance conducted by a Grievance Committee comprising persons drawn from the PCU and technical officers from the MOPD, MIPE&L, and MOE. * Letters acknowledging grievance relating to resettlement issued by the PCU to the aggrieved persons. * The Community Development Officer (CDO) (Social Transformation Officer) for Dennery to provide assistance with dealing with conflict resolution and grievance. The CDO will communicate all disputes and grievances to the PCU immediately when received. Should a dispute arise, the applicable Laws of Saint Lucia will prevail.
Resolution and Follow-up	* Development of Implementation Plan for resolution of grievances.

Source: Remedial Abbreviated Resettlement Action Plan for Dennery Infant School, DVRP (2016) p.9

(6) Institutional Responsibilities for Implementing the ARAP

The CS shall be responsible for implementation of the ARAP, and the CS shall coordinate with relevant institutions to oversee the implementation of this ARAP.

The CS shall ensure that implementation of the ARAP is done in accordance with the requirements of the JICA Guideline, with guidance from the World Bank OP 4.12 and the Resettlement Policy Framework of DVRP.

The agencies involved with implementation of this ARAP are listed in Table 1-41.

Table 1-41 Institutional Responsibilities for Implementing the ARAP

Responsibility	Relevant Institutions
● Securing necessary budget (land acquisition, compensation and other assistances) ● Request for technical coordination to Dept. of Physical Planning and Crown Lands Section ● Transfer of budget to Dept. of Physical Planning and Crown Lands Section	MIPE&L
● Demarcation of necessary land ● Estimation of budget for acquisition and lease	Land and Survey Section, Dept. of Physical Planning
● Negotiation with the PAPs	Chief Surveyor, Land and Survey Section, Dept. of Physical Planning
● Submission of memorandum to Cabinet to acquire the land ● Gazette the Notice of Intention ● Letter to land owners informing potential acquisition; Letter to land owners to request claim of compensation amount, negotiation for compensation including livelihood assistances, compensation payment	PS, Dept. of Physical Planning
● Clearance of properties on Crown Lands and necessary assistance to the owners of private properties ● Registration of the land for road usage	Crown Lands Section, Dept. of Physical Planning
● Study and decision of compensation and assistance to PAPs when negotiation between the CS and the PAP did not reach agreement	Board of Assessment

Source: JICA Survey Team

(7) Schedule of ARAP Implementation

Saint Lucian laws does not mandate the payment of compensation to be finished prior to the commencement of the construction works. There have been cases of continuance of negotiation with PAPs parallel to the implementation of the projects.

On the other hands, WB-assisted Disaster Vulnerability Reduction Project demanded GoSL to comply with its operation policy in the implementation process of the sub-projects. Since the sub-projects had wide range of stakeholder agencies, including Dept. of Physical Planning and Development, the rule of timing of payment is widely recognized among the governmental agencies, although there have been many difficult cases and delay of projects.

During the field assignment of the JICA Survey Team, the Team explained to the stakeholder agencies that JICA Guideline's requirement is the same with WB. It was agreed by MIPE&L and Dept. of Physical Planning and Development that the process of the Project will be; 1) payment of compensation and assistance for the land, loss of assets and loss of livelihood, 2) commencement of clearance of the land, 3) commencement of the construction works.

In addition, In addition, it was also agreed by the agencies that, in cases where the payment can not be completed for some reason, i.e. when the selling conditions or desired amount presented by the landowner exceeds the range considered reasonable, the budget must be pooled in the bank account, and interest for the period until the final payment is completed Will be added to the original amount.

(8) Sources of Funding and Estimated Budget

The cost of acquisition and associated administrative and logistical costs shall be provided for by the MIPE&L as part of the Project cost. Necessary budget shall be estimated after the official

valuation of assets by Department of Physical Planning. The budget shall be transferred from MIPE&L to Department of Physical Planning in the payment phase.

(9) Arrangements and Timetable for Monitoring Implementation of ARAP and Reporting

The SPU, Social Safeguards Officer, is responsible for following up and ensuring that all activities are completed as outlined above and according to agreed upon timelines. In case any difficulty arises, and if the concerned parcel of land may remain as it is for the time being, the monitoring activities may continue after the commencement of the Construction Phase.

The SPU shall ensure that the affected persons are compensated satisfactorily, and in accordance with the ARAP. Minutes of all meetings and consultations will be maintained by the SPU, shared with all parties. The Consultant assigned by MIPE&L shall be informed by email immediately following each meeting, or, if appropriate, observe the activities on site.

Table 1-42 shows the plan for monitoring the implementation of the ARAP. Preliminary monitoring forms to be used in the process are listed in Appendix 5-6. Consultant shall assist MIPE&L in reporting the monitoring results to JICA quarterly (every 3 months).

Table 1-42 ARAP Monitoring Plan

Items to be monitored	Measure	Summarization Frequency	Location	Responsible institution
Information dissemination and consultation about the Project	Daily record and interview	Monthly	Social Safeguards Officer, SPU, MIPE&L	SPU, MIPE&L
Comments and grievance redress on land acquisition and loss of private properties	Daily record and interview	Monthly	Social Safeguards Officer, SPU, MIPE&L	SPU, MIPE&L
Progress of valuation of assets, presentation of compensation options, negotiations, and payment	Daily record and interview	Monthly	Social Safeguards Officer, SPU, MIPE&L	SPU, MIPE&L

Source: JICA Survey Team

1-2-5-11 Stakeholder Meetings

JICA Survey Team conducted stakeholder meetings as listed in Table 1-43~Table 1-45.

The representative of the Project area, MP Hon. Guy Joseph, elected from Castries East Constituency, expressed his support for the Project, commenting the importance of the strong resiliency of the East Coast Road against the risk of flooding.

MIPE&L and Dept. of Physical Planning and Development（PS, DPS, Chief Surveyor, Commissioner for Crown Lands） confirmed in the meetings that in the next phase of the Project, necessary and sufficient communications and information dissemination with potential PAPs, local communities and whoever has interest in the Project, shall be implemented, including explanation of the Project, potential impact from the Project, and receiving attendants' opinions and suggestions for the Project.

Separated from community meetings to disseminate the information about the Project, PAPs shall be contacted by the Chief Surveyor of Department of Phycial Planning or his/her agent individually for

their rights, process of the Project, official census and assessment, voluntary claiming of asset value, necessary assistances, and other negotiation and consultation.

Table 1-43 Stakeholder meetings in scoping stage

1	Agency	Ministry of Infrastructure, Port Services and Transport
	Date	June 8, 2016
	Venue	Ministry of Infrastructure, Port Services and Transport
	Attendants	Mr. Amos Hippolyte, Project Engineer Ms. Naomi Cherry, Assistant Engineer
2	Agency	Ministry of Infrastructure, Port Services and Transport
	Date	June 10, 2016
	Venue	Ministry of Infrastructure, Port Services and Transport
	Attendants	Hon. Guy Joseph, Member of Parliament, elected from Castries East Constituency Ms. Allison A. Jean, Permanent Secretary Mr. Albert John Baptiste, Chief Engineer
3	Agency	Ministry of Infrastructure, Port Services and Transport
	Date	June 13, 2016
	Venue	Ministry of Infrastructure, Port Services and Transport
	Attendants	Ms. Allison A. Jean, Permanent Secretary
4	Agency	Ministry of Infrastructure, Port Services and Transport
	Date	June 23, 2016
	Venue	Ministry of Infrastructure, Port Services and Transport
	Attendants	Mr. Albert John Baptiste, Chief Engineer Mr. Amos Hippolyte, Project Engineer

Source: JICA Survey Team

Table 1-44 Stakeholder meetings in the second field survey

1	Agency	Ministry of Infrastructure, Port Services and Transport
	Date	November 1, 2016
	Venue	Ministry of Infrastructure, Port Services and Transport
	Attendants	Mr. Amos Hippolyte, Project Engineer Ms. Donna Fletcher, Engineering Assistant
2	Agency	Land and Survey Division, Department of Physical Planning , Ministry of Agriculture, Fisheries, Physical Planning, Natural Resources and Co-operation
	Date	November 2, 2016
	Venue	Department of Physical Planning
	Attendants	Mr. John Labadie, Chief Surveyor
3	Agency	Development Control Authority, Department of Physical Planning , Ministry of Agriculture, Fisheries, Physical Planning, Natural Resources and Co-operation
	Date	November 2, 2016
	Venue	Department of Physical Planning
	Attendants	Ms. Joanna Reynolds Atherton, Permanent Secretary, Department of Physical Planning Mr. Hidreth Lewis, Deputy Permanent Secretary (in charge of DCA), Department of Physical Planning
4	Agency	Commissioner of Crown Lands, Crown Lands Section, Department of Physical Planning Ministry of Agriculture, Fisheries, Physical Planning, Natural Resources and Co-operation
	Date	November 2, 2016
	Venue	Crown Lands Commission
	Attendants	Ms. Vernella Charlemagne, Commissioner of Crown Lands

Source: JICA Survey Team

Table 1-45 Stakeholder meetings in the third field survey

1	Agency	Development Control Authority, Department of Physical Planning , Ministry of Agriculture, Fisheries, Physical Planning, Natural Resources and Co-operation
	Date	March 1, 2017
	Venue	Department of Physical Planning
	Attendants	Mr. Hidreth Lewis, Deputy Permanent Secretary (in charge of DCA), Department of Physical Planning
2	Agency	Ministry of Infrastructure, Ports, Energy and Labour
	Date	March 2, 2017
	Venue	Ministry of Infrastructure, Ports, Energy and Labour
	Attendants	Mr. Amos Hippolyte, Project Engineer

		Ms. Naomi Cherry, Assistant Engineer
3	Agency	Ministry of Infrastructure, Ports, Energy and Labour
	Date	March 3, 2017
	Venue	Ministry of Infrastructure, Ports, Energy and Labour
	Attendants	Hon. Mr. Stephenson King, Minister
4	Agency	Commissioner of Crown Lands, Crown Lands Section, Department of Physical Planning Ministry of Agriculture, Fisheries, Physical Planning, Natural Resources and Co-operation
	Date	March 4, 2017
	Venue	Coco Palm Hotel
	Attendants	Ms. Vernella Charlemagne, Commissioner of Crown Lands
5	Agency	Ministry of Infrastructure, Ports, Energy and Labour, Department of Physical Planning
	Date	March 6, 2017
	Venue	Ministry of Infrastructure, Ports, Energy and Labour
	Attendants	Mr. Amos Hippolyte, Project Engineer Ms. Naomi Cherry, Assistant Engineer Ms. Magdalene Henry-Fontenelle, Physical Planning Officer, Development Control Agency Mr. Luther R. Goddard, Deputy Cheif Surveyor
6	Agency	Department of Physical Planning, Ministry of Agriculture, Fisheries, Physical Planning, Natural Resources and Co-operation
	Date	March 7, 2017
	Venue	Department of Physical Planning
	Attendants	Mr. John Labadie, Chief Surveyor Mr. Luther R. Goddard, Deputy Cheif Surveyor

Source: JICA Survey Team

1-2-5-12 JICA Environmental Checklist

JICA Environmental Checklist for the Project is shown in Appendix 5-3-7.

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

(1) Necessity of the Project and Components under Japan's Grant

On the basis of the Application for Grant Aid from Japan – Flood Mitigation Works – Project for Reconstruction of Bridges in Cul-de-Sac Basin dated September 29, 2015 by the Government of Saint Lucia as well as the agreed items between the Government of Saint Lucia and the JICA delligation in the First Site Suvey from June 1 to July 4, 2016, the facilities to be developed under the undertakings by the Government of Japan is limited as follows:

1. Bridge Reconstruction
2. Approach Road Construction
3. River bank protection and riverbed protection around abutments and piers

The Project is targetting the smooth and stable traffics on the Cul-de-Sac bridge on West Coastal Road and Ferrand's and Ravine Poisson bridges on East Coastal Road.

The sites of specific bridges and approach roads are located in the flood plain. As the flood plain extends outwords the sites, the smooth and stable traffic would not be secured even though the Project facilities are completed.

This Preparatory Surveu deals with preparation of a conceptual plan of the river improvement works, which has been additionally requested by the Government of Saint Lucia in the First Site Survey time. An implementation of the facilities shown in the conceptual plan of the river improvement works are recommended as the undertakings of the Saint Lucia side in the future.

(2) Study on Project Scope

Effects and risks of the reconstruction of three bridges as per request from the Government of Saint Lucia are evaluated as summarized in Table 2-1 by implicating the surrounding development conditions.

Table 2-1 Present River Conditions in the Vicinity of Specific Bridge Sites and Effects of the Project

Specific Sites	Adjacent River Channel and Flooding Condition	Project Effects and Risks	Evaluation
Cul-de-Sac Bridge	As the river improvement works on the downstream side of this bridge has been completed, a new bridge can be effectively built by implicating the river improvement plan.	The existing bridge is located in a narrow section of the river, of which discharge capacity can be augmented through the bridge building works. Accordingly, effects of the Project is significantly high.	Good
Ferrand's Bridge	There is no river improvement plan both on downstream and upstream sides. Any river channel dredging and riverbund development have not been done, and the existing river channel	The existing structure is located at the narrow section of the river, which continues downwords up to the existing Cul-de-Sac Bridge. Significant effects are not expected even if a new bridge is	Not Recommended

	largely meanders. The narrow section of the river is regarded as the main cause of floods and inundation in the area.	built because of continuation of long distance of narrow river section. A new bridge construction without river improvement plan migh be in vain when the future river channel is realighned.	
Ravine Poisson Bridge	As the main river and tributary meet together just downstream of the existing bridge, water level is affected by the river confluence and severe damages from over-topping likely took place.	Taking into consideration that overtopping induced at the confluent of the main river and tributary, the bridge should be built by way of maintaining the adequate discharge capacity of the river. If to do so, the effects of the Project would be significantly high.	Good

Source: JICA Survey Team

JICA Survey Team examined the possible scope of the specific bridge combination scenarios as summarized in Table 2-2: viz. 1 bridge implementation case (Cul-de-Sac bridge only), 2 bridge implementation case (Cul-de-Sac and Ravine Poisson bridges) and 3 bridge implementation case (Cul-de-Sac, Ravine Poisson and Ferrand's bridges).

Table 2-2 Examination of 3 Implementation Senarios

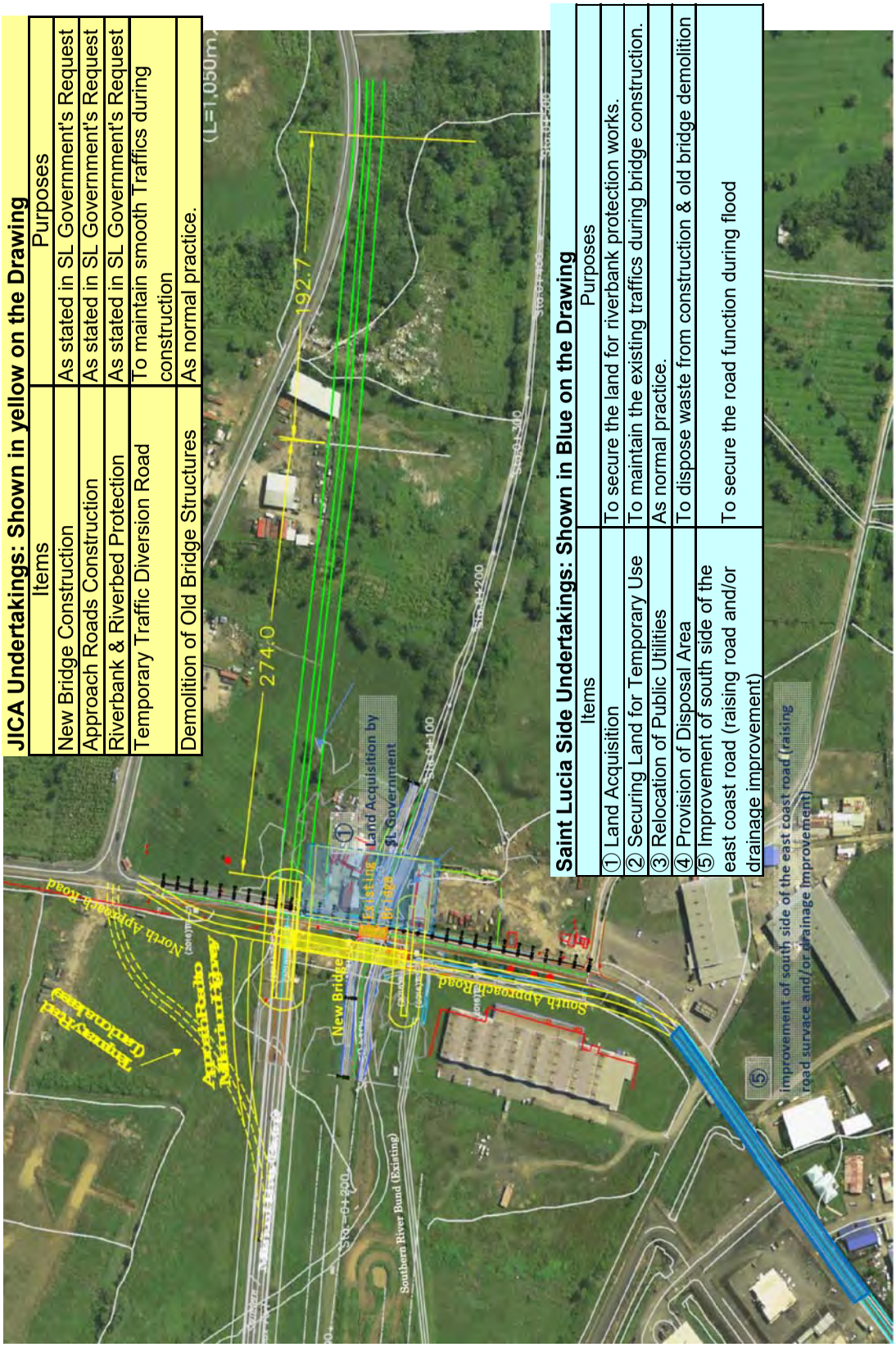
	Case 1	Case 2	Case 3
Implement Senarios	Specific Bridge：1 no. Cul-de-Sac Bridge	Specific Bridges：2 nos. Cul-de-Sac Bridge Ravine Poisson Bridge	Specific Bridges：3 nos. Cul-de-Sac Bridge Ravine Poisson Bridge Ferrand's Bridge
Implement Period	34 Months	34 Months	70 Months
Evaluation	As Cul-de-Sac Bridge is located at the intersection between East and West Coastal Roads, implementation of this bridge is very important and effects are significantly high.	In addition to Cul-de-Sac Bridge, the Saint Lucia side highly expects the early implementation of Ravine Poisson Bridge since the existing bridge structures has been already dilapidated and necessity of increasing the discharge capacity against the floods.	There is no river improvement plan both on downstream and upstream sides in about 1.5 km distance. As river improvement should be carried out in parallel with new Ferrand's Bridge construction, it is prerequisite to clear the fund procurement and land acquisition. Moreover, it is risky to proceed because new Ferrand's Bridge location along with geometric parameters cannot be established.
Overall Evaluation	Good	Excelent	Not Recommended

Source: JICA Survey Team

As a result, the implementation of the Project consists of 2 bridges, viz. Cul-de-Sac Bridge and Ravine Poisson Bridge.

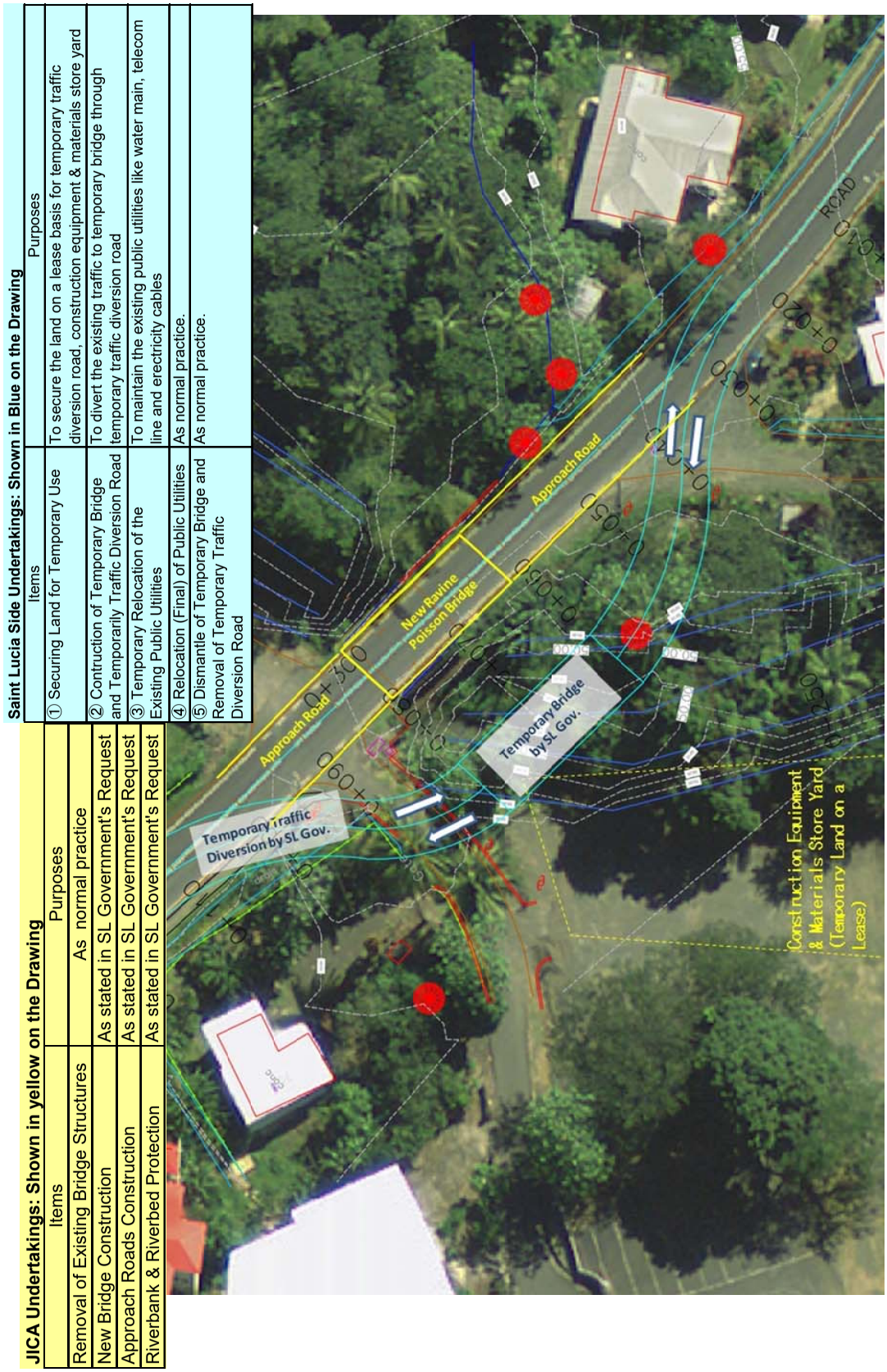
(3) Components of the Project and Undertakings by the Governments

JICA Survey Team prepared the layout plan and examines the undertakings by the Government of Japan and the Government of Saint Lucia as shown in Figure 2-1 and Figure 2-2.



Source: JICA Survey Team

Figure 2-1 Layout Plan of Cul-de-Sac Bridge



Source: JICA Survey Team

Figure 2-2 Layout Plan of Ravine Poisson Bridge

(4) Grades of Components under Japan's Grant

Bridges, aproach roads, riverbank protection and riverbed protection should be designed and constructed in accordance with the Japanese Standards. As for the seismic design, the horizontally equivalent force shall be based on the Saint Lucia standards.

Vertical clearance of the bridge should be between 50 year probability HWL and girder sofit. Required lane number should be based on the forecasted traffic volume for the 20 years after bridge completion.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Principles

- "SAINT LUCIA, MEDIUM TERM DEVELOPMENT STRATEGY, 2012～2016, SECTORAL ACTION PLAN" states that Bridge structures for major rivers are designed to accommodate a 1 in 50 year flood event, which is just same as the related stipulation in Japanese design specifications. Accordingly, the basic design on the bridge structures will be on the basis of return period of 50 years.
- Required lane number of bridge and approach road will be determined based on the traffic studies by the JICA Survey Team.
- The basic design on the riverbank & riverbed protection covers the minimal range to protect the bridge structures.

Development levels and design criteria of bridges are based on "Standards on River Control Structures adopted by Ministry of Land & Transport, Japan", of which gists are as follows:

Development Levels and Design Criteria

1. Bridges should be built to maintain the sofit elevation of DHWL + Vertical Clearance (allowance) or more in order to mitigate the damages by overtopping, debris collision in flood time.
2. To protect undermining of abutment foundation from scouring, river revetment works in its vicinity should be conducted so that the bridge would not be damaged by floods.
3. The design high water level should be determined taking into consideration the existing available flood data and hydrograhic data followed by verification with existing studies. The bridge should be so designed not to adversely affect the discharge volume.

※Explanatory Notes

The First Site Survey reveiled that many bridges and drainage in Saint Lucia have been built without due consideration of the basic requirements discussed above. It is very significant that Japanese technology regarding the flood control and disaster management would be transferred to Saint Lucia through execution of the Project.

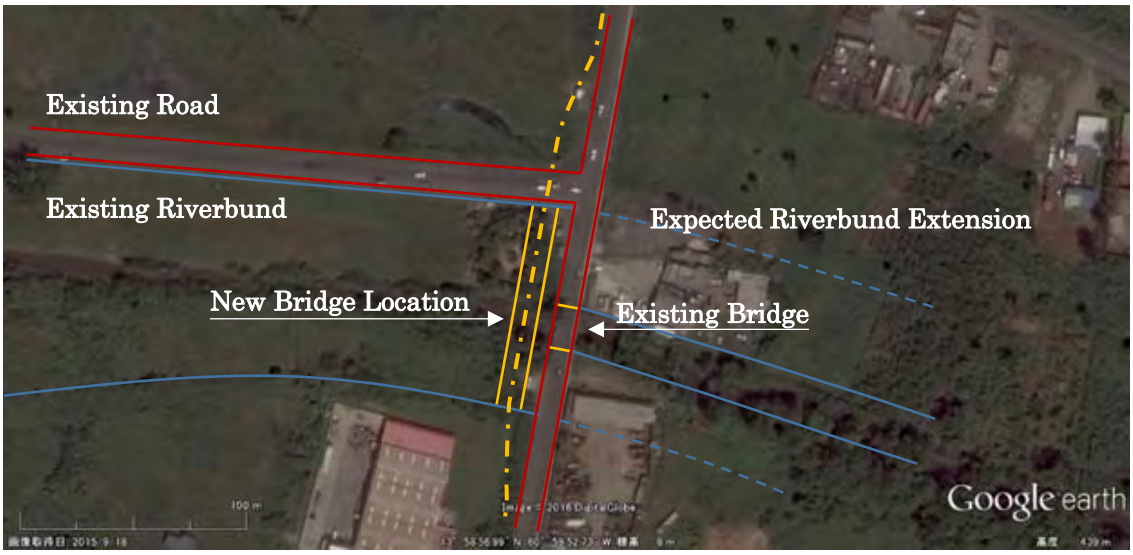
2-2-2 Basic Plan

2-2-2-1 New Bridge Locations

New bridge locations are discussed below taking into consideration the river revetment, relocation of existing public utilities, traffic diversion roads and temporary bridge during construction, land acquisition, resettlement, natural environment and social considerations and construction cost.

(1) Cul-de-Sac Bridge

In case that new bridge is built at the same location as existing one, temporary bridge and traffic diversion roads should be constructed, then being followed by demolishing of the existing bridge and removal of the adjacent buildings before the commencement of the new bridge construction. On the other hand, no residence and building exist on the downstream side of the existing bridge and ROW space is sufficient to accommodate new bridge and new approach roads. Accordingly, JICA Survey Team proposes to locate the new bridge on the downstream side and realign the approach roads.



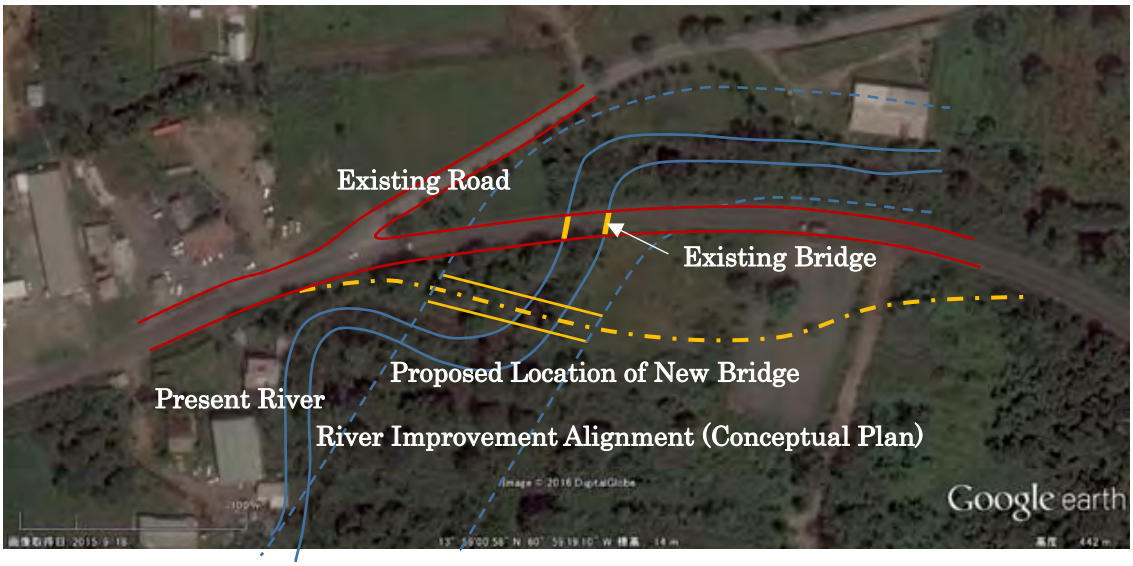
Source: JICA Survey Team

Figure 2-3 Location of New Cul-de-Sac Bridge

(2) Ferrand's Bridge

As with Cul-de-Sac Bridge, construction of temporary bridge and temporary traffic diversion roads as well as demolishing of the existing bridge structures and removal of adjacent houses are needed if new bridge is located just same as the existing one. On the upstream side of the existing bridge, the river channel runs in parallel with the existing road and therefore new bridge cannot be accommodated physically. On the other hand, the area on the downstream side is free to accommodate new bridge along with approach roads. Accordingly, JICA Survey Team proposes the

new bridge location on the downstream side.



Source: JICA Survey Team

Figure 2-4 Location of New Ferrand's Bridge

(3) Ravine Poisson Bridge

Since there are residencial houses and public utilities on both sides along the existing road, it is extremely difficult to acquire land and to solve resettlement issues for new alignment of the bridge. JICA Survey Team proposes to reconstruct a new bridge on the same alignment as existing one, in which case temporary bridge and temporary traffic diversion roads should be constructed by the Saint Lucia side undertakings prior to the commencementt of a new bridge construction.

Source: JICA Survey Team

Figure 2-5 Layout Plan of Ravine Poisson Bridge

2-2-2-2 Road Design Criteria

Road Design is based on AASHTO Geometric Design 2001*[2]. AASHTO standards is sometimes complicate in theoretically and Japanese Road Geometric Standards 2003 will be referred also.

Road Categories	The Project road is the primary trunk road connecting the capital of Castries and Hewannorra International Airport. It will be categorized to Arterial Highway or Rural Principal Arterial Road by ASSHTO. However, design factor of Rural Principal Arterial Road will be applied in this design*[3].	P5&P8
Design Vehicles	Small vehicles and Semitrailer (L16m, W2.5m) will be applied in the design based on the results of traffic survey at site.	
Design Traffic Volume and Design daily traffic volume	Current Traffic Volume of the target road is 8,735 per day (9,193 PCU per day) from the Results of traffic survey*[4]. Future Traffic Volume is 10,643 per day (10years after) and 13,054 per day (25 years after) as shown in Table 2-5.	
Vehicle lane	It should be minimum 3.0 m. Currently, 3.25 m width is applied as same as millennium road.	
Design Speed	Maximum design speed in the project area is assumed to be 80 km/h（50mph）. 60 km/hour is used in case of No3 class of No.3 categories of Japanese Standard	P67
Design Section	Design section in this project is the connection road between Millennium road & East coast road, and the approach roads to 3 bridges.	
	Future plan, future traffic volume, environmental conditions of surrounding area and future road maintenance policies should be considered based on the comments that will be given immediately from St Lucia side.	
Traffic Lane Number	Design traffic volume is defined to be 1500-1800 PCU/ hour/ lane, If level “C” (in stable traffic flow) will be applied among 6 level from A to F, and if peak hour factor (PHF) of 0.85 is applied for the calculation of Daily traffic volume (10 hours traffic volume), which is middle value of 0.75－0.95, daily traffic volume becomes 13,000～15,000 PCU per day. While, Table 2-5 “Estimated future traffic volume” of 2-2-2-2 “Traffic demand forecast” shows maximum traffic volume per day is 13000 in 2040. Therefore, one traffic lane for one direction will be enough.	P78 P84 P83
	One lane for one direction. Two lanes as the total	
Shoulder & sidewalk	Width of Traffic lane is 3.25m Shoulder 0.5m at bridge and road. (Although Minimum 0.6m by AASHTO） Sidewalk will be installed out of shoulder. Sidewalk is necessary by the two reasons: 1) 888 pedestrians were detected during the traffic survey hours (16 hours of week day) 2) Utilize the underground of sidewalk as the space for public utilities 2m width is defined as minimum by the Japanese road standard. No pavement on sidewalk for the time being.	P316－318 p330
Green zone	No installation in this project.	
Side drainage	No installation in this project.	P287, P327

[2] The right column of the table shows the pages to refer the relative clauses in AASHTO geometric standards.
[3] 3rd class of 3rd categories could be applied in case of Japanese Standard
[4] Table 2-3 of 2-2-2-1

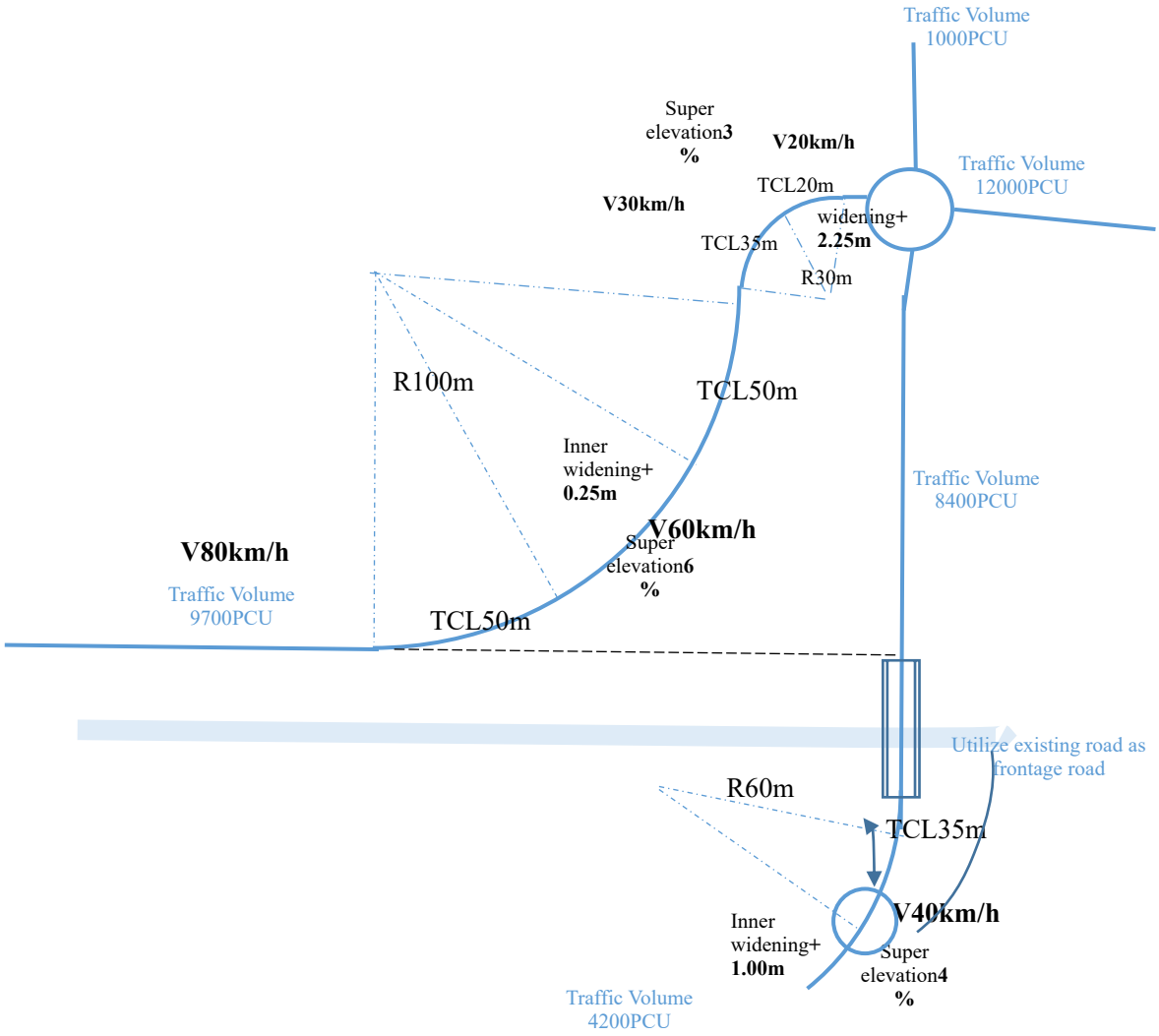
<table>
<tr><td>Parking lot</td><td>No installation in this project.</td><td></td></tr>
<tr><td>Curb section radius & the length</td><td>Allowable minimum radius by AASHTO is decided by design speed, super elevation%, allowable friction coefficient.
Rmin = $\frac{V^2}{127*(0.01e_{max}+f_{max})} = \frac{0.079\,V^2}{0.01e_{max}+f_{max}}$
Here:
V: Design Speed (km/h)
Emax: Maximum rate of super elevation
: decided between 4% and 12%
Fmax: Maximum allowable side friction factor
: It becomes small according to the increasing of speed.
0.10 to 0.16 will be applied normally.
This formula is very theoretical and difficult to apply.
Japanese standard is more practical as shown below:
<table>
<tr><th>Design speed (km/h)</th><th>Curve radius (m)</th><th>Minimum curve radius (m)</th></tr>
<tr><td>20</td><td>15</td><td></td></tr>
<tr><td>30</td><td>30</td><td></td></tr>
<tr><td>40</td><td>60</td><td>50</td></tr>
<tr><td>50</td><td>100</td><td>80</td></tr>
<tr><td>60</td><td>150</td><td>120</td></tr>
<tr><td>80</td><td>280</td><td>230</td></tr>
</table></td><td>P142、p144、p168、p179、p196, p198</td></tr>
<tr><td>Super elevation at curb section</td><td>Maximum super elevation by AASHTO is 10%, and 8% will be applied in this project road.
Super elevation adjustment in transition section will be designed after the agreement of principal design.</td><td>P141</td></tr>
<tr><td>Inner widening at curb section</td><td>Japanese standard defines the widening of lanes at curb section as shown below:(No3 class of No.3 categories)
<table>
<tr><th>Radius（m）</th><th>Widening（m）</th></tr>
<tr><td>90~160</td><td>0.25</td></tr>
<tr><td>60~90</td><td>0.50</td></tr>
<tr><td>45~60</td><td>0.75</td></tr>
<tr><td>32~45</td><td>1.00</td></tr>
<tr><td>26~32</td><td>1.25</td></tr>
<tr><td>21~26</td><td>1.50</td></tr>
<tr><td>19~21</td><td>1.75</td></tr>
<tr><td>16~19</td><td>2.00</td></tr>
<tr><td>15~16</td><td>2.25</td></tr>
</table>Adjustment at transition section is done proportionally</td><td>P213－226</td></tr>
<tr><td>Transition length</td><td>Tangent to Curve Transition
Length of Spiral Curb
Japanese standards define as follows:
<table>
<tr><th>Design speed (km/h)</th><th>Transition curve length (m)</th></tr>
<tr><td>20</td><td>20</td></tr>
<tr><td>30</td><td>25</td></tr>
<tr><td>40</td><td>35</td></tr>
<tr><td>50</td><td>40</td></tr>
<tr><td>60</td><td>50</td></tr>
<tr><td>80</td><td>70</td></tr>
</table></td><td>p169
p177</td></tr>
<tr><td>Sight distance</td><td>There is no special necessity about the longitudinal sight distance because the site is located in almost flat area. It might be necessary to consider the sight distance of plane in curb section, but no specific one for the time being.</td><td>P109
P131
P228 P270</td></tr>
</table>

<table>
<tr><td>Longitudinal gradient</td><td>AASHTO is shown in the pages of the right column.
5% gradient is defined as the maximum considering the vehicles condition/capacity in St Lucia.
Japanese standard shows as follows:
<table>
<tr><th>Design speed (km/h)</th><th>Longitudinal gradient (%)</th><th>Minimum gradient (%)</th></tr>
<tr><td>20</td><td>9</td><td>12</td></tr>
<tr><td>30</td><td>8</td><td>11</td></tr>
<tr><td>40</td><td>7</td><td>10</td></tr>
<tr><td>50</td><td>6</td><td>9</td></tr>
<tr><td>60</td><td>5</td><td>8</td></tr>
<tr><td>80</td><td>4</td><td>7</td></tr>
</table></td><td>P236　P239</td></tr>
<tr><td>Cross sectional gradient (Camber)</td><td>Cross sectional gradient is 2－6% in case of AASHTO
Japanese standards gradient is 1.5～2% at common highway.
2% gradient is applied in this project.</td><td>P310</td></tr>
<tr><td>Safety facilities</td><td>Road sign, road surface sign (Center line, side line etc.) are installed.
St Lucia side will instruct immediately to JICA team about the necessary quantity, specification and their location</td><td>P298</td></tr>
<tr><td>Installation space for public utilities</td><td>Underground space of sidewalk of both side of the road will be utilized.
Width of sidewalk is 2m for one side.
Sidewalk pavement will not be done by JICA side.</td><td></td></tr>
<tr><td>Intersection</td><td>Minimum radius at intersection is different according to the kind of vehicles. Necessary radius at the intersection is 13.7, 12.5, 1.3m for outer, center and inner respectively in case of WB-15 or WB-20 type (5 axle truck) from Table 2-2 of AASHTO.</td><td>P32~P34
P19</td></tr>
<tr><td></td><td>The largest truck in this project is trailer type truck with 6 axles. However, there is no specification for the truck turning trail, and 17m, 15m, 1.3m are decided as the design criteria for outer, center and inner radius respectively. The speed of the vehicle for the minimum turning radius is less than 10 mph (15 km/h).
The detailed design of the intersection will be conducted after the decision of the road alignment.</td><td>p18, P42</td></tr>
<tr><td>Design life</td><td>AASHTO says the design life is as follows:
<table>
<tr><td>ROW</td><td>100 years,</td></tr>
<tr><td>drainage facilities / base course</td><td>50 years,</td></tr>
<tr><td>bridge</td><td>25-100 years,</td></tr>
<tr><td>pavement</td><td>20-30 years</td></tr>
</table>The design life of this project is executed for road geometric design and pavement are 30 years and 20 years respectively.</td><td>P65</td></tr>
</table>

Source: JICA Survey Team

＜Design example of the road alignment＞

Outline design of the road alignment is shown below based on the design criteria explained above.

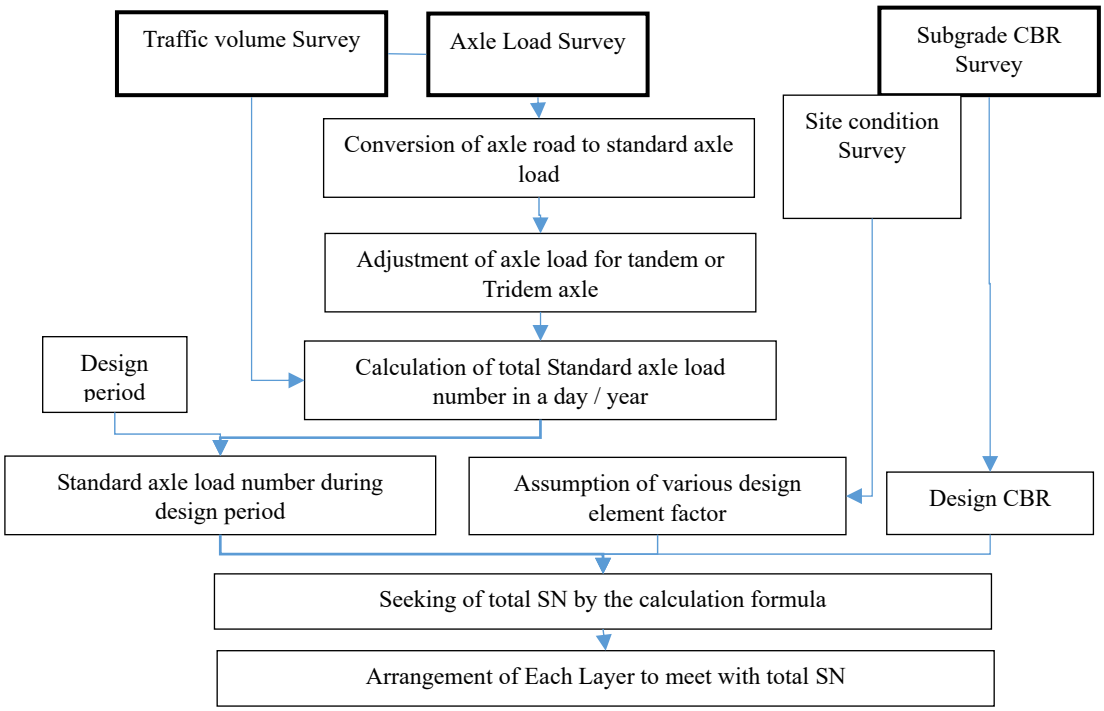


Source: JICA Survey Team

Figure 2-6 Proposed road alignment around Cul-De-Sac Bridge

＜Pavement structure design＞

Pavement structure design methods is done by the following procedures of AASHTO Pavement Design Guide1993:



The target vehicles for the pavement design is middle class or larger than that, and small vehicles may be ignored.

Axle load survey results is summarized in Table 2-4 Axle Load survey of 2-2-2-1 Traffic survey (7) axle load survey results as shown below:

Truck	(Sample No)	1st Axle	2nd Axle	3rd Axle	4th Axle	5th Axle	6th Axle	Total
2-Axle	69	3.1	3.9					7.0
3-Axle	15	8.0	9.0	8.7				25.8
4-Axle	8	7.6	7.3	5.4	6.0			26.4
5-Axle	4	7.8	10.2	12.9	12.7	12.0		55.7
6-Axle	1	8.6	11.2	10.7	8.4	13.6	12.6	65.0

Sample number of above table is around 11% of total truck.

The table below shows the ratio of each axle load against the 18 kips axle load. For example, 0.02 of the 1st axle of 2axle truck means the axle load numbers is only 2% of the one passing by the standard axle load of 18kips.

Truck	(Sample No)	1st Axle	2nd Axle	3rd Axle	4th Axle	5th Axle	6th Axle	Total
2-Axle	69	0.02	0.05					0.07
3-Axle	15	0.94	1.51	1.31				3.76
4-Axle	8	0.75	0.66	0.20	0.29			1.89
5-Axle	4	0.83	2.44	6.31	5.90	4.70		20.19
6-Axle	1	1.23	3.55	2.96	1.12	7.72	5.68	22.26

The axle load factor cells of the above Table, which are surrounded by bold line, shows the axles is placed in adducent each other. It is called tandem axle, or tridem axle in case of two axles or three axles. These axle arrangements were developed to reduce the load impact to the pavement, and several kinds of calculation methods have been proposed. One of them is shown in the Table D2 (for tandem) and Table D-3 (for tridem) in Appendix D "Conversion of Mixed Traffic to Equivalent Single Axle Loads" of AASHTO Pavement Design Guide1993. The below figure shows a part of Table D3. If three axle loads of 18kips is arranged as tridem, the theoretical total load of becomes 54kips. The line of 54 kips shows the same factor of 1.66 without relations of SN. It means the theoretical total of three axle load could be calculated to be 18kips x 1.66=29.88.

Appendix D *D-5*

Table D.3. Axle Load Equivalency Factors for Flexible Pavements, Triple Axles and p_t of 2.0

Axle Load (kips)	Pavement Structural Number (SN)					
	1	2	3	4	5	6
2	.0000	.0000	.0000	.0000	.0000	.0000
4	.0001	.0001	.0001	.0001	.0001	.0001
6	.0004	.0004	.0003	.0003	.0003	.0003
50	1.17	1.18	1.20	1.20	1.19	.987 1.18
52	1.40	1.40	1.42	1.42	1.41	1.40
54	1.66	1.66	1.66	1.66	1.66	1.66
56	1.95	1.95	1.93	1.93	1.94	1.94
58	2.29	2.27	2.24	2.23	2.25	2.27
86	13.9	13.5	12.5	11.8	11.9	12.5
88	15.5	15.0	13.8	13.0	13.2	13.8
90	17.2	16.6	15.3	14.3	14.5	15.2

In like manner, Table D2 shows 1.38 at the line of total load of 36kips. It means that total tandem axle load of 36kips could be calculated as 18kips x 1.38 = 24.84kips.

The axle load survey result in this time shows that each axle load is smaller than 18kips, and each neighbor axle load is not same. Therefore, the combination axle load is calculated to multiply the factors to the average load of each axle group. The example is shown in Table below:

	First Axle	Second Axle
Ratio to 18kips axle	2.44	6.31
average	(2.44+6.31)/2=4.375	
Multiply x 1.38	6.04	

The table below shows the calculation results based on the above methods:

Truck	(No)	1st Axle	2nd Axle	3rd Axle	4th Axle	5th Axle	6th Axle	Total	EVN
2-Axle	69	0.02	0.05					0.07	5
3-Axle	15	0.94	1.94					2.88	43

4-Axle	8	0.75	0.66	0.34				1.74	14
5-Axle	4	0.83	6.04		7.32			14.19	57
6-Axle	1	1.23	4.49		8.04			13.76	14
								total	133

EVN (Equivalent Vehicle Number) means the converted passing number of 18kips axle x Actual vehicle passing number from the survey results, and the bottom column in total shows the passing number of 18 kips axle load per day.

The sample rate is 11%. Therefore, estimated 18kips total axle number becomes 133/0.11＝1209 for both direction. One direction is around 1209*0.54=652. (Unbalance ratio of the traffic flow: 51～56%*[5])

Converted Axle load to 18kips passing numbers in a year 652 x 365＝**237.985**

In a 20 years **7,869,180** by the growth rate of 5%.

CBR is assumed to be 15 from the survey results table as shown below:

	TPC1	TPC2	TPC3	TPC4	TPR1	TPR2	TPR3	TPR4	TPF1	TPF2	TPF3	TPF4
CBR	15.8	15	20	29	50	34	22	19	4	15	18	18

Geological Survey Report (p10) by AMARNA on Oct 5, 2016

AASHTO formula to seek SN is as follows. The calculation results is SN=3.0.

$$\mathrm{Log}_{10}(W_{18}) = Z_R * S_0 + 9.36 * \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10}(M_R) - 8.07$$

Here following conditions are supposed :

W18　18kips converted number　**7,869,180**

Zr　Standard Deviation 1.282 in case of reliability of 90%

S0 standard deviation on forecasting traffic volume　0.42

ΔPSI (difference of performance index)　2.5　(initial 5 and terminal value is 2.5)

Mr (resilient factor of subgrade)　1500*CBR=22500

[5] Table 2-3 Outline of Traffic Survey Results in （6） Summary of the Traffic Survey

Following is the checking calculation by **Japanese standard**:

Truck	(No)	1st Axle	2nd Axle	3rd Axle	4th Axle	5th Axle	6th Axle	Total	EVN
2-Axle	69	0.01	0.02					0.03	2.3
3-Axle	15	0.42	0.86					1.28	19.2
4-Axle	8	0.33	0.29	0.15				0.77	6.2
5-Axle	4	0.37	2.68		3.24			6.29	25.2
6-Axle	1	0.55	1.99		3.56			6.10	6.1
								total	59
				20year	3,488,913	yearly	105,514	day	289

Standard axle load is 10ton, therefore total passing axle numbers are different from AASHTO.

Japanese pavement calculation Formula is simple as shown below:

Japanese $Ta = 3.84 * N^{0.16} / CBR^{0.3}$

$= 3.84 * (3{,}488{,}913)^{0.16} / (15)^{0.3} = 19.0$ ㎝ (SN=3.0)

Note 1：CBR 15 will be treated as 12 usually considering allowance in case of Japanese standard, but used CBR 15 for the comparison.

Note 2：Ta correspond to SN*2.54/0.4 roughly

Pavement structure will be as follows in case of SN2.6

	Alternative 1			Alternative 2[6]		
	material	thickness	SN	material	thickness	SN
Surface	AC	2”	0.84	AC	2”	0.84
Binder	AC	3”	1.2	AC	3”	1.2
Base course	GAA CBR>80	4”	0.56	GAA CBR>80	4”	0.56
Subbase	C/R CBR>20	5.5”	0.44	C/R CBR>40	4.5”	0.45
Total		14.5”	3.04		13.5”	3.05
AC: Hot Mixed Asphalt Concrete (Stability>350kg) GAA: Grading Adjusted Aggregate for Base course (CBR>80) C/R: Crusher Run aggregate for subbase course						

[6] If good subbase course material (CBR>40) is available

If applied CBR is changed, necessary SN and the pavement structure will be changed as follows

CBR	15		12		8		6		4	
	inch	SN	inch	SN	inch	SN	inch	SN	inch	SN
Surface	2	0.84	2	0.84	2	0.84	2	0.84	3	1.26
Binder	3	1.2	3	1.2	3	1.2	4	1.6	4	1.6
Base C	4	0.56	5	0.7	7	0.98	7	0.98	7	0.98
Subbase	5.5	0.44	6	0.48	9	0.72	8	0.64	10	0.8
Total	14.5	3.04	16	3.22	17.5	3.74	19	4.06	22	4.64

Reference

SN of each pavement materials are summarized as follows:

		Condition	Structural Co.	Ta Co
Surface & Binder	Hot mixed asphalt		0.44~0.30	1.0
Base	Hot Bituminous Stabilization	Stability>350kg	0.32	0.80
	Cold bituminous stabilization	Stability>250kg	0.22	0.55
	Cement stabilization	UCS(7days) 30kgf/cm2	0.22	0.55
	Lime stabilization	UCS(10days) 10kgf	0.18	0.45
	Mechanical stabilization	Modified CBR>80	0.14	0.35
	Slag stabilization	Ditto UCS(14days) 12kgf	0.14	0.35
Subbase	Crusher run Slag, Sand etc	Modified CBR>30 Ditto 20~30	0.1 0.08	0.25 0.20
	Cement stabilization	UCS(7days) 10kgf/cm2	0.1	0.25
	Lime stabilization	UCS(10days) 7kgf	0.1	0.25

Source: Prepared by JICA Team based on Japanese Pavement Manual 1989 and AASHTO Pavement design 1993

2-2-2-3 Bridge Design Criteria

(1) Design Standards

The design is carried out basically based on the Japanese standards (bridge and road) under the agreement with Ministry of Infrastracture as shown in Table 2-3

Table 2-3 Standards appried in the design

Item	Design Conditions			Remarks
Scope of the Project	Reconstruction of new bridges and access roads			
	Bridge	Length	(under study)	
		Type		
Name of the Bridge	Cul De Sac Bridge, Ferrands Bridge, Ravine Poisson Bridge			
Design Standard	Specifications for Highway Bridge (JSHB) 2012 (Japan Road Association), Road Design Standards 2004 (JRA), Seismic Coefficient (Cs): the Seismic Research Centre at UWI, Trinidad and Tobago and the European Centre for Training and Research in Earthquake Engineering - EUCENTRE – Pavia, Italy.			

Source: JICA Survey Team

(2) Design criteria

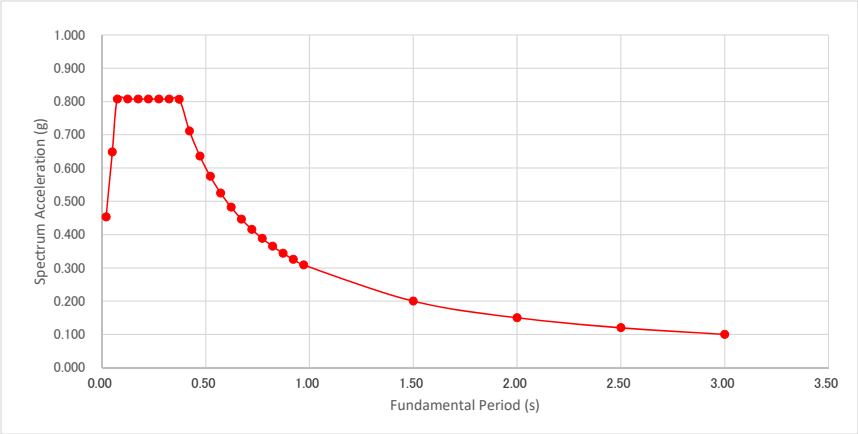
The design criteria is summarized in Table 2-4.

Table 2-4 Design Criteria

<table>
<tr><th>Item</th><th>Design Conditions</th><th>Remarks</th></tr>
<tr><td>Pavement</td><td>Asphalt concrete
Carriageway t=80mm , Pedestrian t=40mm</td><td></td></tr>
<tr><td>Wheel guard</td><td>Carriageway h=200mm
Pedestrian w=400mm, h=100mm</td><td></td></tr>
<tr><td>Railing</td><td>Pedestrian h=1100mm, W=0.5kN/m (design weight)</td><td></td></tr>
<tr><td>Design Load</td><td>1) Dead Load (unit: kN/m3)
<table>
<tr><th>Material</th><th>Unit Weight</th></tr>
<tr><td>Reinforced Concrete</td><td>24.5</td></tr>
<tr><td>Prestressed Concrete</td><td>24.5</td></tr>
<tr><td>Concrete</td><td>23.0</td></tr>
<tr><td>Asphalt Pavement</td><td>22.5</td></tr>
<tr><td>Construction Steel</td><td>77.0</td></tr>
<tr><td>Casting Iron</td><td>71.0</td></tr>
</table>
2) Live Load
JSHB Live Load Type-B</td><td>Note 1</td></tr>
<tr><td>Design Temperature</td><td>10°C - 50°C (rise of 20°C, fall of 20°C)</td><td></td></tr>
</table>

Note 1: Comparison of both live loading, JSHB B-Type loading is slightly heavier than AASHTO HS20-44 loading.

Then we apply the JSHB B-type loading for live loading of bridge.

<table>
<tr><th>Item</th><th>Design conditions</th><th>Remarks</th></tr>
<tr><td>Acceleration</td><td>Ss=1.100g for 0.2s, S1=0.375g for 1.0s</td><td>Note 2</td></tr>
<tr><td>Spectrum Acceleration</td><td> 
</td><td></td></tr>
<tr><td>Design Horizontal Seismic Coefficient</td><td>Cs=0.10 (peak value of Class D, stiff soil profile)</td><td></td></tr>
<tr><td>Performance Level</td><td>Stress shall not be exceed the allowable stress in seismic design (all the members are in the elastic area).</td><td></td></tr>
</table>

Note 2: Seismological Society of America within a joint collaboration project between the Seismic Research Centre at UWI, Trinidad and Tobago and the European Centre for Training and Research in Earthquake Engineering -EUCENTRE – Pavia, Italy.

Source: JICA Survey Team

(3) Design policy

The bridge location and the structural type which are determined in the survey are summarized below;

1) Bridge Locations

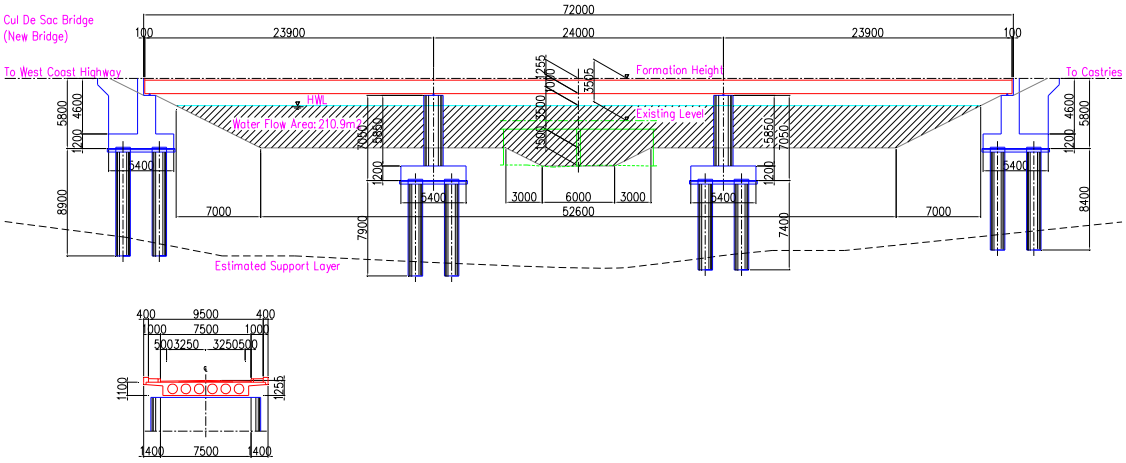
As shown in 2-2-2 Basic Plan

New Bridge Locations, New Cul-De-Sac bridge is planned on the new alignment, understream side of the existing bridge and New Ravine Poisson bridge on the same as the existing bridge.

2) Bridge planning

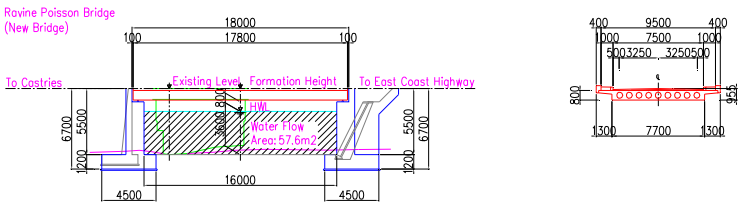
New Cul-De-Sac bridge can be planned as the bridge of which length is 80m in order to secure necessary flow area at the section, and 3 spans arrangement is more suitable than 2 not to disturb flow of low water channel. Thus the bridge with 3 spans, 80m length is planned as the new in the survey, so that the span length can be determined about 23m to 27m.

New Ravine Poisson bridge can be planned as the bridge of which length is about 20m and have single span.



Source: JICA Survey Team

Figure 2-7 Draft plan of New Cul-De-Sac Bridge



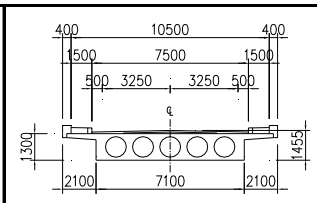
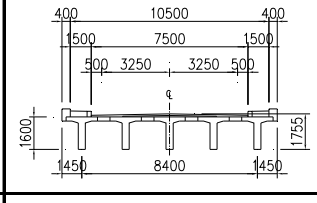
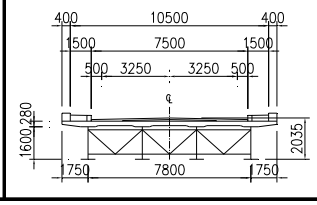
Source: JICA Survey Team

Figure 2-8 Draft plan of New Ravine Poisson Bridge

3) Structural Type

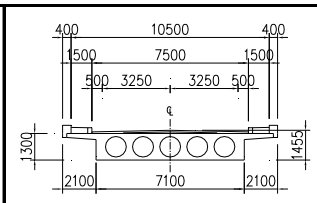
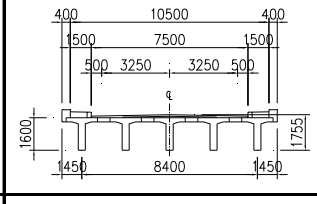
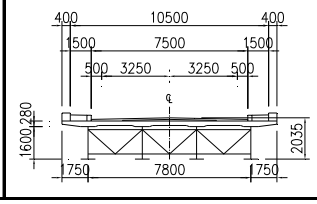
Comparison table for the selection of structural type is prepared based on the bridge planning from aspects of economical, construction easiness and some other issues. The evaluation results are summarized in Table 2-5 and Table 2-6. The hollow slab can be adapted as type of the superstructure in this project.

Table 2-5 Comparison table for structural type of New Cul-De-Sac bridge

Cross Section		Economical		Comments		Evaluation	
Opt. A: PC Hollow Slab		Most economical option by falsework method without large crane. Length of access road is short because low girder height		Structural	High stability for 3 span continuous structure.	8/10	Recommend
				Construction	Simple erection by falsework method. It is a prerequisite erection in dry season. Construction period is in about 24	16/20	Total
		Ratio	Evaluation	Environment	No major impacts.	4/5	90/100
		1.000	50/50	Maintenance	Minimum maintenance work.	12/15	
Opt. B: PC T Girder		Procurement cost of large crane for main girder erection is higher. Length of access road is longer than Option A.		Structural	Excellent running performance for the consolidated structure.	7/10	Good
				Construction	Large crane erection by both side. Possible to work even in rainy and dry season. Construction period is in about 20 months.	14/20	Total
		Ratio	Evaluation	Environment	No major impacts.	4/5	83/100
		1.080	46/50	Maintenance	Minimum maintenance work.	12/15	
Opt. C: Steel I Girder		It is the most expensive option by material cost of steel girder. Length of access road is longer than Option A.		Structural	High stability for 3 span continuous structure and light weight girder.	9/10	Not Recommend
				Construction	Crane erection by both side. Possible to work even in rainy and dry season. Construction period is in about 20 months.	18/20	Total
		Ratio	Evaluation	Environment	No major impacts.	4/5	74/100
		1.350	33/50	Maintenance	Requiring repainting regularly.	10/15	

Source: JICA Survey Team

Table 2-6 Comparison table for structural type of New Ravin Poisson bridge

Cross Section		Economical		Comments		Evaluation	
Opt. A: PC Hollow Slab		Most economical option by falsework method without large crane. Length of access road is short because low girder height		Structural	High stability for 3 span continuous structure.	8/10	Recommend
				Construction	Simple erection by falsework method. It is a prerequisite erection in dry season. Construction period is in about 24	16/20	Total
		Ratio	Evaluation	Environment	No major impacts.	4/5	90/100
		1.000	50/50	Maintenance	Minimum maintenance work.	12/15	
Opt. B: PC T Girder		Procurement cost of large crane for main girder erection is higher. Length of access road is longer than Option A.		Structural	Excellent running performance for the consolidated structure.	7/10	Good
				Construction	Large crane erection by both side. Possible to work even in rainy and dry season. Construction period is in about 20 months.	14/20	Total
		Ratio	Evaluation	Environment	No major impacts.	4/5	83/100
		1.080	46/50	Maintenance	Minimum maintenance work.	12/15	
Opt. C: Steel I Girder		It is the most expensive option by material cost of steel girder. Length of access road is longer than Option A.		Structural	High stability for 3 span continuous structure and light weight girder.	9/10	Not Recommend
				Construction	Crane erection by both side. Possible to work even in rainy and dry season. Construction period is in about 20 months.	18/20	Total
		Ratio	Evaluation	Environment	No major impacts.	4/5	74/100
		1.350	33/50	Maintenance	Requiring repainting regularly.	10/15	

Source: JICA Survey Team

2-2-2-4 Design of River Bank Protection

(1) Basic Layout

1) Ravine Poisson Bridge

Because of existing road alignment and site conditions, the bridge replacement will be done at the same location. Riverbank protection is designed based on the said design discharge.

Particularly in the upstream of the bridge, the river alignment is turned by around 90 degree. This makes water level high and velocity fast at outer of the river bend. It is necessary to design more durable bank protection there. In addition, at the confluence with the tributary, turbulence flow would be occurred, the river bank protection area shall be extended considering this condition.

2) Ferrand's Bridge

Ferrand's Bridge is planned to be relocated to immediately downstream of the existing bridge.

River section is designed based on the premise of connection to the downstream improved river section. In addition, the river channel at bridge site is located at bend section as same as the Ravine Poisson Bridge. It is necessary for the design to consider the river alignment at water impact points and installation of durable river bank protection.

3) Cul de Sac Bridge

Cul de Sac Bridge is planned to be relocated to immediately downstream of the existing bridge.

River section is designed to keep a cross section as same as the downstream improved river section.

(2) Type of River Bank Protection Works

1) Extent of river bank protection works

River bank protection works shall be installed in the area to satisfy hydraulic requirement for protecting the river bank adjacent to the bridge structures. The river bank protection works is provided both for upstream and downstream of the bridge in 15 m in length from the bridge abutment. In addition, transition of bank protection works from the design section to the existing river channel is provided for a required length considering the design section and site topographic conditions.

2) River bed materials and geological conditions

Based on the results of the geological survey for the proposed bridge site, riverbed materials and geological condition at the foundation of the river bank protection works and bridge substructures is classified as below:

Table 2-7 Riverbed Materials and Geological Conditions at Proposed Bridge Sites

Bridge	Riverbed Material	Geological Condition
Cul de Sac Bridge, Ferrand's Bridge	silt, clay and fine sand	Level of foundation rock (approx. 30 m deep from existing ground level)
Ravine Poisson Bridge	sand and gravel, cobble	Outcrops of basalt layer

Source: JICA Survey Team

Since the outcrop of the hard basalt layer is found in river channel in the Ravine Poisson Bridge, local scouring around the bridge abutment and piers would be slight and not affect the bridge substructure. For the Cul de Sac Bridge and Ferrand's Bridge, river bed materials are composed with fin sand and silt, therefore, the design depth of the local scouring is considered as 1.0 m referring to the longitudinal profile of the existing river channel.

3) Design velocity

Table below shows the design velocity at each bridge site. The design velocity is set based on the computed velocity by the non-uniform flow analysis with consideration of some increases due to curve bend and scouring depth of the river channel.

Table 2-8 Design Velocity at Proposed Bridge Sites

Item	Ravine Poisson Bridge	Ferrand's Bridge	Cul de Sac Bridge
Computed velocity	4.47 m/s	3.85 m/s	2.26 m/s
River width (at channel bottom)	16 m	42 m	64 m
Radius of curve bend	R=30m	R=30m	0 m
Design scouring depth	0.0m	1.0 m	1.0 m
Rate of increase (outer)	1.200	1.178	1.083
(inner)	1.200	1.100	1.083
Design Velocity (outer)	5.4 m/s	4.6 m/s	3.6 m/s
(inner)	5.4 m/s	4.3 m/s	3.6 m/s

Source：JICA Survey Team

4) Comparison of type of river bank protection

Comparison study is conducted to select appropriate type of the river bank protection taking into account the river channel alignment, design cross section and design velocity.

(a) Cul de Sac Bridge

Side slope of low water channel : 1:2.0

Side slope of high water channel : 1:2.0

Design Velocity : 3.6 m/s

Channel alignment : straight

As a river bank protection which can be applied on the above conditions, three (3) types of bank protections i.e. gabion, stone pitching and wet masonry are selected for the comparison study.

As the result of the comparison, the stone pitching is proposed for the appropriate bank protection for the low water channel considering the advantage on future maintenance works because it is installed below the normal water level and to be affected by salinity water intrusion due to tidal effect.

For the high water channel, the wet masonry is recommended because of the requirement of durability as a bridge abutment protection and abundant experiences of construction in St.Lucia.

(b) Ferrand's Bridge

Side slope of low water channel	: 1:2.0
Side slope of high water channel	: 1:2.0
Design Velocity	: 4.3- 4.6 m/s
Channel alignment	: bend

Because of the similarity on the hydraulic conditions and river cross section with the Cul de Sac Bridge, same type of river bank protections are proposed as the stone pitching for the low water channel and the wet masonry for the high water channel. In particular, the design velocity is faster than the Cul de Sac section due to the bend section, proposed bank protection is designed to secure required stability against shear force of the design flow.

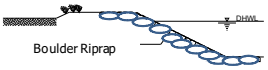
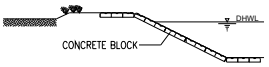
(c) Ravine Poisson Bridge

Side slope of channel	: 1:0.5
Design Velocity	: 5.5 m/s
Channel alignment	: bend

The design velocity at the Ravine Poisson Bridge section is faster than 5.0 m/s, and river bank slope is steep due to its topographic condition. As a river bank protection which can be applied on the above conditions, three (3) types of bank protections i.e. stone pitching, wet masonry and concrete retaining wall are selected for the comparison study.

As the result of the comparison, the concrete retaining wall is proposed for the appropriate bank protection considering the advantage on durability against collision of faster flow velocity and rolling stones over the river bed. For the transition between the bridge bank protection and the existing channel, stone pitching is adopted because of flexibility of deformation and advantage of maintenance.

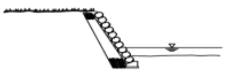
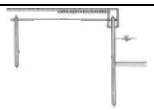
Table 2-9 Comparison of Flexible Type of River Bank Protection (Bag, Gabion, Block)

Type	(A-1) Boulder Riprap	(A-2) Gabion Mattress	(A-3) Concrete Block
Photo			
Illustration of section			
Allowable Design Velocity (Va) and Structure stability	Va < 5.0 m/s -6.5m/s -stable against design velocity	Va < 5.0 m/s -6.5m/s -stable against design velocity -weakness of wire against salinity water and rolling stones	Va > 5.0 m/s -most stable structure among the alternatives
	○	△	◎
Construction	- relatively longer construction works - required skilled labor	- relatively longer construction works - required skilled labor	- relatively faster construction works due to utilize of precast blocks
	○	○	◎
Maintenance/Rehabilitation	- easiness of maintenance/ rehabilitation under water - ample construction experiences in St.Lucia	- weakness against suction of bed soils under the protection - ample construction experiences in St.Lucia	- few construction experience in St.Lucia
	◎	○	△
Cost	- relatively lower construction cost due to usage of local sourced materials	- relatively lower construction cost due to usage of local sourced materials	- most expensive among the alternatives - weakness against suction of bed soils under the protection
	○	○	△

Note: Symbols in the table means; ◎: Better, ○:Good, △Fair

Source: JIAC Study Team

Table 2-10 Comparison of Fixed Type of River Bank Protection (Wet Masonry, Concrete Wall, Sheet Pile)

Type	(B-1) Wet Masonry	(B-2) Concrete Wall	(B-3) Sheet Pile
Photo			
Illustration of section			
Allowable Design Velocity (Va) and Structure stability	Va > 5.0 m/s -high durability against erosion	Va > 5.0 m/s -high durability against erosion	Va > 5.0 m/s - high durability against erosion - high durability against local scouring
	○	○	◎
Construction	- relatively longer construction works - required skilled labor and dewatering for foundation works	- relatively longer construction works - required skilled labor and dewatering for foundation works	- faster construction works because of no need of dewatering
	○	○	◎
Maintenance/Rehabilitation	- ample construction experiences for bank protection in St.Lucia	- ample construction experiences for bank protection in St.Lucia	- easiness of maintenance/ rehabilitation under water
	○	○	◎
Cost	- relatively lower construction cost due to usage of local sourced materials	- relatively lower construction cost due to usage of local sourced materials	- most expensive among the alternatives
	◎	○	△

Note: Symbols in the table means; ◎: Better, ○:Good, △Fair

Source: JIAC Study Team

(3) Summary of Design of Bank Protection at Bridge

The table below shows the summary of the plan for river bank protection works at the objective bridges.

Table 2-11 Plan for River Bank Protection Works at Each Bridge

Item	Ravine Poisson Bridge	Ferrand's Bridge	Cul de Sac Bridge
Design Discharge	143m^3/s	640m^3/s	720m^3/s
Design Longitudinal Profile	1/60	1/400	1/400
Design River Width	16.0m	60.0m	80.0m
Design Side Slope	1:0.5	1:2.0	1:2.0
Roughness Parameter	n=0.045	n=0.030	n=0.030
Design Riverbed Level	AMSL +48.00m	AMSL +2.50m	AMSL +0.00m
Design Highwater Bed Level	-	AMSL +5.50m	AMSL +3.00m
Design Water Level	AMSL +51.20m	AMSL +9.90m	AMSL +6.00m
Freeboard	0.80 m	1.00 m	1.00 m
Design Velocity	3.0-5.5 m/s	4.3-4.6 m/s	2.5-3.6m/s
Type of Bank Protection			
for low water channel	Concrete retaining wall	Boulder riprap	Boulder riprap
for high water channel	-	Wet masonry	Wet masonry
Highwater bed protection	-	Gabion	Gabion
Slope of Embankment (Land Side)	Sodding	Sodding	Sodding

Source: JIAC Study Team

2-2-2-5 Design of Draiange Facility

(1) Basic Approach for Design of Drainage Facility

The design of drainage facility for the riverbank protection works is prepared for the following two facilities:

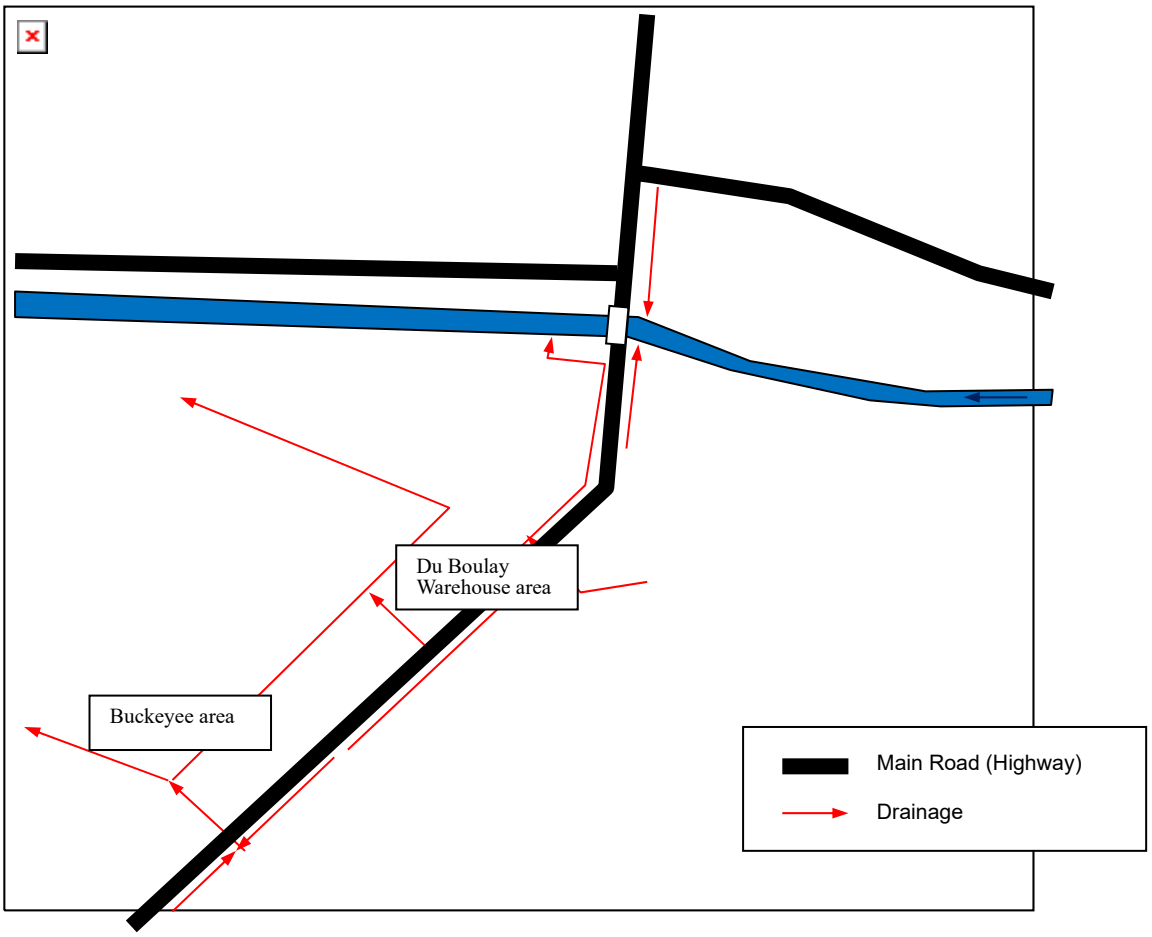
i) Outlet of local drainage canal joining at the downstream left bank of the Cul de Sac Bridge

ii) Outlet of the tributary joining at the downstream right bank of the Ravine Poisson Bridge

(2) Cul de Sac Bridge Site

1) Objective facility

At present, there are three (3) drainage outlets connecting to the Cul de Sac Bridge as shown in figure below. The biggest one is a outlet of local drainage canal joining at the downstream left bank of the bridge. In this study, the design is prepared for this structure. For other two (2) drainage outlets installed at the upstream of the bridge, they are designed together with the design for approach road of the bridge because they are small gutter for local road drainage,



Source: JIAC Study Team

Figure 2-9 Existing Draiange System in Surrounding Area of Cul de Sac Bridge

2) Site conditions of existing drainage outlet

- Existing drainage canal is constructed along the bridge approach road (West Coast Highway).
- The canal is unlined gutter with a trapezoid cross section about 3m in bed width and about 1.5m in height.
- The outlet of the canal is connected to about 10 m downstream of the existing bridge.
- The drainage canal bundles local drainage system in the left bank of the bridge collecting road drainage and local run-off of rainwater from the ruminant catchment.
- In 1998, in association with the flood bund construction a basic study was conducted for a local drainage from the private property (Du Boulay Warehouse Area) adjacent to the bridge. It deems that existing drainage outlet was designed referring to the part of this study.

3) Layout of proposed drainage facility

The existing drainage canal and outlet shall be relocated in connection with

reconstruction of the Cul de Sac Bridge and the approach road. Alignment of the canal is designed along the new approach road and the extent of new canal is installed up to the end of road construction area at which the upstream end of the canal is connecting to the existing canal.

The outlet of the canal is relocated to around 5 m downstream of the new bank protection for the high water channel of the bridge.

4) Design conditions of drainage facility

(a) Design Scale

There is no definite standard and criteria for design scale of drainage facility in St.Lucia. In this study, taking into consideration the size of existing drainage facility and relating drainage study in the past, 10 year probable rainfall is adopted as the design scale of the drainage facility.

(b) Design bed level and design bed slope of drainage canal

The bed level of the drainage outlet is set at 1.5m above of the design riverbed level in order to avoid adverse impacts of riverbed fluctuation, sediment inflow and back water of the mainstream. The design bed slope is adopted at 1/400 considering the existing topographic condition.

(c) Lining

In association with the design of river bank protection of the bridge, the drainage canal and outlet is provided a lining with reinforced concrete.

(d) Flow capacity and freeboard

The flow section of the drainage facility in the Cul de Sac Bridge is designed referring to the design criteria of the road drainage canal. Taking into account mixing of sediment in flow and sediment deposits in the canal, the designed flow section shall be designed to have a required capacity for the design discharge including an increase of 20% considering the required freeboard. The cross section of the canal is applied U-type to reduce the land acquisition area.

Based on the results of hydraulic analysis, the design of the drainage canal is prepared as shown in table below:

Table 2-12 Design of Drainage Facility at Left Downstream of Cul de Sac Bridge

Item	Design	Remarks
Cross Sectional Shape	U-type	

Bed width	1.00 m	
Height	1.00m	
Design discharge	1.0m^3/s	10 year flood (including 20%of increase)
Bed slope	1/400	Exiting topographic conditions
Roughness parameter	n=0.015	RC lining

Source: JICA Survey Team

(3) Ravine Poisson Bridge Site

1) Objective facility

There is no drainage facility in the Ravine Poisson Bridge, but a tributary joins from right bank immediately downstream of the bridge. The structural design is provided for the outlet of the tributary in connection with the reconstruction of the Ravine Poisson Bridge

2) Site conditions of existing outlet of the tributary

- The tributary is a natural river channel without any river improvements and river bank protections.
- At the outlet of the tributary, the right abutment wall of the bridge is utilized as a part of the channel sidewall of the tributary.
- The outcrops of rocks are appeared on the riverbed, no significant local scouring and damages on the existing structure is observed.
- Because of the presences of a confluence at immediately downstream as well as a narrow bridge section, the flood water level in the upstream of the bridge is increased.

3) Layout of proposed drainage facility

The location of new outlet of the tributary is set at 5 m downstream of new bridge abutment. From the view of structural stability, the new outlet is designed separated from the abutment structure so that each structure can secure required stability independently.

The extent of the new outlet is designed about 15 m long covering the required area for the construction of bridge and river bank protection. The upstream end of the outlet is connecting to the existing channel.

In addition, to protect river bank from turbulence flow at the confluence, the river bank protection works are provided in and opposite bank of the outlet.

4) Design conditions of drainage facility

(a) Design Scale

10 year probable rainfall is adopted as the design scale of the drainage facility as same as that of the

Cul de Sac.

(b) Design bed level and design bed slope of drainage canal

The bed level of the drainage outlet is set at 1.5m above of the design riverbed level. The design bed slope is adopted at 1/30 considering the existing topographic condition.

(c) Lining

In association with the design of river bank protection of the bridge, the drainage canal and outlet is provided a lining with reinforced concrete.

(d) Flow capacity and freeboard

The flow section of the drainage facility in the Ravine Poisson Bridge is designed referring to the design criteria of the river canal. The designed flow section shall be designed to have a required capacity taking into account mixing of sediment in flow of 10% and required freeboard (>0.6 m) . The cross section of the canal is applied trapezoid.

Based on the results of hydraulic analysis, the design of the drainage canal is prepared as shown in table below:

Table 2-13 Design of Drainage Facility at Left Downstream of Ravine Poisson Bridge

Item	Design	Remarks
Cross Sectional Shape	Trapezoid	
Bed width	2.00m	
Height	2.00m	Including 0.6m freeboard
Side slope	1:0.5	
Design discharge	22m^3/s	10 year flood (including of sediment mixing)
Bed slope	1/30	Exiting topographic conditions
Roughness parameter	N=0.025	RC lining

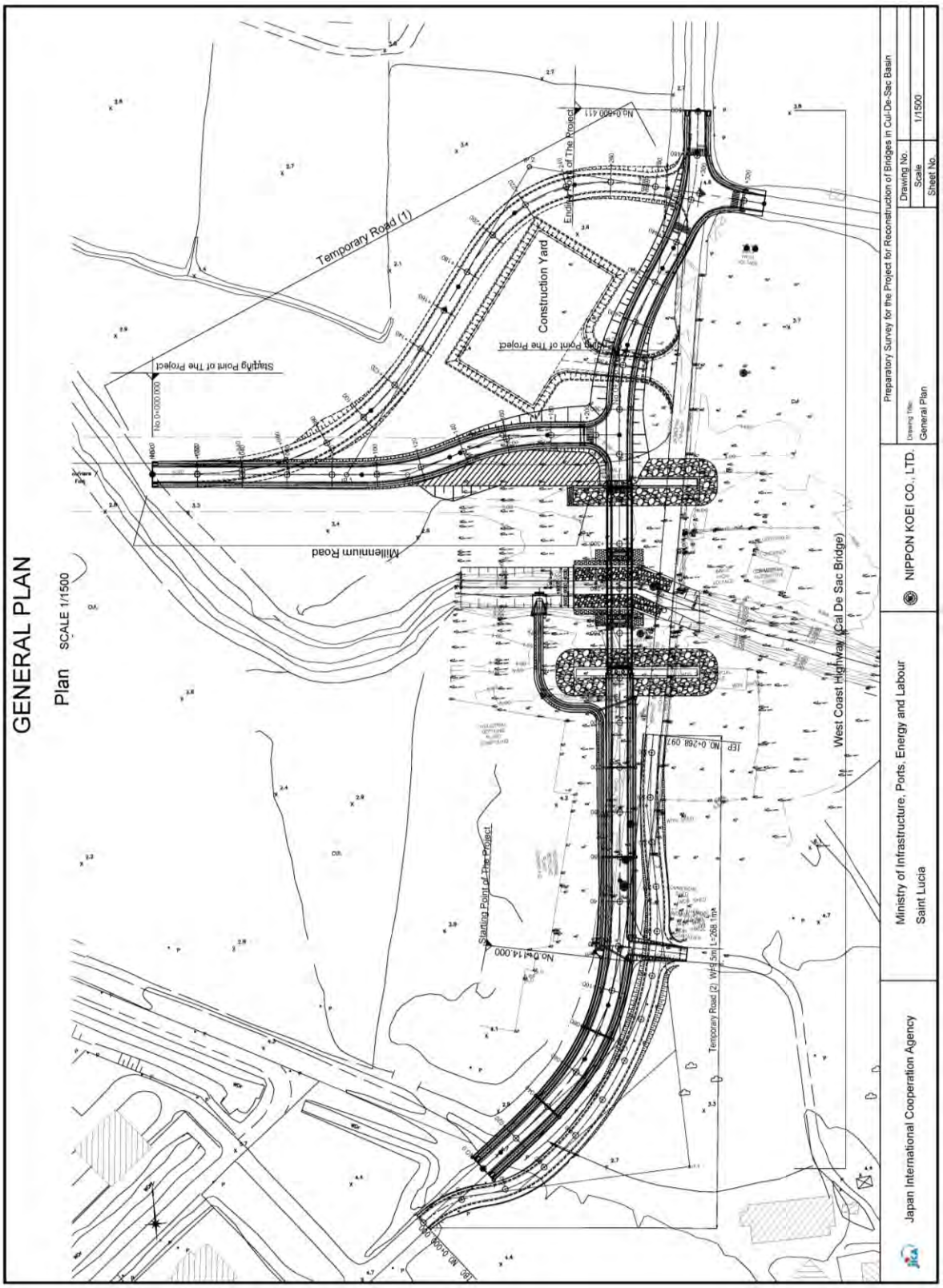
Source: JICA Survey Team

2-2-3 Outline Design Drawings

Design Drawings are prepared based on the design principles and criteria described in 2-2-1 and 2-2-2.

(1) Cul De Sac Bridge

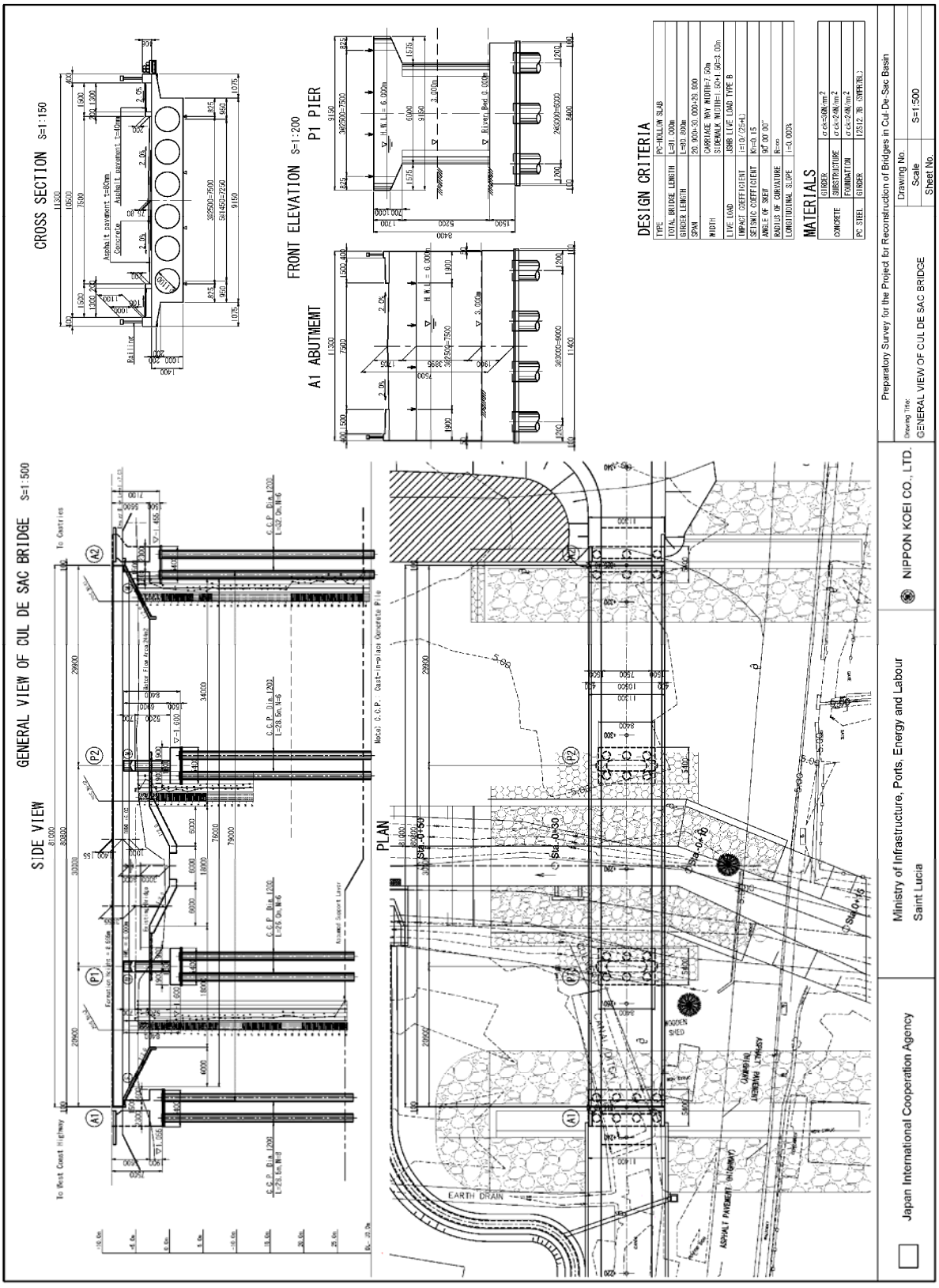
1) General Plan



Source: JICA Survey Team

Figure 2-10 Draft General plan of New Cul-De-Sac Bridge

2) Bridge View

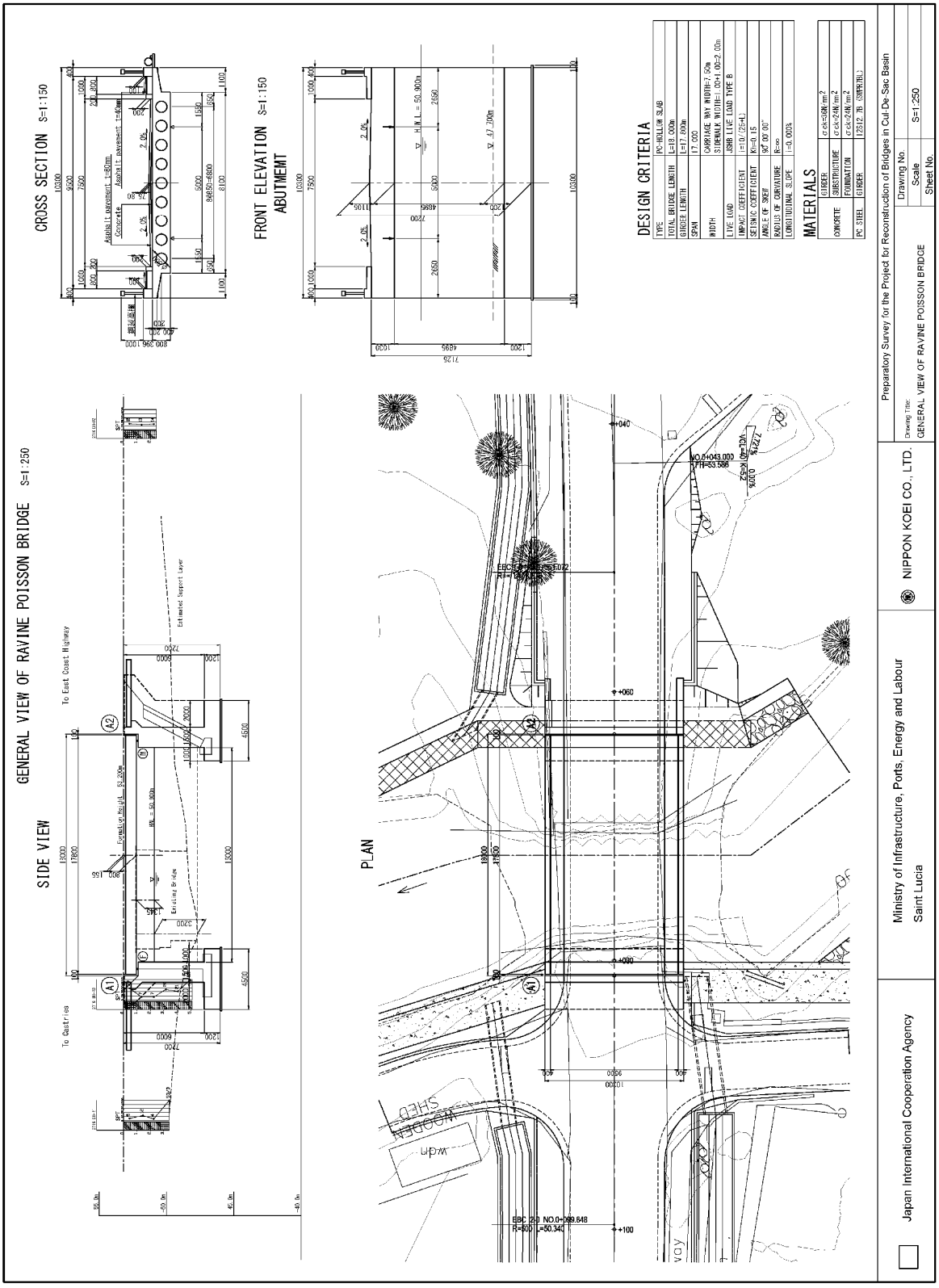


Source: JICA Survey Team

Figure 2-11 Draft Bridge View of New Cul-De-Sac Bridge

(2) Ravine Poisson Bridge

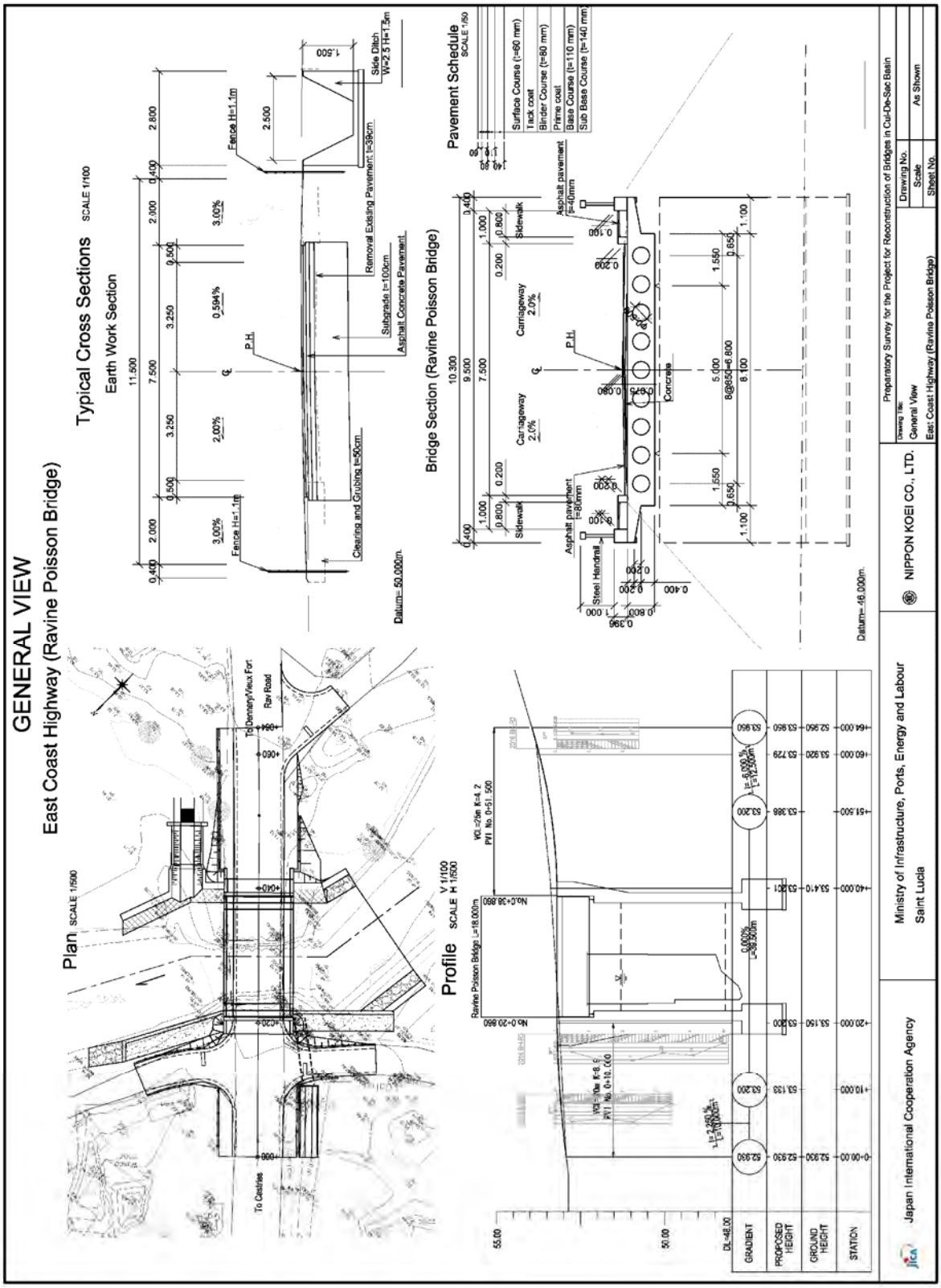
1) General Plan



Source: JICA Survey Team

Figure 2-12 Draft General plan of New Ravine Poisson Bridge

2) Bridge View

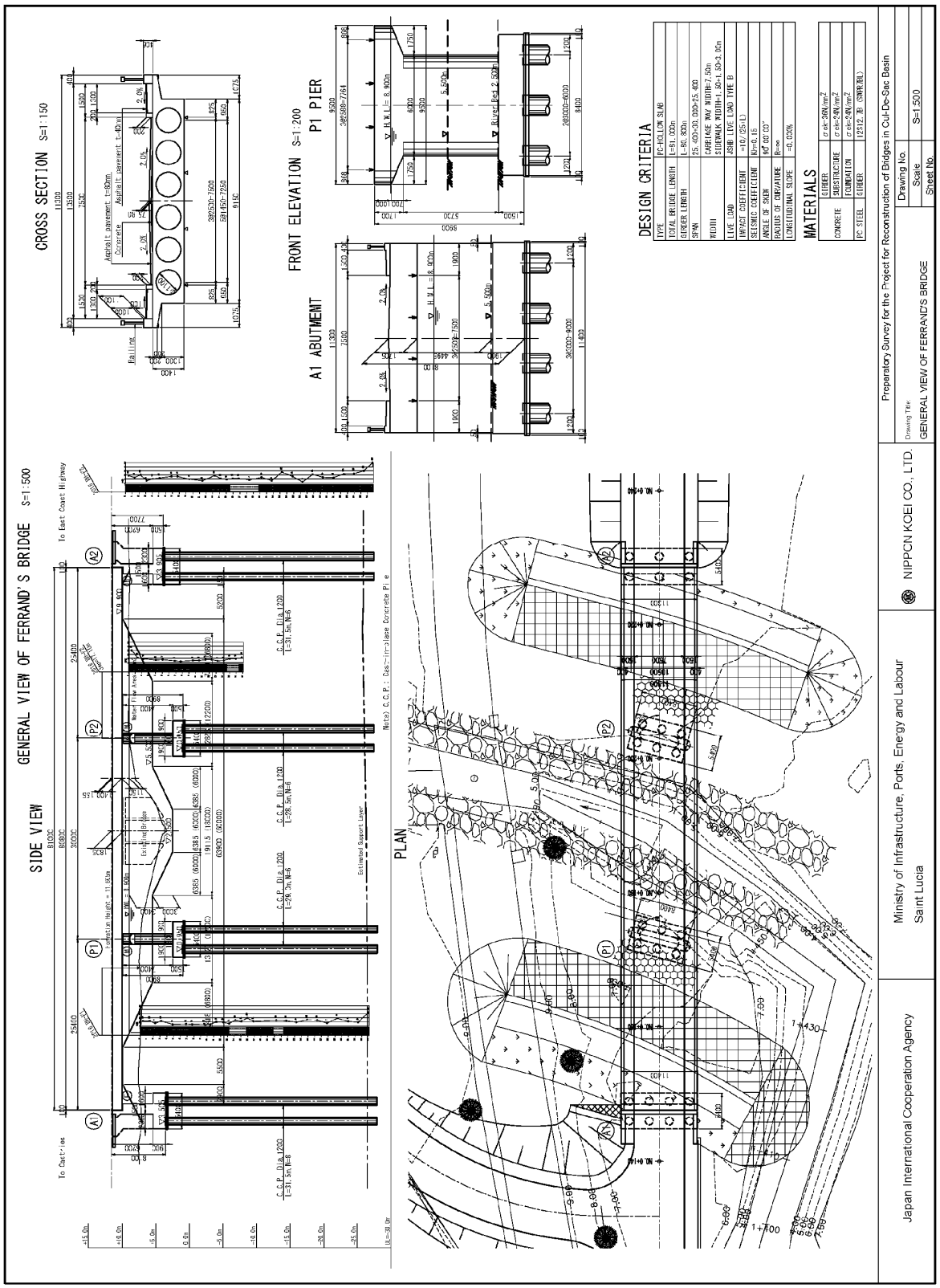


Source: JICA Survey Team

Figure 2-13 Draft Bridge View of New Ravine Poisson Bridge

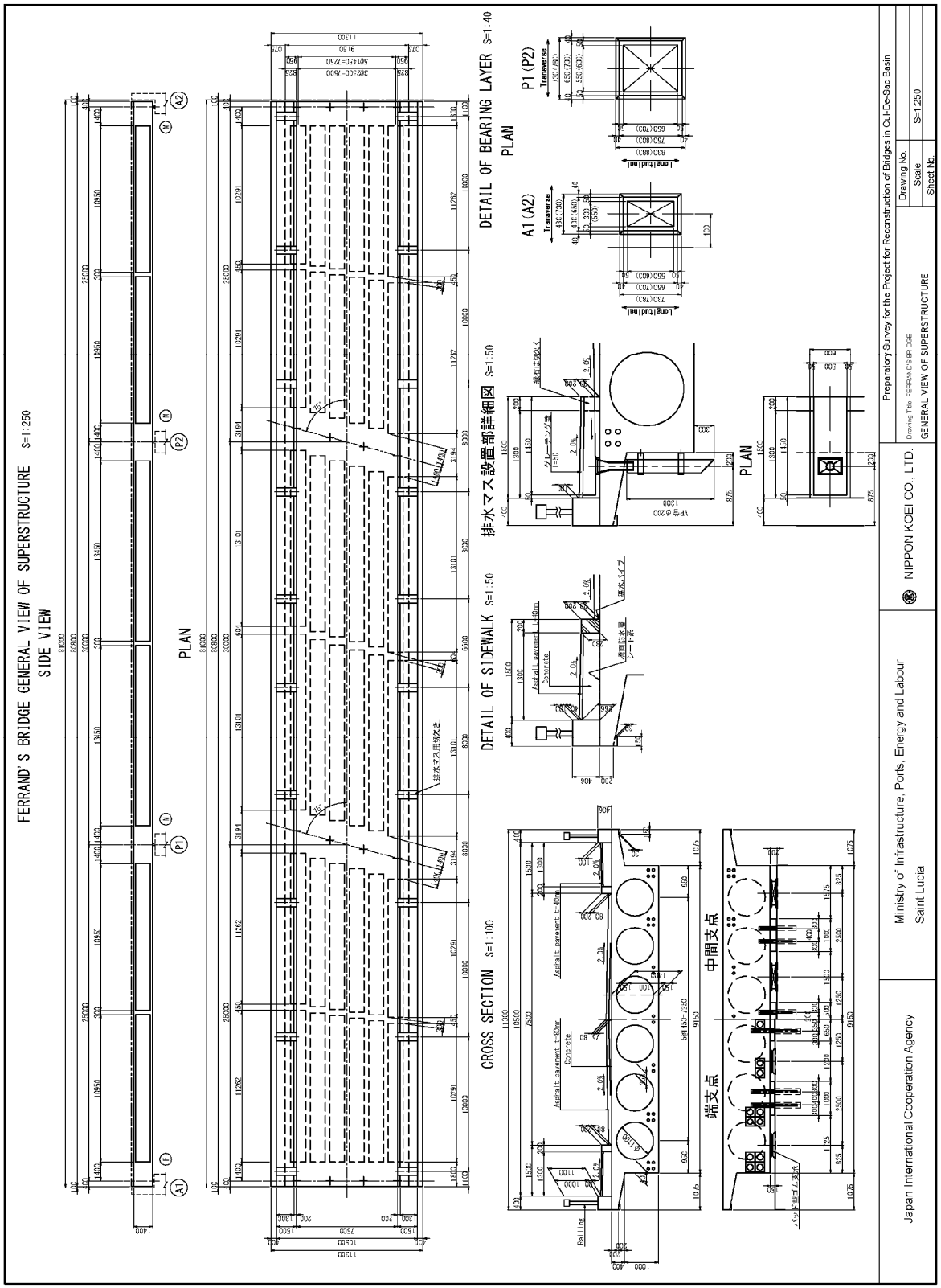
(3) Ferrands Bridge

1) General Plan



Source: JICA Survey Team

2) Bridge View



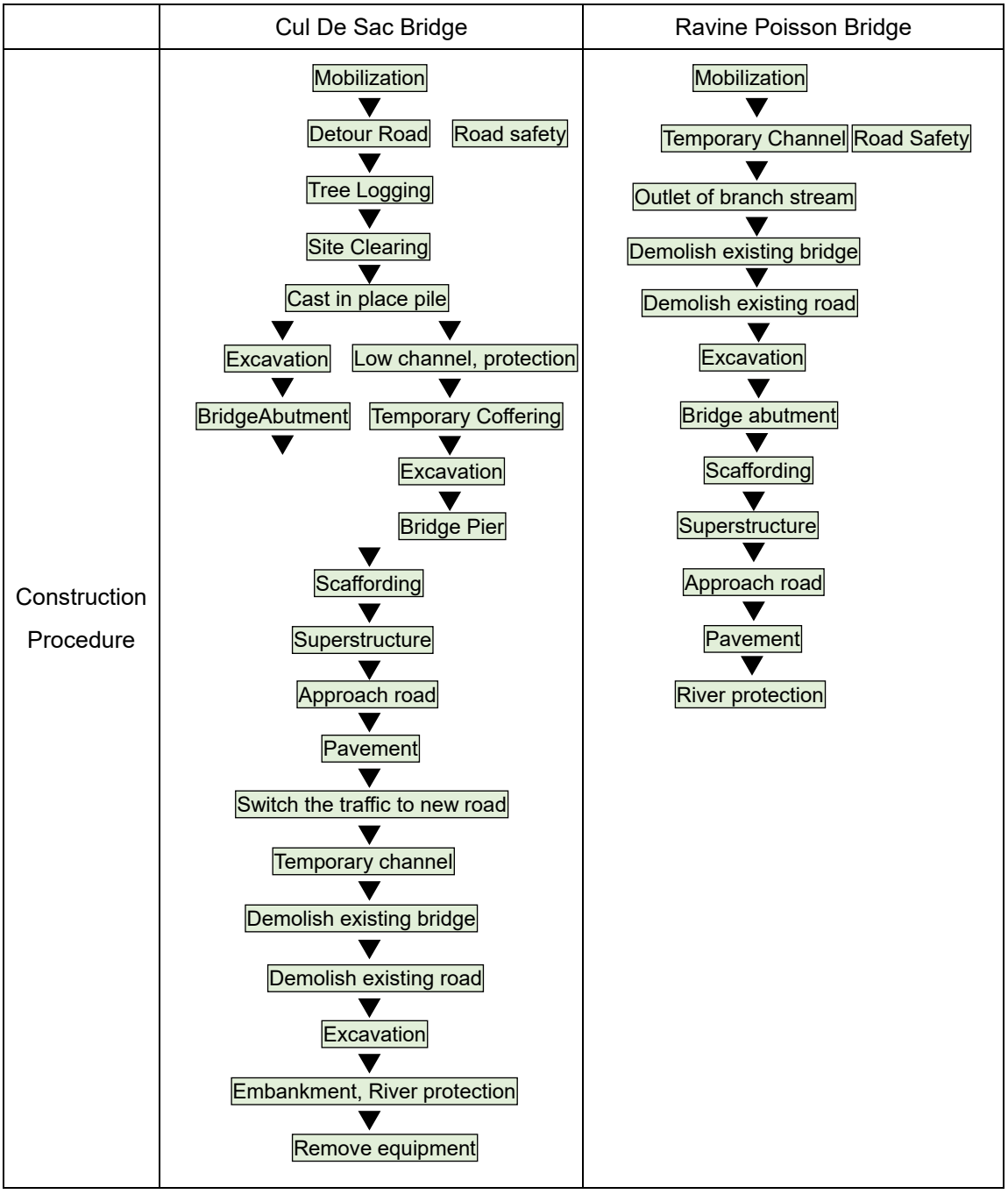
Source: JICA Survey Team

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

(1) Construction Procedure

Construction procedure is shown in Figure 2-14.



Source: JICA Survey Team

Figure 2-14 Construction Procedure

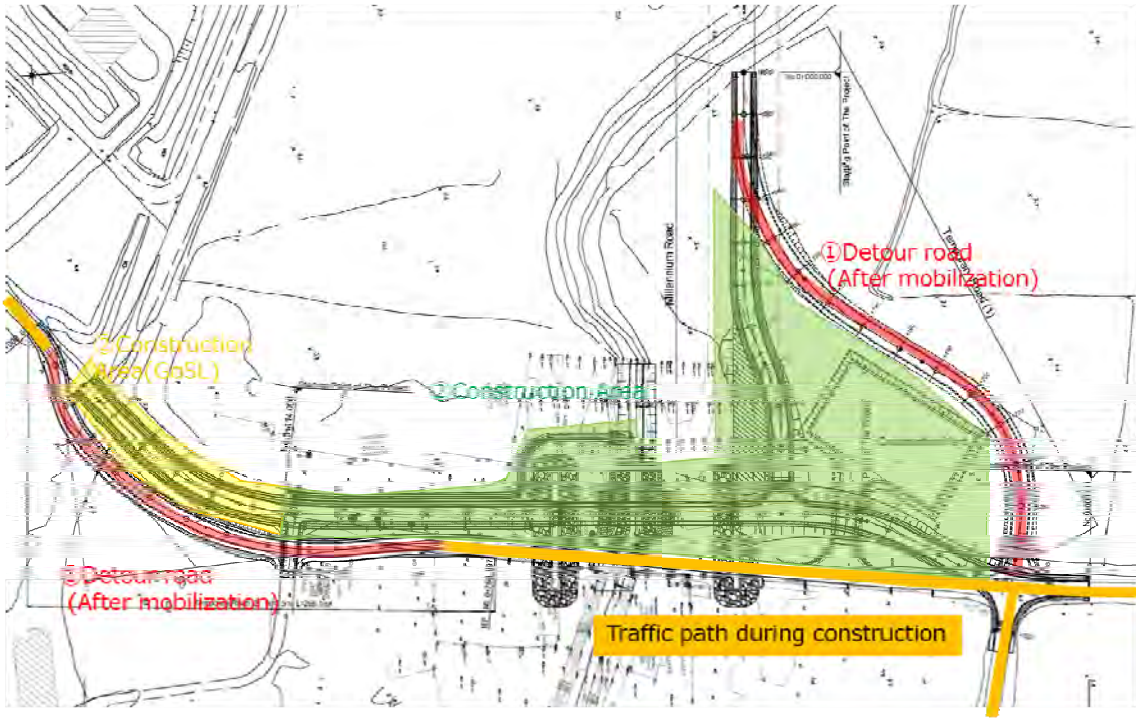
(2) Detour road plan

Detour road plan is shown in Source: JICA Survey Team

Figure 2-15 and Source: JICA Survey Team

Figure 2-16.

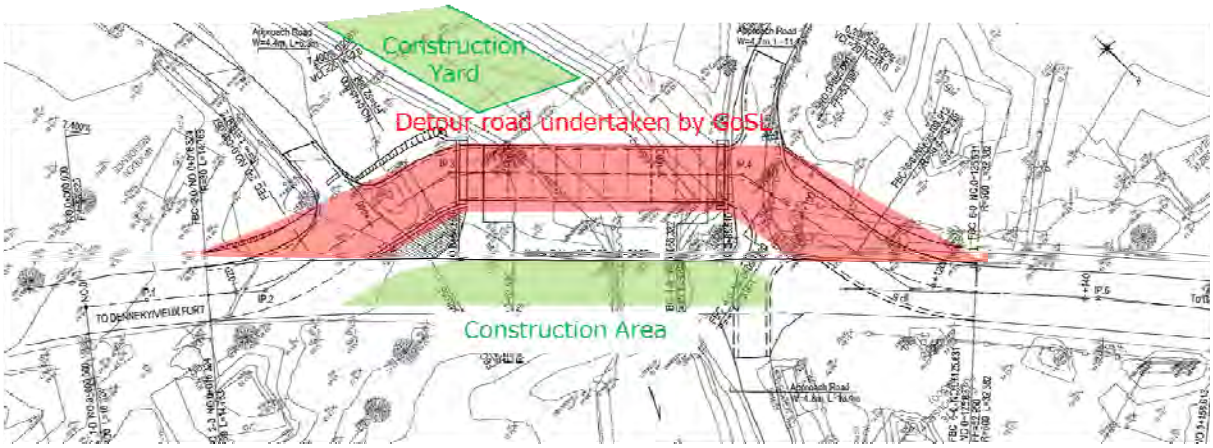
1) Cul De Sac Bridge



Source: JICA Survey Team

Figure 2-15 Detour road plan (Cul-De-Sac Bridge)

1) Ravine Poisson Bridge



Source: JICA Survey Team

Figure 2-16 Detour road plan (Ravine Poisson Bridge)

2-2-4-2 Implementation Conditions

(1) Labour Law

The contractor should manage its labour properly with an adequate safety control plan

and should prevent conflicts with local labour. In any circumstance, the contractor should abide by the labour laws and regulations enforced in Saint Lucia.

(2) Traffic Safety

For traffic safety during construction of the connection between the access road, the traffic control plan is to be submitted by the contractor. The consultant will check the plan with the MIPE&L.

(3) Importance of Concrete Quality Control

The quality of concrete has a huge influence on the lifetime of the concrete structures. It is important to use good quality and durable concrete to reduce cracks. Concrete material selection factors such as aggregates, sand, water and cement, low W/C ratio, contained air, calibration of concrete plant, and regulation of transpoting and placing concrete, are given priority in order to produce high quality concrete.

2-2-4-3 Scope of Works

The scope of works to be undertaken by the GoJ is from No.0+114~No.0+500.411 on main road and new bridge, and No.0+000~No.0+230 on millennium road in Cul De Sac bridge, and No.0+000~No.0+100 on new bridge and approach road in Ravine Poisson bridge.

The scope of works to be undertaken by the GoSL is from No.0+000~No.0+114 and South section on west coast road and temporary detour road in Ravine Poisson bridge.

2-2-4-4 Consultant Supervision

(1) Supervision

The engineering services for construction supervition will begin with the acceptance of the construction contract and the issuance of a Notice to Proceed (N/P) to the contractor. The consultant shall perform his duties in accordance with the criteria and standards applicable to the construction works and shall exercise the powers vested in him as the engineer under the contract to supervise the field works done by the contractor.

The consultant, within his capacity as the engineer, shall directly report to MIPE&L, St.Lucia office of JICA about the field activities and shall issue field memos or letters to the contractor regarding various matters, including progress, quality, safety and payment for the works under the project. After one year from the completion of the construction, the final inspection for defects liability will be conducted as the final task of the consultant.

(2) Implementation Organization

Resident engineer basically stay at the construction site to conduct both construction supervision and project management. The necessary specialist for each stage are shown as follows;

- Team Leader: Support tender/contact process, resident engineer on commencement and end of construction period
- Resident Engineer: Coordination and liaison for all the project activities to ensure smooth progress and management of all technical aspects.
- Foundation Engineer: Technical and quality control of pilling works.
- Superstructure Engineer: Technical and quality control of superstructure works.
- River Engineer: Technical and quality control of river works.

2-2-4-5 Quality Control Plan

Quality control will be carried out in compliance with Genral specifications for civil construction works, MILT, Japan.

2-2-4-6 Procurement Plan

Procurement plan was made as shown in Table 2-14 and Table 2-15 considering the current condition in Saint Lucia..

(1) Construction Material

Table 2-14 Procurement Plan of construction material

Material	Description	Country
Aggregate	-	St.Lucia
Deformed Steel Bar	-	St.Lucia
Concrete	-	St.Lucia
Asphalt Concrete	-	St.Lucia
Material for Scafforlding	Be procured from Japan to secure the quality in compliance with the standards.	Japan
Void form	Be procured from Japan to secure the quality in compliance with the standards.	Japan
Steel handrail, Shoe, Expansion joint	Be procured from Japan to secure the quality in compliance with the standards.	Japan
Fuel	-	St.Lucia

Source: JICA Survey Team

(2) Construction Machine

Table 2-15 Procurement Plan of construction machine

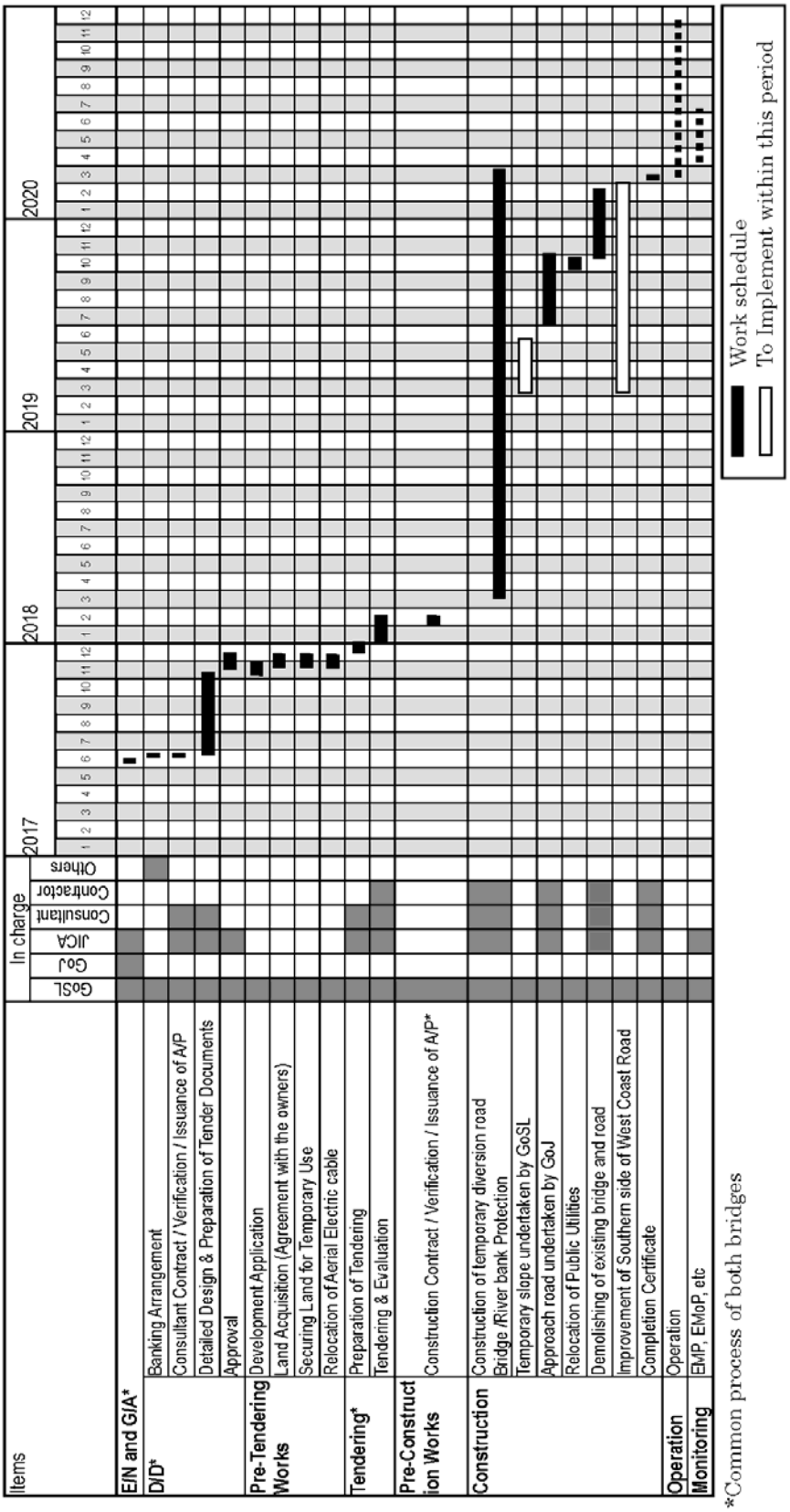
Machine	Country
Cast in place pilling machine all casing type, class:d=2,000mm	Japan
Clawler Clane, Class:50~55t	Japan
Rough Terrain Clane, Class:25t	Japan
Breaker	Japan
Concrete Pumping Vehicle	St.Lucia
Backhoe	St.Lucia
Road Roller	St.Lucia

Bulldozer	St.Lucia
Asphalt finisher	St.Lucia
Tire Roller	St.Lucia

Source: JICA Survey Team

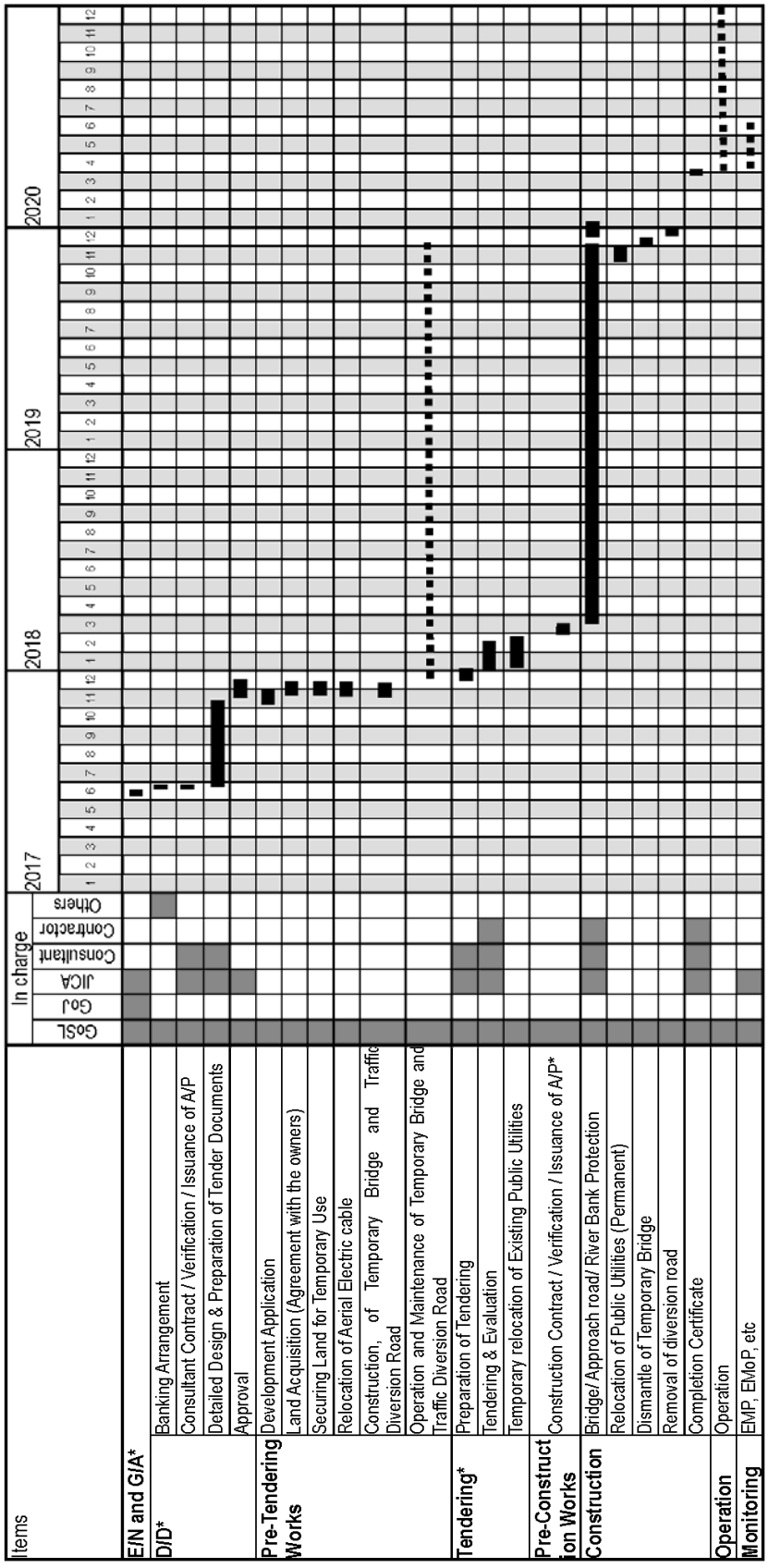
2-2-4-7 Implementation Schedule

(1) Cul-De-Sac Bridge



Source: JICA Survey Team

(2) Ravine Poisson Bridge



Source: JICA Survey Team

2-3 Obligations of Recipient Country

1. Before the Tender

NO	Items
1	To open bank account (B/A)
2	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the Consultant
3	To issue 'Letter of Acknowledgement on the Project,' as a substitute for the IEE approval and the development approval
4	To secure the necessary budget and implement land acquisition and resettlement (including preparation of resettlement sites, if needed), and compensation with full replacement cost in accordance with ARAP (including clearing and leveling as needed)
5	To secure and clear the following lands 1) Temporary construction yard and stock yard near the Project area for Cul-De-Sac Bridge site and Ravine Poisson Bridge site 2) Borrow pit and disposal site near the Project area (if needed)
6	Relocation of public utilities (aerial electric cable)
7	Construction of temporary bridge and traffic diversion road at Ravine Poisson Bridge
8	Temporary relocation of public utilities at Ravine Poisson Bridge
9	To submit project monitoring report (with the result of detail design)

2. During the Project Implementation

NO	Items
1	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the Contractor(s)
2	To bear the following commissions to a bank of Japan for the banking services based upon the B/A
	1) Advising commission of A/P
	2) Payment commission for A/P
3	To ensure prompt unloading and customs clearance at the port of disembarkation in recipient country and so assist the Contractor(s) with internal transportation therein
	1) Tax exemption and customs clearance of the products at the port of disembarkation
	2) To assist Contractor (s) with internal transportation from the port of disembarkation to the project site
4	To accord Japanese nationals and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the country of the Recipient and stay therein for the performance of their work
5	To ensure that customs duties, VAT, internal taxes and other fiscal levies which may be imposed in the country of the Recipient with respect to the purchase of the Products and/or the Services be exempted or be borne by MIPE&L without using Grant
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project
7	To submit Project Monitoring Report
	To submit Project Monitoring Report (final)
8	Relocation of public utilities (Permanent)
9	To maintain temporary bridge and traffic diversion road
10	To dismantle of temporary bridge and removal of diversion road at Ravine Poisson
10	To implement EMP and EMoP

11	To submit results of environmental monitoring to JICA, by using the monitoring form, on a quarterly basis as a part of Project Monitoring Report
12	To implement ARAP (Abbreviated livelihood restoration program, if needed)
13	To implement social monitoring, and to submit the monitoring results to JICA, by using the monitoring form, as a part of Project Monitoring Report - Period of the monitoring may be extended if affected persons' livelihoods are not sufficiently restored. Extension of the monitoring will be decided based on agreement between MIPE&L and JICA.
14	To submit a report concerning completion of the Project
15	To construct temporary slope between new road and West Coast road. (approx.110m)
16	To implement the road improvement of South section of the existing bridge on West Coast road, Cul-De-Sac area (approx. 600m) and drainage improvement including land acquisition and securing, construction and demolition temporary diversion road and relocation of utilities. Note) Review of scope, cost and schedule of implementation would be done at detailed design stage

3. After the Project

NO	Items
1	To implement EMP and EMoP
2	To submit results of environmental monitoring to JICA, by using the monitoring form, semiannually - The period of environmental monitoring may be extended if any significant negative impacts on the environment are found. The extension of environmental monitoring will be decided based on the agreement between MIPE&L and JICA.
3	To implement social monitoring, and to submit the monitoring results to JICA, by using the monitoring form - The period of monitoring may be extended if any significant negative impacts are found. The extension of monitoring will be decided based on the agreement between MIPE&L and JICA.
4	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid 1) Allocation of maintenance cost 2) Operation and maintenance structure 3) Routine/Periodic inspection

Source: JICA Survey Team

2-4 Project Cost Estimation

2-4-1 Initial Cost Estimation

Initial project cost undertaken by Japanese government is confidencial before tender.

The project cost undertaken by GoSL is estimated as shown in Table 2-16.

Table 2-16 Project cost undertaken by Saint Lucian government

No	Items	Cost Estimated (XCD)
1	To open bank account (B/A)	10,000
2	To secure the necessary budget and implement land acquisition and resettlement (including preparation of resettlement sites), and compensation with full replacement cost in accordance with RAP	2,000,000
3	To secure and clear the following lands 3) Upstream side of existing Cul De Sac bridge for River works	130,000

	4) Temporary construction yard and stock yard near the Project area for Cul De Sac Bridge site and Ravine Poisson Bridge site Borrow pit and disposal site near the Project area	
4	Relocation of Public Utilities (Aerial Electric cable)	100,000
5	Construction of Temporary Bridge and Temporarily Traffic Diversion Road	750,000
6	Temporary Relocation of Public Utilities at Ravine Poisson Bridge	100,000
7	Advising commission of A/P	30,000
8	Payment commission for A/P	30,000
9	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the country of the Recipient with respect to the purchase of the Products and/or the Services be exempted or be borne by MIPE&L without using Grant	1,250,000
10	Relocation of Public Utilities (Permanent)	200,000
11	To maintain Temporary Bridge and Temporarily Traffic Diversion Road	75,000
12	To dismantle of Temporary Bridge and Removal of diversion road at Ravine Poisson	50,000
13	To implement EMP and EMoP	75,000
14	To construct approach road between new road and West Coast road. (approx.110m)	600,000
15	To implement the road improvement of South section of the existing bridge on West Coast road, Cul De Sac area (approx.. 600m) and drainage improvement.	3,000,000
16	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid 4) Allocation of maintenance cost 5) Operation and maintenance structure Routine/Periodic inspection	80,000/yr
Total exclusive of No.16		8,400,000

Source: JICA Survey Team

2-4-2 Operation and Maintenance Cost

Operation and maintenance const was estimated as shown in Table 2-17.

Table 2-17 Operation and maintenance cost

Item	Remarks	Frequency	Cost(XCD)
Periodic inspection		1 time /1yr	6,500
Drainage facilities	Maintenance	1 time /1yr	6,500
Road safety facilities	Repair/Replace	1 time /10yrs	25,000
Slope	Weeding	Twice /1yr	5,250
Pavement	Repair	1 time /10yrs	500,000
Steel Handrail	Repainting	1 time /10yrs	120,000
Expansion Joint	Replace	1 time /10yrs	120,000
Annual Cost			100,000

Source: JICA Survey Team

Chapter 3 Project Evaluation

3-1 Preconditions

The Project is to build new Cul-De-Sac Bridge and Ravine Poisson Bridge along with construction of approach roads, riverbank and riverbed protection. In case of implementation of the Project, JICA Survey Team exchanged opinions with the concerned officers of MIPE&L of the Saint Lucia side and unanimously concluded the Saint Lucia's undertakings in the following items (1) and (2). With regard to tax exemption privileges of the Japanese contractors under the Japanese grant aid scheme, both sides confirmed that such customs duties, internal taxes and other internal levies including VAT, commercial tax, income tax and corporate tax, which shall be clarified in the bid documents by MIPE&L during the implementation stage of the Project. In addition, nessecary proceedings and formalities between the Japanese side and Saint Lucia's side were confirmed, viz. Exchanges of Notes, Grant Agreements, Banking Arrangement, and Authorization to Pay.

(1) Cul-De-Sac Bridge

1) Undertakings by the Japanese Side

No.	Major Undertakings
1	New Bridge Construction
2	Approach Roads Construction
3	Riverbank and Riverbed Protection
4	Temporarily Traffic Diversion Road
5	Demolition old bridge structures

Source: JICA Survey Team

2) Undertakings by the Government of Saint Lucia

No.	Major Undertakings	Period
1	Development Application	Before PQ Notice
2*1	Land Acquisition	Before Commencement of the Work*2
3*1	Securing Land for Temporary Use	Before PQ Notice
4*1	Relocation of Public Utilities (Aerial Electric cable)	Before PQ Notice
5	Relocation of Public Utilities 2 (Water Supply, Telecom and Electric on the bridge/ under the road side/Aerial Electric cable)	Within 1 month after completion of bridge construction*3
6	Designation of Disposal Area	Before Commencement of the Works
7	Implementation of south side of the West Coast Road (raising road and/or drainage improvement)	Before Completion of the Project

Notes: *1 Budget allocation for FY 2017/18 should be required.

*2 Agreement with owners must be concluded by PQ Notice.

*3 Agreement with the management uthority must be concluded by PQ Notice

Source: JICA Survey Team

(2) Ravine Poisson Bridge

1) Undertakings by the Japanese Side

No.	Major Undertakings
1	Removal of Existing Bridge Structures
2	New Bridge Construction
3	Approach Roads Construction
4	Riverbank & Riverbed Protection

Source: JICA Survey Team

2) Undertakings by the Government of Saint Lucia

No.	Major Undertakings	Period
1	Development Application	Before PQ Notice
2*1	Securing Land for Temporary Use	Before PQ Notice
3*1	Relocation of Public Utilities (Aerial Electric cable)	Before PQ Notice
4*1	Construction of Temporary Bridge and Temporarily Traffic Diversion Road	Before PQ Notice
5	Temporaly Relocation of the Existing Public Utilities	Before Commencement of the Works*3
6	Relocation (Final) of Public Utilities	Within 1 month after completion of bridge construction*3
7	Dismantle of Temporary Bridge and Removal of Temporarily Traffic Diversion Road	Before Completion of the Project

Notes: *1Budget allocation for FY 2017/18 should be required.

*2 Agreement with owners must be concluded by PQ Notice.

*3 Agreement with the management uthority must be concluded by PQ Notice

Source: JICA Survey Team

3-2 Necessary Inputs by Recipient Country

The Technical Division of MIPE&L would have to conduct the following inputs during the construction stage and after the completion of the Project.

(1) Assignment of Project Perssonel

The following perssonel should be assigned throughout the construction time.

[Project Manager] Responsible for managing the Project, applying and reporting the Project matters to the concerned entities on the Saint Lucia side, coordinating and managing the public traffic diversion at the sites in collaboration with Traffic Police, dealing with the resolution against claims from stakeholders, and so on.

[Civil Engineer] Responsible as the Client's engineer for daily activities of technical matters related to bridge, road and river protection structures, as well as environmental matters including construction and traffic safety, dusts, niise and vibration in nigt work.

(2) Future Inspection and Maintenance of the Facilities after the Project Completion

For proper use of the completed facilities of the Project, periodic and ad hoc inspection and repair works of the structural elements of bridges, approach roads, and river protection.

3-3 Important Assumptions

(1) Maintenance Technology Levels for Ensuring Proper Use of Facilities

Prestressed concrete hollow slab for the Cul-De-Sac Bridge and the Ravine Poisson Bridge is to be introduced firstly in Saint Lucia. In addition, reinforced earth retaining wall to be adopted as the southern side approach road structure for the Cul-De-Sac Bridge is also the first attempt in the country. Accordingly, technology level-up of the maintenance engineers is very essential.

(2) Measures for Enjoying Much More Benefits of the Completed Facilities

As flooding risks at the Ferrands Bridge is still remain, safe and smooth traffics can be obtained if new Ferrands Bridge is completed. For this purpose, the following two facility development plans are required:

- ✓ Extension of River Bunds from Cul-De-Sac Bridge up to Ferrands Bridge
- ✓ Re-construction of Ferrands Bridge as with the scale of new Cul-De-Sac Bridge

3-4 Project Evaluation

3-4-1 Relevance

(1) Recipient Population of the Project

Almost 100% of Domestic transportation of Saint Lucia depends on road transportation. The total population is 182,300 (WB 2013) in the total land area of 610 km^2.

The Cul-De-Sac Bridge is located on the West Coast Road and the Ravine Poisson Bridge is on the East Coast Road. Road links to connect the Capital City Castries in the north and Hewanowa International Airport in the south depend on both of the East Coast Road and the West Coast Road.

Major economic activities are concentrated in the north region and south region which includes Hewanowa and Vieux Fort. Road transportationbetween north and south regions should use Cul-De-Sac Bridge or Ravine Poisson Bridge, both of which are likely affected by natural disaster of floods.. To build these 2 bridge can decrease the potential risks of road closure due to natural disaster and obtain stable transport networks.

Although Saint Lucia Government requested to reconstruct 3 bridges but the implementation of the Project consists of 2 excluding the Ferrands Bridge, some feeder roads can have role od detour road of the Ferrands Bridge and accordingly the East Coast Road will function as the road link between the north and south regions.

Accordingly recipient population is regarded as total population of the country.

(2) . Goals of the Project

The Project aims at reconstruction of the Cul-De-Sac Bridge and Ravine Poisson Bridge both of which are located in the high risk areas of floods from the natural disasters such as hurricanes and tropical storms taking into consideration the design requirement of probable floods for 50 year return periods. As such, transport risks from the natural hazards of the major roads of the East Coast Road and the West Coast Road would decrease being resulted in stable traffics.

By implementing the Project, recipients are regarded widely spreading to all the areas of the country and strengthening the opportunities of tourism industry development and increasing the potential investment.

(3) .Implication of National Plan in Saint Lucia

National Vision Plan, which is a long term plan covering all areas of the country and aiming at enlargement of future investment, was published in 2008.

"MEDIUM TERM DEVELOPMENT STRATEGY, 2012-2016, Sectoral Action Plan" was published in September 2012. "Goal 18: Economic Infrastructure" deals with the concerned matters of the Project. The objectives of Goal 18 consists of the following 3 activities, in which the first one is closely related to the Project.

18.1 To rehabilitate and upgrade the network of roads and bridges damaged by Hurricane Tomas

18.2 To rehabilitate and upgrade the water system

18.3 To rehabilitate and secure other infrastructure

PDM of the above 18.1 in the Medium Term Development Strategy is re-produced in Table 3.4.1.

Table 3.4.1 PDM of Object 18.1

Objective 18.1	Indicators	Means of Verification	Assumptions/Risks
Outcome	A safer and more reliable system of roads & bridges		Universal commitment to enhanced standards in construction of roads and bridges – CUBiC and beyond
Outputs	■ Critical links between North and South restored in Year 1 ■ Roads damaged by Hurricane Tomas reconstructed & upgraded during Years 1 – 3 ■ Bridge structures for major rivers are designed to accommodate a 1 in	■ Survey ■ Survey ■ Guidelines of the Ministry of Communications & Works ■ Survey	Need for urgency in coordination by authorities well appreciated by them

	■ 50 year flood event Existing bridges are replaced by open span structures during Years 1 – 5		

Source: "MEDIUM TERM DEVELOPMENT STRATEGY, 2012-2016, Sectoral Action Plan", September 2012.

Related matters to the Cul-De-Sac Bridge and Ravine Poisson Bridge are in the 2nd and 3rd paragraph of Outputs in the table; "Roads damaged by Hurricane Tomas reconstructed & upgraded during Years 1 – 3", and "Bridge structures for major rivers are designed to accommodate a 1 in 50 year flood event".

(4) Related Japanese Policy of Foreign Assistance

Priority sectors of Japanese Foreign Assistance are mainly in the following 2 sectors.

[Priority Sector 1: Disaster Risk Reduction and Environment]

As Saint Lucia is located in the disaster affected area by Hurricane and floods, the assistance for urgent issues of the country such as climate change measures and disaster prevention measures to the country would be continued taking into consideration the bio-diversity aspect. As for the present conditions that Saint Lusia largely depends on electricity energy generation by using fossil fuel, assistance to diversify the energy generation system from fossil to re-newable energy system and saving energy system.

[Priority Sector 2: Fisheries]

Saint Lucia intends to industrial diversification and employment creation, the fishery industry has been contributing Saint Lucia nationals to supply high qualified protein and increasing job opportunity. Sustainable use of marine resources is just same as Japanese target, and therefore continuous assistance to the fishery industry of Saint Lucia.

The Project is to reconstruct the Cul-De-Sac Bridge and the Ravine Poisson Bridge in the high risk area of flooding by hurricane ans toropical storm, and therefore the objective of the Project satisfies the Priority Sector 1 in the above. Moreover, both bridges are located along the transportation corridors of industrial products between markets mostly in the capital Castries region and fisheries harbours. In this regard, the Project also satisfy the Priority Policy Sector 2 in the above.

3-4-2 Effectiveness

(1) Quantitative Indicators

Effect		Base Value (2016)	Target Value (2023)
Impassable car due to road blocked[*1] (number/year)	the Cul-De-Sac bridge	64,000	0 [*3]
	the Ravine Poisson bridge	2,000	0 [*3]
Number of days of Road closed due to overtopping[*2]	the Cul-De-Sac bridge	8 days/year	0 [*3]
	the Ravine Poisson bridge	2 days/five years	0 [*3]
Average daily passenger (number /year)	the Cul-De-Sac bridge	9.90 mil	10.00 mil (11.70 mil)[*5]
	the Ravine Poisson bridge	6.50 mil	6.55 mil (7.50 mil) [*5]
Average cargo weight(ton/year) [*4]	the Cul-De-Sac bridge	1.90 mil	2.00 mil (2.30 mil) [*5]
	the Ravine Poisson bridge	1.40 mil	1.42 mil (1.60 mil) [*5]

*1 Due to occurrence of flood
*2 Overtopping is defined as the circumstances of which the river water level is higher than 5.3 m at the Cul-De-Sac Bridge and higher than 3.0 m at the Ravine Poisson bridge.
*3 In case rainfall does not exceed the values of 50-year return period in the term
*4 Transport volume is on the basis of actual value by traffic survey results and anticipated value by future demand forcast (See also Appendix5-4)
*5 The indicators in parentheses are calculated based on the predicted future average daily traffic volume.

Source: JICA Survey Team

(2) Intangible Benefits

[Reconstruction of Cul-De-Sac Bridge]

- After completion of the bridge reconstruction, the high risks of flood disaster of CPJ Distribution Center, of which location is immediately downstream on the south bank, reduces then being resulted in enabling the smooth and stable transport of food products from the factory to the major market of the north region including the national capital Castries. It should be noted that this factory has been most severly affected by flood disaster of the Cul-De-Sac River.
- On upstream side of the north bank, OB Sado Engineering Services Limited is operating his buisiness including construction equipment storage yard which is likely affected by over-topping of water floods of the river. After completion of the bridge recnstruction, disaster risks of floods will slightly reduce around the equipment storage yard. If an extension of riverbund is implemented on the upstream side in the future, disaster risks will greatly reduce.
- Near the river mouth of the Cul-De-Sac River, an oil storage company, Buckeye Terminal Saint Lucia, has a number of oil storage tanks on the south bank side. As

location of the company's storage tanks is very close to the river mouth, the disaster risks of floods is not significant even at present.

- A little bit apart from the Cul-De-Sac River, there are several companies on the south, viz. Massy Store Supermarket Saint Lucia, West Indies Shipping & Trading Co., Ltd., hardware supplier company WIZO, gas station and automobile accessory shop RUBIS Total Auto, and so on. As the locations of them are a little bit away from the river, the experience of disaster damage by them seems little and the damages in the past are not significant.
- In fact, JICA Survey Team conducted interview survey to 10 companies in the vicinity of the site including the abovementioned companies, and only 3 companies responded. Desire to the bridge reconstruction is high and none of negative opinions was given to JICA Survey Team.

[Reconstruction of Ravine Poisson Bridge]

- There are residents, Zion SDA Church, George Charles Secondary School and South Casteries Secondary School in the west (Cul-De-Sac Br. And Ferrands Br. side) of the bridge. Very close to the bridge, also on the west bank side, WASCO operates a pump house, which is very important for local people life. Now water main is accommodated on the bridge structure. After completion of the bridge reconstruction along with the water main being accommodated on new bridge structure, water supply will be maintained safely and inhabitants' life improve significantly.
- Existing structures of the Ravine Poisson Bridge is much aged and repair works were conducted very often. Once the bridge reconstruction is completed, inhabitants' mental fear of old Ravine Poisson Bridge will cease.
- If the bridge reconstruction is completed under the disaster risk reduction aspect as well as better car driving condition on new bridge is provided, users of vehicles will enjoy alleviation from the bridge damage.