Chapter 5 The Formulation of Flood a Management Plan

Chapter 5 Flood Management Plan for Priority Areas

5-1 General

From the results of the evaluation in Chapter 3, the Flood Management Plan for the Seychelles is summarised in the following:

1. Most of the rivers in the country have the capacity to discharge rainwater. The main countermeasures to be applied in the short term are drainage improvement, O/M and non-structural measures
2. After the completion of the short-term measures, in order to upgrade risk management to a medium-term scale, river improvements are adopted with simultaneous implementation of O/M and non-structural measures.
3. Victoria Town is the only urbanised town in the Seychelles. However, due to rapid development in the country, many locations will be urbanised in the future. An urban drainage improvement plan will be proposed for Victoria Town for the application of short-term measures, while river improvement works will apply medium-term measures.
4. Pointe Larue, Anse Aux Pins, Au Cap and Anse Royale are selected as priority areas for the preparation of the flood management plan.
5. In the above districts, the main drainage is provided along the main road (one side or both sides) and secondary drainage from the residential areas, schools and other facilities is connected to the main drainage. However, the drainage system is not uniform due to the different implementation times, with different agencies' designs and different purposes. It is necessary to solve this problems.
6. For other districts, basically the proposed drainage improvement will apply short-term countermeasures while medium-term measures will be applied for river improvement. However, in some locations drainage and rivers have no clear boundaries, and in these cases, stepwise implementation is proposed.
7. Structural measures for drainage and river improvement works will take into consideration available materials, equipment and methods in the Seychelles.
8. Structural measures require the proper quality, quantity, safety and schedule control. Moreover, good O/M will contribute to longer structural life and savings in the government budget. In order to achieve/improve skills, training of engineers is of great importance.
9. Moreover, in order to implement river improvement works in the medium term, river basins and river boundaries must be properly maintained by regulations and the Land Use Act. Otherwise, there will be fewer options for countermeasures for flood mitigation in the future, leading to grave questions in the future.
10. Even with all the countermeasures, people living on low land will still suffer inundation by rainwater.
11. It should be noted that in the long-term measures, structural measures have limitations because of scale and cost implications. The Government of the Seychelles must start sending clear messages and implementing measures based on the SSDS 2012.

The proposed countermeasures in the flood management plan for Victoria Town and other priority districts are listed in Table 5-1-1 and Table 5-1-5 respectively.

Table 5-1-1: Victoria Town Action Plan

Item	Explanation
Conditions	The town has been developed and urbanised in the seaward direction by reclamation. The ground level of the reclaimed land is higher than that of the old town.
Problems	The flow capacity of the drains and rivers is not enough for flood water.
Evaluation of Alternatives	The main cause is lack of drainage capacity. Therefore, the most appropriate measure is to increase the capacity of the drains under the road rather than to make a new drainage system. For medium-term improvement, an increase in the flow capacity of the rivers is preferable.
Short-Term Plan	Improvement of 8 drainage channels totalling 1.3km in length with a 40% capacity increase. The channels are located at Olivier Maradan (88m), Market Street (108m), Huteau Lane (179m), Palm Street (121m), Benezet Street (125m), State House Avenue (96m), Independence Avenue (223m) and Francis Rachel (321m)
Medium-Term Plan	River improvements including 1,080m-long bed excavation, 340m-long channel widening, 780m-long wall construction and a 28 m-long elevated dike. The five rivers are the River Anglaise, River Moosa, River Maintry, River St. Louis and River La Poudriere.

Table 5-1-2: Point Larue Action Plan

Item	Explanation
Conditions	At one time the road ran along the coast and small rivers flowed out to the sea. The Seychelles International Airport and main highway were developed on reclaimed land fronting the old coastal road.
Problems	The reclamation obstructs the river flow and drainage from the road. Flooding on the road makes it difficult to access the airport from Victoria Town. Also, drainage problems are severe at three lowland sites.
Evaluation of Alternatives	As a short-term measure, drainage improvement was proposed. In the medium term, enlargement of the existing culvert was proposed. As the cause is lack of proper drainage, direct improvement or extension is more appropriate than reducing flood discharge by construction of a retarding basin.
Short-Term Plan	Drainage improvement by a culvert (30m) under the road, extension of the drainage channel (40m) to the wetland and widening of the existing channels are proposed.
Medium-Term Plan	Enlargement of the existing 8m-long culvert is proposed.

Table 5-1-3: Anse Aux Pins Action Plan

Item	Explanation
Conditions	Along the coast wetland formed and at one time stored flood water. The lowland around the wetland has been developed for housing or public facilities such as schools.
Problems	The sand deposited at the outlet by the waves causes flooding problems in the residential area on low land. At Chetty Flat the drainage does not work well due to lack of management.
Evaluation of Alternatives	At Chetty Flat the improvement of the existing channel is long and needs land acquisition. The proposed new channel is short and easy to maintain. The improvement of the rivers was considered according to the characteristics of each river and the appropriate improvement selected.
Short-Term Plan	At Chetty Flat the construction of a new 120m-long drainage channel to the sea is proposed.
Medium-Term Plan	Improvement of the river near the mouth is proposed. One measure is 300m-long riverbed excavation and the other is widening of the river for 200 m with construction of a new box culvert.

Table 5-1-4: Au Cap Action Plan

Item	Explanation
Conditions	Along the coast wetland formed and at one time stored flood water. The low land around the wetland has been developed for housing estates and public facilities such as schools.
Problems	The sand deposited at the outlet by the waves causes flooding problems in the residential area on low land. New measures using pipes have been adopted but the flow capacity is not enough.
Evaluation of Alternatives	The flooding is caused by the lack of flow capacity at the mouth. Therefore, increasing the capacity by widening or dredging of the river and maintaining the river mouth is appropriate.
Short-Term Plan	Improvement of the drainage system is proposed.
Medium-Term Plan	Improvement of the river near the mouth is proposed by widening of the river (620m) and two bridges with widening of the river mouth (230m).

Table 5-1-5: Anse Royale Action Plan

Item	Explanation
Conditions	Along the coast wetland formed and at one time stored flood water. The lowland around the wetland has been developed for housing or public facilities such as schools.
Problems	The sand deposited at the outlet by waves causes flooding problems in the residential area on low land.
Evaluation of Alternatives	Flooding is caused by the lack of flow capacity at the mouth. Therefore, increasing the capacity by widening or dredging of the river and maintenance of the river mouth is appropriate.
Short-Term Plan	A 120m-long drainage ditch of is proposed.
Medium-Term Plan	Improvement of two rivers near the mouths is proposed by widening of the rivers (170m), river bed excavation (1400m) and a bridge with widening of the river mouth (130m).

5-2 Flood Management Plan for the Priority Areas

5-2-1 Victoria Town

(1) Profile of Victoria Town

Victoria is the largest settlement on Mahe and also the capital of the Republic of the Seychelles. About one-third of the people in the Seychelles live in Victoria which has a population of 23,300.

In the *Preliminary Study of the Flooding Problem in Victoria* report mentioned above, two zones were identified, the Central Victoria Area and the Greater Victoria Area as shown in Figure 5-2-1, covering about 1.18 km^2 and 10.05 km^2, respectively.

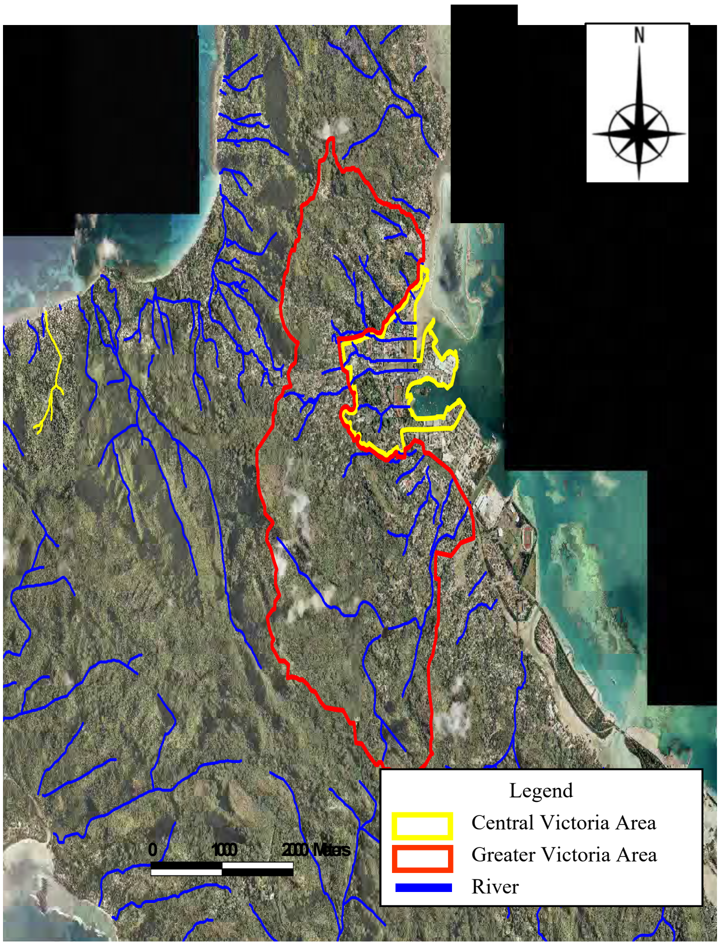


Figure 5-2-1: Definition of Central and Great Victoria Areas

Review of the results of the *Preliminary Study of the Flooding Problem in Victoria, 2005*, as well as investigation of the existing conditions and discussions with DOE, reveal that the inundation points are concentrated in five catchments, namely the River Anglaise, River Moosa, River Maintry, River St. Louis and River La Poudriere areas. The core area of Mahe Island and the problem of the drainage facilities in this area are of great importance and urgency and quick improvement is needed. Therefore, these five catchments are the target areas for the formulation of the urban flood management plan for Victoria Town. The study area is as indicated in Figure 5-2-2.

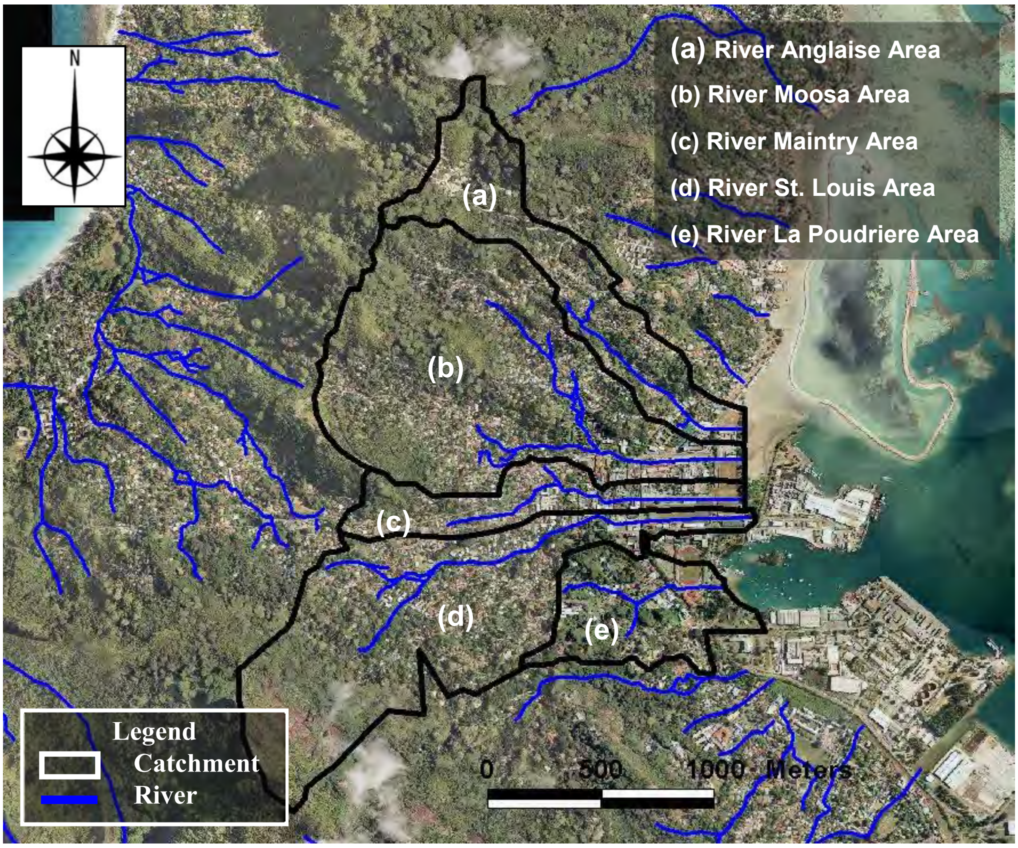


Figure 5-2-2: Study Area

(2) Existing River and Drainage System

As mentioned above, the study area consists of five river catchments. Detailed descriptions of the existing drainage system in each catchment are as described below.

River Name	Catchment Area, km^2	Width, m	Depth, m	Problems at the Site
Anglaise River	0.57	4.1- 5.2	1.3-3.0	Obstructions in river
Moosa River	1.35	3.7-12.3	1.0-3.0	Water overflow at confluence point
Maintry River	0.33	1.7-3.7	0.4-2.3	Sand silting and obstruction by pipes and cables
St. Louis River	1.18	3.5-13.5	0.9-2.6	Obstruction by pipes, cables and concrete structures
La Poudriere River	0.38	2.1-4.4	1.1-2.5	Obstruction by pipes, cables and concrete structures

The five rivers have good flow conditions and are well maintained. However, in some locations, the flow capacity of the original sections has been diminished due to obstacles such as concrete structures, cables and pipes as shown below.

Photo 5-2-1:
Obstacle in River Anglaise

Photo 5-2-2:
Obstacle in River Maintry

Photo 5-2-3:
Obstacle in River La Poudriere

Most of the drains have good flow conditions and are well maintained, but some drains are already present and are not in proper working condition as shown in Photo 5-2-4. In some locations, obstacles are found in the drains as shown below.

Photo 5-2-4:
Present side drain at Market Street

Photo 5-2-5: Obstacle near junction of 5th June Ave. and Manglier Rd.

(3) Flood Survey

In the Preliminary Study report, the inundation areas and condition of the drainage system are mentioned. However, there is no detailed and specific information on the flooding such as frequency, depth and duration. Therefore, a flood survey was carried out by DOE and the JICA Study Team to confirm the detailed situation. The flood prone areas and the results of the survey are shown in Figure 5-2-3.

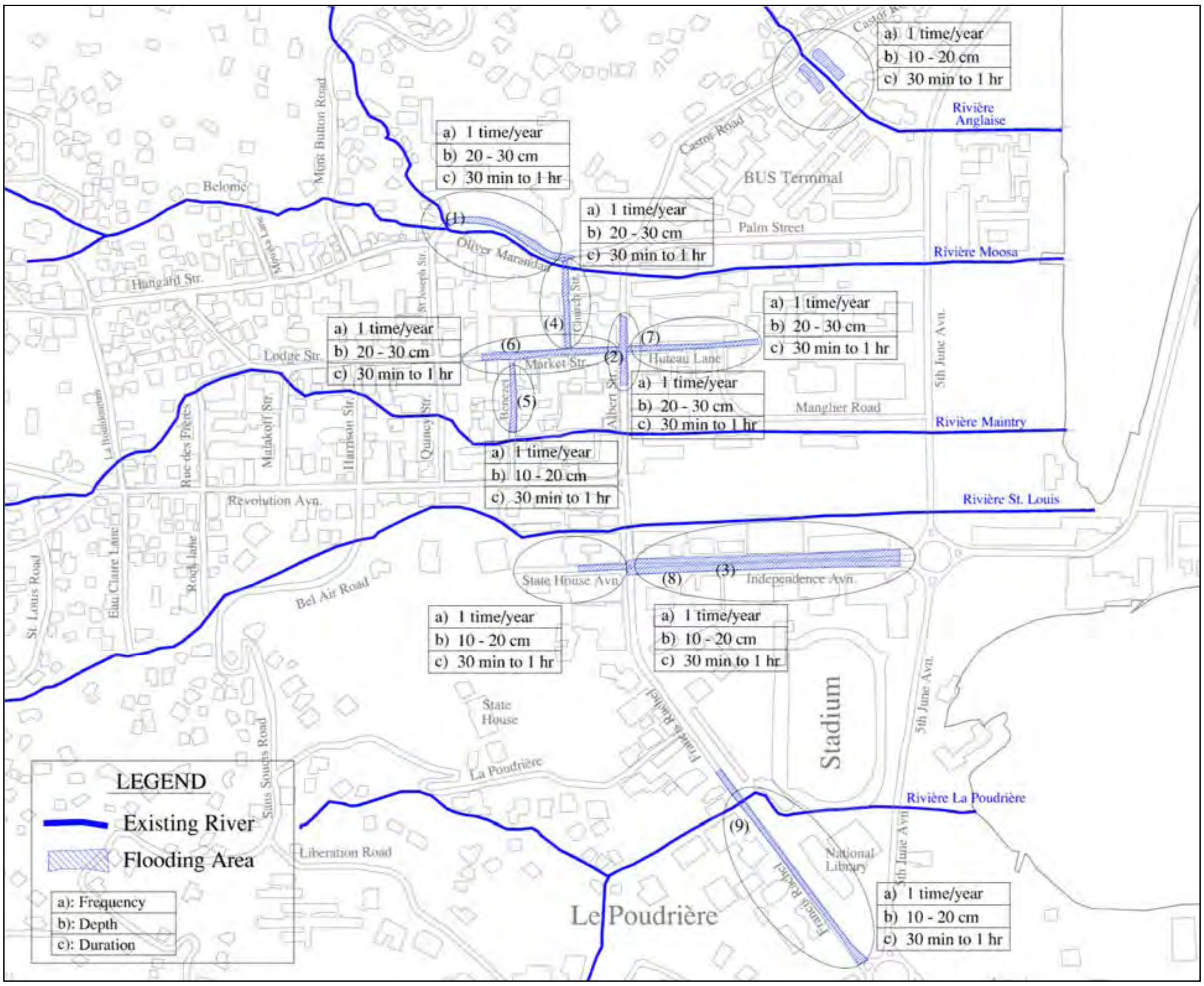


Figure 5-2-3: Flood Prone Areas in Victoria Town

According to the results of the flood survey, the average inundation depth is less than 30 cm, which is below the sidewalk, and the average inundation duration is less than 1 hour, in other words, there is no serious damage from heavy rain. In fact, after the heavy downpour in December 2004 (daily rainfall was about 200 mm), as shown below, there were some inundated areas in Victoria Town, but no serious damage.

(1) Photo 5-2-6: Intersection of Market St. and Albert St. (30 December 2004)

(2) Photo 5-2-7: Intersection of Market St. and Albert St. (29 December 2004)

(3) Photo 5-2-8: Independence Ave. (29 December 2004)

Note: * Locations of photos (1) ~ (3) are shown in Figure 5-2-3.

On 30 October 2011, heavy rainfall of about 100 mm lasted for 4 hours (daily rainfall was about 130 mm). For reference, photos taken on that day are shown below.

(4) Photo 5-2-9: Church St. (30 October 2011)

(5) Photo 5-2-10: Benezet St. (30 October 2011)

(6) Photo 5-2-11: Market St. (30 October 2011)

(7) Photo 5-2-12: Huteau Lane (30 October 2011)

(8) Photo 5-2-13: Independence Ave. (30 October 2011)

(9) Photo 5-2-14: Francis Rachel (30 October 2011)

Note: * Locations of photos (4) ~ (9) are shown in Figure 5-2-3.

As shown in the photo above, there was no inundation in the town area even though the observed daily rainfall (235.5mm) was greater than the rainfall on 28 December 2004. This seems to be the result of some drainage projects carried out after the 2004 flood as proposed by the Drainage Task Force Committee.

(4) Problem Analysis

A hydraulic analysis was conducted to evaluate the existing drainage network. A 10-year return period was used as recommended in the Drainage Design Guidelines.

The inadequate drains for the 10-year design return period are shown in Figure 5-2-4.

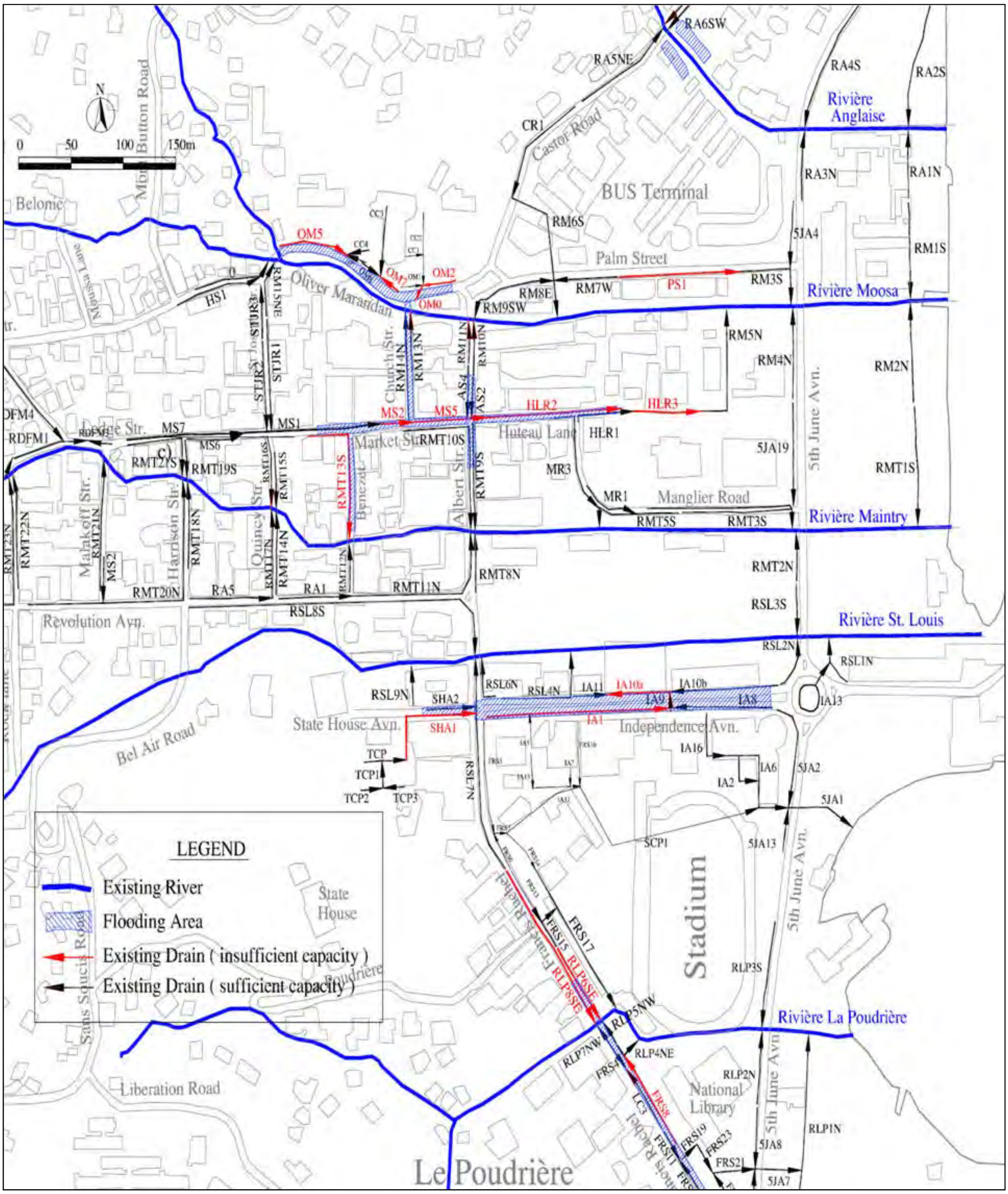


Figure 5-2-4: Results of Hydraulic Analysis

The location of the flood prone areas almost matches the location of the inadequate drains. It is obvious that the main cause of flooding in Victoria Town is the insufficient capacity of the drains (undersized and/or improper longitudinal slope, etc.). A summary of the insufficient capacity of the drains is tabulated in Table 5-2-1.

Table 5-2-1: Summary of the Insufficient Capacity of the Drains

Area		**Location**	**Existing Size Width x Height (m)**	**Existing Capacity (m3/s)**	**Required Capacity (m3/s)**
Moosa	OM7	Olivier Maradan	0.37 x 0.31	0.05	0.06
	OM5	Olivier Maradan	0.27 x (0.18~0.80)	0.05(minimum)	0.11
	OM2	Olivier Maradan	0.30 x 0.20	0.01	0.02
	OM0	Olivier Maradan	0.15 x 0.15	0.004	0.034
	MS2	Market Street	0.50 x 0.45	0.36	0.54
	MS5	Market Street	0.70 x 0.70	0.54	0.58
	HLR2	Huteau Lane	0.94 x 0.60	0.23	0.70
	HLR3	Huteau Lane	0.60 x 0.70	0.49	0.81
	PS1	Palm Street	0.50 x 0.50	0.13	0.23
Maintry	RMT13S	Benezet Street	0.50 x 0.50	0.04	0.10
St. Louis	SHA1	State House Avenue	0.40 x 0.50	0.22	0.23
	IA1	Independence Avenue	0.50 x 0.40	0.10	0.14
La Poudriere	IA10a	Independence Avenue	0.50 x 0.80	0.27	0.28
	RLP8SE	Francis Rachel	0.60 x 0.50	0.14	0.28
	RLP6SE	Francis Rachel	0.20 x 0.25	0.01	0.02
	FRS8	Francis Rachel	0.30 x 0.30	0.05	0.07

(5) Urban Drainage Improvement Plan

A number of the drainage problems were discussed in the previous section, leading to the recommended plan for future drainage improvement. In this sub-section the required infrastructure components are identified. The following discussions outline the drainage improvement plans for each area.

(a) Outline of the Improvement Plans for Each Area

1) River Moosa Area

The calculated discharges based on the foregoing discussions are shown in the appropriate columns in Table 2-5-17. Some drains have inadequate design discharge. The proposed drainage improvement plans are shown in Table 5-2-2. The locations of the proposed drains which are to be improved are shown in Figure 5-2-5.

Table 5-2-2: Proposed Drainage Improvement Plan for River Moosa Area

Drain Sr. No.	Location	Existing							Proposed							Remark
		Ld	W	H	Beginning Point		End Point		Ld	W	H	Beginning Point		End Point		
		m	m	m	GL	Invert EL	GL	Invert EL	m	m	m	GL	Invert EL	GL	Invert EL	
OM7	Oliver Marandan	20.61	0.37	0.31	2.81	2.50	2.55	2.24	20.61	0.37	**0.40**	2.81	2.41	2.55	2.15	Improvement work -open drain in rock - H 0.31m → 0.40m
OM5	Oliver Marandan	54.63	0.27	0.18~0.80	4.71	4.53	3.50	3.32	54.63	0.27	0.18~0.80	4.71	4.53	3.50	3.32	Rehabilitation work -remove the sediments for open & covered drains Improvement work
OM2	Oliver Marandan	47.79	0.30	0.20	2.83	2.63	2.80	2.60	47.79	0.30	**0.30**	2.83	2.53	2.80	2.45	Improvement work -open drain in rock - H 0.20m → 0.30m
OM0	Oliver Marandan	20.00	0.15	0.15	2.83	2.68	2.80	2.65	20.00	**0.30**	**0.30**	2.80	2.53	2.83	2.40	Improvement work -closed drain under the road - 0.15x0.15m → 0.30x0.30m
MS2	Market Street	34.40	0.50	0.45	2.10	1.65	1.80	1.35	34.40	0.75	0.45	2.10	1.65	1.80	1.35	Improvement work -covered drain under walkway - B 0.50m → 0.75m - provide the new grating or concrete cover
MS5	Market Street	73.70	0.70	0.50	1.80	1.30	1.38	0.88	73.70	**0.80**	0.50	1.80	1.30	1.38	0.88	Improvement work -covered drain under walkway - B 0.70m → 0.80m - provide the new grating or concrete cover
HLR2	Huteau Lane	138.60	0.94	0.60	1.38	0.78	1.34	0.74	138.60	**1.10**	0.70	1.38	0.68	1.34	0.44	Improvement work -covered drain under the road - 0.94x0.60m → 1.10x0.70m - provide the new grating or concrete cover
HLR3	Huteau Lane	40.40	0.60	0.70	1.34	0.64	1.21	0.51	40.40	**1.10**	**0.70**	1.34	0.44	1.55	0.35	Improvement work -covered drain under the road - 0.60x0.70m → 1.10x1.00m - provide the new grating or concrete cover
PS1	Palm Street	121.10	0.50	0.50	2.00	1.50	2.00	1.40	121.10	0.50	**0.70**	2.00	1.50	2.00	1.30	Improvement work -covered drain under walkway - H 0.50m → 0.70m

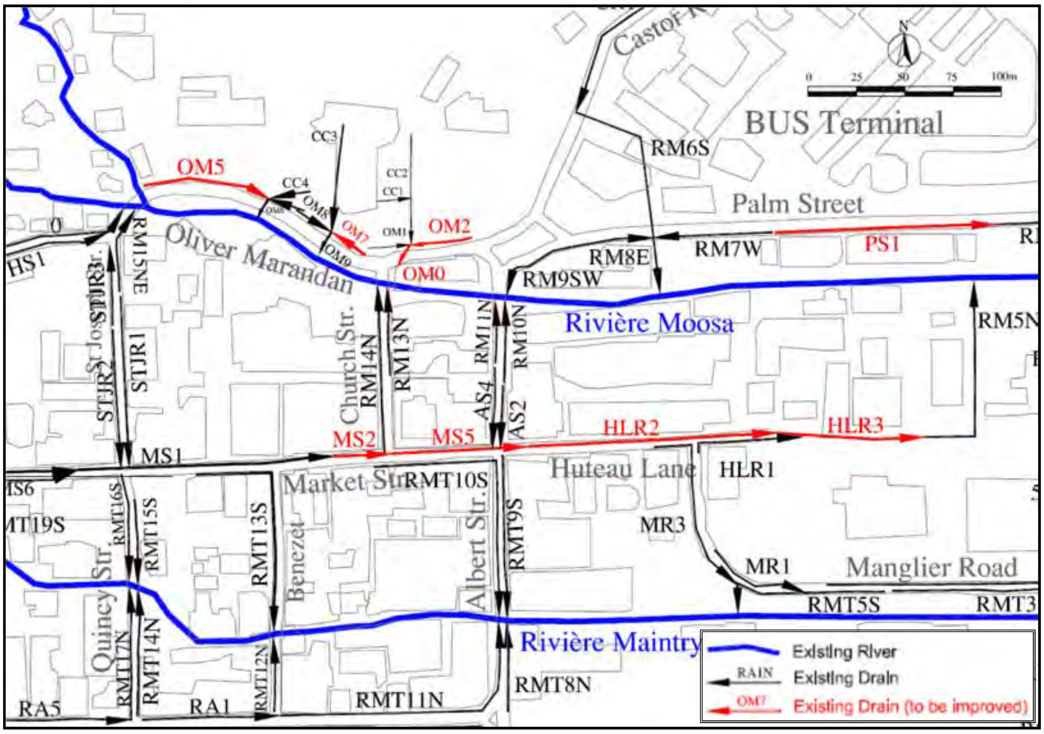


Figure 5-2-5: Location of the Proposed Drains in River Moosa Area

2) River Maintry Area

The calculated discharges based on the foregoing discussions are shown in the appropriate columns in Table 5-2-3. Some drains have inadequate design discharge. The proposed drainage improvement plans are shown in Table 5-2-3. The locations of the proposed drains which are to be improved are shown in Figure 5-2-6.

Table 5-2-3: Proposed Drainage Improvement Plan for River Maintry Area

Drain Sr. No.	Location	Existing							Proposed							Remark
		Ld	W	H	Beginning Point		End Point		Ld	W	H	Beginning Point		End Point		
		m	m	m	GL	Invert EL	GL	Invert EL	m	m	m	GL	Invert EL	GL	Invert EL	
RMT13S	Benezet Street	125.40	0.50	0.50	2.48	1.98	2.77	1.97	125.40	0.50	**0.60**	2.48	1.88	2.77	1.77	Improvement work -covered drain under walkway - H 0.50m → 0.60m

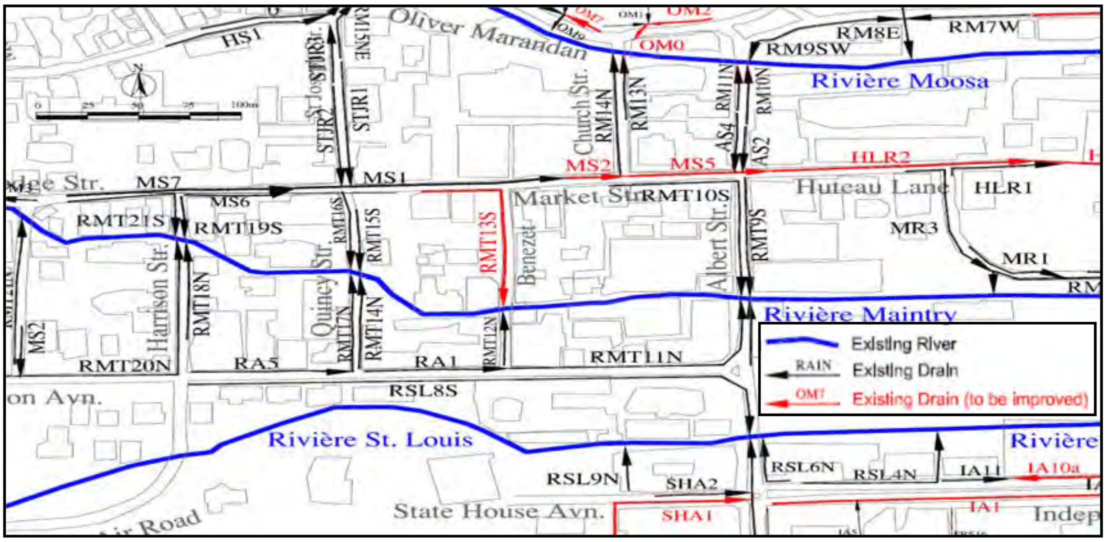


Figure 5-2-6: Location of the Proposed Drains in River Maintry Area

3) River St. Louis Area

The calculated discharges based on the foregoing discussions are shown in the appropriate columns in Table 5-2-4. Some drains have inadequate design discharge. The proposed drainage improvement plans are shown in Table 5-2-4. The locations of the proposed drains which are to be improved are shown in Figure 5-2-7.

Table 5-2-4: Proposed Drainage Improvement Plan for River St. Louis Area

Drain Sr. No.	Location	Existing							Proposed							Remark
		Ld	W	H	Beginning Point		End Point		Ld	W	H	Beginning Point		End Point		
		m	m	m	GL	Invert EL	GL	Invert EL	m	m	m	GL	Invert EL	GL	Invert EL	
SHA1	State House Avn.	95.50	0.40	0.50	2.00	1.50	1.56	1.06	95.50	**0.50**	0.50	2.00	1.50	1.56	1.06	Improvement work -covered drain under the walkway - B 0.40m → 0.50m
IA1	Independence Avn.	163.40	0.50	0.40	1.58	1.02	1.28	0.88	163.40	0.50	**0.50**	1.58	1.02	1.28	0.78	Improvement work -covered drain under the road - H 0.40m → 0.50m - provide the new grating or concrete cover
IA10a	Independence Avn.	60.00	0.50	0.80	1.24	0.44	1.27	0.37	60.00	**0.60**	0.80	1.24	0.44	1.27	0.37	Improvement work -covered drain under walkway - B 0.50m → 0.60m - provide the new grating or concrete cover

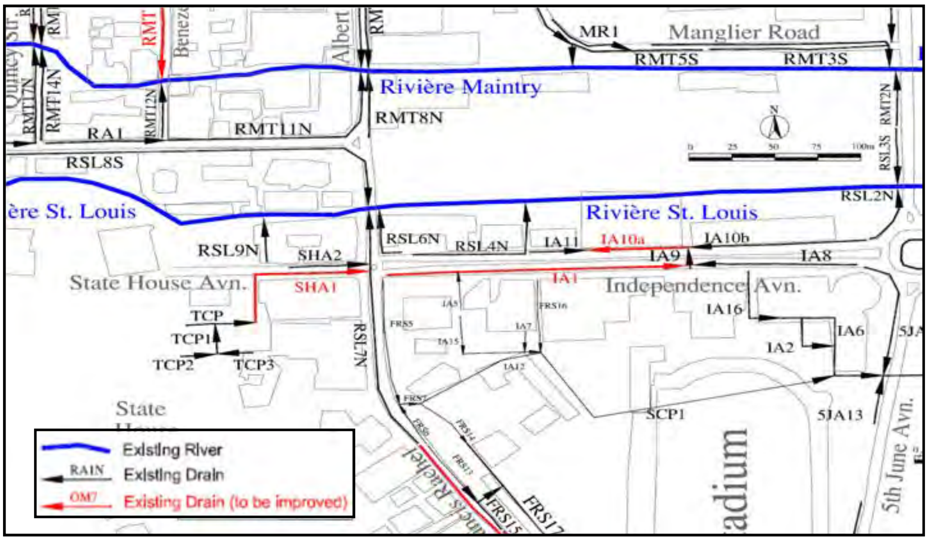


Figure 5-2-7: Location of the Proposed Drains in River St. Louis Area

4) River La Poudriere Area

The calculated discharges based on the foregoing discussions are shown in the appropriate columns in Table 5-2-5. Some drains have inadequate design discharge. The proposed drainage improvement plans are shown in Table 5-2-5. The locations of the proposed drains which are to be improved are shown in Figure 5-2-8.

Table 5-2-5: Proposed Drainage Improvement Plan for River La Poudriere Area

Drain Sr. No.	Location	Existing							Proposed							Remark
		Ld	W	H	Beginning Point		End Point		Ld	W	H	Beginning Point		End Point		
		m	m	m	GL	Invert EL	GL	Invert EL	m	m	m	GL	Invert EL	GL	Invert EL	
RLP8SE	Francis Rachel	168.10	0.60	0.50	1.50	1.00	1.40	0.90	168.10	0.60	**0.75**	1.50	0.80	1.40	0.60	Improvement work -covered drain under walkway - H 0.50m → 0.75m New construction work -covered drain same as existing drain
RLP6SE	Francis Rachel	58.70	0.20	0.25	1.39	1.14	1.40	1.10	58.70	**0.30**	0.25	1.39	1.14	1.40	1.10	Improvement work -open drain along the road - B 0.20m → 0.30m
FRS8	Francis Rachel	95.30	0.30	0.30	1.51	1.21	1.30	1.00	95.30	**0.45**	0.30	1.51	1.21	1.30	1.00	Improvement work -open drain along the road - B 0.30m → 0.45m

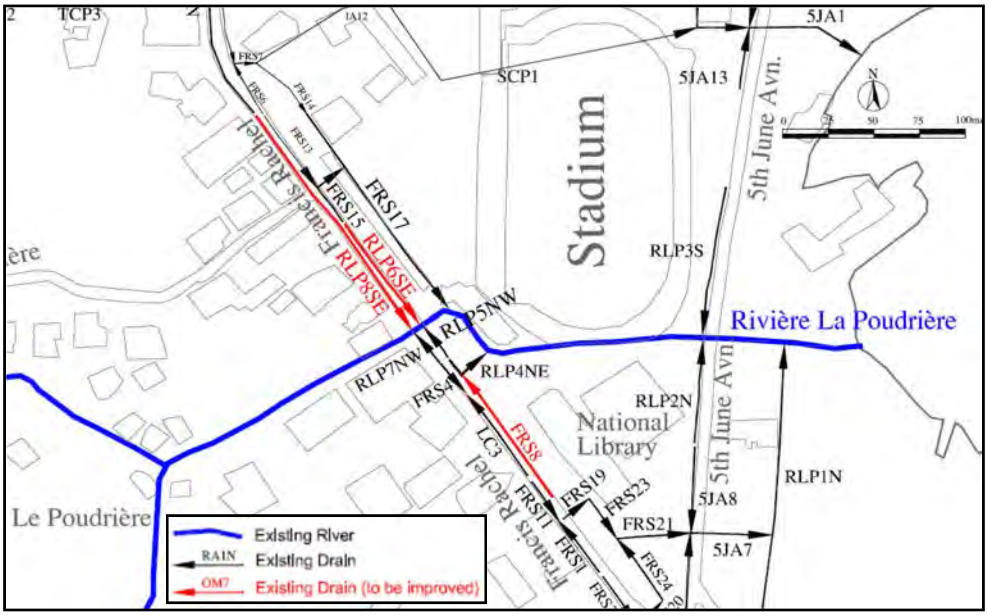


Figure 5-2-8: Location of the Proposed Drains in River La Poudriere Area

(b) Short-Term Plan (10-year Return Period)

The calculation results for design discharge with a 10-year return period are as shown in Figure 5-2-9. A representative section of each river is shown in the same figure with the design HWL. No overflow was observed which suggests that there is no need for measures under the short-term plan.

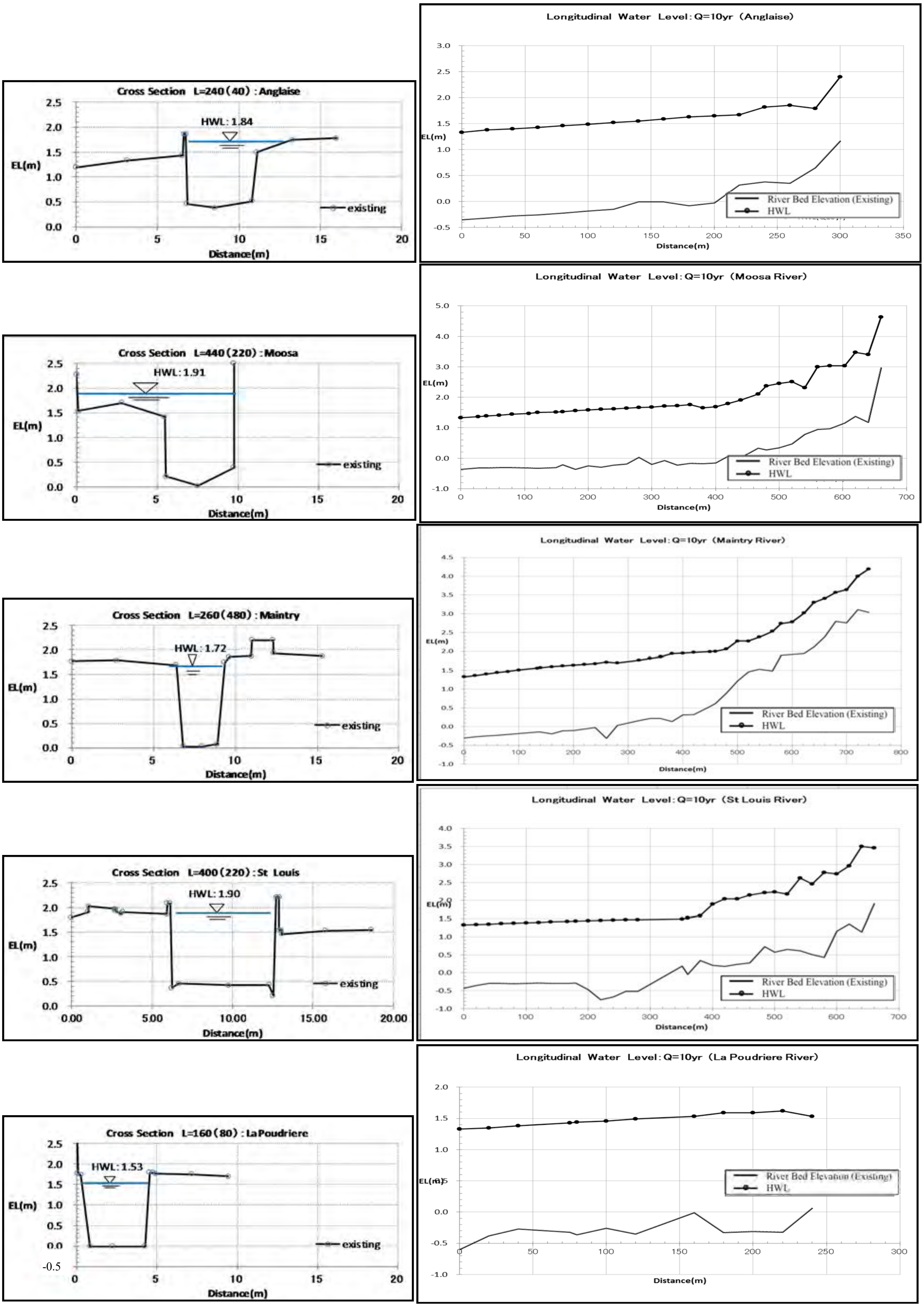


Figure 5-2-9: HWL in Short-Term Plans (10-year) for 5 rivers

(c) Medium-Term Plan (25-year Return Period)

In the analysis of the results of the medium-term plan (25-year return period), the highest water level is 20 to 30 cm higher than for the 5-year return period, so an overflow section of the river is anticipated. However, since Victoria Town is urbanised and is located by the sea, it is difficult to change the alignment of the river bed. It is planned to lower the HWL below the existing ground level. The proposed structural countermeasures for Victoria Town are listed in Table 5-2-6 and Figure 5-2-10 to Figure 5-2-14.

Table 5-2-6: Proposed Structural Countermeasures for Victoria Town

River Name	Station No.		Length	Thickness	Width	Remark	Amount(SR)					
	Start	End	m	m	m		Parapet levee	Revetment	underpining	river bed excavation	Bridge	Total
Anglaise	120	160	40	0.1						6,000		6,000
	200	260	60	0.3						28,000		28,000
	200	260	60		1.0					42,000		42,000
		280	280			H=0.5m	390,000					390,000
		280	280			H=2.0m		3,491,000				3,491,000
Moosa	280	300	20	0.15						5,000		5,000
	400	620	220	0.3						103,000		103,000
	400	620	220			H=0.75m	449,000					449,000
Maintry		400	400	0.3					2,026,000	94,000		2,120,000
		280	280		1.0					245,000	2,394,000	2,639,000
		280	280			H=2.5m		4,560,000				4,560,000
	400	420	20	0.15						2,000		2,000
St. Louis	300	540	240	0.3						168,000		168,000
	540	560	20	0.15						7,000		7,000
La Poudriere	120	140	20	0.15						4,000		4,000
	140	160	20	0.3						7,000		7,000
	160	180	20	0.15						4,000		4,000
Total							839,000	8,051,000	2,026,000	715,000	2,394,000	14,025,000

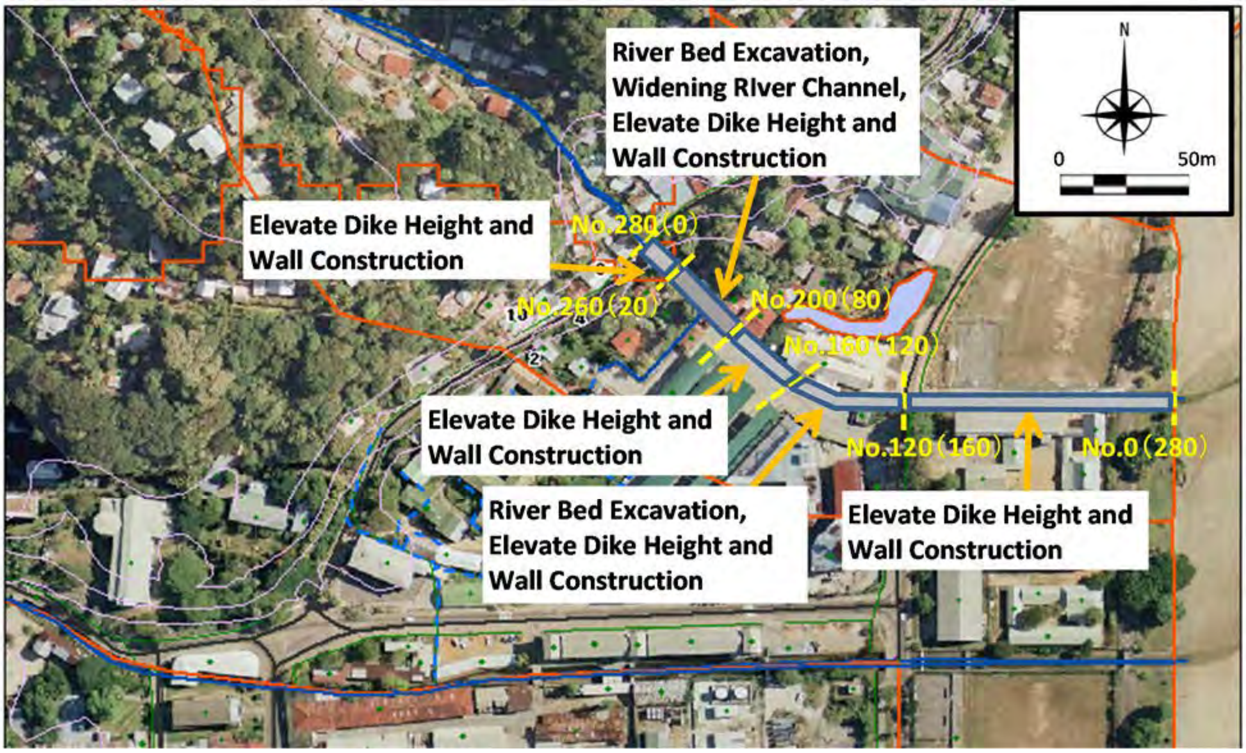


Figure 5-2-10: Location of Proposed Countermeasures in Victoria Town (Anglaise River)

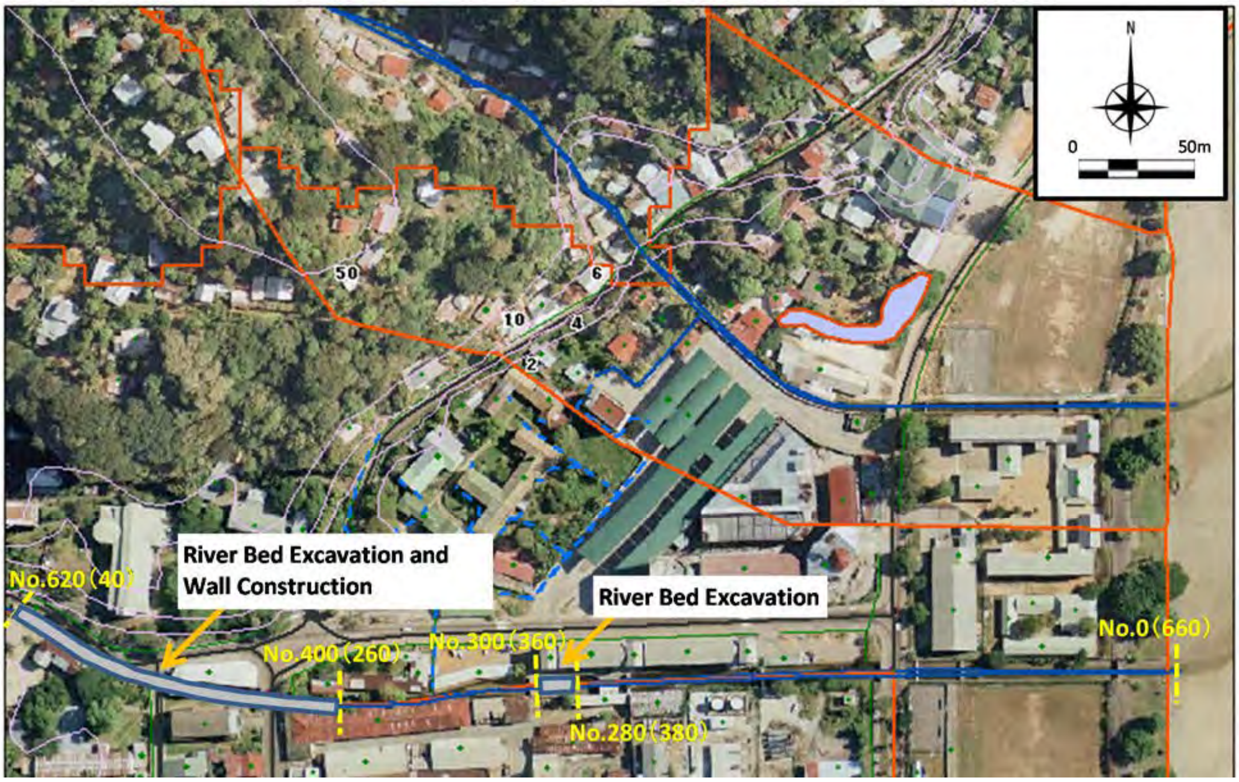


Figure 5-2-11: Location of Proposed Countermeasures in Victoria Town (Moosa River)

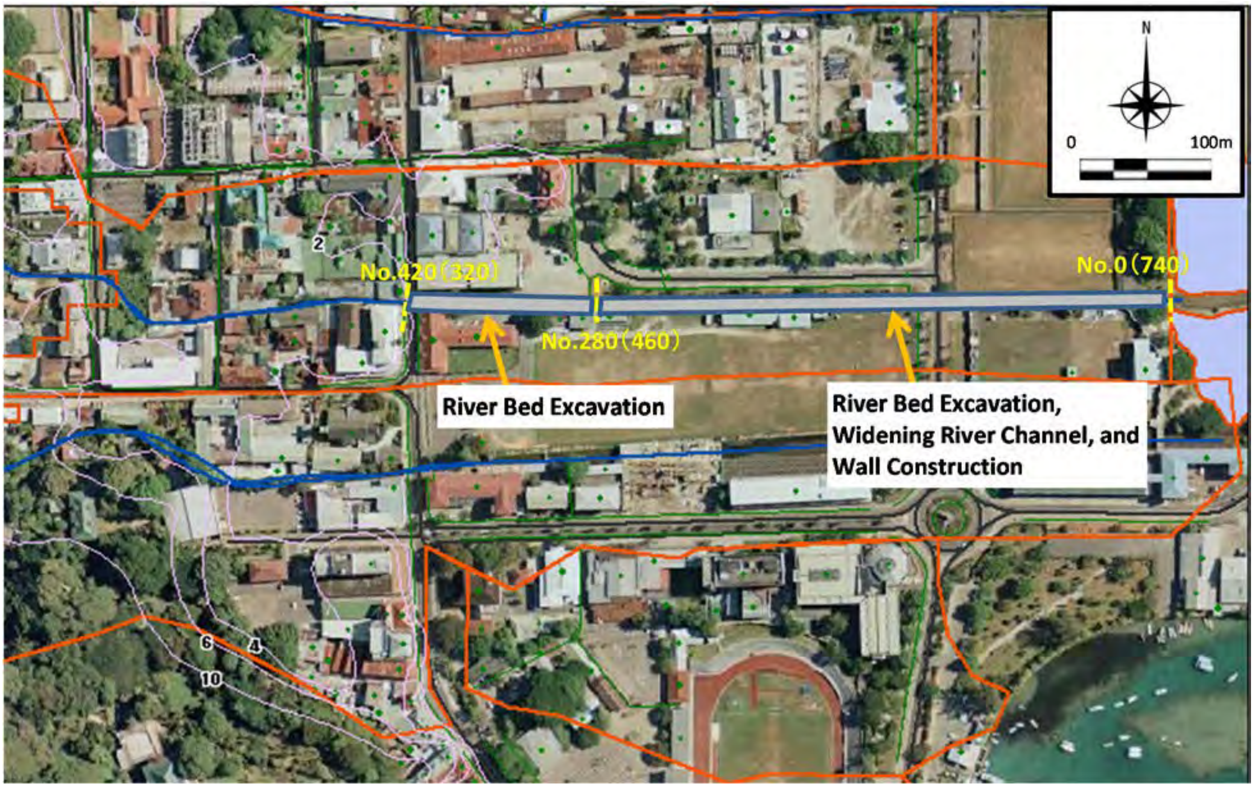


Figure 5-2-12: Location of Proposed Countermeasures in Victoria Town (Maintry River)

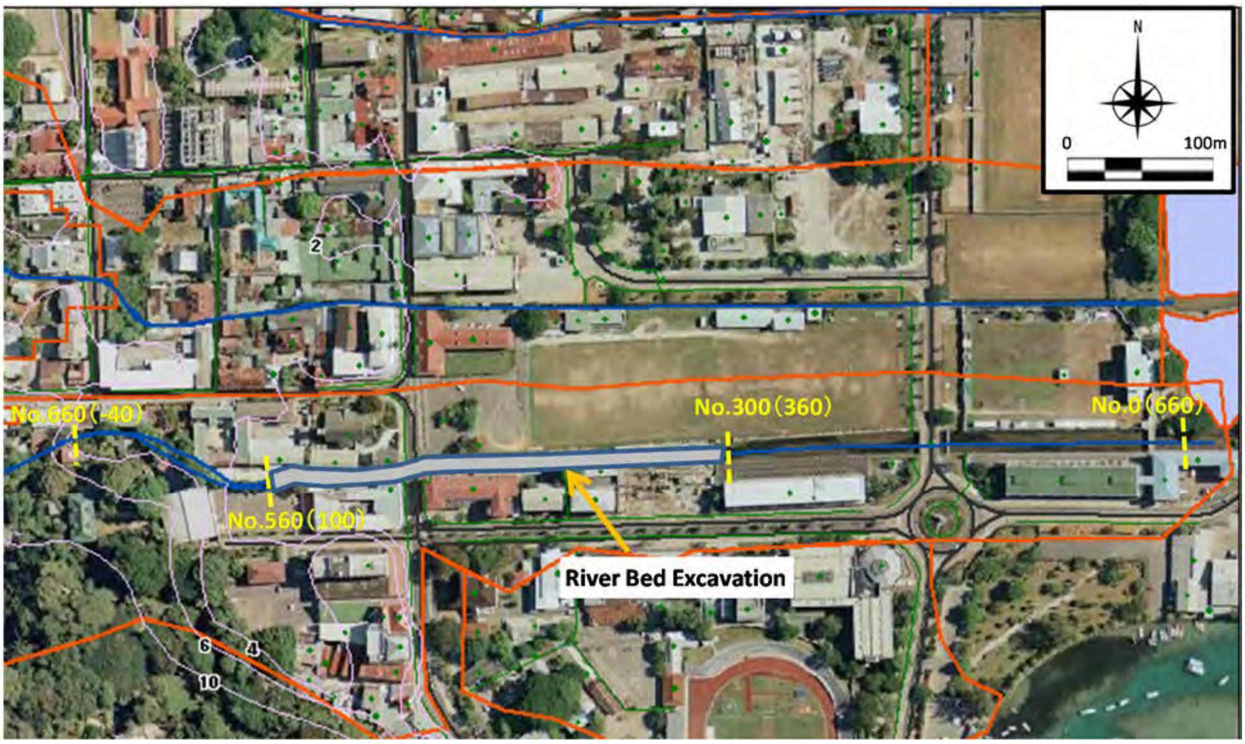


Figure 5-2-13: Location of Proposed Countermeasures in Victoria Town (St. Louis River)

Figure 5-2-14: Location of Proposed Countermeasures in Victoria Town (La Poudriere River)

5-2-2 Pointe Larue

Pointe Larue is an important district for the Government of the Seychelles because of the Seychelles International Airport that is accessed by the main highway (East Coast Road) on Mahe. However, based on the explanation by DOE, the East Coast Road suffers frequently from flood damage by intensive rainfall.

The drainage system at Pointe Larue can be divided into three sections from north to south: Anse Des Genets, Pointe Larue Central and Mirabelle. The location map is shown in Figure 5-2-15.

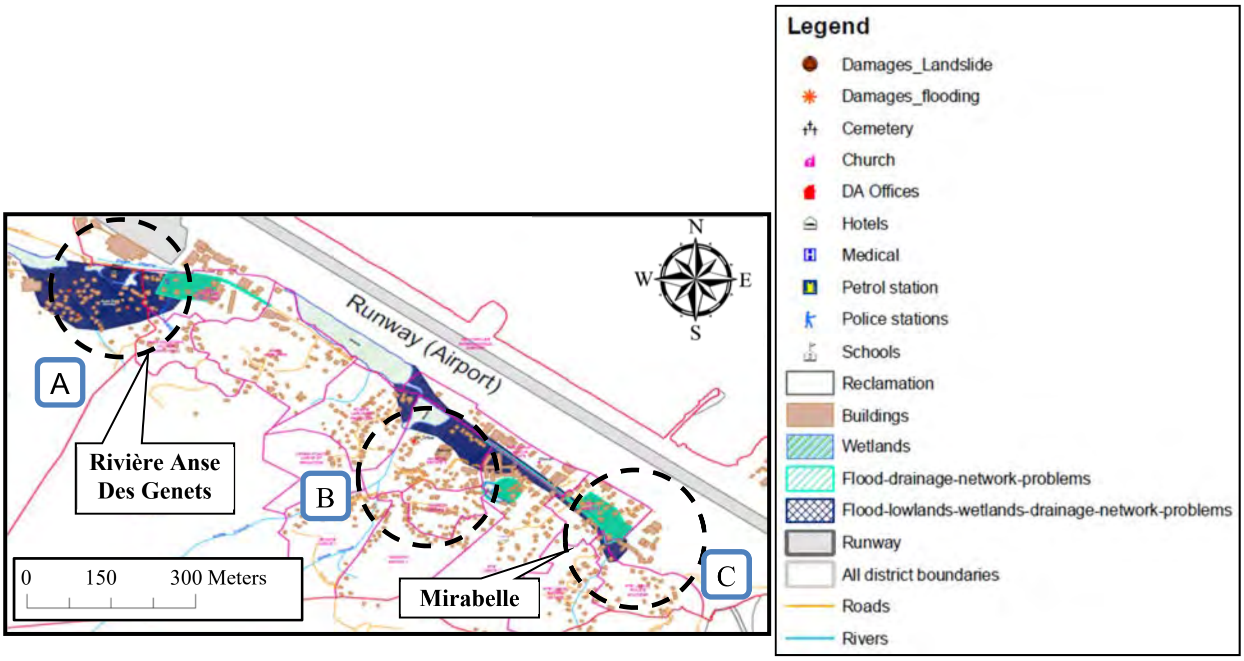


Figure 5-2-15: Location Map of Flood Risk Areas at Pointe Larue

The cause of flooding at each location is as summarised in Table 5-2-7.

Table 5-2-7: Existing Conditions at Pointe Larue

Location	Existing Conditions (Causes of Flooding)	Major Facility at Site
Anse Des Genets (A)	▪ Drainage is unconnected ▪ Culvert is small ▪ Drainage was backfilled by soil	Petrol Station
Pointe Larue Central (B)	▪ Drainage is unconnected ▪ Drainage capacity of airport drains is small	Pointe Larue Secondary School
Mirabelle (C)	▪ Drainage capacity is small ▪ Lack of maintenance of drainage channel	Police Academy Airport

Photo 5-2-15:
Narrow drainage inlet (A) (April 2011)

Photo 5-2-16:
Airport drainage channel (C) (April 2011)

The proposed structural countermeasures for the short term and medium term are as follows.

<u>Short-Term Countermeasures</u>

Estimating the highest water level for a 5-year return period by the existing ground level,

- Pointe Larue A area needs a new drainage ditch from the petrol station to the lagoon area and de-silting of the existing ditches.
- Pointe Larue B area needs the missing road drain to be connected to the wetland.
- Pointe Larue C area drainage system is all connected to the Seychelles International Airport. The drainage system in the airport is not adequate to drain surface water.

Medium-Term Countermeasures

Estimating the highest water level for a 25-year return period by the existing ground level,

- In Pointe Larue A area the highest water level for a 25-year return period was determined as lower than the existing ground level, therefore structural countermeasures are not required.
- In Pointe Larue B area the highest water level is 2.1 m, which is slightly higher than the ground level. The inundation area will depend on the actual ground elevation.
- Since the Study Team was not able to obtain the latest results of an aerial topographic survey from the counterparts, identification of the inundation area will be up to the DOE.

The proposed structural countermeasures at Pointe Larue for the short term and medium term are as summarised in Table 5-2-8 and Figure 5-2-16.

Table 5-2-8: Proposed Structural Countermeasures for Pointe Larue

Location Name	Work Item(facilities)		Size		Length	Type	Remark	Amount (SR)						
	Short Term	Middle Term	W m	H m	m			Drain	Revetment	Underpinning	River bed excavation	Bridge	Land price	Total
Point Laure A	Drainage Ditch (new)		1.0	1.0	30	culvert	construction of new catch basin and connecting under ground ditch from Gas station side to lagoon (direct)	368,000						368,000
Point Laure A	De-silting the existing ditch						OM works of DOE, (south side of Gas station)							
Point Laure A		Enlarge the existing culvert	2.25	1.5	8	culvert	enlarge the culvert in Golden Egg River, existing size is W=1.2m, H=0.45m	231,000						231,000
Point Laure B	Drainage Ditch (new)		1.5	1.1	40	open	extend an existing drainage to wetland	327,000						327,000
Point Laure C	Widen existing drainage ditch					open	inside of Seychelles International Airport							
Point Laure C	De-silting the existing ditch						OM works of DOE, (small hill beside police academy)							

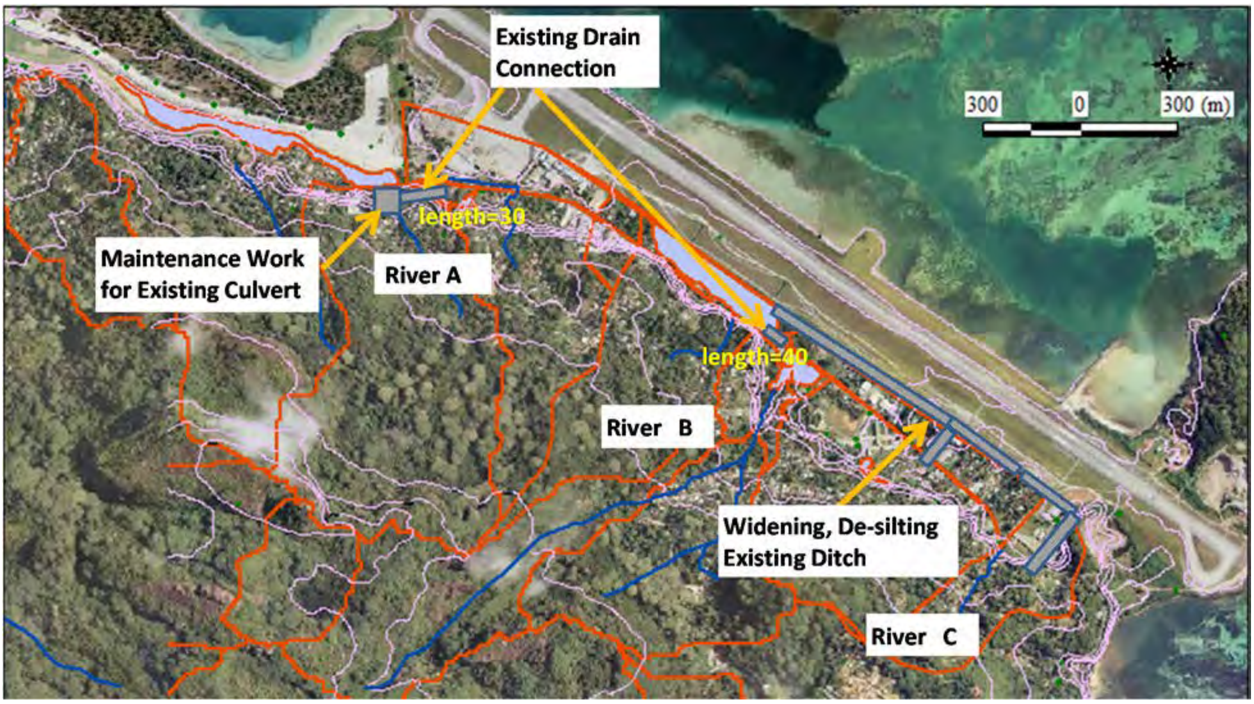


Figure 5-2-16: Location of Proposed Countermeasures in Pointe Larue

5-2-3 Anse Aux Pins

Anse Aux Pins is located to the south of Pointe Larue and flooding is concentrated around the wetland area. The location map is shown below in Figure 5-2-17.

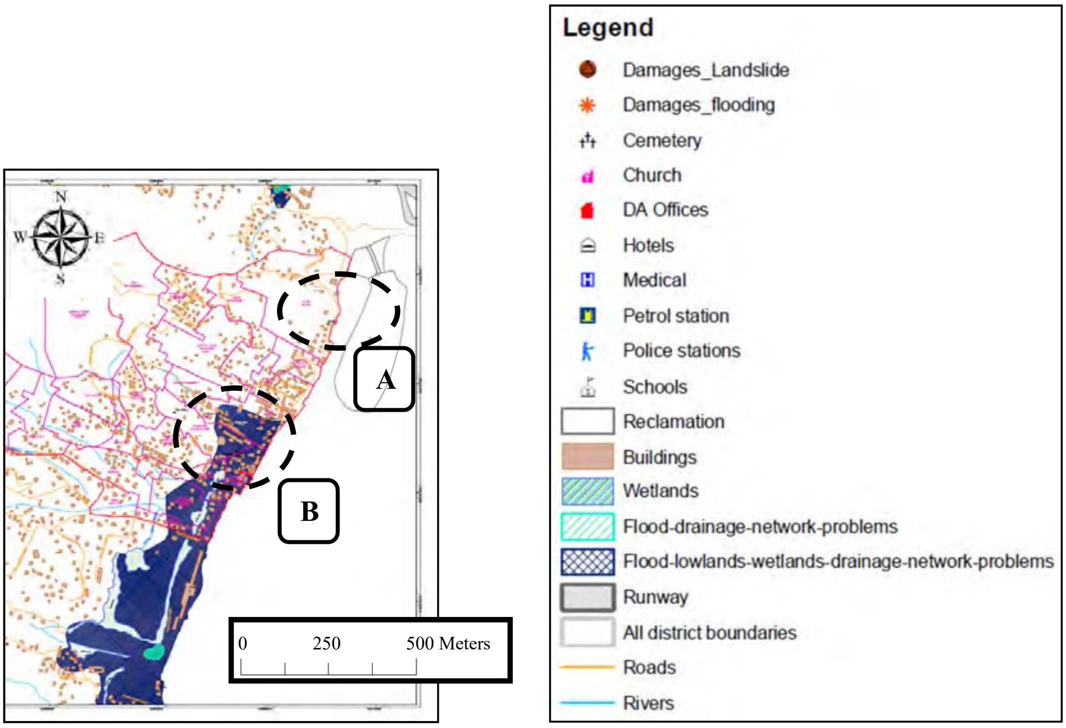


Figure 5-2-17: Location Map of Flood Risk Areas at Anse Aux Pins*

The cause of flooding at each location is as summarised in the table below.

Table 5-2-9: Existing Conditions at Anse Aux Pins

Location	Existing Conditions (Causes of Flooding)	Major Facility at Site
Mondon River (A)	▪ Deposition of sand at the mouth of the channel	DA office
Bassin Grand River (B)	▪ Outlet capacity is small ▪ Residential area is located on low land	Bus Station

The wetland at Anse Aux Pins receives water discharged from the Bassin Grand River and another three rivers. Floodwater gathers in the wetland before flowing out through the river mouth. The residential area around the wetland is basically a lowland area which is always inundated by rainwater during high tides. On the other hand, the Mondon River has been maintained by DOE since 2010.

The proposed structural countermeasures for the short term and medium term are as follows.

<u>Short-Term Countermeasures</u>

Estimating the highest water level for a 5-year return period by the existing ground level,

- Chetty Flat needs new drainage in order to discharge rainwater.
- In Anse Aux Pins A area the highest water level is 2.0 m, which is the same as the ground level. No river improvement is required in the short term. However, riverbed excavation is recommended in order to ensure additional security.
- In Anse Aux Pins B area it was not possible to consider the effectiveness of wetland as a reservoir due to the limited data. The accuracy of the calculation results could not be confirmed, therefore, no structural countermeasures are proposed for the short term.

<u>Medium-Term Countermeasures</u>

Estimating the highest water level for a 25-year return period by the existing ground level,

- Pointe Larue A area requires the implementation of river bed excavation of 0.3 m.
- In Pointe Larue B area, the highest water level will be about 2.3 m which is 0.3m higher than the existing ground elevation. It is necessary to widen the river channel around the river mouth area, while, on the other hand, river mouth clogging cannot be overlooked.

The proposed structural countermeasures at Anse Aux Pins for the short term and medium term are as summarised in Table 5-2-10 and Figure 5-2-18.

Table 5-2-10: Proposed Structural Countermeasures for Anse Aux Pins

Location Name	Work Item(facilities)		Size		Length	Type	Remark	Amount (SR)						
	Short Term	Middle Term	W m	H m	m			Drain	Revetment	Underpining	River bed excavation	Bridge	Land price	Total
Chetty Flat	Drainage Ditch (new)		1.5	1.2	120	open		989,000						989,000
Anse Aux Pins A		River Bed Excavation		0.3	293	open					31,000			31,000
Anse Aux Pins B		Short-cut outlet of river	6.0		50	open	River mouth measures + Wall (2m)		692,000		210,000		150,000	1,052,000
Anse Aux Pins B		Bridge (new) or Box culvert	6.0				1 location					2,394,000		2,394,000
Anse Aux Pins B		widen existing river channel	5.0		200	open	excavation of river channel + wall (2m)		2,767,000		350,000			3,117,000

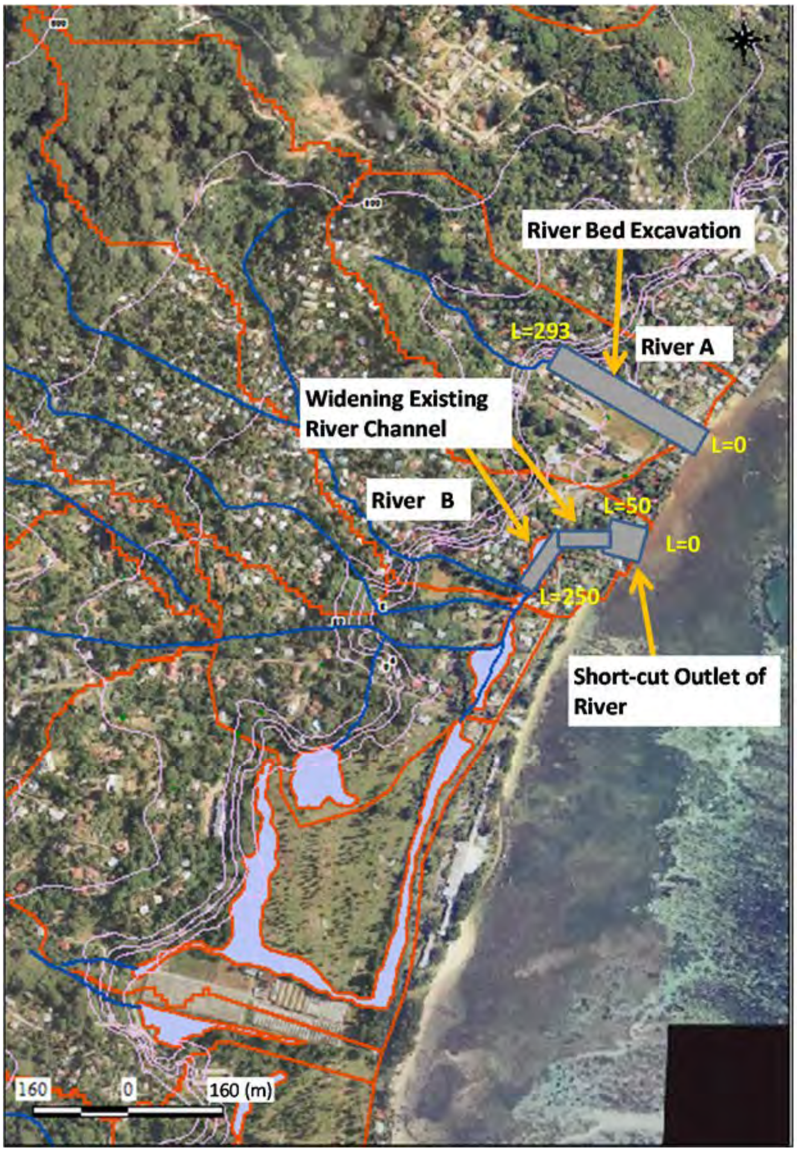


Figure 5-2-18: Location of Proposed Countermeasures in Anse Aux Pins

5-2-4 Au Cap

Au Cap is located to the south of Anse Aux Pins. The district boundary runs from the Reef Estate Road to Pointe Au Sel. The East Coast Road passes though Au Cap along the shoreline and most residents live within 300 m of the coastline. The location map is shown in Figure 5-2-19.

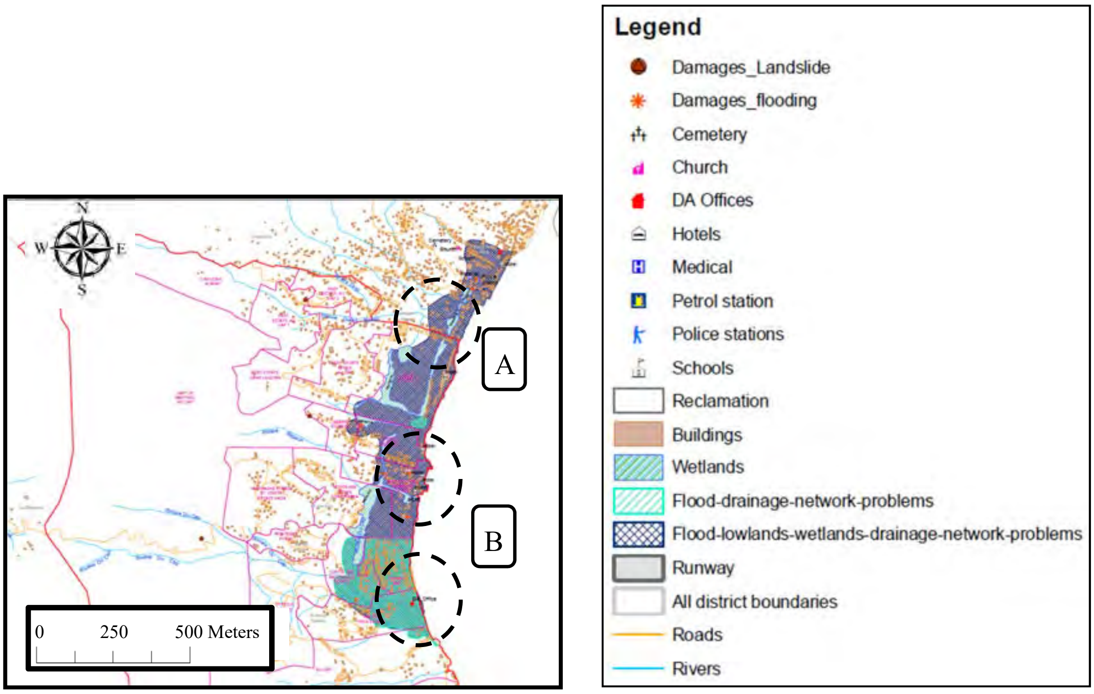


Figure 5-2-19: Location Map of Flood Risk Area in Au Cap

Most of the residential areas are also on low land in flood prone areas. As reported, the new school at Turtle Bay experiences flooding once every two or three years. New countermeasures have been adopted for river mouth clogging at River Au Cap; however, the capacity of the pipes is not enough to discharge the rainwater during the rainy season. The cause of flooding in each location is as summarised in Table 5-2-11 below.

Table 5-2-11: Existing Conditions in Au Cap

Location	Existing Conditions (Causes of Flooding)	Major Facility at Site
Turtle Bay (A)	▪ Lowland area ▪ Outlet capacity is small	Green Estate
Au Cap River (B)	▪ Outlet capacity is small ▪ Channel capacity is not enough	Pipe outlet


Photo 5-2-17: Outlet from Wetland (May 2011)


Photo 5-2-18: Rain Water Discharged by Pipe at River Au Cap (May 2011)

The proposed structural countermeasures for the short term and medium term are as follows.

<u>Short-Term Countermeasures</u>

Estimating the highest water level for a 5-year return period by the existing ground level,

- At Turtle Bay and Tyfoo widening of the existing drainage ditches is recommended. In addition, improvement works are being conducted by the DOE in the Turtle Bay portion.
- At Naiken's Farm extension of the outlets towards the sea is needed for about 50m, in order to improve water discharge due to river mouth clogging. This location was selected for one of the pilot projects in the Study; monitoring works are currently implemented by the Study Team and DOE.
- The highest water level of the other outlets for the short term is estimated at about 2.1m which is slightly higher than the existing ground level. Therefore, there might be some local inundation but nothing serious.

<u>Medium-Term Countermeasures</u>

Estimating the highest water level for a 25-year return period by the existing ground level,

- At Au Cap A area it is necessary to widen the existing river mouth and provide a new 5.0 m-wide outlet channel. Due to the widening of the river channel, the existing bridge will have to be extended.
- At Au Cap B area it is necessary to widen the existing river mouth and provide a new 5.0 m-wide outlet channel. Due to the new channel, it will be necessary to provide a new bridge or a box culvert facility for crossing the main road.

The proposed structural countermeasures at Au Cap for the short term and medium term are as summarised in Table 5-2-12 and Figure 5-2-20.

Table 5-2-12: Proposed Structural Countermeasures for Au Cap

Location Name	Work Item(facilities)		Size		Length	Type	Remark	Amount (SR)						
	Short Term	Middle Term	W m	H m	m			Drain	Revetment	Underpinning	River bed excavation	Bridge	Land price	Total
Turtle Bay	Drainage Ditch (enlarge)		1.3	1.0		open								
Naiken's Farm	Extension of drainage (new)	River Month (New)	2.0	1.5	50	culvert	Rubble Armor retaining wall for drainage for first stage widen the retaining wall based on the Au Cap B	1,376,000	1,050,000					2,426,000
Tyfoo	Drainage Ditch		1.5	1.0		open								
Au Cap A		Widening River Mouth	5.0		30	open	River mouth measures + Wall (1.5m), 0.2 m excavtaion		315,000	77,000	102,000		75,000	569,000
Au Cap A		Bridge (extend or new)	16.0				1 location, crossing river, cab be extended existing bridge					6,384,000		6,384,000
Au Cap A		Widening River Channel	5.0		170	open	0.2m excavation				552,000		425,000	977,000
Au Cap B		Widening River Mouth	5.0		200	open	River mouth measures + Wall (1.5m), 0.2 m excavtaion		2,102,000	512,000	762,000		500,000	3,876,000
Au Cap B		Bridge (new) or Box culvert	5.0				1 location					1,995,000		1,995,000
Au Cap B		Widening River Channel			450	open	0.1m excavation				88,000			88,000

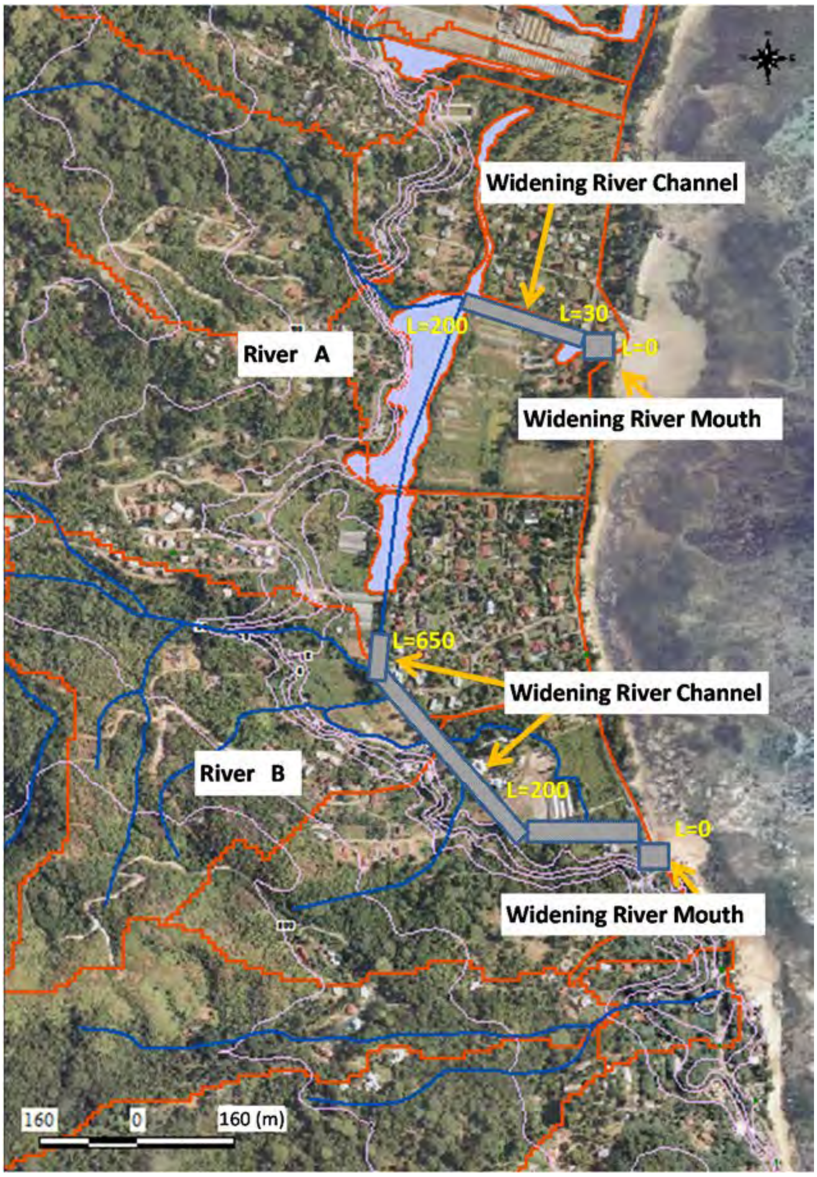


Figure 5-2-20: Location of Proposed Countermeasures in Au Cap

5-2-5 Anse Royale

Anse Royale has the second largest population on Mahe and is famous for agriculture and fishing. Based on recent development, Anse Royale has become the centre of educational, residential and commercial establishments. The location map is shown in Figure 5-2-21.

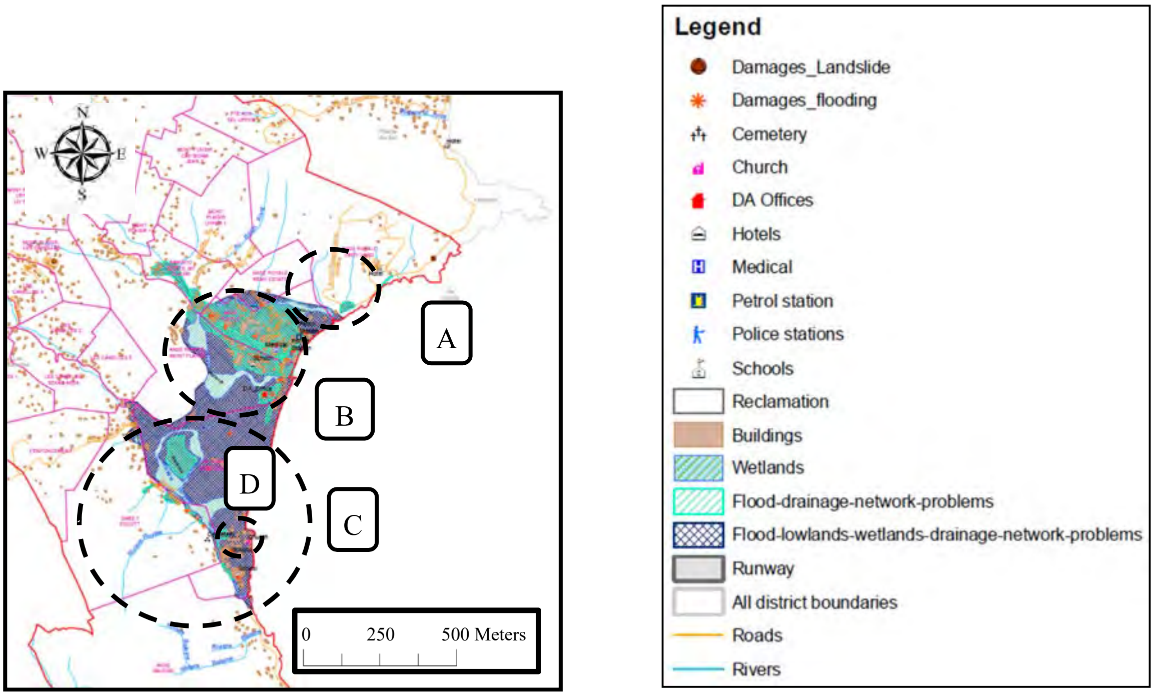


Figure 5-2-21: Location Map of the Flood Risk Areas at Anse Royale

The cause of flooding at each location is as summarised in Table 5-2-13 below.

Table 5-2-13: Existing Conditions at Anse Royale

Location	Existing Condition (Causes of Flooding)	Major Facility at Site
Remise Estate (A)	▪ River mouth clogged by sand	
Mont Plaisir (B)	▪ Inadequate outlet capacity ▪ Inadequate channel capacity ▪ Lowland area	University
Anse Royale Secondary School Channel (C)	▪ Inadequate outlet capacity ▪ Inadequate channel capacity	Pipe outlet Church

Anse Royale has three large wetlands that conserve discharge from the upper rivers which flow into the sea via four outlets.

- Location (A) is the outlet for the discharge of rainwater from the Anse Royale Remy Estate and the Anse Royale Hospital. The outlet is totally clogged by sand and water is stagnated under the bridge. Due to the residential development upstream, the sand bar formed by the balance between the river discharge and the tide has moved to the land side.
- Location (B) is the outlet for the discharge of rainwater from Anse Royale, Mont Plaisir and Bamboo Estate. The size of the outlet was reduced before reaching the river mouth in order to increase the discharge velocity and flush out the sand to the sea, thus maintaining the function

of the outlet. However, the outlet structure is under continuous attack by waves and the foundation has eroded.

- Locations (C) and (D) are the outlets for the discharge of rainwater from Sweet Escott, St. Joseph, Anse Baleine and Les Cannelles. Location (D) is near the church and is used for road drainage. The outlet was designed not to face the sea in order to prevent sand clogging. Outlet C adopts the same method as at Au Cap by using pipes for the discharge of rainwater.

Photos of the above outlets are as shown below:


Photo 5-2-19: Outlet A river mouth clogged (April 2011)


Photo 5-2-20: Residential Development at Remy Estate (April 2011)


Photo 5-2-21: Outlet B Structural Damage by Erosion (April 2011)


Photo 5-2-22: Outlet B Reduced width of Outlet (April 2011)


Photo 5-2-23: Outlet D is not in Water (May 2011)


Photo 5-2-24: Outlet D (April 2011)


Photo 5-2-25: Outlet C Discharge by Pipes (April 2011)


Photo 5-2-26: Inlet of Pipes (April 2011)


Photo 5-2-27: Outlet C, under improvement (Jan 2014)

The proposed structural countermeasures for the short term and medium term are as follows.

<u>Short-Term Countermeasures</u>

Estimating the highest water level for a 5-year return period by the existing ground level,

- Anse Royale A has enough capacity to discharge the volume of surface water for a 5-year return period, therefore it is not necessary to improve this channel.
- Anse Royale B has a large wetland before the river reaches the mouth, therefore this river has some wetland storage effect. For the short term improvement works are not considered.
- Anse Royale C needs a new drainage ditch to discharge excess water. The new drainage will be 1.6 m wide and 1.3 m high with a slope of 1/400. The length of the new ditch will be 120 m.

<u>Medium-Term Countermeasures</u>

Estimating the highest water level for a 25-year return period by the existing ground level,

- Anse Royale A area does not need additional improvement works.
- Anse Royale B requires riverbed excavation and widening of the channel with extension of the existing bridge span.
- Anse Royale C requires riverbed excavation and widening of the river mouth.

The proposed structural countermeasures at Anse Royale for the short term and medium term are as summarised in Table 5-2-14 and Figure 5-2-22.

Table 5-2-14: Proposed Structural Countermeasures for Anse Royale

Location Name	Work Item(facilities)		Size		Length	Type	Remark	Amount (SR)						
	Short Term	Middle Term	W	H				Drain	Revetment	Underpining	River bed excavation	Bridge	Land price	Total
			m	m	m									
Anse Royale B		Widening River Mouth	3.0		30	open	River mouth measures + Wall (2m), 0.3m excavation		415,000	77,000	81,000		45,000	618,000
Anse Royale B		Bridge (extend or new)					1 location, crossing river, cab be extended existing bridge					7,182,000		7,182,000
Anse Royale B		River Bed Excavation		0.2	170	open					451,000			451,000
Anse Royale B		River Bed Excavation		0.1	400	open					530,000			530,000
Anse Royale C		River Bed Excavation		0.4	350	open	Wall (1.5m)		3,678,000	895,000	273,000			4,846,000
Anse Royale C		Widening River Mouth	10.0	0.4	100	open	Wall (1m)		710,000		459,000		500,000	1,669,000
Anse Royale C		River Bed Excavation		0.1	650	open					355,000			355,000
Anse Royale C	Drainage Ditch (New)		1.6	1.3	120	open	Wall (1.3m),S=1/400	2,268,000						2,268,000

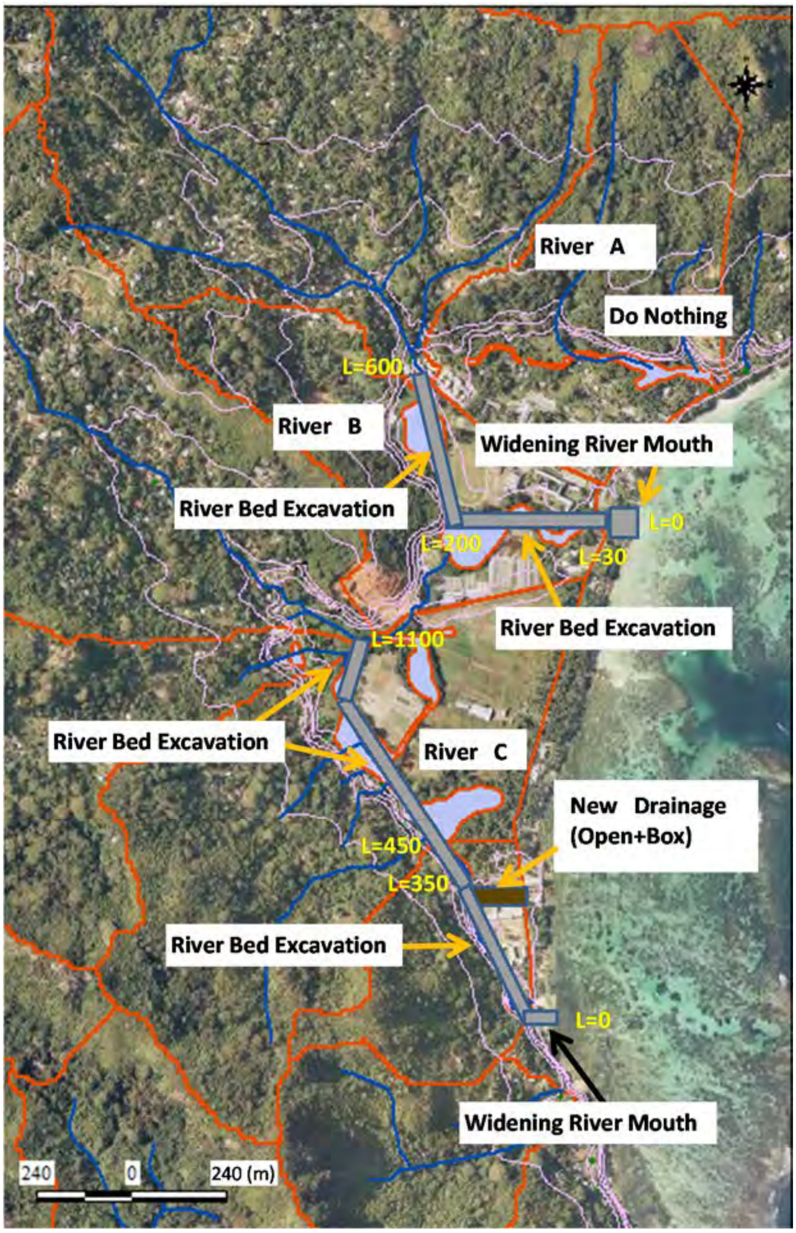


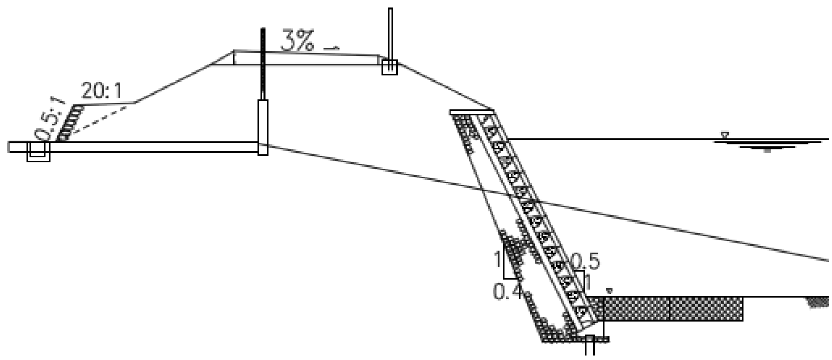
Figure 5-2-22: Location of Proposed Countermeasures in Anse Royale

5-3 Basic Design

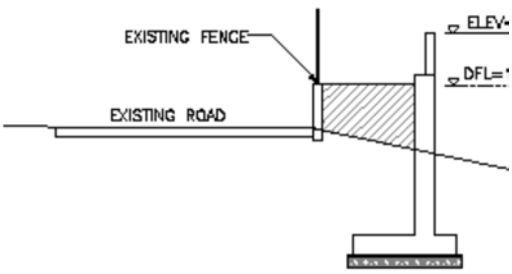
5-3-1 River Improvement

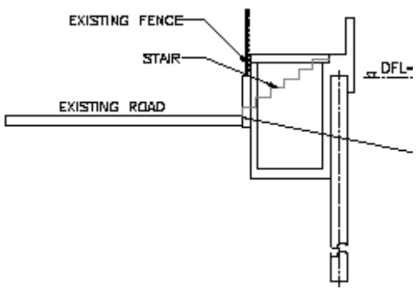
River improvement works include widening the river channel, constructing a river dike and implementing control structures against river mouth clogging. River improvement works ensure the discharge of floodwater to the sea. Construction works are of the type commonly adopted in the Seychelles and the materials are those available in the market. Therefore, maintenance of the completed structures will be minimised. Usually, a river channel needs a constant width from the middle reaches to the outlet (ocean) to ensure the smooth discharge of rainwater. However, in the Seychelles the river channels near the outlet portions are narrower than the upstream channels because of the ground elevation or topography. Therefore, the implementation of river improvement works requires land acquisition and compensation. In addition, to implement river improvement works in the future, it is necessary to conserve both sides of the river channel in a prompt manner by considering land use regulations or zoning ordinances. As for flexibility to climate change, structural facilities cannot easily or sharply make up for such changes.

Basically, river improvement works are located in lowland areas, therefore the river walls will be constructed higher than the existing ground elevation. River walls can be wet-stone masonry, precast concrete and piling types. Wet stone masonry is inexpensive and the piling type requires less land acquisition. The typical cross sections are shown below:



(a) Wet Stone Masonry Type

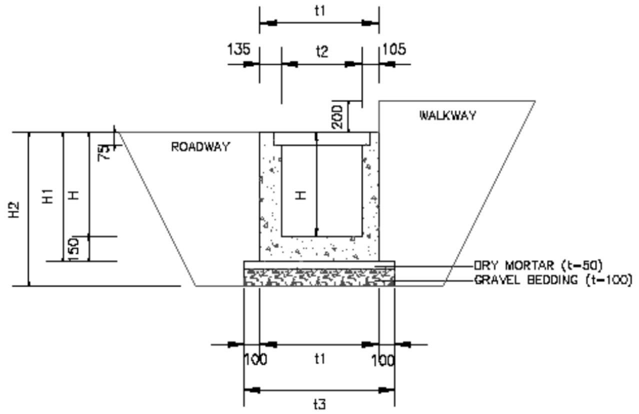




(b) Concrete Wall Type (c) Piling Type

5-3-2 Drainage Improvement

Drainage works include extension of the drainage channel and reconstruction of the drainage in an appropriate size. Drainage improvement works are commonly practiced by DOE and DOT. The construction cost is less expensive than river improvement works. The drainage ditch in Victoria Town will be provided with a cover in order to maintain the width of the road and safety of pedestrians. The typical section will be as shown below:



(d) Typical Section of Drainage Channel in Urban Area

5-4 Operation and Maintenance Plan for the Priority Areas

Operational and maintenance works (O&M works) have been started as explained below. At this moment, the effectiveness and necessity should be studied for improvement of the present operational programme. The main part of the works is related to removal of the vegetation which grows rapidly in the tropical climate. From observation, the best time can be identified for effective management. The removal of debris also has to be improved. If the deposition of debris comes from river sediment, it can be reduced by improved river alignment. If the debris is of human origin, it is better to educate people not to throw trash away carelessly.

The responsibility for O&M of the river and drainage system is shared by two offices, the EEWS Wetland and River Unit and the Landscape and Waste Management Agency (a parastatal organisation since 2009). Originally, cleaning of the rivers and drainage systems was mainly carried out by the Landscape and Waste Management Agency and desilting of the rivers was carried out by the Wetland and River Unit. This meant that there were two government agencies doing similar kinds of work in the same river channel, which caused overlapping of roles and responsibilities.

From 2009, the EEWS started a new type of O&M, i.e. having an annual contract with a contractor to carry out the ordinary maintenance works. The ordinary works include the following:

1. Removal of debris and litter;
2. Cutting and uprooting of specific vegetation; and
3. Cutting and clearing of overhanging vegetation.

Before and after completion of the works, a site visit is conducted and evaluation is conducted based on the required form. Work evaluation is carried out jointly by the contractor, the employer (EEWS) and the DA.

Aside from the ordinary works, EEWS also conducted large scale de-silting and debris clearing projects in seven rivers in Victoria Town for flood mitigation in 2011. These kinds of large-scale projects are only conducted once every several years due to budget limitations. For 2010, the budget for de-silting works in Victoria Town was SR 2.5 million. Based on the interview survey, the roles and responsibilities for O/M activities related to rivers and drainage systems are shown below in Table 5-4-1 and Table 5-4-2.

Table 5-4-1: Operation and Maintenance of Rivers and Drainage Systems

Category	Works	Scale	Work Period	Remarks (implementing office)
Rivers	De-silting (occasionally)	Large	6 weeks + (2 weeks)	EEWS-Wetland and River Unit (WRU)
	Clearing debris and litter (ordinary works)	Small	Anytime within the contract	Same as above
	Rehabilitation/Repairs			Same as above
	Flood awareness activities			Same as above
	Flood hazard maps			DRDM
	Planning & construction			EEWS-Drainage Management Unit (DMU)

Table 5-4-2: Operation and Maintenance of Rivers and Drainage Systems

Category	Works	Scale	Work Period	Remarks (implementing office)
Drainage	De-silting	Small		Landscape & Waste Management Agency
	Clearing debris and litter	Small		Same as above
	Rehabilitation/Repairs	Small		Seychelles Land Transport Agency (SLTA) or EEWS-DMU*(1
	Rehabilitation/Repairs	Large		EEWS-DMU
	Flood awareness activities			EEWS-DMU
	Flood hazard maps			EEWS-DMU
	Planning, design & construction			SLTA or EEWS-DMU*(2

*(1 Rehabilitation/Repairs along roads will be undertaken by SLTA, others will be carried out by EEWS-DMU

*(2 EEWS-DMU will review and evaluate the plan and design and monitor the construction.

At DOE-EEWS, the O/M areas on Mahe are divided into five regions and the total number of regions is 7 including Praslin and La Digue.

On Mahe, the contract costs for O/M works by the contractor in 2011 are as listed below:

Table 5-4-3: List of Contract Costs for Outsourced Maintenance Works in 2011 (Mahe)

Region	Contract Cost (SR)	Remark
Central Region	453,728.00	1 year contract Cleaning and maintenance works
North Region	582,216.00	
East Region	480,000.00	
West Region	271,644.00	
South Region	257,796.00	

The O/M costs for Praslin and La Digue are approximately SR 760,000 and SR 400,000, respectively. The regional chart for O/M on Mahe is shown in Figure 5-4-1. Based on the O/M budget, the number of rivers and wetlands under the management of DOWE-EEWS is 90 on Mahe, 19 on Praslin and 14 on La Digue.

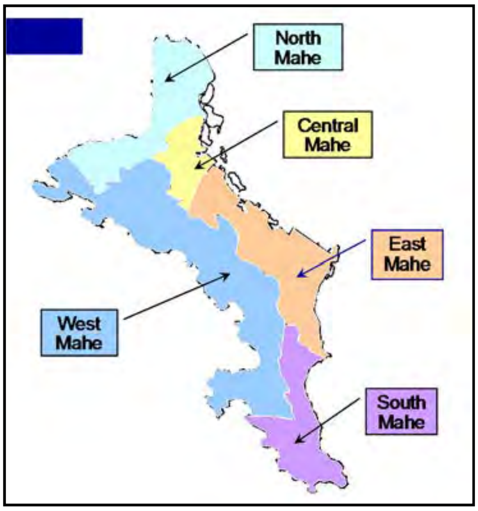


Figure 5-4-1: Regional Chart for O/M by EEWS-DOE

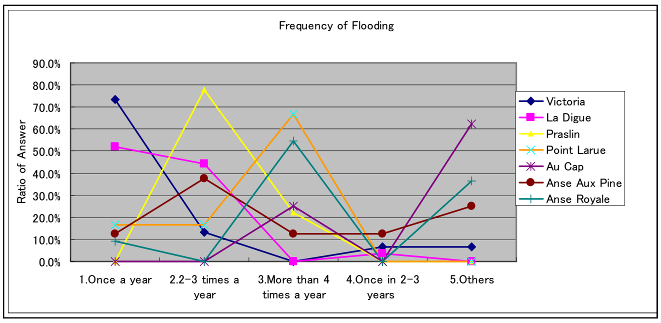
5-5 Public Awareness and Stakeholder Involvement

For flood risk management, and especially to raise public awareness and stakeholder involvement, the following activities are recommended for flood risk management based on the interview survey.

- Engineers and stakeholders should maintain good communication with the DA at all times.
- Engineers and the DA should have a common understanding of flood risk management.
- DA should have a grasp of the flood risk areas in the district and record the damage properly in order to submit a situation report to DRDM.
- Engineers, DA and residents should conduct the same awareness exercises and share an understanding of risk management.
- Since flooding occurs a few times per year or more, awareness programmes should target the next generation, such as secondary school children. It is necessary to prepare text books for secondary schools to ensure a better understanding of flood risk management in the Seychelles.

The purpose of the interview and questionnaire survey which was conducted three times of residents in flood risk areas, the DA and concerned government officers was to understand the flood conditions and the eventual implementation of flood risk management. Some of the results are shown below.

Table 5-5-1: Results of the Interview and Questionnaire Survey

<table>
<tr><th>Flood Damage Survey in Districts</th><th>Decision on Flooding</th></tr>
<tr><td>


Frequency of Flooding
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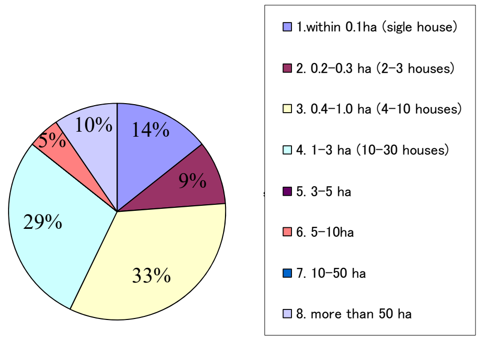
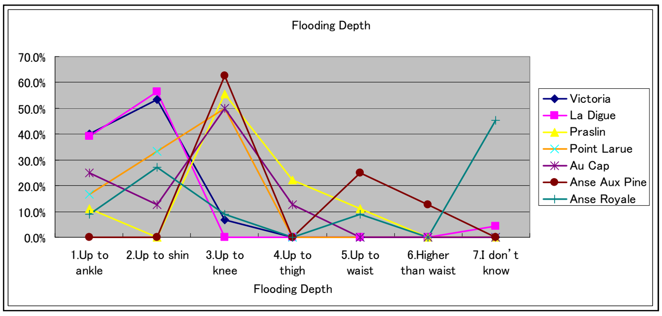


Flood Area
</td></tr>
<tr><td>


Flood/Inundated Depth
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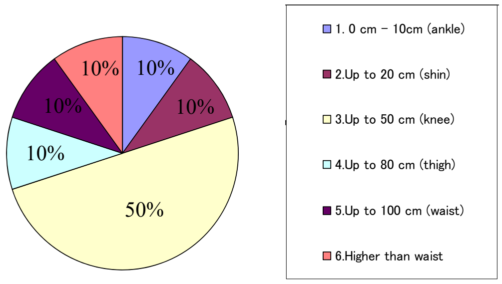

Flood/Inundated Depth
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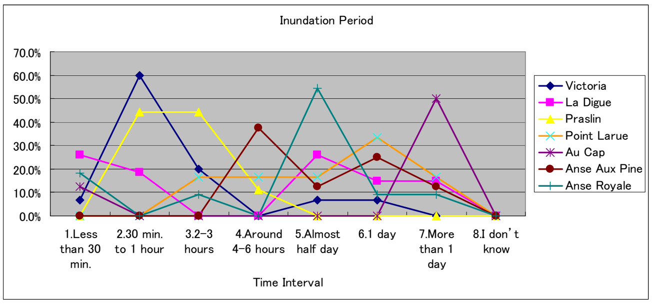

Flood/Inundated Period
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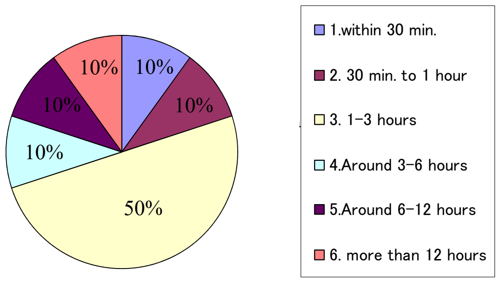


Flood/Inundated Period
</td></tr>
</table>

From evaluation of the survey results, the following points are summarised:

- There is no distinction between flooding and inundation, therefore, people commonly use the term flooding for all the events.
- People living in lowland areas are aware of and admit the inundation situation.
- Some residents know what caused the flooding in their area.
- Most of the flood or inundation periods are within a few hours of the turning of the tide.
- The results of the questionnaire to the DA about the preparation of flood risk management and awareness activities in each district are shown below. The results show that the transparency of hazard maps and awareness activities are not enough since the DA is responsible for disaster risk management in the district. Fortunately, DRDM already plans to conduct these activities nationwide starting this year. They should carefully be monitored by DOE and the achievements evaluated in order to contribute and modify future activities.

Table 5-5-2: Result of the Questionnaire Survey to the DA

	Question	Yes	No
A.	Preparation for Flood Risk Management		
1	Disaster Response Plan	71%	29%
2	Hazard Map	40%	60%
3	Brigade for disaster activities	90%	10%
4	Evacuation center	75%	25%
B.	Awareness about Flood Risk Management in Past		
1	Conduct awareness program	40%	60%
2	Evacuation drill	25%	75%
3	Map exercise	26%	74%
4	Provide hazard map	11%	90%
5	Request for awareness	85%	15%

Note: survey conducted on 23rd March 2012

5-6 Environmental and Social Considerations

Based on the collected information and preliminary observations in the study of the sites, IEE (Initial Environment Examination) analysis of five sites in the flood management plan was conducted as shown in Table 5-6-1 for environmental impact assessment. The analysis summarised below will be correlated to the following environmental impact assessment study for the pilot projects. The evaluation in the table below only indicates the impact below "C-" which signifies that the extent of negative impact is unknown, whereas the impact evaluated as "D" which signifies that no impact is expected has been omitted.

Table 5-6-1: Summary of EIA for Flood Conservation Plan

Category	Item	Remarks	Location				
			Victoria Town	Point Larue	Anse Aux Pins	Au Cap	Anse Royale
Social Environment	Local Economy such as Employment, Livelihood, etc.	The contents of the plan may have little effect on the local economy.	X				
		The contents of the plan are not enough to influence the local economy.		X	X	X	X
	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	The contents of the plan may influence the social institutions.	X	X	X	X	X
	Hydrological Situation	The flood management plan may cause adverse changes in the hydrological conditions in some cases.		X	X	X	X
Natural Environment	Flora, Fauna and Biodiversity	The flora, fauna and biodiversity may be affected by the flood management plan, especially in the wetlands.		X			
		The flora, fauna and biodiversity may be adversely affected due to diminution of habitat by widening of the river channel, and favourably affected by water purification in the flood management plan, especially in the wetlands.			X	X	X
	Landscape	The implementation of preventive measures will have little effect on the landscape.	X				
Pollution	Air Pollution	During the construction of structures, in some cases air pollution will be expected, but the effects will be slight because the scale of individual construction is small and the duration of the construction work is short.	X	X	X	X	X
	Water Pollution	The flood management plan causes modification of the water quality in the related area.	X	X	X	X	X
	Noise and Vibration	Construction machines will emit noise, but the effects will be slight because the scale of individual construction is small and the duration of the construction work is short. Vibration will also be emitted by construction machines and vehicles, but the effects will be slight for the same reasons as noise. In any case, it is desired that restrictions on work at night and on holidays are contained in the contract.	X	X	X	X	X
	Accidents	Accidents during construction of the drains can be avoided by appropriate safety management.	X	X	X	X	X

Source: Study Team

Chapter 6 Pilot Projects

Chapter 6 Pilot Projects

The pilot projects were implemented from the selected plans to clarify the effectiveness of the plan, acquire the necessary technology and improve the plan. The project was executed in consideration of EIA procedures, procurement procedures and the participation of local people through discussions. According to the schedule, the pilot projects started in May 2012 after the formulation of the coastal conservation plan and flood management plan and were completed in April 2013.

6-1 Selection of Pilot Projects

Nine pilot projects were proposed for coastal conservation and flood control in the first stage in the priority areas of North East Point (Mahé), Baie Lazare (Mahé), Anse Kerlan (Praslin), La Passe (La Digue), Victoria Town (Mahé), Pointe Larue (Mahé), Au Cap (Mahé), Anse Aux Pins (Mahé) and Anse Royale (Mahé).

The pilot projects were selected in view of urgency, importance and technology transfer together with applicability to the Seychelles and project scale. Urgency means that problems such as inundation or wave overtopping happen frequently and it is necessary to respond immediately by some means. Importance means that the project is important for mitigating coastal erosion or flood disasters in the Seychelles by both short- and long-term measures. The effects of the project contribute to the solution of such kind of disasters in a wide area. Technical transfer means that the measures are new to the Seychelles and can be applied to other similar problems in the future based on the experience of the projects. The planning, designing and execution of the projects contribute to the capacity building of the DOE, consultants and contractors. Project scale means that the scale of the project is within the project budget and the execution and monitoring period of the project is within the duration of the Study. Table 6-1-1 shows the criteria and results of the selection. In the table the ○symbol shows that the project fits the criteria and ◎ shows that the project has been selected.

Four projects were proposed within the budget, two for coastal conservation and two for flood mitigation. For coastal conservation, the measures at North East Point, Baie Lazare and La Passe are candidates. At North East Point and Baie Lazare, the prevention of coastal erosion and wave overtopping on the road is necessary. The measures at North East Point and Baie Lazare are almost the same. Therefore, it is better to select one of the places. At La Passe the construction of a groyne is appropriate.

For drainage problems, the prevention of flooding near the airport at Pointe Larue is urgent and necessary. The construction of a culvert from the road drainage to the wetland under the road is proposed. The other proposal is improvement of the river outlet by the construction of a jetty (groyne). Analysis of the drainage problem in the lowland shows a marked rise in the flood water level. The introduction of new technology for river outlet improvement will be effective against similar problems.

There are several methods of river outlet improvement. Basically, the outlet is controlled by wave action and the river flow. If the wave action can be reduced or the discharge increased through the river flow, the outlet will be maintained. A jetty is one solution and it acts to prevent alongshore movement caused by waves and to reduce incoming wave height. An increase of the water surface area in the wetland or lagoon just upside of the outlet is also one solution. Maintenance dredging is also effective in some cases. The introduction of these kinds of measures for outlet improvement is useful to improve the outlet and reduce flooding in the Seychelles.

Table 6-1-1: Selection of Pilot Project Sites

Project Site	Urgency	Importance	Technology Transfer	Project Scale	Total
Coastal Conservation					
North East Point	○	○	○	○	◎
Baie Lazare			○		
Anse Kerlan	○	○	○		
La Passe	○	○	○	○	◎
Flood Management					
Victoria		○			
Pointe Larue	○	○		○	◎
Anse Aux Pins		○			
Au Cap		○	○	○	◎
Anse Royale		○	○		

From the results of Table 6-1-1 and discussions with DOE, four sites were selected as the pilot project sites as shown in Figure 6-1-1. They are North East Point, La Passe, Pointe Larue and Au Cap.

Coastal erosion in the Seychelles can be classified into several types. The first is sand mining on the beach for construction purposes. Mining has already been banned and offshore dredging of quartz sand has started. The second is sediment loss caused by offshore transport through reef channels or river outlets. The third is erosion and accretion caused by seasonal changes in the wave climate, namely the northwest monsoon in winter and southeast trade winds in summer. The dynamic movement of beaches also brings erosion and accretion problems although there is no sediment loss in total. The fourth is the impact of coastal structures such as the construction of breakwaters.

There are several countermeasures to each coastal erosion type. The basic measure is artificial supply of sediment as sand nourishment. Longshore sediment can be controlled by the construction of groynes. As accommodation measures for erosion due to climate change, land use regulations or setting setback lines will be applied in future.

On the priority coasts, sand nourishment was proposed at North East Point and Baie Lazare. North East Point was selected as one of the pilot project sites because wave overtopping there is more frequent than at Baie Lazare. Analysis of the sediment transport mechanism and causes of erosion is also one of the purposes at North East Point. Sediment movement together with the effectiveness of the nourishment will be traced by beach monitoring. Introduction of sand nourishment is also planned in the pilot projects because there is no experience of sand nourishment in the Seychelles.

The erosion at Anse Kerlan in Praslin and La Passe in La Digue is the result of longshore transport. At La

Passe the construction of breakwaters causes longshore transport with accretion in the anchorage and erosion of the adjacent beach. Groynes can be applied to control the longshore transport. La Passé was selected as a pilot project site because it is a good example of the effectiveness of groynes and it also shows how to reduce the impacts of breakwaters. Sand bypassing is also introduced from the accreted area to the eroded area. Anse Kerlan is eroded and is also an important coast for tourism. However, the scale of the project exceeds the size of the pilot projects.

The inundation problems can be classified into two types. The first is improper drainage planning or design. The second is inadequate flow capacity from the lowland to the sea. This is mainly caused by clogging of the river mouth by wave action. One countermeasure is to increase the flow capacity of the drainage system or rivers. Another is river outlet improvement.

In the priority area, drainage improvement at Victoria Town, Pointe Larue, Anse aux Pins, Au Cap and Anse Royale is proposed. The drainage at Point Larue is located at the entrance to the international airport and improvement will contribute to smooth access though it is technically not difficult. The drainage in Victoria Town can be improved by the Seychelles side because the damage was not very great during the heavy rainfall in 2011. River outlet improvement at Au Cap was selected due to the importance of the project and as a good example of the new measures.

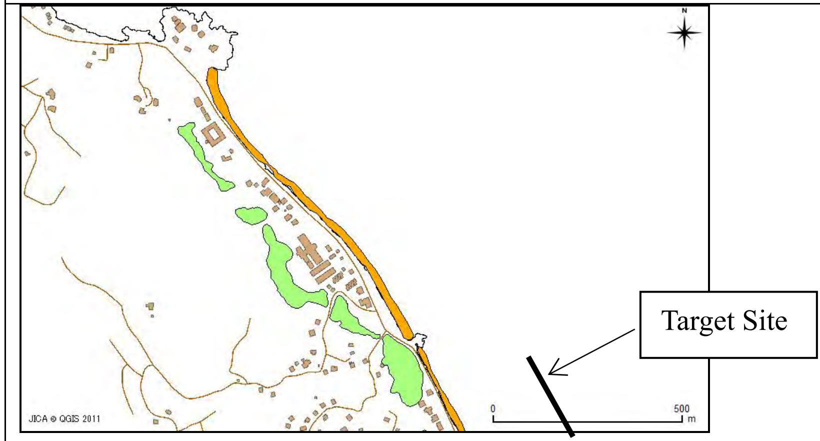
The purpose of each pilot project is summarised as follows. At North East Point, the effectiveness and impact of beach nourishment will be monitored for the introduction of new measures together with analysis of the causes of coastal erosion. At La Passe, beach erosion will be prevented on the coast south of the breakwaters by groyne construction. At Point Larue, inundation in front of the airport entrance will be solved. At Au Cap, the effectiveness and impact of the outlet improvement measures will be monitored for the introduction of new structures.

The scale and cost of the projects are listed as shown in Table 6-1-2.

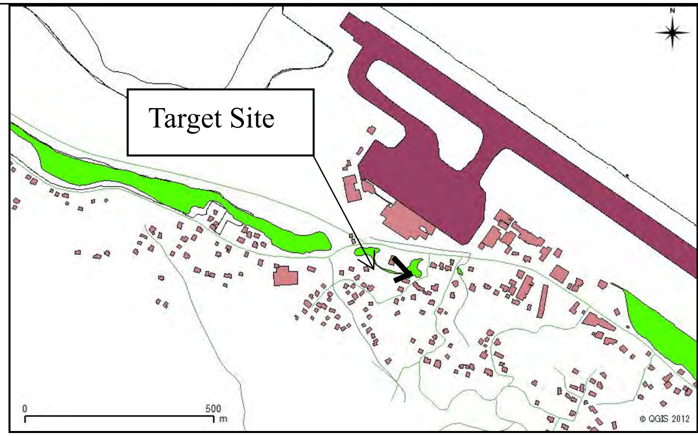
Table 6-1-2: Scale and Cost of Pilot Projects

Site	Measures	Scale	Cost (Rs)
North East Pointe	Sand nourishment	400m long, 6,600t	580,000
La Passe	Groyne & nourishment	50m long & 800t	1,160,000
Pointe Larue	Culvert & channel	16m & 17m	540,000
Au Cap	Outlet channel	25m	1,790,000
Total			4,070,000

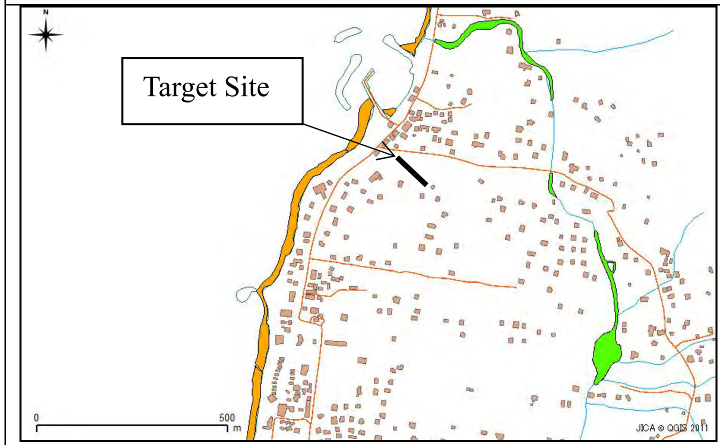
(1) North East Point (Sand Nourishment L = 400 m)



(3) Pointe Larue (Culvert L = 16m, Channel L = 17 m)



(2) La Passe (Groynes L = 50 m, Nourishment 800t)



(4) Au Cap (Outlet L = 25 m)

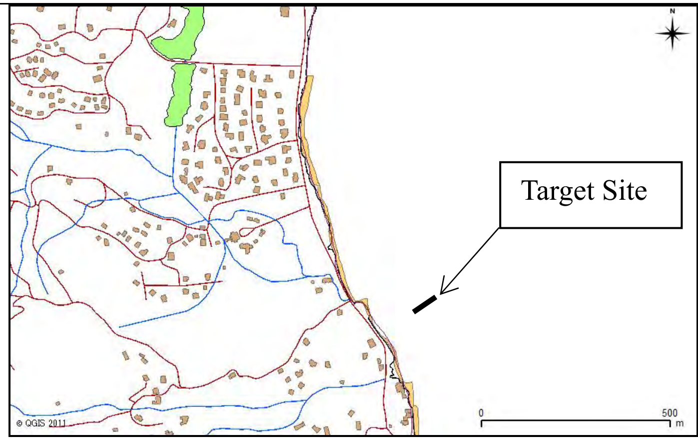


Figure 6-1-1: Site of Pilot Projects and Structures

The pilot projects are intended to show the applicability of mitigation measures and contribute to the capacity building of the related organisations in general. At North East Point the problems are long-term beach erosion, seasonal changes of the beach and wave overtopping on the coastal road. The loss and seasonal changes of sediment volume will be obtained from the beach monitoring data to estimate the necessary maintenance volume of sand nourishment, maintenance cost and effectiveness and impact of the nourishment on the adjacent beach.

In the Seychelles the beaches are a kind of tourism resource and their maintenance is essential. Sand nourishment will be a major measure to maintain the beaches because a source of sand deposition was found further northwest on Mahe Island. For the planning and designing of the nourishment, the estimation of sand loss is very difficult. The results will provide good information.

The expected movement of the nourished sand is onshore-offshore movement and alongshore movement. The movement is caused by waves and tides as external forces. The beach profile data together with the tide and wind observation data can be used to identify the beach response to external forces. High waves bring offshore movement and the northwest wind causes erosion north of the beach. The profile of the beach will be monitored every season and the tide and wind data can be obtained from the NMS office. The wave height and direction are estimated by the wind speed, duration and direction.

The stability of the beach sand and the response to wave forces can be obtained from the analysis to show the effectiveness of the nourishment and the maintenance volume for future planning. North East Point is one of the more eroded beaches compared with the other beaches. The quantitative data on sand loss will provide a good estimation for the other beaches in the planning of nourishment.

At La Passe the problems are coastal erosion and accretion caused by the construction of breakwaters. The results of the pilot project will provide the measures to mitigate the impacts of such structures. The erosion has been caused by longshore transport which is usually controlled by groynes. The effectiveness of groynes varies according to the wave and topographical conditions at the site. There is not enough experience of groyne construction especially on reef coasts. The groyne at La Passe was planned and designed according to guidelines without reefs. Analysis of the beach monitoring data will provide the applicability and improvement of the design method for groynes on a reef beach.

In the Seychelles the wave climate undergoes seasonal changes due to the northwest monsoon in summer and the southeast trade winds in winter. The changes cause longshore movement on the beach. The results at La Passe will contribute to mitigation of such kinds of sediment movement.

At Pointe Larue the problem is inundation of the road leading to the international airport. The old drainage channel was blocked by continuous land reclamation for the airport. The project was intended to solve such problems by the construction of a culvert. However, the project was cancelled because of the disagreement of the landowner.

At Au Cap the problem is sedimentation at the outlet caused by waves. The outlet opening is controlled by wave action and currents. In the Seychelles there is no information on the relationship between the river mouth profile, wave height and flow discharge. The monitoring data on the water level at the outlet and sediment accumulation in the channel by photos, together with the tide and wind observations by NMS, can be used to analyse the relationship. To reduce the sedimentation in the channel, some improvements were proposed such as changing the direction of the outlet opening and raising the channel bed. The effectiveness is also investigated.

On the south coast of Mahe, the same kind of outlet sedimentation causes inundation of the lowland area at Anse Aux Pins, Au Cap and Anse Royale. The results will contribute to the mitigation of flooding in those areas when planning and designing outlet improvement works. At Au Cap the opening is maintained by the tidal inflow and outflow against wave action. The tidal flow depends on the surface water area and the amplitude of the tide. Quantitative data at Au Cap can be obtained by monitoring after the completion of the channel work.

As capacity building in the construction and monitoring of concrete structures, the testing of concrete specimens and the monitoring of concrete forms were introduced during the pilot project. This will improve the quality of concrete structures if it is applied to other works.

6-2 Detailed Planning and Design

6-2-1 North East Point

(1) Location

The project site is located on the northeast coast of Mahe as shown in Figure 6-2-1.

Figure 6-2-1: Location of the Project Site at North East Point

(2) Measures

The proposed measure in the coastal conservation plan is nourishment. In the pilot project, sand nourishment was conducted to mitigate coastal erosion and wave overtopping on the coastal road and to investigate the causes of erosion and the effectiveness of sand nourishment.

(3) Design Conditions

The design wave and tide conditions were set according to the basic conditions in the management plan and are shown in Table 6-2-1.

Table 6-2-1: Design Conditions at North East Point

Item	Design Condition	Remarks
Design wave height	4.0 m	Return period=1/25 years
Design wave period	8.0 s	Return period=1/25 years
Design tidal high water level	MSL+1.44 m	Return period=1/25 years
Highest astronomical tide	MSL+1.00 m	
Mean sea level	MSL+0.0 m	
Lowest astronomical tide	MSL-0.90 m	

(4) Beach Nourishment Design

The dimensions and materials for beach nourishment were designed according to the site and design conditions and the purpose of the nourishment. They are summarised as follows and shown in Figure 6-2-2.

- Length: 400m
- Material: sand fill (mineral sand)
- Nourishment section: Crown level +2m above MSL, Width at crown 10m, Seaside slope 1:3
- Volume of sand: 4,400m^3 , Weight of sand: 6,600 t

The length of nourishment along the coast was decided at 400m on the southern part of the coast separated by rocks on both sides. According to the conservation plan, the required length is 1350m, separated partly by rocks into 950m and 400m of sandy beach. It is better to test the performance of the sand nourishment in the shorter part as the pilot project first, and then to extend the results to the longer part.

The material was selected from two alternatives, sand fill and coral fill. There is a plentiful stock of sand fill and it can be used continuously in future, though the size and colour may be a little bit different from the existing sand. Coral fill is limited and will be difficult to use in future.

The volume and section of nourishment were designed in view of the estimated eroded volume of sand, wave run-up, scale of beach change and available funds. The special beach changes show a difference between the mean profile and the eroded profile of 11m^3/m on average. The estimated wave run-up for the mean profile is 2.4m above MSL and 2.5m for the eroded profile. If 11m^3/m of sand is nourished, the run-up decreases under average conditions.

An experimental method was applied from several proposed methods to decide the nourishment volume because of the lack of data especially on coastal changes. (Thieler, E. R., O. H. Pilkey, R. S. Young, D. M. Bush, and F. Chai: The Use of Mathematical Models to Predict Beach Behaviour for U. S. Coastal Engineering: A Critical Review, J. Coastal Research, Vol.16, No.1, pp.48-70, 2000) The principle is to nourish a certain volume as an experimental base and observe the beach changes. It is usually said that the nourished sand will be lost in 3 to 12 years. At North East Point the long-term coastline erosion is estimated at 0.5m/year and the volume will be 1.5m^3/m/year. If 11m^3/m of sand is nourished, the lifetime will be about

7 years. From the above consideration, the volume was determined at $11m^3/m$ and the total volume at $4,400m^3$. From the beach profile data, the crown level of sand accumulation is estimated at +2m above MSL, so the crown width will be about 10m if the volume is $11m^3/m$.

(5) Work Methodology

All the work is carried out on the beach except for transportation of the sand fill. The work proceeds from the south side to the north side. Sand fill is transported from Ile Du Port, dumped on the beach by pickup truck and spread by loader. For quality, the control crown level shall be confirmed by proper survey every 50m and the allowable error shall be ±0.5m. The crown width shall be confirmed every 50m and the allowable width error shall be -2m.

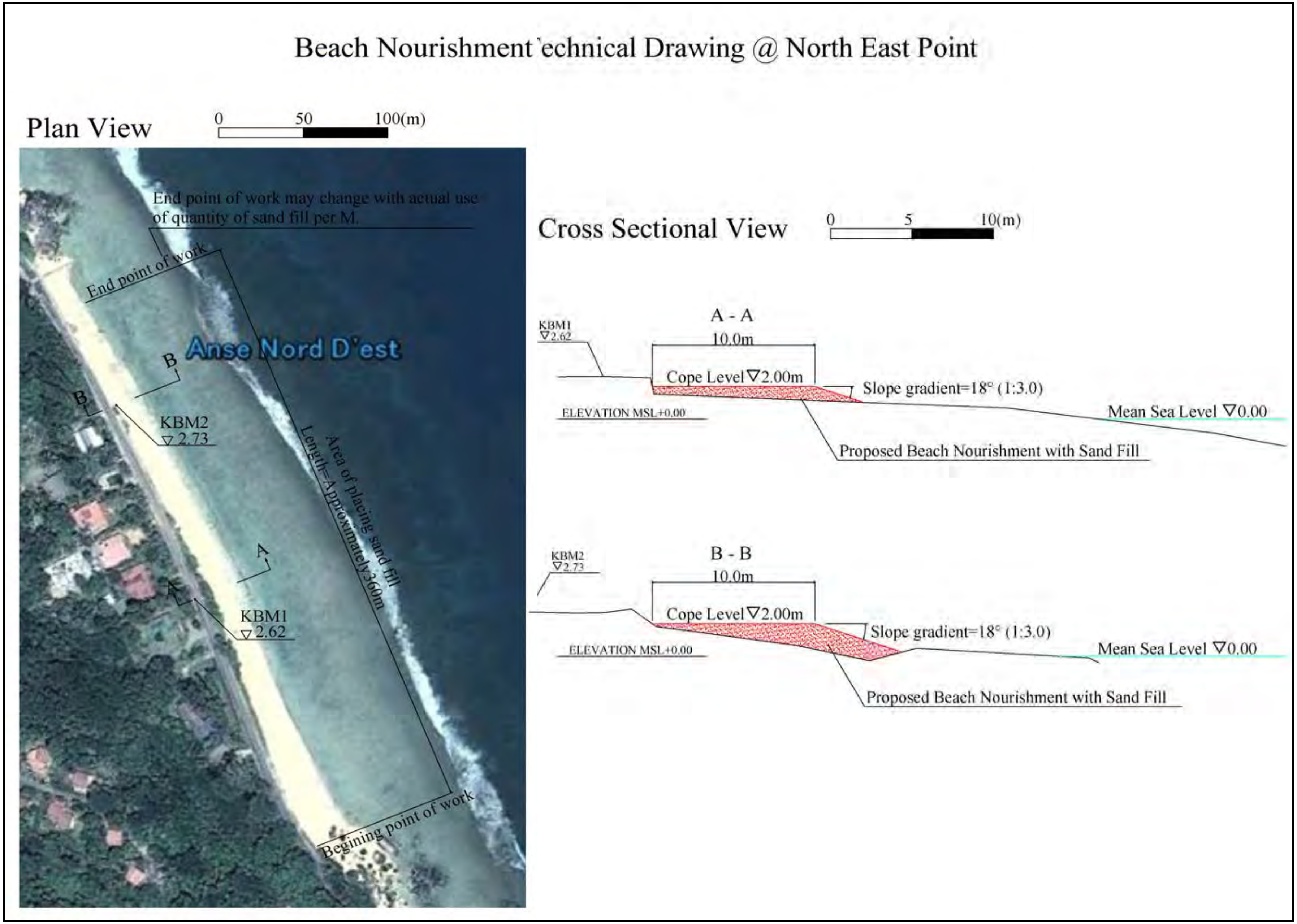


Figure 6-2-2: Plan for Beach Nourishment at North East Point

6-2-2 La Passe

(1) Location

The project site is located on the northwest side of La Digue as shown in Figure 6-2-3.

Figure 6-2-3: Location of the Project Site

(2) Measures

The conservation plan proposed the construction of a groyne near the hospital and beach nourishment with the accumulated sand on the south side of the jetty. The groyne prevents alongshore movement of sediment to the north and accretion on the south side of the jetty. A new beach will be formed on the south side of the groyne and it will protect the hospital from wave overtopping. The beach nourishment with the accumulated sand mitigates the accumulation on the south side of the jetty and restores the sand to the north side of the groyne.

It must be noted that the project does not solve all the existing problems. The groyne is effective against waves and longshore currents coming from the south. However, it is less effective against waves and longshore currents coming from the southwest. Therefore, erosion may occur on the north side of the groyne after the project is completed and accretion may continue on both the north and south sides of the jetty. It is difficult to predict these situations at present because of lack of fundamental observational data. It is appropriate to observe the subsequent situation and to take measures as needed.

(3) Design Conditions

The wave, tide and other design conditions were as shown in Table 6-2-2.

Table 6-2-2: Design Conditions

Item	Design Condition	Remarks
Design tidal high water level	MSL+1.44m	Return Period=1/25 years
Mean high water spring	MSL+0.53m	
Wave height on the reef (Hs)	4.0 m	
Water depth at groyne (h)	1.1 m	
Unit weight of rock (ρr)	2.65t/m^3	Natural granite
Unit weight of seawater (ρw)	1.03t/m^3	
Stability coefficient of rock (KD)	3.5	Hudson Formula

(4) Groyne and Beach Nourishment Design

(a) Groyne

The groyne was designed according to the site conditions and purpose based on the manual. The results are summarised as follows and shown in Figure 6-2-3.

- Length : 50m
- Material : 0.1t of rocks, 400 0 500mm in diameter
- Sectional dimension: Crown width: 2.0m, base width: 8.0m, height: 2.5m, Slope gradient : 1:1.2
- Rock material: 800t

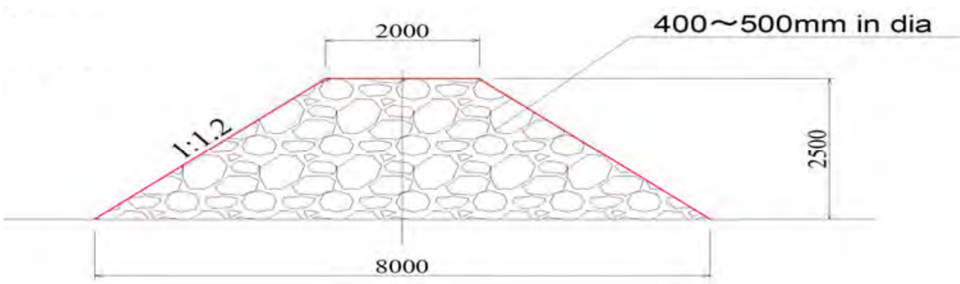


Figure 6-2-4: Groyne and Nourishment Plan at La Passe

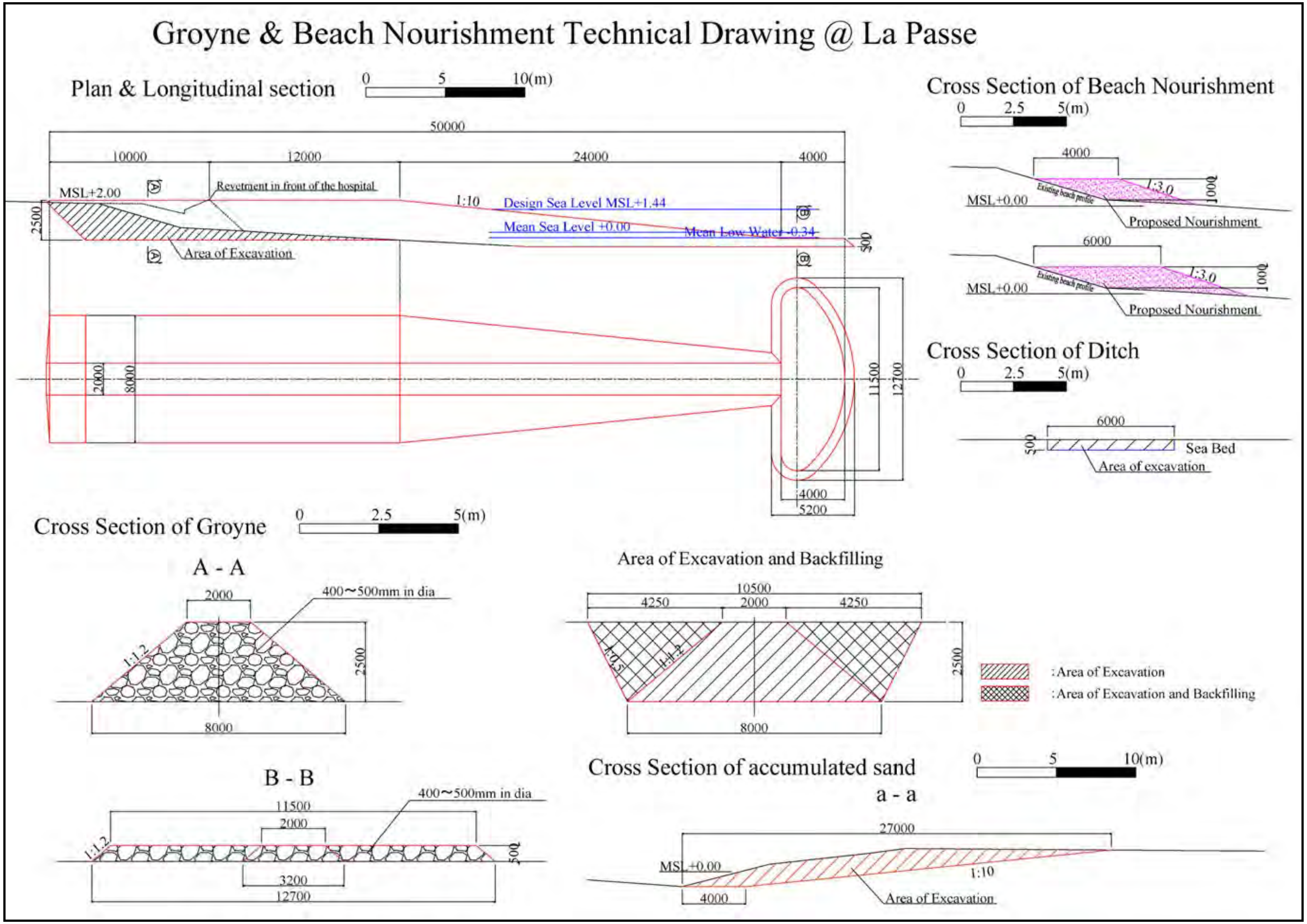


Figure 6-2-5: General Plan of Groyne at La Passe

The function of the groyne is to control the longshore sediment transport. The groyne is extended to the active zone of sediment movement. The sediment moves along the beach and the active zone can be detected from aerial photographs or Google Earth. The length was determined as 50m.

The weight of the rock is determined by the Hudson Formula to resist wave action.

$$W = \frac{\rho r * H^3}{K_D * \cot\alpha * (\rho r / \rho w - 1)^3}$$

where W: weight of rock (t), H: wave height on reef (m), K_D: stability coefficient, α: slope, ρr: unit weight of rock (t/m^3), ρw: unit weight of seawater (t/m^3).

The size of the rock is determined by the following formula:

$$D = (W * \frac{24}{4 * \pi * \rho r})^{1/3}$$

where D: diameter of rock (m).

The wave height on the reef is estimated by wave deformation calculation. From the results, a simplified useful relationship is derived as follows:

H=0.5*(h+0.1*Hs)

where H: significant wave height on reef or in front of structure (m), h: water depth (m) measured from tidal level, Hs: incident significant wave height (m) on the reef.

The equation is derived from simple assumptions as the wave height inside the reef is proportional to the water depth. The depth is determined by the tidal level and wave set-up caused by incident waves. Wave set-up is assumed to be 10% of the incident wave height.

The top width is determined in view of the minimum number of rocks, three, for the stability of the groyne. The gradient depends on the size of the rocks.

The first 22m from the land is determined to form the necessary back beach and the height should be approximately 0.5 m higher than the design sea level as shown in Figure 2-3-2-8. The next 24m is determined to form a gentle slope with the same gradient as the slope of the existing beach as shown in Figure 6-2-4. The height is down to the mean low water level.

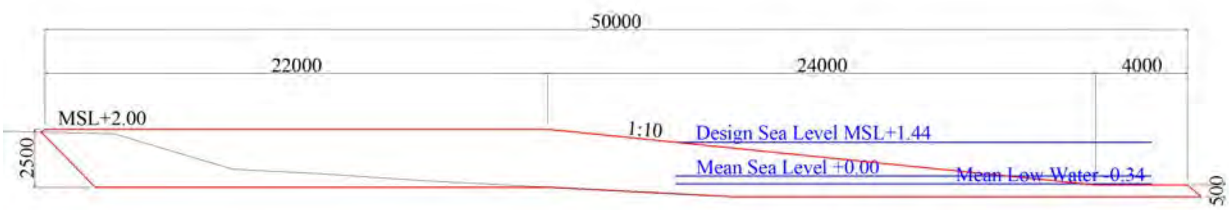


Figure 6-2-6: Longitudinal Section of Groyne

(b) Beach Nourishment

The dimensions and materials for beach nourishment were designed according to the site and design conditions and the purpose of the nourishment. They are summarised as follows and shown in Figure 6-2-7.

- Length: 180m
- Material: accumulated sand on the south side of the jetty

- Nourishment section: Crown level +1m above MSL, Width at crown 4 to 6m, Seaside slope 1:3
- Volume of sand: 970m^3

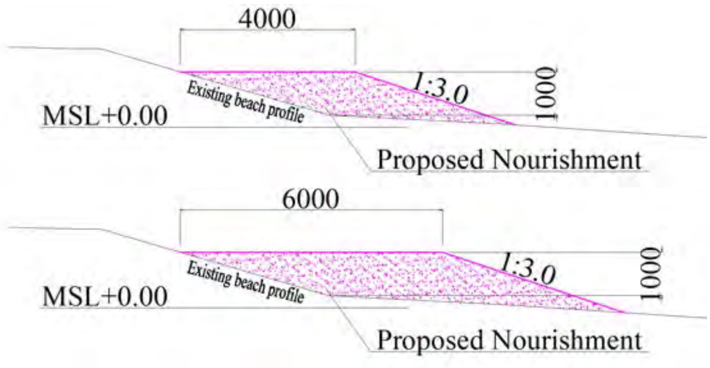


Figure 6-2-7: Beach Nourishment Section

The length is determined from the circumstances of erosion of the existing beach. The length was eventually changed from 180m to 100m. The top width is determined in view of the necessary width to allow passage of the machinery for beach nourishment so that it can be used for transporting the rocks for the groyne. The width is expanded from 4m to 6m in some places to allow the machines to pass each other. The gradient is expected to become gentler and stabler by wave action after the construction.

(c) Other Works

A channel will be constructed around the groyne to allow fishermen's boats to pass the groyne. A width of 6m and depth of 0.5m were determined by the boat size with a length of 70m. A small rock armouring was placed around the trees which stand near the beach to protect them.

(5) Work Methodology

All the dead trees along the shoreline were removed for site clearance. The trees which were located at the connection point of the groyne were removed.

The groyne was constructed with a 29 ton excavator. The machinery had to be brought from Mahe by barge. Because it has caterpillar tracks and was too heavy to travel on the roads in La Digue, old tyres were laid on the road and the machine was driven over the tyres. The construction was started from offshore to landward.

The sand was obtained from the south side of the jetty with the 29 ton excavator. The sand was directly loaded in a 5 ton dumper, so the duration of this work depended on the transportation time of the dumper. Two 5 ton dumpers were used. The sand was just dumped along the shoreline without forming any shape.

6-2-3 Pointe Larue

(1) Location

The project site is located in front of the international airport as shown in Figure 6-2-8.

Figure 6-2-8: Location of the Project Site

(2) Measures

Pointe Larue is an important district because of Seychelles International Airport, access to which requires passing along the main highway (East Coast Road) on Mahe. However, the East Coast Road suffers frequently from flood damage due to intensive rainfall.

The possible causes are the reclamation for the international airport and lack of capacity of the existing drains. All the floodwater from the catchment area goes to the upside marsh and then to the existing box culvert near the petrol station, but the drain does not have enough capacity.

As a countermeasure, the construction of a covered drain in front of the international airport is planned.

The proposed covered drain will connect the upside marsh to the downside marsh directly so that water flows into the downside marsh instead of into the existing drain. A bank will be constructed at the edge of the upside marsh to change the direction of the water flow, and a sidewalk will be also constructed along the upside marsh.

(3) Design Conditions

(a) Hydraulic Design Conditions

Item	Design Condition	Remarks
Design Discharge Volume	$0.64m^3/s$	Return Period=1/5
Manning's n	0.015	Concrete

(b) Design Conditions for Structures

Item		Design Condition	Remarks
Dead Load	Soil	$18.0kN/m^3$	
	Water	$10.0kN/m^3$	
	Pavement	$22.5kN/m^3$	
	Reinforced Concrete	$24.0kN/m^3$	
Live Load	Vehicles (Main Road)	150kN/axle $15kN/m^3$	Impact coefficient =0.3
	Vehicles (others)	$7kN/m^3$	
	Pedestrians (Sidewalk)	$3.5kN/m^2$	
Earth Pressure Coefficient		0.33 - 0.5	
Ground Water Level		MSL+1.13m	Astronomical tide
Allowable Stress of Reinforcement Concrete	Design Strength	$30N/mm^2$	Grade 30
	Allowable Compressive Unit Stress	$8.0N/mm^2$	
	Allowable Tensile Unit Stress	$180N/mm^2$	
	Allowable Shearing Unit Stress	$0.39N/mm^2$	
	Allowable Bond Unit Stress	$1.6N/mm^2$	
Minimum Cover of Re-bar		40mm	

(4) Drain Design

(a) Drain

- Length: 33.4m,   Type A: 11.5m, Type: 16.3m, Type: 5.6m
- Gradient: 1/400

- Section: Type A (Open Channel, Reinforced Concrete) Width: 1.0m, Height: 0.1m – 1.15m
  Type B (Culvert, Precast Concrete) Width: 1.0m, Height: 0.6m
  Type C (Open Channel, Reinforced Concrete) Width: 1.0m, Height: 0.7m – 1.2m

The size of the covered drain is calculated by the following formula.

$$Q = A * V$$

$$A = B * h$$

$$V = \frac{1}{n} * I^{1/2} * R^{2/3}$$

$$R = \frac{A}{S}$$

$$S = B + 2 * h$$

where Q: design discharge volume (m^3/s), A: flow area (m^2), V: flow velocity (m/s), B: width of drain (m), h: flow depth (m), n: Manning's n (m-1/3 s), I: slope, R: hydraulic radius (m), S: wetted perimeter (m).

The flow depth is usually decided as 80 – 90 % of the drain height. The slope is decided from the relationship between the drain height and the bed height of the upside marsh and downside marsh.

(b) Other Works

Side Works

- Length: 90m
- Sectional dimension (refer to Figure 6-2-9)
- Width: 1.5m
- Slope: 1:1.5

(5) Work Methodology

Traffic restrictions have to be imposed during construction because the new drain crosses the road. The drain will be constructed one side at a time to reduce the impact on the traffic. The drain will be produced near the site, and then it will be placed under the road so that backfilling can be done immediately. There are Cable & Wireless cables under the road which need to be relocated before the drains are laid.

The main work procedures are shown below.

(1) Construction of Type A drain. Half of the Type B drains are produced near the site at the same time.

(2) Laying of half the Type B drains on one side of the road. The remaining Type B drains are produced near the site at the same time.

(3) Relocation of cables.

(4) Laying of remaining half of Type B drains on one side of the road.

(5) Construction of Type C drain.

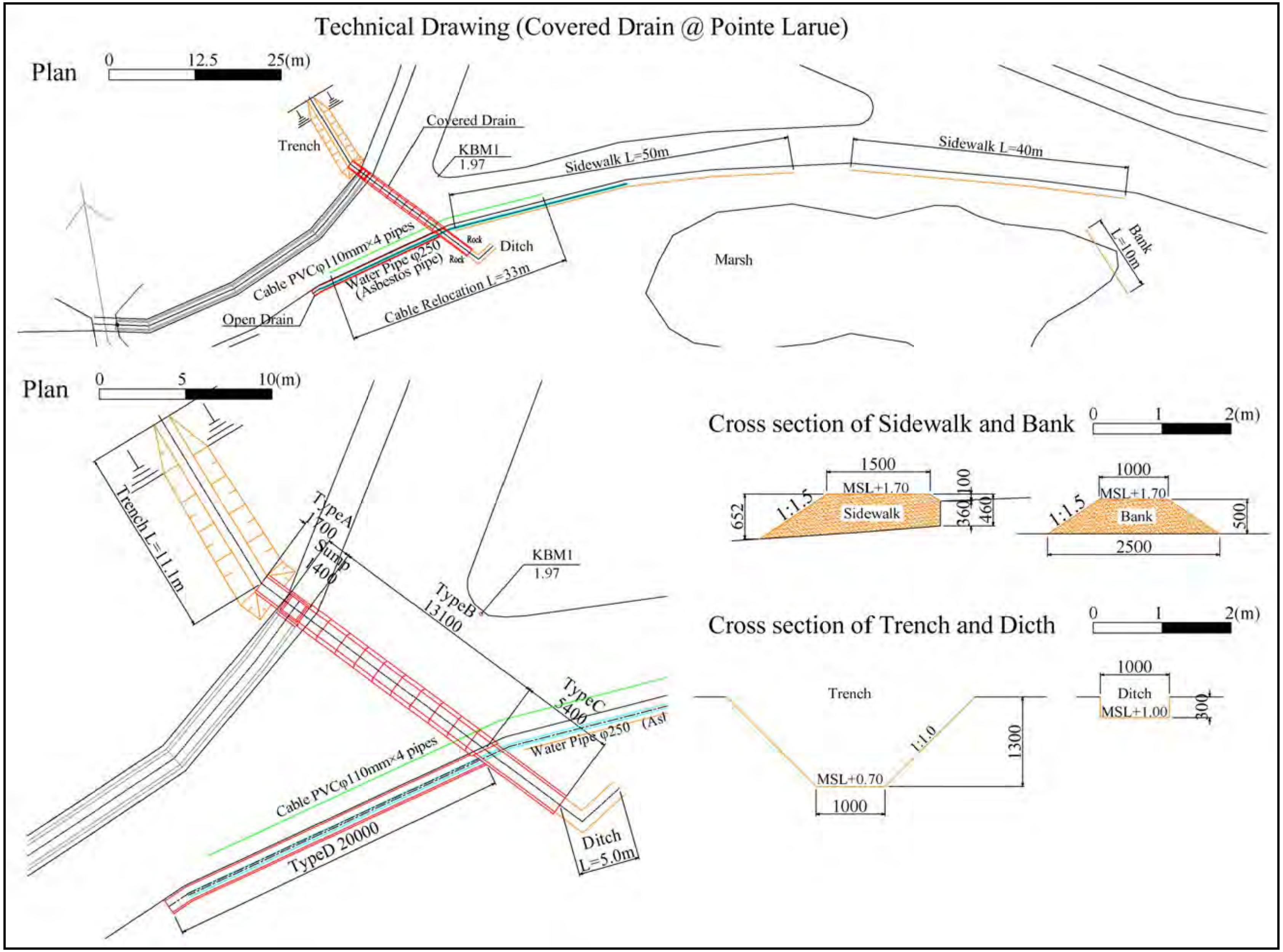


Figure 6-2-9: Plan of Drainage Channel (Pointe Larue)

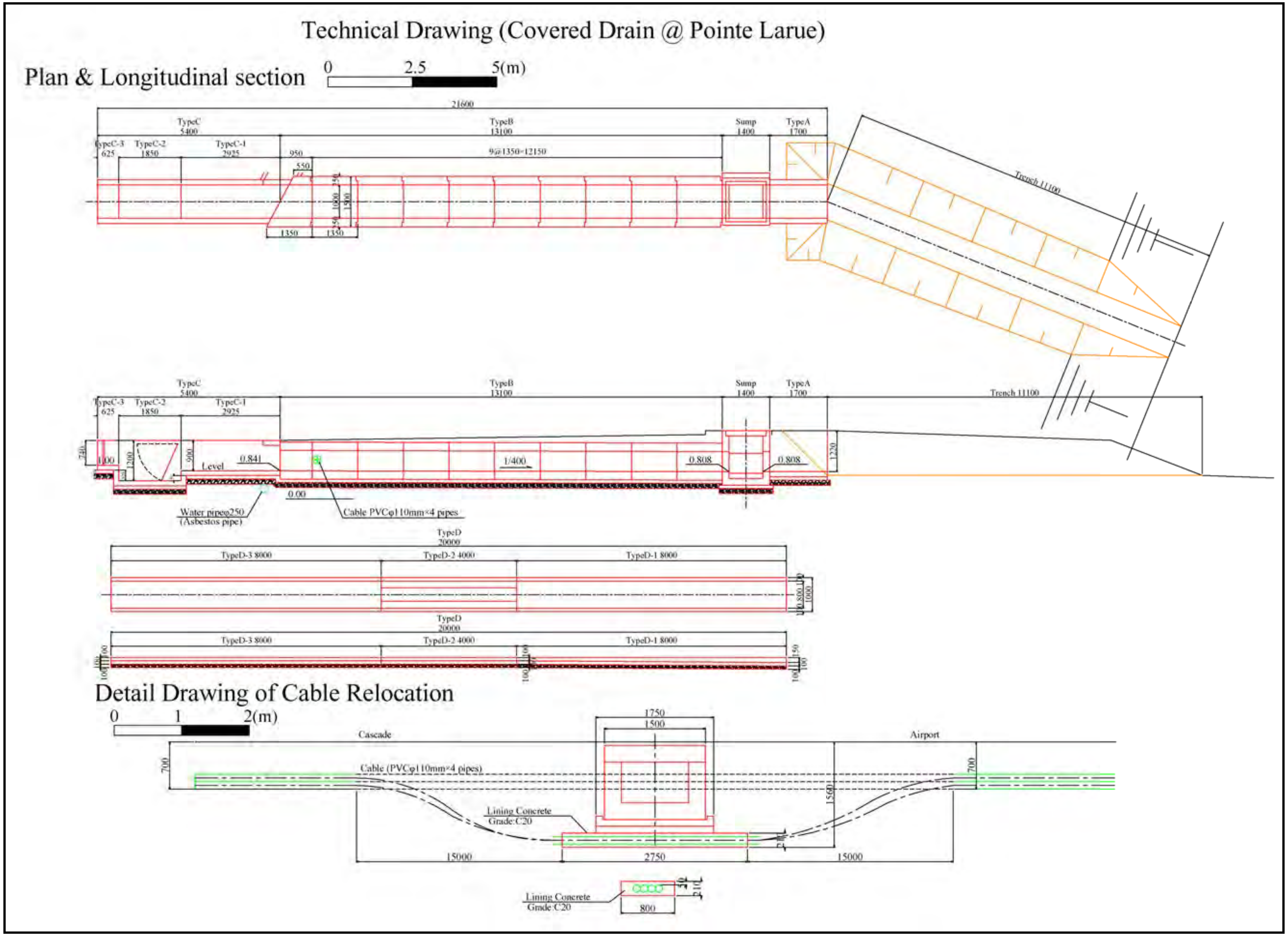


Figure 6-2-10: Section of Drainage Channel (Pointe Larue)

(6) Cancellation of the project

The drain has to be cut through Plot No.5348 as shown in Figure 6-2-11.

Plot No.5348 is private land and the landowner is trying to develop his land through reclamation. After the meeting with the landowner, it was concluded that the project had to be cancelled because it was not approved by the landowner.

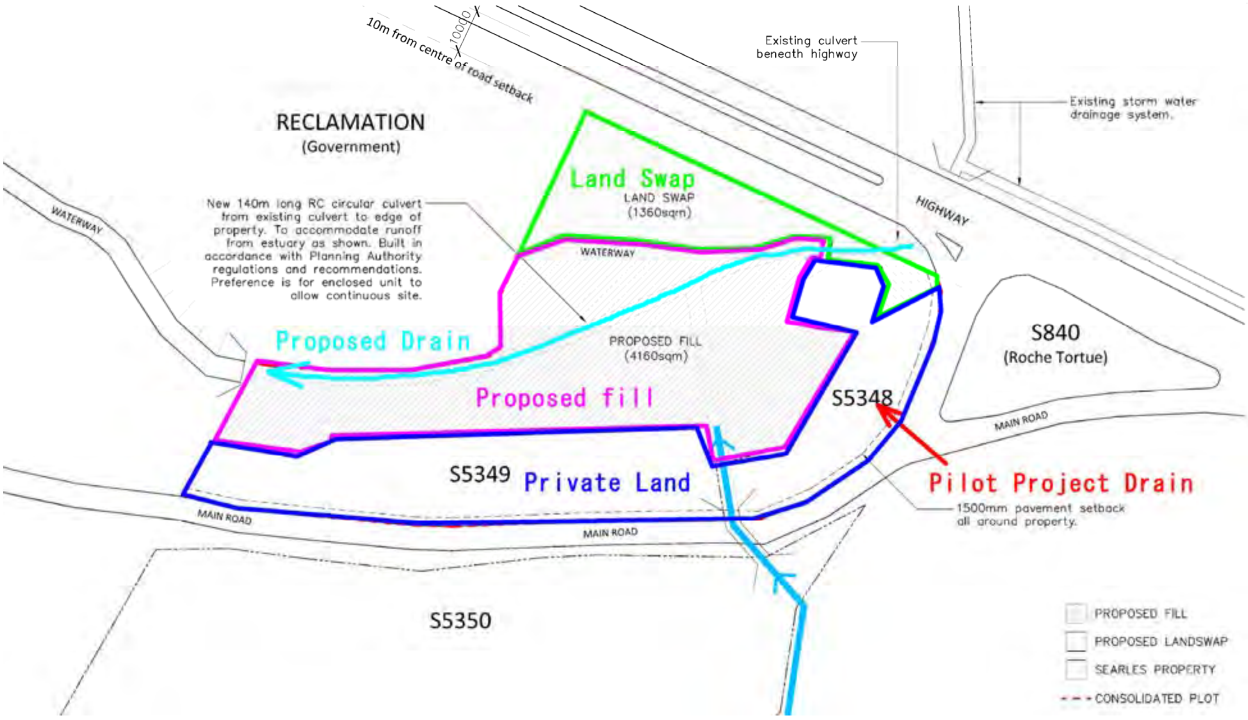


Figure 6-2-11: Area of Private Land

6-2-4 Au Cap

(1) Location

The project site is located near Niken's farm as shown in Figure 6-2-12.

Figure 6-2-12: Location of the Project Site

(2) Measures

In Au Cap, most residents live within 300 m of the coast and most of the residential areas are on lowland in flood prone areas. There are 3 pipes that have been laid as a countermeasure for river mouth clogging. However, the capacity of the pipes is not enough for the discharge volume during the rainy season as compared with the size of the existing upstream river. As a countermeasure, construction of an outlet channel instead of the existing pipes is planned in order to increase the discharge volume and prevent inundation of the residential area.

(3) Design Conditions

The design conditions are shown in Table 6-2-3.

Table 6-2-3: Design Conditions

Design Condition		Value	Remarks
Design Tide		MSL+1.44m	Target Year=2010 Return Period=1/25
Wave Height on the Reef (Hs)		5.0 m	
Wave Period		8.0s	
Water Depth in Outlet Channel (h)		1.85m	
Dead Load	Sand	18.0kN/m^3	
	Seawater	10.3kN/m^3	
	Reinforcement Concrete	24.0kN/m^3	
Live Load	People	3.5kN/m^2	
Earth Pressure Coefficient		0.5	
Maximum Accumulation Level (Ground Water Level)		MSL+1.81m	Top level of side wall
Allowable Stress of Reinforcement Concrete	Design strength	30N/mm^2	Grade 30
	Allowable compressive unit stress	8.0N/mm^2	
	Allowable tensile unit stress	160N/mm^2	
	Allowable shearing unit stress	0.39N/mm^2	
	Allowable bond unit stress	1.6N/mm^2	
Minimum Cover of Re-bars		70mm	
Safety Factor against Falling		1.2	
Safety Factor against Sliding		1.2	
Coefficient of Friction		0.6	

(4) Outlet Design

- Length: 25m
- Slope: Horizontal
- Section Width: 4.0m, Height 1.8m

The thickness of the wall and base and arrangement of the reinforcement bars are calculated by the allowable stress method and stability analysis. The wave pressure is calculated by the Goda formula. The size of the channel is designed with reference to the existing arch culvert across the road. The height of the side wall is determined to be higher than the maximum accumulation level.

Since the river mouth is clogged by accumulated sand, the channel is extended offshore to a point where sand will never accumulate.

The channel only has one mouth on the south side to prevent waves and floating sand coming from the

north as shown in Figure 6-2-13. Waves and floating sand coming from the south are not expected because they will be prevented by the existing groyne.
The longitudinal slope of the channel is determined at a level where the bed height is higher than the sea bed at a point where sand never accumulates. The discharge volume cannot be calculated by uniform flow rate calculation when the slope is level. However, it does not cause any problem because the actual flow is non-uniform and the flow rate is dependent on the water-surface slope.

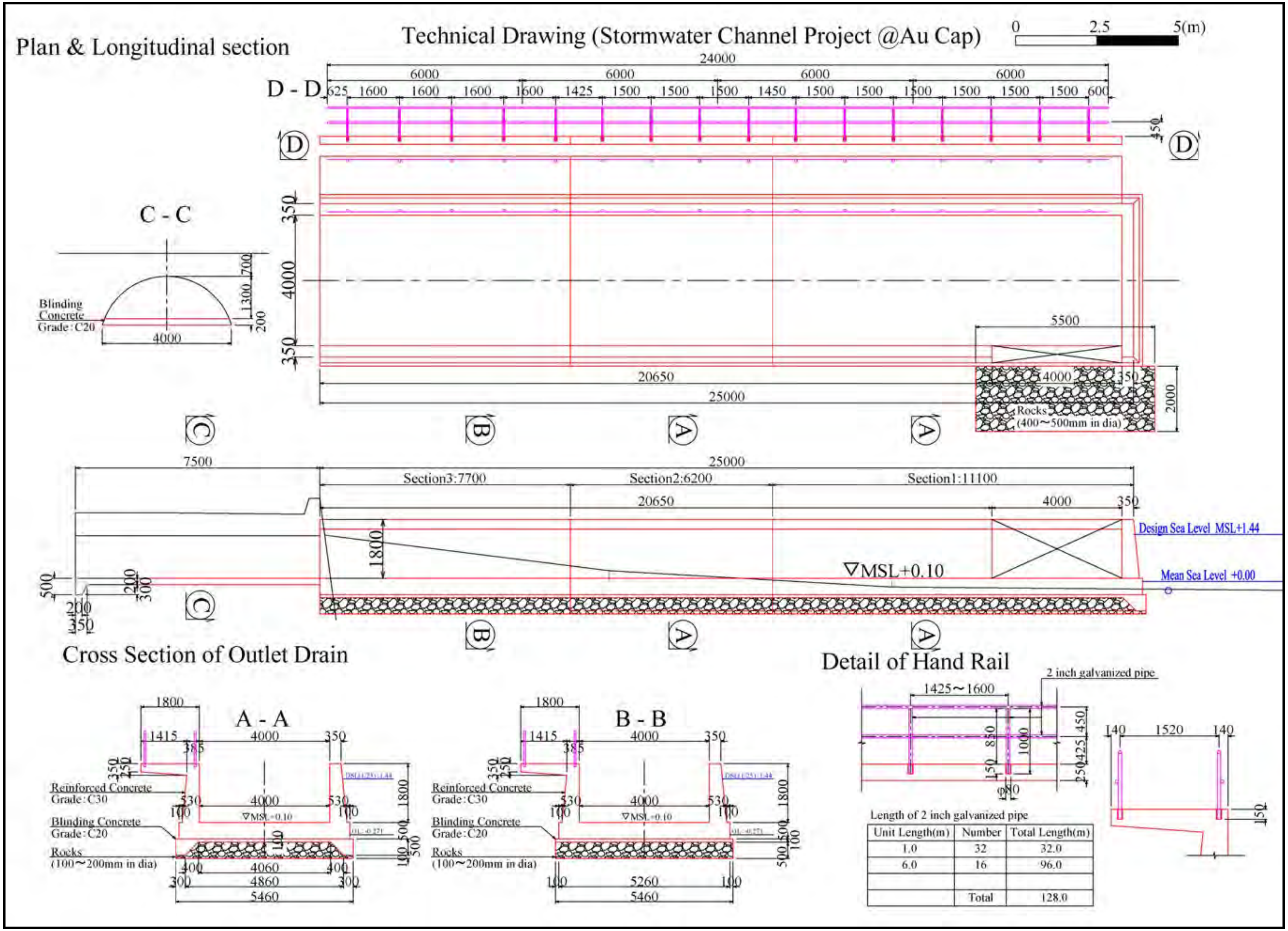
A temporary bank is constructed to provide dry conditions in which to cast the concrete. Also, a temporary ditch is constructed to divert the water flow during construction.
However, the design of the temporary bank was modified because it was not solid enough against wave action, and it collapsed (refer to (7) Variations of Plan and Design during Construction).

(5) Work Methodology

The following work methodology is based on the above-mentioned variations and was eventually adopted.
The channel is divided into 3 sections and will be constructed from the road to offshore. A temporary bank will be extended into the sea to allow the construction of each section.
A system of PVC pipes will be adopted for dewatering. This includes two 150mm pipes to be laid from the culvert inlet to the temporary ditch. A small temporary bank will be constructed at the culvert inlet to prevent seawater flowing back from the sea into the work area through the pipes. The four pipes which were removed from the existing culvert will be installed at the bottom of the bank, and a temporary drainage pit will be constructed in the bank. The existing arch culvert will be kept open for the entire construction duration. In the event of heavy rainfall, the temporary bank will be removed to evacuate the flood water. The main work procedures are shown below.

(1) Excavation under the existing arch culvert.
(2) Laying of two 150mm diameter pipes under the culvert and construction of a small temporary bank up the culvert.
(3) Excavation of a temporary ditch.
(4) Laying of blinding concrete under the culvert.
(5) Construction of a temporary bank for construction of sections 2 and 3 of the channel.
(6) Installation of two pipes which were removed from the existing culvert at the bottom of the bank, and construction of a temporary drainage pit.
(7) Construction of sections 2 and 3 of the channel.
(8) Extension of the temporary bank for construction of section 1 of the channel.
(9) Construction of section 1 of the channel
(10) Removal of the temporary bank.

Figure 6-2-13: Plan of Outlet Channel (Au Cap)



Unit Length(m)	Number	Total Length(m)
1.0	32	32.0
6.0	16	96.0
	Total	128.0

Figure 6-2-14: Plan and Longitudinal Section (Au Cap)

6-3 Procurement

Procurement was carried out in accordance with the Public Procurement Act 2008 as shown in Table 6-3-1.

Table 6-3-1: Procurement Procedures

Ref No.	Description	General Period	Remarks (Necessary Documents)
1	Estimation	-	Cost and time for completion (Bills of Quantities)
2	Seek permission from POU*1(NTB*2) for bidding documents	Day 1	(Bidding documents / advertisement / letter of approval of bidding documents)
3	Post advertisement and start selling bidding documents	Day 8	Publication period: 3 days
4	Finish selling bidding documents	Day 14	Minimum period: 1 week from start of sale of bidding documents
5	Site visit	Day 15	-
6	Bid opening	Day 21	Minimum period: 1 week from site visit carried out right after closing bid
7	Tender evaluation	Day 21 ～ Day 27	Carried out by tender evaluation committee (Bidding documents submitted by bidders)
8	Receive permission from POU (NTB) for award of contract	Day 28 ～ Day 41	Review is held every Tuesday (Tender evaluation report / Letter of submission of tender evaluation report)
9	Notification of tender result	Day 42	Contesting period starts from this day (Letters of acceptance / Letters of rejection)
10	Contesting period*3 (Prepare contract documents)	Day 42 ～ Day 55	10 working days
11	Conclude contract	Day 56	Contract documents (3 copies) / Letter of commencement)

*1 POU: Procurement Oversight Unit
*2 NTB: National Tender Board
*3 If a bidder submits a challenge, the chief executive officer issues a written decision within 10 working days. If the bidder is not satisfied with the decision of the chief executive officer, the bidder submits the matter to the Review Panel. The Review Panel makes a decision within 30 days.

Since all the procurement procedures are carried out under the surveillance of POU (NTB), fairness of procurement is guaranteed. Also, since the bidding documents and contract documents are drawn up based on FIDIC, the contract satisfies the required conditions.

However, the estimation method and tender evaluation method are considered to have room for improvement. Therefore, the issues and proposals are shown in the following section.

6-4 Construction Management and Supervision

Construction management and supervision are very important not only for ensuring the quality of the structures but also for accumulation of data on actual work duration and actual cost.

6-4-1 Schedule Control

According to the bidding documents, the detailed programme of works is submitted by the contractor within 7 working days of signing of the contract. However, it is recommended that the employer also draws up a work schedule for a feasibility study. It is better for the schedule of tasks to be as detailed as possible.

Tasks for typical concrete drainage works are shown below for reference.

- Excavation, transport of excavated soil
- Laying of aggregate foundation
- Blinding concrete - Installation of form
  - Casting of concrete
- Base concrete - Installation of re-bars
  - Installation of form
  - Casting of concrete
  - Curing of concrete
- Side wall concrete - Installation of re-bars
  - Installation of form
  - Casting of concrete
  - Curing of concrete
- Removal of form
- Back-filling
- Compressive Test in 7 days

6-4-2 Quality Control

Quality control and construction work inspections should be carried out by the contractors. At least, completion drawings, final actual quantities and photographs (workmanship, test results, etc.) have to be submitted by the contractors. These should be included in the contract documents.

The employer should supervise the contractors especially regarding things that cannot be judged after completion of the works, such as the work method, status of materials, etc.

6-4-3 Environmental Considerations

The environmental management which was implemented during construction for each project is shown below.

(1) North East Point

- A hoarding fence was placed at the entrance to the beach at the beginning of construction and at the end of construction to prevent the public from entering the construction area.

(2) La Passe

- It was decided that the works would be undertaken late in the morning and well away from Logan Hospital to minimise the noise nuisance for hospital patients. A letter of reassurance was sent to the Nurse-in-Charge at Logan Hospital.
- All boats had to be removed from the beach area near Taroza to avoid any accidents.
- A tree near the groyne was damaged as a result of the works, so it was decided that a new protection system would be put in place. This entailed placing sand and rocks around the tree roots to stabilise and protect them.

(3) Au Cap

- Warning tapes were installed at the entrance to the beach at the beginning of construction and at the end of construction to prevent the public from entering the construction area.
- There were some teenagers playing inside the taped area of the project site. They were asked to evacuate the area.
- Owing to the risk of the main road flooding, it was necessary to remove part of the banding to allow for the evacuation of flood water. The banding was removed on Saturday 26th January and the small banding in the existing river was removed on Sunday 27th January.
- Traffic control was implemented with traffic signs and by traffic controllers while the concrete mixer was on site.
- As a result of heavy rain, a large amount of debris and waste was washed into the construction area. The contractor removed it, so that it would not get washed into the sea.

6-5 Environmental and Social Considerations

6-5-1 Environmental Overview

(1) General description

Through the previous study for the coastal management and flood control plan in 2011 conducted by JICA, four pilot projects were approved by the GoS. General descriptions of the pilot projects are shown on Table 6-5-1. However, one of the projects on Point Larue was not deployed due to difficulties in coordinating a conflict of interest between the government and the landowner.

Table 6-5-1: Approved Pilot Projects

Name	Location	Project Description	Remarks
Beach Nourishment	North East Point (Mahe)	Nourishment with coral fill for a distance of 1,350m in width and 340m in length.	Coastal conservation
Groyne Construction	La Passe (La Digue)	Construction of one groyne, 1.0m high, 4.0m wide and 50m long, on La Passe beach with 200m beach nourishment.	Coastal conservation
Drainage Construction	Point Larue (Mahe)	Construction of drainage from existing wetland to the north and south. (33m long)	Flood management
Outlet Construction	Au Cap (Mahe)	Construction of 25m channel to improve river mouth drainage	Flood management

Source: The Study Team

(2) Baseline of Natural and Social Environment

(a) North East Point (Mahe)

The projected site for the beach nourishment is an approximately 300-meter-long coral beach located on the northeast side of Mahe Island and the projected area is about 80 meters long within the total beach area. A road along the beach is the main access to Victoria for the local community with moderate traffic throughout the year and several private hotels and small miscellaneous stores have been developed along the road in front of the projected site. Vegetation along the seashore is dominated by vines and beach morning glory (*Ipomoea pes-caprae*) and no significant trees or shrubs are found on the beach. The small wetland and stream connecting the water body and beach lie between the buildings along the road behind the projected beach area with the function of retaining and draining rainwater.

The beach has witnessed a huge amount of sand movement described as coastal erosion, which has affected the local tourism industry as well as the lives of the local community. The lack of beach sands and exposed beach rocks do not attract tourists and heavy wave overtopping blocks automobile accessibility for the local community.

Photo 6-5-1

Photo 6-5-2

(b) La Passe (La Digue)

The projected site for the groyne construction is located on the northwest side of La Passe coast on La Digue Island, adjacent to the main jetty for local ferry transport between La Digue and Praslin Islands, private pleasure boats, and other economic and shipping activities. In terms of the current situation of the construction site, although the beach is not used for leisure, there are anchor spaces owned by local fishermen here and there along the beach and the site is right behind the public hospital. Additionally, there are small-scale broken groynes lying on the beach and approximately 2.0 meter high sea walls constructed by cooperation between the government of the Seychelles and the USA in previous implementation of measures to counter coastal erosion. Regarding the social environment, the coastal area is mainly used as an access route for small fishery boats from offshore to the anchor area. There is neither a constructed anchoring facility nor space laid down by certain regulations. However, Seychelles Fishery Committee recognized the use of general area for anchoring as their usual custom by the local fisherman community. Vegetation on the site is characterised by a combination of coastal trees and vines, including trees such as *Hibiscus tiliaceus*, *Hernandia nymphaefolia* and *Scaevola sericea* and vines such as beach morning glory (*Ipomoea pes-caprae),* but the number of coconut trees (*Cocos nucifera)* seems to have diminished due to the continuous coastal erosion.

Photo 6-5-3

Photo 6-5-4

(c) Au Cap (Mahe)

The projected site for the construction of the drainage system is located on the east coast of Mahe known as Au Cap beach. In terms of the current situation of the site, an approx. 2.5m-wide channel which connects the inland water area and coastal area is not functioning due to blockage of the channel under the road by sand from the beach. No effects on the existing floral and faunal environment were found, or on the social environment. However, it should be noted that the changes in the drainage system after the construction may affect sand movement especially in front of the outlet channel which could trigger a negative impact on the social and natural environment around the relevant area.

Photo 6-5-5

Photo 6-5-6

6-5-2 Environmental Impact Assessment

Based on the basic survey and analysis of environmental and social impacts, the Study evaluates the pilot projects using the impact matrix and describes the major impacts of each project. The scope items are selected as those items having either a positive or negative impact on the construction and operational phases based on the screening previously analysed in the study.

(1) Pilot Project 1: Beach Nourishment of North East Point (Mahe)

Category	No.	Item	Rating			Remarks
			SR	C	O	
Social Environment	12	Hazards (risk) Infectious Diseases such as HIV/AIDS	B	D	A+	The pilot project will reduce the risk of disaster.
Natural Environment	13	Topography and Geographical Features	B	D	B+	The pilot project will change the volume of sand on the beach, shift the shoreline offshore and extend the width of the beach.
Natural Environment	17	Coastal zone	B	D	A+	The pilot project will make the coast durable against beach erosion.
	20	Landscape	C	D	B+	Widening of the beach will change the landscape of the coast making it more spacious, and the application of coral fill will maintain its aesthetic value.
Pollution	23	Water Pollution	C	C-	D	Clayey particles of nourishment sand will diffuse and make the water muddy during the activities, and may affect benthos and fishes.
	27	Ground Subsidence	C	C	D	The pilot project in North East Point will not cause any ground subsidence.

SR: Scoping Rate, C: Construction Phase, O: Operational Phase
A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected to some extent. C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact will be clarified as the study progresses), D: No impact is expected.

(2) Pilot Project 2: Construction of Groyne at La Passe (La Digue)

Category	No.	Item	Rating			Remarks
			SR	C	O	
Social Environment	9	Local Conflict of Interest	B	B-	B-	The new groyne may hinder movement of fishermen's boats and arbitrary mooring.
	12	Hazards (risk) Infectious Diseases such as HIV/AIDS	B	D	A+	The pilot project will reduce the risk of disaster.
Natural Environment	13	Topography and Geographical Features	B	D	B+	The pilot project will change the shape of the beach, shift the shoreline offshore and extend the width of the beach.
	17	Coastal zone	B	D	A+	The pilot project will make the coast durable against beach erosion.
	18	Flora, Fauna and Biodiversity	B	B-	D	Construction of the groyne includes removal of trees and grasses. The effects on flora will be slight due to minimum removal of vegetation.
Pollution	23	Water Pollution	C	C-	D	Construction of the groyne will diffuse particles of base sand or material and make the water muddy for a short span of time. But adverse impact will be too slight to affect the ecology, landscape, etc.
	26	Noise and vibration	C	B-	D	Construction machinery will emit noise and vibration. Understanding of and agreement to the project by the hospital and neighbouring residents are necessary to mitigate suffering. Publication and dissemination of information about the programme are also necessary. Noise abatement measures, e.g. temporary enclosure, will be effective.

SR: Scoping Rate, C: Construction Phase, O: Operational Phase
A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected to some extent. C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact will be clarified as the study progresses), D: No impact is expected.

(3) Pilot Project 3: Construction of Outlet Channel at Au Cap (Mahe)

Category	No.	Item	Rating			Remarks
			SR	C	O	
Social Environment	4	Social Infrastructure as Institutional Activities	C	D	B-	The new outlet channel will affect regional management activities of the river and drainage systems.
	12	Hazards (risk) Infectious Diseases such as HIV/AIDS	B	D	A+	The pilot project will reduce the risk of disaster.
Natural Environment	16	Hydrological Situation	B	D	A+	Restoration of the outlet will provide protection against flooding and improve the water quality of the Du Cap River.
Pollution	23	Water Pollution	C	C-	D	The pilot project will not cause any water pollution.

SR: Scoping Rate, C: Construction Phase, O: Operational Phase
A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected to some extent. C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact will be clarified as the study progresses), D: No impact is expected.

6-5-3 Mitigation Measures

For all of the negative impacts evaluated in the scoping analysis above, it will be advisable to implement mitigation measures to avoid serious disturbance of the environment and local communities. The mitigation measures either for the construction or operation phase of the pilot projects are described below.

(1) Construction Phase

(a) Flora, fauna and biodiversity

For the construction of the groyne in the La Passe area, even though the existing vegetation on the site does not qualify as significant indigenous plants in the Seychelles, disturbance of the trees, especially large trees, needs to be minimised during the construction. The DoE officer in charge of conservation of the coastal environment should be consulted about the detailed construction plan and the plan should be changed if so required by the officer.

(b) Water pollution

The negative impact of water pollution is defined as seawater diffusion caused by disturbance of the existing beach sand during construction in the beach areas of North East Point, La Passe and Au Cap. However, it should be noted that, depending on the conditions, the impact will be negligible since the construction area and size are small and limited. As mitigation measures, it is recommended to facilitate blockages to prevent beach sand diffusion from the construction area only if a negative impact is clearly expected.

(c) Noise and vibration

The construction of the groyne at La Passe will be carried out by heavy machinery and the construction area is close to existing tourism points such as restaurants and the jetty for the regular ferry service between La Digue and Praslin Islands. Therefore, the construction should be planned so as to avoid using existing tourist access routes and disturbing tourist areas by establishing a yard for construction materials. Setting of the work hours for the construction from not too early and until not too late is crucial for noise control. It is recommended to discuss the operation schedule with representatives from the region, such as the district assembly, to obtain a consensus on the construction with the region.

(d) Existing infrastructure and services

For the construction of the drainage channel at Point Larue, it is important to closely check the existing underground pipes for drinking water and telephone and electricity cables before the construction because the construction work involves excavation of the existing roads, in order to avoid accidents by damaging these infrastructures. In addition, the machinery operator needs to beware of unexpected existing infrastructure not shown in the checked information.

Excavation of the existing road asphalt requires blocking the existing traffic during the construction. Therefore, before the construction it is crucial to have a detailed construction plan to ensure smooth traffic flow and to have discussions about the construction plan with the relevant authority and obtain approval for the overall construction scheme.

(e) Local conflict of interest

On the site of the groyne construction in the La Passe area, an existing boat route for the local fishermen has been verified through the focus group meeting and the planned groyne will block the existing boat route during and after the construction, which will have a negative social impact on the economic activities of the fishermen. As a mitigation measure for the impact, it is recommended to construct an alternative boat route at the tip of the new groyne to secure the function of the existing boat route. In addition to the existing boat route, there are several boats, either fishing boats or pleasure boats, anchored on the beach in the project area, and these boats will be required to relocate only during the construction. It will be worthwhile to have an opportunity to discuss the general concept of the pilot project with the boat owners and share information on the positive and negative environmental and social impacts in order to arrive at mutual agreement on the inconvenience. Both ideas concerning the alternative boat route and relocation of the boats during the construction need to be approved by the stakeholders.

(2) Operation Phase

(a) Flora, fauna and biodiversity

Since the construction of the outlet channel in the Au Cap area will be accompanied by opening of the existing clogged drain after the construction, it is expected to cause some changes to the floral and faunal biodiversity. If the changes to the existing environment are too dramatic, it could cause damage to the biodiversity due to too much salt water from the sea. Continuous monitoring of the floral and faunal species in the original drainage channel will be effective for identifying future negative impacts.

(b) Local conflict of interest

On the site of the groyne construction in the La Passe area, it is recommended to monitor the alternative boat route after the construction to check whether it is functioning or not. Because the construction of the alternative boat route could be affected by seasonal waves over a long span of time and fishing activities rely on the marine environment including the movement of sand and growth of coral reefs, it will be better to encourage development of a plan for a new port including anchoring and boat route facilities for the long-term development of La Digue Port.

(c) Social infrastructures as institutional activities

When we look at similar drainage channels from wetland areas or streams to coastal zones, it is obvious that the facilities need periodical maintenance to ensure their functions. Without maintenance, fallen leaves and other debris come from upstream in times of heavy rain and clog the drain where it passes the channels or paths. To avoid such clogging, it is important to implement periodical and continuous maintenance of the drainage channels including removal of leaves, debris and even sand from the beach. In order to enhance the knowledge of flood mechanisms among the local community, entrusting the maintenance to an instructor from DoE will be one option under the policy for capacity building of local residents.

6-5-4 Public Consultation

(1) General

The public consultation process in the Seychelles is mentioned in the EIA regulations as a requirement of public review. The public is informed by a notice in the national newspaper when the EIA is ready, and the EIA document is delivered to the public offices over a period of one or two weeks. In order to comply with the idea of public consultation in EIA, the Study Team conducted focus group meetings, which can also be described as stakeholder meetings, to notify the stakeholders of general information about the pilot projects including background, purpose and design as well as the expected positive and negative impacts on the social and natural environment and to share opinions on the environmental impact assessment from the viewpoint of local residents. In the Study, the meetings were held according to the following schedule and the discussed items are shown in Table 6-5-2:

Table 6-5-2: Major Items Discussed in Stakeholders Meeting

Meeting	Items Discussed Related to Environmental and Social Considerations
Focus Group Meeting 29th June 2012 with fishermen, pleasure boat owners and SFC on the pilot projects in La Passe and La Digue	(La Passe) - Construction of a canal along the tip of the planned groyne is requested by the fishermen to ensure the current functioning of fishing activities. - Requirement for temporal relocation of the anchorage area for fishing and pleasure boats is accepted with understanding of and agreement to the pilot project.
Stakeholder Meeting (1) 4th July 2012 with the District Administrator of the relevant district, members of La Digue Development Board and members of National Assembly	(All) - It is important to develop a monitoring plan to ensure the effectiveness of the pilot projects. (La Passe) - It is important to remember that the environmental impact is affected by waves with seasonal changes. - Impact on the existing landscape is one of the major issues even in the construction phase. - How to manoeuvre barges in the shallow coastal area is the key to smooth construction work. (North East Point) - To ensure local safety, phased fence construction is needed.
Stakeholder Meeting (2) 20th July 2012 La Digue Board	(La Passe) -Location of an area for parking of heavy machinery during the construction is approved. -There are no upcoming development projects to be undertaken at a similar time that could affect the implementation of the pilot project. - A consensus was reached by all members that there is no need to discuss the project with members of the public.

Source: Study Team

6-5-5 Environmental Management and Monitoring Plans

The Environmental Management Plan (EMP) is not clearly referred to in the EPA. However, actions or measures for the development activities are required in EIA. The monitoring of EIA implementation is mentioned in Part V of the EPA which states that the authorized staff are responsible for the activities.

Although the projects are not required to implement EIA, the study proposed setting out Environmental Management and Monitoring Plans based on JICA environmental and social guidelines in this section to ensure the countermeasures and recommendations of the scoping analysis.

Table 6-5-3: Environmental Management Plan

Impact	Mitigation Measures	Responsible Institution	Time Framework
Involuntary resettlement	Land acquisition Provision of similar type/size of land plots.	Execution agency	Before construction work
Soil erosion	Implementation of appropriate protection measures by contractors for construction activities involving heavy machinery.	DoE, Contractor	During construction work
Water pollution	Implementation of appropriate protection measures by contractors for construction activities involving heavy machinery.	DoE, Contractor	During construction work
Waste	Dumping of waste in appropriate place as instructed by related authority. Environmental management plan of contractor to protect the environment.	Execution agency	During construction work
Noise	Implementation of appropriate protection measures by contractors for construction activities involving heavy machinery.	DoE, Contractor	During construction work
Accident	Installation of warning signs and assignment of security staff in populated areas during construction.	DoE, Contractor	During construction work
	Installation of traffic safety devices in populated areas.	DoE, Contractor	During construction work

Source: Study Team

Table 6-5-4: Environmental Monitoring Plan

Project Phase	Monitoring Items	Parameters	Location	Frequency
Construction Phase	Surface water quality	pH, BOD, Suspended Solids (SS), Hydrocarbons	In surface waters downstream of construction activities	Once during construction
	Liquid discharge from construction site	pH, COD, BOD, SS	Downward from exit of the construction site	Once during construction
	Solid waste	Food waste, plastics, cardboard, metal products, etc.	In the temporary yard for construction work and road construction sites	Once during construction
	Hazardous waste	Fuel, oil, solvents, paints, used tyres, batteries, etc.	In the temporary yard for construction work and road construction sites	Once during construction
	Biodiversity	Pollution from work sites in and near water flows	Entire project area	Once during construction
		Vegetation and tree plantations where possible	Entire project area	Once during construction
Operation Phase	Biodiversity	General flora	In and near inhabited areas, near water flows, on slopes and in forested areas along coast	Twice a year
	Inland water quality	EC, pH, BOD, Suspended Solids (SS), Hydrocarbons	Inland water areas or wetlands	Every three months
	Water level	Record water level to determine the water level changes	Inland water areas or wetlands	Every three months
	Sand movement	(1) Coastal survey by hand level (2) Aerial photos by helicopter (3) Bathymetric survey by echo sounder	Major coasts on Mahe, Praslin and La Digue Islands	Twice a year

Source: Study Team

6-6 Monitoring and Evaluation

After completion of the pilot projects, observations, coast profile surveys and aerial photos by helicopter were conducted at each site. At Au Cap the water level at the outlet was also measured. The results show that the pilot projects are useful tools for understanding the phenomena and for future application to coastal conservation and flood management as structural measures though the observation period is limited.

6-6-1 North East Point

(1) General

At North East Point the planning cycle explained in Chapter 3 is shown in Figure 6-6-1: as an example.

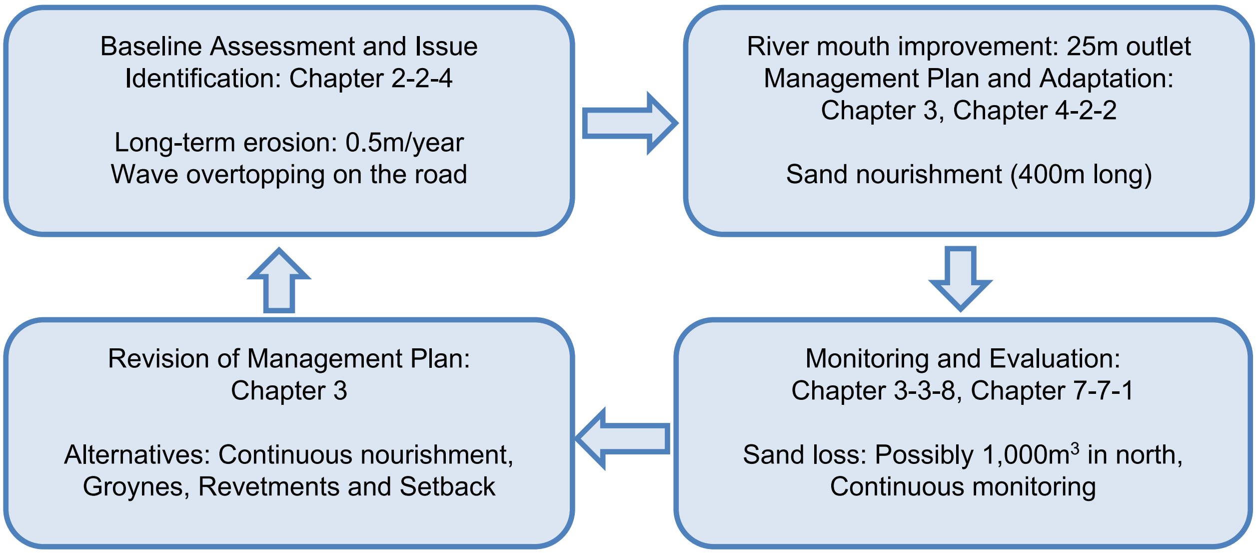


Figure 6-6-1: Example of Planning Cycle at North East Point

The coastal erosion, waves, tides and topography and the issues were summarised as in Chapter 2 as the basic study. It is clear that the beach has eroded over the long term together with seasonal variations. Coastal conservation measures were investigated as in Chapters 3 and 4 for several alternatives such as nourishment and groyne construction. From the results, continuous sand nourishment was proposed. Detailed design, environmental assessment and procurement were executed in the pilot project.

The objectives of the pilot project at North East Point are to introduce sand nourishment to the Seychelles as a mitigation measure for coastal erosion, to evaluate the effectiveness of the nourishment and to estimate the causes and volume of sediment loss on the beach. The nourished sand amounted to 6,600t or 4,000m^3.

The coast receives waves from the northwest monsoon from November to April and from the southeast trade winds from May to October. Due to the changes in the waves, seasonal changes in the coastline are predominant. There is erosion in the north and accretion in the south due to the northeast winds and accretion in the north and erosion in the south due to the southeast winds. Sediment is possibly lost offshore during longshore sediment movement in the long term because the coral reef is narrow with a width of about 100m and steep in front. There is beach rock at low tidal level.

The causes of coastal erosion are interruption of the sediment supply from the hill side by the construction of the coastal road and the offshore loss of sediment due to the seasonal changes in sediment movement in the northern part where the reef is limited.

On the coast, the risk is high in the northern part where waves overtop at the bus stop and the rehabilitation centre. The waves overtop at the time of erosion by the northwest winds and the high tides in spring.

The changes in the past and present coastline are shown in Figure 6-6-2 to Figure 6-6-4 taken by satellite and helicopter.

Figure 6-6-2: GIS Data in 1998

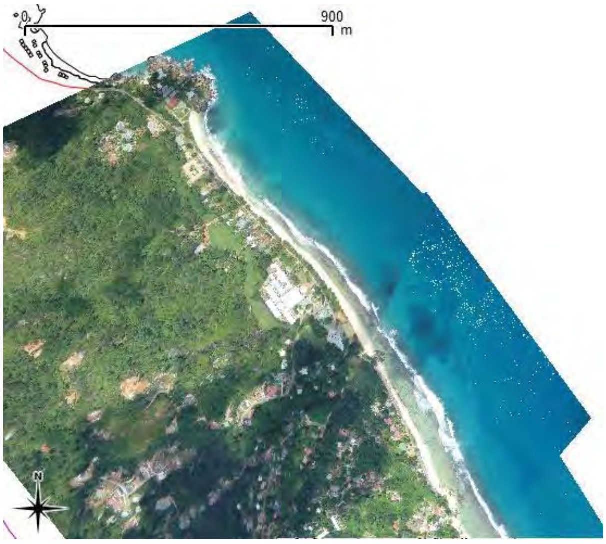


Figure 6-6-3: Aerial Photo in May 2011

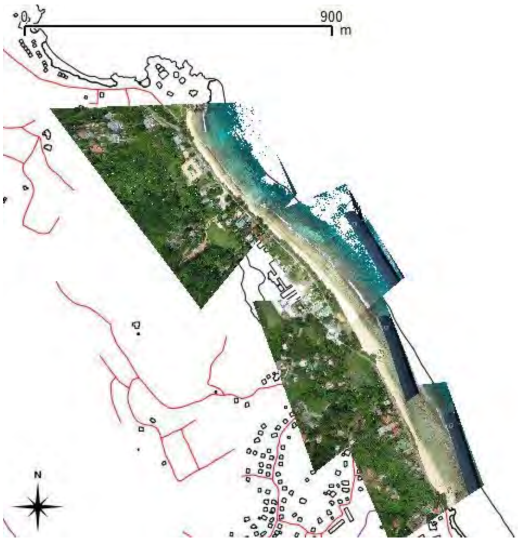


Figure 6-6-4: Aerial Photo in March 2012

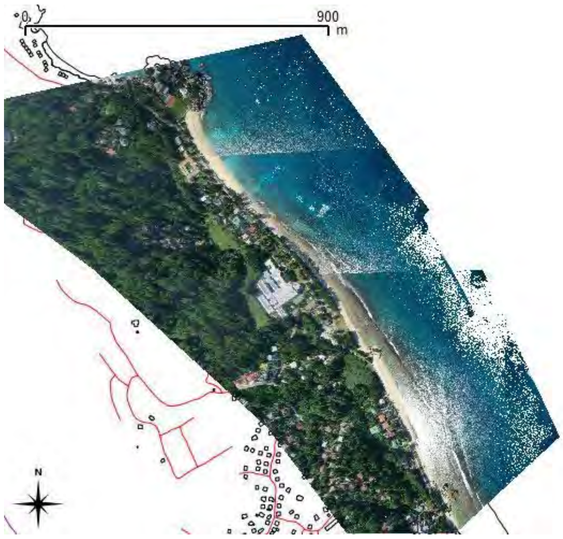


Figure 6-6-5: Aerial Photo in November 2013

As the pilot project 6,600t (about 4,000 m^3) of sand was nourished in the southern part for a length of 400m in March 2013.

(2) Monitoring

Figure 6-6-7 and Figure 6-6-8 show the beach condition just after the nourishment and in November, 7 months after the nourishment, respectively. In November the beach has eroded and rock revetment has appeared in the southern part. On the other hand, in the northern part sand has accumulated. The changes in the beach section area before the nourishment, from March 2011 to April 2013, and after the nourishment, from April 2013 to October 2013, are shown in Figure 6-6-6. The sections are taken from the north at intervals of about 200m. The nourishment is 400m long from 1,100m to 1,500m in the figure and the interval of the section is 100m. The changes within 2 years of the nourishment are accretion for a longshore distance of 0m and erosion north of the rock reef for a longshore distance of 900m. South of the rock reef, the beach has accreted and the volume corresponds to that of the nourishment. The changes 6 months after the nourishment are erosion in the south, accretion south and erosion north of the rock reef, and accretion in the north. The sediment moved north in this period due to the southeast waves and the volume is estimated at about 7,000 m^3. The sediment budget for the whole beach showed no change from March 2011 to April 2013 during 4 months, and 1,000 m^3 of erosion. From these results, the beach changes seasonally and the budget changes yearly.

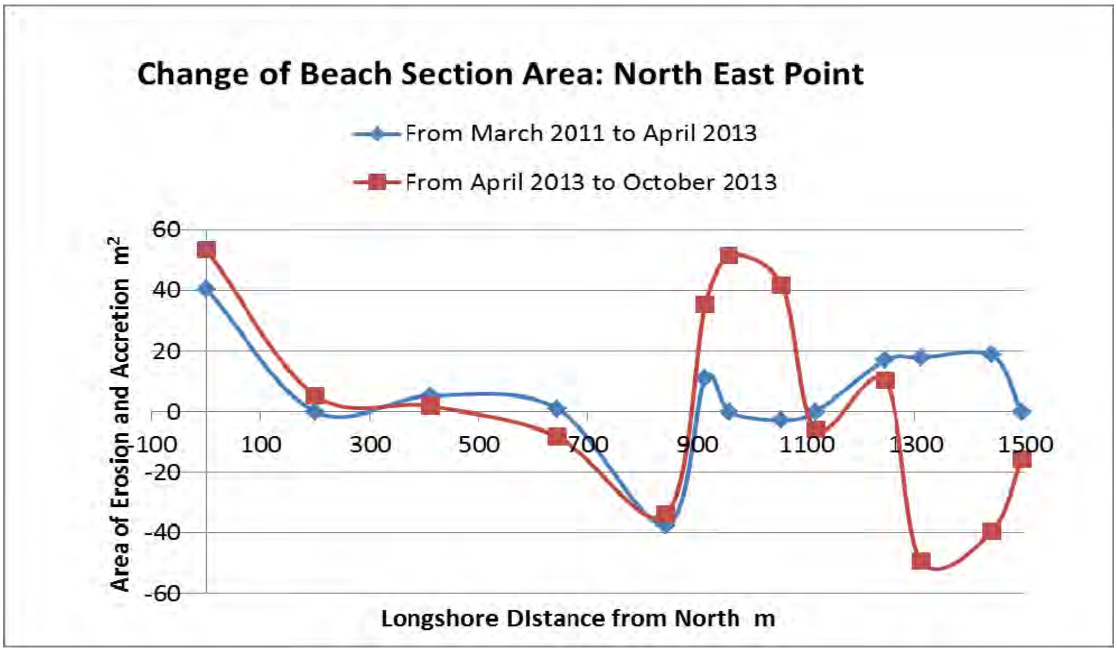


Figure 6-6-6: Changes in Beach Section Area at North East Point

Figure 6-6-7: After the Nourishment in April 2013

Figure 6-6-8: Photo in November 2013

(3) Evaluation

The long-term volume of erosion is difficult to estimate from the monitoring results for one year because of seasonal changes. It is necessary to continue the beach monitoring. The effect of the nourishment is clear as of January 2014 from accretion due to the nourishment in the northern part where the risk is high.
The volume of nourishment and location were planned to investigate the effectiveness of nourishment and the movement of sediment in the pilot project. The volume was about 4,000 m^3 in view of clarifying the effectiveness and budget for the construction. From past records, the long-term shoreline erosion was estimated at 0.5m/year, corresponding to a volume of 1,000 m^3/year to 1,500 m^3/year. The monitoring results show no loss before the nourishment from 2011 to 2013 and a loss of 1,000 m^3 after the nourishment from March 2013 to October 2013 and large seasonal variations. Therefore, it is necessary to continue the beach monitoring for more than 5 years to understand the erosion and the effects of the nourishment.
The nourishment position in the southern part was decided in view of the construction time in March and to study sediment movement caused by the southeast trade winds. The results were as expected and the sediment moved north. The results show that the rock reef in the middle of the coast reduces longshore movement.
As the nourishment method, the sand was transported to the beach by dump truck and levelled on the beach. There was no major contamination and the method was appropriate. Because of active sediment movement by the waves, the beach changed according to the incoming waves. Detailed levelling was not necessary. No claim letters were received during the construction.
The condition and volume of erosion are not fully clear at present. The long-term monitoring will identify the loss of sediment and the conservation plan will be revised if necessary.
The direction of the measures is (1) continuous sand nourishment as planned, (2) control of longshore sediment movement by a groyne with nourishment in the south and setback in the north, and (3) construction of rock armouring if the loss of sediment is too great. The continuous monitoring will indicate the best solution from the alternatives by understanding and comparison.
The Marine Conservation Society Seychelles started beach monitoring at North East Point in July 2011 at the start of the pilot project. There is a trend towards the Seychelles studying the beach changes by themselves.

6-6-2 La Passe

(1) General

The planning cycle explained in Chapter 3 is shown in Figure 6-6-9 as an example of the pilot project at La Passe.

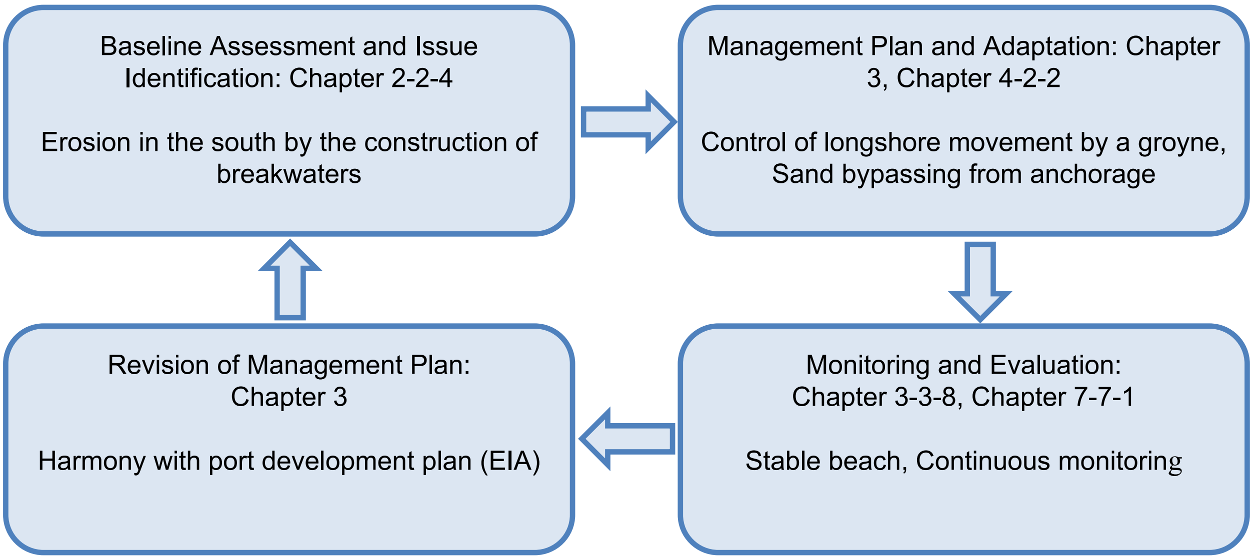


Figure 6-6-9: Example of Planning Cycle at La Passe

The coastal erosion, waves, tides and topography and the issues were summarised as in Chapter 2 as the basic study. It is clear that the beach has eroded due to the construction of breakwaters in the south and accretion at the anchorage. Coastal conservation measures were investigated as in Chapters 3 and 4 for several alternatives. From the results, the construction of a groyne was proposed to reduce longshore sediment movement and sand bypassing from the anchorage to the eroded area. Detailed design, environmental assessment and procurement were executed in the pilot project.

The objective of the pilot project at La Passe is to mitigate the impact of the breakwaters on coastal erosion and sedimentation at the anchorage. The creation of sheltered areas by the breakwaters causes accretion near the jetty and erosion on the south coast. A 50m-long groyne was constructed to prevent northward sediment movement and about 1,000 m^3 of sand which was dredged from the anchorage was nourished north of the groyne.

(2) Monitoring

It was clear from the field observations that the groyne prevented longshore transport because it caused accretion in the south and erosion in the north. Another groyne which appeared following sand dredging also prevents northward transport together with the new groyne. The nourished sand created a beach which is used as a volleyball court.

The satellite and aerial photos of the construction of the structures and beach changes from past to present are shown in Figure 6-6-10 to Figure 6-6-13.

Figure 6-6-10: GIS data in 1998

Figure 6-6-11: Aerial Photo in May 2011

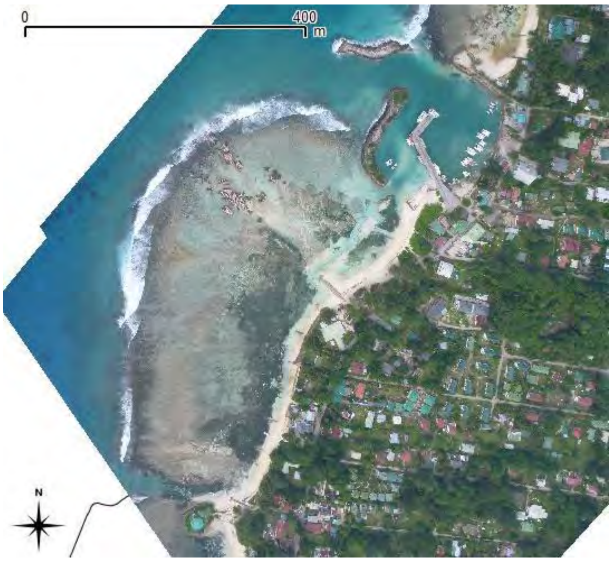


Figure 6-6-12: Aerial Photo in January 2013

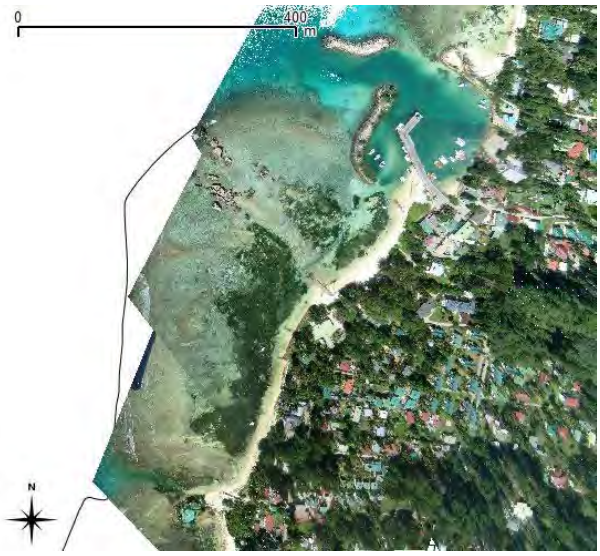


Figure 6-6-13: Aerial Photo in November 2013

The changes in the beach section area were investigated from the beach monitoring data after the construction of the groyne. The change in the sectional area before the project from March 2011 to April 2013 and six months after the project from April 2013 to October 2013 is shown in Figure 6-6-14. There is no major change and the beach is stable though there is a small variation near the groyne.

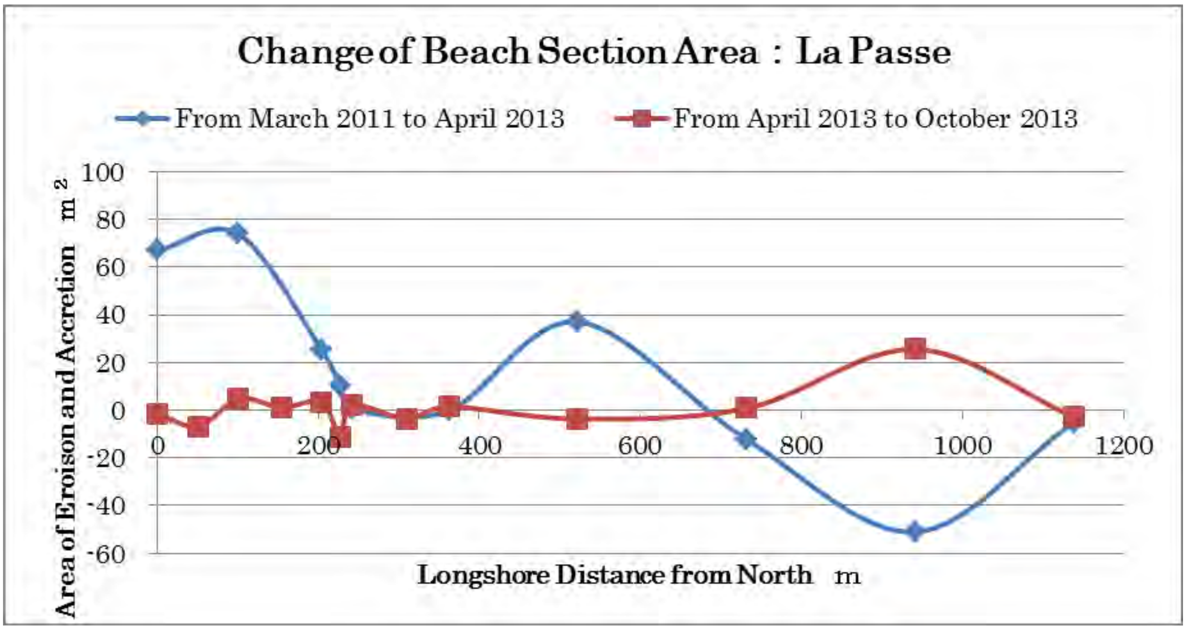


Figure 6-6-14: Change of Beach Section Area at La Passe

(3) Evaluation

At present, the groyne is effective for preventing longshore sediment transport. Long-term monitoring is also necessary. The newly created beach is contributing to beach use by tourists and local people.

The height and length of the groyne control the effectiveness of reducing longshore sediment movement caused by the construction of breakwaters. In the design, the length of the groyne is 50m based on the satellite images which show the active sediment zone and the height is 0.5m above the beach surface. The design is suitable because the accumulation at the anchorage is not clear and the groyne is effective.

The groyne was constructed of armour rocks of a size designed by the Hudson Formula. There is no movement and it is stable at present. The groyne does not cause discomfort and it harmonizes with the surroundings.

Erosion was expected south of the groyne before the construction and sand was nourished at the site. At present there are no clear changes. The breakwater was extended after the planning of the pilot project and accretion at the anchorage will progress gradually. Coordination with the port development plan is necessary.

In the past there has been little impact of coastal structures in the Seychelles. The proposed mitigation measures using groynes can be used for similar impacts by structures.

Harbour development is planned at La Passe and the beach should be protected as an important tourism resource. The results of the pilot project will contribute to the sustainable development of the port by mitigation measures by the construction of breakwaters.

6-6-3 Au Cap

(1) General

The planning cycle explained in Chapter 3 is shown in Figure 6-6-9 as an example of the pilot project at Au Cap.

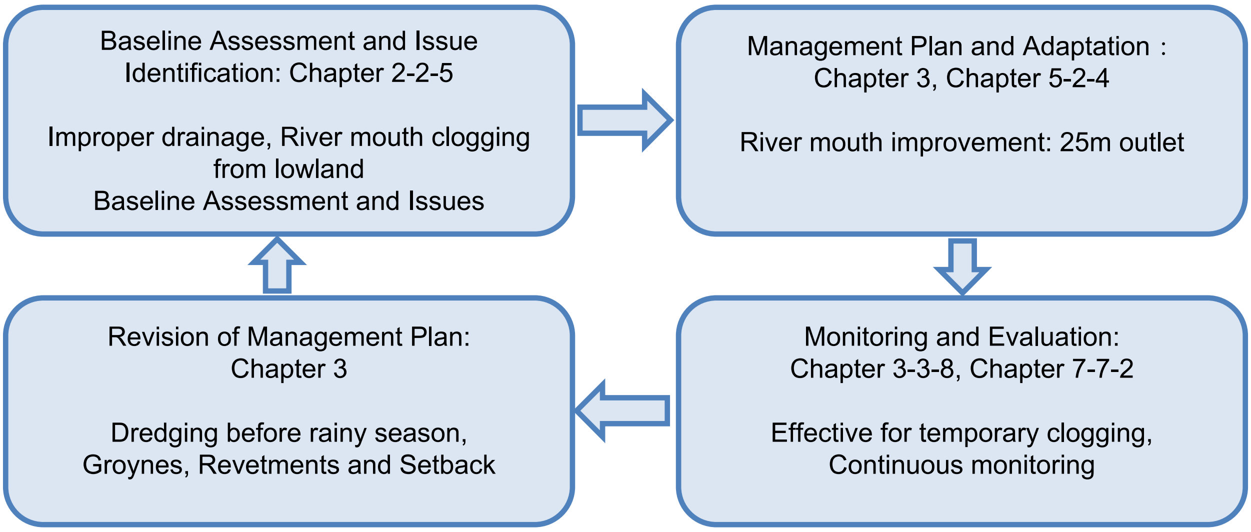


Figure 6-6-15: Example of Planning Cycle at Au Cap

The flooding and inundation, rainfall and topography and the issues were summarised as in Chapter 2 as the basic study. It is clear that the flooding was caused by insufficient flow capacity at the river mouth. Flood management measures were investigated as in Chapters 3 and 4 for several alternatives such as drainage or river improvement. From the results, river improvement and also river mouth improvement were proposed. Detailed design, environmental assessment and procurement were executed in the pilot project.

The objectives of the pilot project at Au Cap are to improve the outlet for flood mitigation, to improve the existing measures for outlets especially at the river mouth in lowland areas and to improve the design and management capacity of DOE for this kind of work. A 25m-long outlet channel was constructed to the sea to enable the smooth flow of floodwater and prevent accumulation of sediment in the channel.

The drainage at Au Cap consisted of three pipes as shown in Figure 6-6-16. It was not sufficient and the sand was dredged in times of flooding.

Figure 6-6-16: Drainage by Three Pipes (2012)

Figure 6-6-17: Clogging of Culvert (17/5/2012)

An outlet was proposed to prevent waves and accumulation of sediment inside in the outlet by making the opening in the side as a pilot structure. Basically, the mouth is maintained by the current action of the rivers and tides and clogged by wave action.

(2) Monitoring

The mouth was maintained from April to July 2013 by small waves according to the monitoring results. In August high waves were generated by strong winds from the southeast and sediment accumulated in the outlet during the neap tide. The outlet is possibly maintained by small waves after dredging in September and in the rainy season.

The record of the water level just inside the mouth after the construction of the outlet in 2013, measured by a water level gauge, is shown in Figure 6-6-18. The water level changes according to the changes in the tidal level outside the outlet. The lowest water level started to increase from 4th August and reached its maximum on 22nd August. During this period, the wind speed was 15 knots until the middle of August and increased to 20 knots after that. The lowest water level, which shows the height of the river bed, increased during the neap tide when the tidal change was small. Sediment accumulated in the outlet from 22nd August to 14th September due to the small tidal change. On 14th September the outlet was dredged and closed by sand bags at the mouth for the prevention of waves. However, it was not effective and the outlet was dredged again on 22nd September. Since then, the mouth has been maintained by weak winds and tidal currents by the lowering of the river bed.

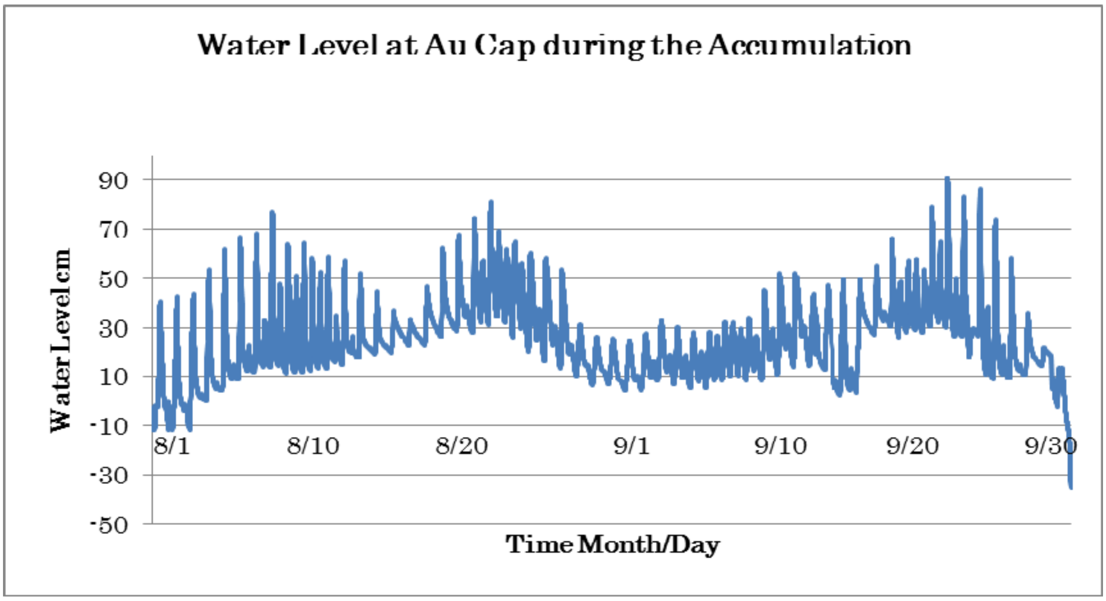


Figure 6-6-18: Water Level Changes at Au Cap during Sediment Accumulation

The change in the opening from south to north contributes to maintaining the mouth. At the beginning, the opening was made to the south in expectation that the existing groyne would prevent waves from the south. However, the sediment crossed the groyne and accumulated between the outlet and the groyne. Therefore, the direction was changed from south to north in January 2014. There was little accumulation of sediment in the outlet from November 2013 to February 2014 and the river bed showed a tendency to lower gradually.

The channel was maintained after the construction until July by tidal action. However, in August the combination of southeast waves and neap tide caused the accumulation of sediment and closing of the channel. After the maintenance dredging, the opening was maintained. In September the rainy season started and increased the river discharge which contributes to keeping the channel open. The little rainfall from March to August caused clogging also that year. Other reasons are the concrete blocks in the culvert under the road that act as a partition and the accumulation of sediment south of the outlet. The removal of the concrete blocks was requested.

(3) Evaluation

The monitoring results show that the flow condition at the outlet has improved compared with before the construction, though some maintenance is necessary before the rainy season.

In order to prevent clogging of the river mouth, measures were proposed and executed to reduce the incoming waves by changing the opening direction at the mouth and by using tidal action. The position of the opening will be located on the outside of the active sediment movement zone. Actually, the opening is located at the end of the sandy beach and is in an appropriate location judging from the site condition.

The direction of the opening was set to the south because the groyne in the south prevents sediment movement and also waves from the south. However, in fact sediment accumulated between the outlet and the groyne. Therefore, the direction was changed from south to north to prevent incoming sediment. On coasts without structures, the direction of the opening should avoid the prevailing wave direction. If there are structures, caution is necessary. It is better to design the structures according to the change in the conditions.

The height of the outlet was designed at 0.5m above beach level to prevent incoming sand. Traces of incoming sand were seen. However, the sediment in the outlet came from the opening and the height is adequate. The width of the outlet was designed to be the same width as the upstream river and there are no obstructions.

The bed at the outlet was designed from the actual elevation and it is not necessary to make it lower because of the actual sediment accumulation. To prevent accumulation in the outlet, it is better to make it higher than the sea bed and thepresent condition is the same as the previous one at the site.

In the Seychelles inundation is caused by clogging of the channel connecting the wetland located behind the sand bar on the coast to the sea. As one of the countermeasures, outlet improvement was proposed to reduce the incoming waves and was executed as a pilot project. The measure was effective and can be applied to similar rivers. However, sometimes clogging occurs due to high waves and neap tides. In this case, dredging is necessary though the chance is rare after the improvement.

DOE adopted the same kind of measures at Typhoo based on the results at Au Cap and constructed an outlet. Though less than one year has elapsed and no southeast trade winds have been received, there were no clogging problems as of January 2014. The pilot project contributes to helping the counterparts learn about measures against river mouth clogging and will be the start of new applications by the counterparts.

The results will be applied to the recovery works from the January 2013 flood, though several improvements are needed such as the direction of the opening and the type of structures.

A temporary bank was necessary for the concrete works to provide dry conditions. Before the pilot project, rock armouring was used. In the pilot project, a sand bank covered by rock armouring was used. This work was easy to modify for the flooding which happened during the pilot project and was cost effective. DOE plans to apply this kind of temporary bank.

In the pilot project, capacity development of the counterparts was conducted during designing, procurement and supervision, that is, during designing of side wall stability, cost estimation based on past examples, schedule control from the detailed schedules and quality control of the concrete by testing. The results have been used for the recovery works from the January flood. This means that one of the purposes of the pilot project has been achieved.

6-7 Application of the Pilot Projects

The pilot projects were selected from the management plan for the priority areas and executed. The application of the results is discussed in the following. The measures used are sand nourishment, groynes and outlet improvement and their application is explained. The use of these measures in the coastal conservation plan and flood management plan is discussed.

6-7-1 Sand Nourishment

Sand nourishment as a measure for coastal erosion basically aims to maintain the sediment budget and to supply the same volume of sand as the eroded volume. The study items are the source of material, volume of nourishment, work method and environmental impact. The application of the pilot project results to the conditions in the Seychelles is as follows.

A source of quartz sand has already been found on the sea bed between Mahe and Silhouette. The sand was dredged and used. The price is 135 SCR/t with a medium diameter of 0.6mm. At North East Point the grain size is the same as the existing sand. The colour is a little bit different. Therefore, the sand can be obtained easily.

The volume of nourishment has to be decided. Generally, the volume is taken as the volume lost within 5 to 10 years. If the volume is large, the loss will be bigger. If the volume is small, the effect is not clear. At North East Point the erosion of the shoreline is 0.5m/year and the loss is about 1m^3/m/year. The volume from short-term monitoring is in the same order. In the Seychelles the loss is the same at maximum. As the first estimation of the volume loss, the figure of 1m^3/m/year can be used and after the nourishment the volume can be revised based on the monitoring results. The monitoring needs to be carried out for 5 to 10 years. This can be done using satellite images and the cost is not expensive in combination with beach profiling.

It is necessary to consider the variations caused by wave climate change. The sediment transport rate changes according to the changes in wave height and direction. There are seasonal variations and also yearly variations. In order to measure the long-term changes, it is necessary to conduct beach monitoring for more than 10 years. Recently, climate change has to be considered.

The work method used at North East Point can be applied, namely transporting by dump truck and spreading by loader. The natural beach will be formed by the waves. The impact on water quality is not severe if the sand does not contain silt. The impact of the difference between coral sand and quartz sand

can be expected. The impact seems to be small because the existing beach sand also contains mineral sand.
The beach slope of nourished sand is controlled by the diameter and wave conditions. Usually, the beach slope is 1/7 in the Seychelles. The rougher the sand, the steeper the slope.
The monitoring results will give the volume of sand loss and the mechanism of erosion and the applicability of nourishment will be clearer.

6-7-2 Groyne

In order to mitigate the impact of the breakwaters, a groyne was constructed at La Passe as the pilot project. The study items are the function, structure and environmental impact. The application of the pilot project results to the situation in the Seychelles is as follows.
The longshore sediment is mainly controlled by the groyne length. If the active zone of sediment movement at the shoreline is covered by the groyne, longshore movement can be stopped. In the case of a reef, the active zone is estimated from satellite images in which the zone is the same white colour as the beach. In La Passe the same method was applied and the groyne is effective in reducing longshore movement.
The height of the groyne is designed to be 0.5m higher than the beach to stop sand overtopping. The direction is perpendicular to the beach because this is more effective. In the Seychelles the material will be rock because it is easy to obtain. The size can be estimated by the Hudson Formula. A smooth profile like La Passe is good for the landscape.
The breaking waves at the reef edge generate a reef current which is different from a tidal current. The changes in the current pattern have to be estimated by the installation of groynes because the sediment is moved by the reef current. The reef current is under study at present. The pattern is estimated by the pattern of the bed material.

6-7-3 Outlet

The outlet was constructed at Au Cap to improve river mouth clogging. The study items are the applicability of the method, the river profile at the mouth, the opening and the dimensions of the outlet. The application of the pilot project results to the situation in the Seychelles is as follows.
Basically, the river mouth is closed by the action of the waves and opened by the action of the currents including river or flood currents and tidal currents. The use of tidal currents can be applied to maintaining the river mouth because no river currents are expected. In this case, the wetland should be located at the river mouth. The current speed at the mouth depends on the water surface area of the wetland. If the area is large, the current is fast and the sediment deposition is controlled. The action of the waves will be small if the direction of the opening is alongshore. The measures can be applied if there is wetland near the river mouth and sometimes wetland can be made artificially.
The river profile at the mouth will be determined by the geographical and geological conditions, and river and tidal flow conditions. The profile of the newly excavated channel will be designed according to similar rivers. The sectional profile has to be designed for flooding. Sometimes it is difficult to maintain

and needs dredging and maintenance.
The height of the channel bed at the mouth will be determined by the longitudinal upstream profile and beach profile. Usually, it will be the mean sea level. If the tidal or river current is strong, the bed will be low and vice versa.
The opening should be designed to prevent incoming waves and to enable the flow of floodwater. The direction should be decided in the opposite direction to the incoming waves or in the direction of predominant longshore sediment transport. If there are structures near the mouth, detailed investigation is necessary. One idea is to construct an obstructive structure at the opening. In this case, the flow is separated onto both sides and it is not effective. If the condition is not clear, it is better to make an opening on both sides and to decide the direction.
The height is the same as the groyne and 0.5m higher than the beach to prevent wave overtopping.
If the river or channel is wide, bed concrete is not necessary and the side walls can be constructed by rock armouring.

6-7-4 Application to the Management Plan

Nourishment and groynes are included in the coastal conservation plan. However, only river mouth improvement is proposed in the flood management plan and not actual measures. This is because there are no established measures and sometimes dredging is only the solution.
The pilot project at Au Cap and the outlet improvement at Typhoo were implemented and the measures used have the possibility of being effective for river mouth clogging. The monitoring during the southeast trade winds will indicate the applicability of the measures. The results will be applied in the flood management plan.

Chapter 7 Technical Transfer

Chapter 7 Technical Transfer

7-1 General

The technical transfer was conducted for 1) improvement of the technical guidelines, 2) acquisition of engineering knowledge, 3) acquisition of planning and management knowledge, and through 4) seminars, workshops and training in Japan. An outline of these items is given in Table 7-1-1 based on the present conditions, problems, actions and future requirements.

Table 7-1-1: Summary of Technical Transfer

Item	Contents
Improvement of technical guidelines	
Present Conditions	There are EIA guidelines for coastal conservation and flood management. Also, there are beach monitoring guidelines for coastal conservation and stormwater drainage design guidelines for flood management.
Problems	EIA should be improved for reclamation activities and the construction of structures because the impacts of coastal erosion or flooding have been caused. The monitoring guidelines for coastal conservation are only for beach profile measurement and no consideration has been given to their use in coastal conservation. Recently simple machines can be used and guidelines are required for coastal surveys. The guidelines for drainage design are the guidelines used in Australia and their applicability has not been verified. The estimation of flood run-off is only explained simply in the guidelines.
Actions	The EIA guidelines were improved to prevent coastal erosion and flooding due to development in coastal areas. The beach monitoring guidelines were also improved to obtain correct data for coastal erosion mitigation. In the study coastline measurement and bathymetric surveys were conducted using relatively simple measures and guidelines were created for their future application. The applicability of the drainage design guidelines was improved after study of analysis of their reliability. HEC-RAS hydraulic calculation software was used in the study. Then the guidelines were created for use of the software.
Future Requirements	The EIA guidelines have to be improved by the continuous collection of examples to add the necessary items. The main structural measures are revetments, groynes and sand nourishment. It is necessary to gather design examples and to create guidelines for coastal conservation in the Seychelles. Improvement of the drainage design guidelines is necessary by analysis of the observation data. The design guidelines for river mouth improvement as one of the pilot projects can be created by the accumulation of experience. Guidelines for coastal conservation and flood management planning are required. However, this is a future problem because development is underway in consideration of future climate change.
Acquisition of Engineering Knowledge	
Present Conditions	Engineering knowledge is necessary to mitigate coastal erosion and flooding, such as investigation, planning, designing and maintenance. In the past, the Environmental Management Plan (EMP) and SSDS were formulated by MEE which has some experience. Beach monitoring was conducted in the past for coastal conservation. The knowledge is limited but exists. Following the flood in 2004, a drainage task force was established and conducted improvement works. At that time the drainage design manual was used. The drainage channels have been maintained since 2009 by DOE which has some practical knowledge. There is no other knowledge mentioned above.
Problems	General knowledge for understanding the coastal conditions and the changing coastline and for designing coastal structures is limited. Flood management requires information on disaster damage. The ability to study the damage and to design structures is lacking.

Actions	On–the-job training (OJT) and lectures were given to the C/P including coastal observation, taking of aerial photographs, GIS application and structural design for coastal conservation. The disaster damage was surveyed by the C/Ps as OJT in flood management.
Future Requirements	The ability to plan and design coastal structures such as revetments, groynes and sand nourishment will be required. This can be obtained from past experience and training during actual works. Following the floods in January 2013 and 2014, recovery projects have been conducted. The necessary knowledge and experience can be obtained through the projects. Knowledge of river mouth improvement works will be obtained from the pilot projects and similar projects.
Acquisition of Planning and Management Knowledge	
Present Conditions	In the past, the C/Ps were taught to make and evaluate EMP and SSDS including integrated coastal zone management. Therefore, they have some kind of knowledge of planning.
Problems	The plan includes everything under the limits of human resources and financial conditions. The problem is mainly lack of action. It is necessary to concentrate on the important points within the limited resources. In the study OJT was planned during the pilot projects and subsequent monitoring. However, the C/Ps were very busy conducting recovery projects and it was difficult for them to spare enough time.
Actions	OJT was conducted in formulating plans and evaluating the results during the construction in the pilot projects and after the projects.
Future Requirements	It is necessary to select the important items and to implement the selected items because of the limited resources (manpower and budget) and the uncertainty of future climate change.

Five of the guidelines were selected and improved or created. They are summarised in Table 7-1-2.

Table 7-1-2: Items and Contents of Guidelines

Item	Purpose	Contents
(1) Improvement of EIA Guidelines	EIA is not effective because coastal erosion due to the construction of structures and flooding due to land development were caused. Items were added to the EIA manual to regulate such activities.	The added items are channel dredging in reefs, accretion and erosion in the sheltered area of breakwaters, impact of structures on longshore sediment transport, development of lowland, development of riverine wetland and obstruction of drains. The guidelines will be used to mitigate several impacts related to coastal erosion and flooding.
(2) Improvement of Drainage Design Guidelines	The existing guidelines lack several coefficients for the Seychelles conditions related to flood run-off.	The added items are the run-off coefficients for the geology and land use in the Seychelles, the intensity duration curve for short and long periods and the estimate method for detention functions. The guidelines improve drainage design.
(3) Beach Monitoring Guidelines	Items related to the analysis method and related monitoring measurements are added for the planning and management of measures against coastal erosion.	The arrangement of the transect for monitoring purposes, method of analysing coastal changes and estimation of coastal changes are proposed and explained. DOE has a monitoring plan and it contributes to the acquisition of useful information.
(4) Aerial Photo Guidelines	Taking aerial photos by helicopter using a digital camera is effective for obtaining long-term coastal changes and land use. The method is explained in the guidelines.	The method and accuracy of taking photos, factors to be considered such as tide and weather, orthogonal transformation method and related software are explained. When there is a need for aerial photographs, the guidelines will be effective.
(5) Bathymetric Survey Guidelines	It is necessary to know the bottom profile of the need for coastal conservation. The use of echo sounders by fishermen is proposed as a measure.	Measures using echo sounders and the arrangement of the survey course are explained in the guidelines. Cautions when surveying are also stated. There is a need for bathymetric surveys and the guidelines will be used.

For engineering knowledge, OJT and lectures were conducted as summarised in Table 7-1-3.

Table 7-1-3: Items and Contents of Engineering Knowledge

Item	Purpose	Contents
(1) Coast Observation	It is more important for coastal conservation to understand the actual conditions of the coasts and to study the effectiveness of past structures than to obtain knowledge from books.	During the field observation, the counterparts (C/P) studied with the team members how to observe and what to focus on in on-the-job training (OJT). The results were used in the study and contributed to understanding of the coastal conditions.
(2) Taking aerial photographs	In order to acquire the know-how for taking aerial photographs by helicopter, the counterparts took photos according to the guidelines.	The C/P learned how to take photos during the basic study. A part of the work was done by the C/P as OJT. The training will be used when aerial photography is planned.
(3) Flood Damage Survey	In order to obtain information, a flood survey was conducted of local people who lived in a flood prone area by the C/P and the Study Team. The C/P learned the survey method.	In the flood prone area, the C/P gathered information on past floods and damage through personal interviews based on a predetermined questionnaire. It is a useful tool for understanding flood damage.
(4) GIS Training	Training and lectures were given to the C/P in understanding the use of GIS, which is very useful for management.	Training was provided in a co-project for environmental impact assessment. Open source GIS software was used. GIS makes it easy to manage the coastal zone.
(5) Structural Design	The C/P's capacity for structural design was enhanced to enable them to understand how to calculate the stability of structures.	Training in design conditions, modelling and calculation methods of force and stability was provided through lectures. The results were applied to the disaster recovery works from recent flooding.
(6) Formulation of Managemen t Plans by OJT	In order to understand the processes of coastal conservation and flood management planning, training was given in evaluation of pilot projects and planning methods.	The C/P learned through OJT with the Study Team how to monitor the results of pilot projects, to identify problems in designing and planning, and to improve the plans. This will contribute to revision of the management plan.

The details are explained in the following sections.

7-2 Improvement of Technical Guidelines

The guidelines for environmental impact assessment and coastal monitoring for coastal conservation and the stormwater drainage guidelines will be elaborated taking into account their application in the Seychelles.

7-2-1 Environmental Impact Assessment

In relation to coastal erosion and flood management, there are already three guidelines for environmental impact assessments (EIA), namely guidelines for coastal zone management, construction and construction transport infrastructure.

(1) Guidelines for coastal zone management

In the guidelines for coastal zone management, there is a check list which includes the following items.

- Area of island
- Length of coastline
- Has ecological characterisation been conducted?
- Has the sand removal been controlled?
- Has the sand removal been monitored?
- Are coastal erosion mechanisms in place?
- If so, have appropriate studies been carried out?
- Are sea walls to be built?
- Are piers to be built?
- Are reef channels to be made?
- Are breakwaters to be constructed?
- If yes for the above, have baseline studies been conducted?
- Has EIA been carried out?

(2) Guidelines for construction

In the construction guidelines, there is a check list. For coastal erosion and flood problems, the following items can be applied to risk management.

Ensure that the project site is not located in the following areas:

- Major floodplain
- Coastal zone flood risk area

Parameters that should be systematically checked before granting planning permits including the following items:

- Absence of potential risks: landslide, flooding, polluted area
- Production areas: forests, agriculture, tourism, aquaculture

In the guidelines, hints and tips for inside the coastal strip are shown as follows;

- Is the project located inside the coastal strip?
- Is the project located in another sensitive area?
- Is the project required to submit a simplified or a full environmental impact assessment?

If simplified assessment is required: Answer the following

Describe the main characteristics of the project:

- Where is the project / development to be implemented?
- What kind of construction is it? (house, shop, workshop, others...)
- Surface and highest elevation for the construction
- Surface of the plot
- Materials to be used
- Is there an existing building on the site?
- According to the land-use plan or development plan, what kind of land-use is expected for this area?

Natural characteristics to be considered are:

- What is the elevation above the high water mark?
- Is it a rocky or a sandy shore?
- Is it sometimes eroded?
- Are there wetlands or streams in the surrounding area?
- Is the area sometimes flooded?
- Is the construction on the plot as far as possible from the shore?

(3) Guidelines for transport

In the transport guidelines, there is a check list. For coastal erosion and flood problems, the following items are useful. Several impacts are specifically presented in the guidelines.

(a) Coastal erosion

Though the coastal area of many parts of the Seychelles appears to be flat, slight slopes can be observed, upon which sand tracks have been built in some places. These sand tracks are used by motor vehicles and are sometimes turned into regular roads or car parks. These infrastructure elements are not stable and are bound to generate coastal erosion.

(b) Drainage

Roads immediately create an impervious surface upon which run-off is accelerated, an outlet for rainwater and a hydrological barrier cutting through existing hydrological networks. In this sense, the drainage system built along the road drains water both from the road surface and from upstream.

Roads can generate very detrimental environmental effects on all these functions, basically increasing the suspended solids and chemical pollution load, increasing the likelihood of flooding in some places and completely changing the water regime of several streams.

(c) Construction of transport infrastructure

Road infrastructure building should be planned in such a way that no delays arise between the construction of the road and the surfacing (asphalting). This may mean reducing the ambitions of programmes such as the Land Bank Project and implementing the reduced programme in a better way. Possible pressure from local decision-makers should be resisted. Better inter-agency coordination is a must for minimising the worst environmental impacts of road construction.

There are also practical hints and tips explained as follows:

- Is coastal erosion associated with roads adequately considered?
- Are setback lines for coastal roads used?
- Is the road drainage properly sited to deal with catastrophic events?
- Will there be “downstream” effects from the road siting?
- Is EIA carried out before siting is considered?
- Is the drainage adequate, engineered properly and constructed on time?
- Are sea walls or steep revetments to be built?

- Are there alternatives to sea walls?
- Is beach sand to be removed?

(4) Improvement of EIA guidelines

The EIA guidelines principally explain the important points. Only actual examples are necessary to understand the activities that cause coastal erosion and flooding in view of the local conditions in the Seychelles. The impact of human activities on coastal erosion has already been reported by Shah as in 3.1.5 Past records of natural disasters and damage.
The important items are classified based on past examples and the details are explained in the supplementary report. The following items were selected for coastal erosion.

Breakwater Construction

Breakwaters modify the wave conditions which cause accretion and erosion on the adjacent coast such as at La Passe in La Digue. The types of impacts are prevention of longshore sediment transport with accretion on the updrift side and erosion on the downdrift side, accretion in the sheltered area and erosion in the adjacent area. The mitigation measures are modification of the breakwater arrangement, construction of groynes and sand bypassing.

Groyne Construction

Groynes are constructed to reduce longshore sediment transport and to mitigate erosion as at Anse Kerlan. However, the coastal downdrift side will be eroded by the reduction in sediment supply. The mitigation measures are the construction of groynes on the whole sandy coast or setback on the downdrift side.

Channel Opening in Lagoons

Sometimes a channel is opened in a lagoon for navigation of fishing boats. This causes modification of the reef current by the change in the coast or loss of sediment from the beach to offshore. The mitigation measures are reduction of the concentration of the offshore current by modification of the channel dimensions and course.

Vertical Revetment Construction

Vertical revetments cause scouring in front and modification of the beach alignment adjacent to the revetments. Wooden pile revetments also cause the same impact. As structures, wave run-up is also increased compared to gentle revetments. The mitigation measures are construction of gentle revetments.

Land Use in Dynamic Zone

The beaches change according to the changes in tides and waves and have dynamic characteristics. If a building is constructed, it will be affected by erosion or wave run-up. The mitigation measures are land use regulations and shifting or raising of buildings.
The following items were selected for flood management.

Land Reclamation

Several drainage problems are caused by land reclamation such as at Victoria and Pointe Larue. In particular, reclamation at the outlet to the sea causes reduced flow capacity and flooding upstream.

Blocking of the outlet or increased drainage channel length are the main problems. The mitigation measures are improvement of the drainage capacity in the reclamation area.

Lowland Development

In the past, housing and public facility developments in lowland areas themselves caused drainage problems, such as at Chetty Flat, schools in Pointe Larue, Anse Aux Pins, Anse Royale and others. The lowland area acts as a detention pond for flood water. Therefore, development causes flooding problems there and in the adjacent area. The mitigation measures are creation of a detention pond or raising of the buildings.

Drainage Modification

Sometimes the drainage channel is blocked by the construction of roads, buildings and utilities. The scale of activity is small but the impact is not. Maintenance of drainage facilities is important and immediate action is necessary.

7-2-2 Stormwater Drainage Design Guidelines

The Stormwater Drainage Design Guidelines were prepared by the Land Transport Division of the Ministry of Environment and Transport in February 1999 (at present HAETE). The design guidelines were the first guidelines to assist stormwater drainage design engineers in the Seychelles. The guidelines contain the required basic data for calculation of drainage and culvert structures.

(1) Present Conditions

In this study, it is planned to re-evaluate the calculation equations in the guidelines and their effectiveness in the existing field conditions.

During the field study, some issues in application of the guidelines were observed as follows:

- There is not enough available basic data for the calculations.
- Actual data for using the calculations is not recorded in the database, therefore it is difficult to trace the design conditions and calculations.
- Without proper basic data (or with only a small amount of data), the results of the calculations have a poor degree of accuracy. This causes variable sizes of drainage structures in the same drainage system.
- A monitoring system for basic data is not yet well organised by the concerned agencies.
- Based on the above conditions, the guidelines are not yet a practical tool for design at present.

(2) Improvement of Guidelines

Topographic and cross section surveys were conducted in Victoria and other flood risk areas. From the surveys the accuracy of the equations in the guidelines was studied using the new survey data. Based on the above results, the calculation equations were improved and a hydraulic calculation sheet was prepared for drainage design. With this new basic data, engineers are expected to put the design guidelines into practice easily. The main improvements are as follows and the details are explained in the supplementary report.

- New proposal of runoff coefficients
- Simple relationship between rainfall and discharge
- Method for the estimation of flooding in wetland

7-2-3 Guidelines for Aerial Photos

(1) Introduction

The analysis of coastline changes in the long term is very important for solving coastal erosion problems. The recent rapid development of digital cameras makes it easy to take photos and analyse the coastline from the photos. The purpose of the manual is to provide guidelines for each step from preparation to analysis. The contents are preparation, photograph taking, correction of lens distortion and transformation to orthogonal projection.

(2) Preparation

It is necessary to consider several conditions in order to take good photos. They are:

- Weather conditions: preferably no cloud, no haze or smoke
- Tide: at the mean sea level when photographing the coastline
- Time of day: 3 hours after sunrise to 3 hours before sunset
- Sun angle: vertical is preferable and over 30 degrees to the horizon
- Cloud cover: avoidance of clouds and cloud shadows

The flight course is determined by the target coastline.

The changes in the sandy beach within the littoral cells will be analysed.

The timing of the photographs

The coastline changes mainly according to the wave conditions, especially direction. In the Seychelles, the climate is divided into two seasons, the northwest monsoons and the southeast trade winds. April is the boundary between the northwest monsoons and the southeast trade winds. November is the boundary between the southeast trade winds and the northwest monsoons. Therefore, April and November are suitable seasons for taking photographs.

The camera and accessories such as the battery and memory should be checked.

(3) Photograph Taking

From the helicopter, photographs are taken continuously along the sandy beach coastline with a land area of 60% to 70% and a sea area of 40% to 30% in each photograph. Vertical or near-vertical photographs are preferable because of the accuracy of the coastline.

(4) Correction of Lens Distortion

Lens distortion can be corrected from a lattice image photo which is taken of a tiled wall or tiled floor. The correction parameter is obtained from the x and y data values of the photo and the actual X and Y values of the tiles by applying the correction equations. For the correction, software is used and more than five sets of x and y data are required.

(5) Transformation to Orthogonal Projection

Orthophotos are photographic images constructed from vertical or near-vertical aerial photographs, such that the effects of central perspective, relief displacement and tilt are (practically) removed.

7-2-4 Guidelines for Bathymetric Surveys

(1) Introduction

For analysis of coastal erosion problems, the profiles of the beach and coral reef are essential. One of the methods of measuring the profiles is by using an echo sounder together with GPS which measures the position. The purpose of the manual is to provide guidelines for each step from preparation to analysis.

(2) Preparation

It is necessary to consider several items for the echo sounding. They are:

- Making the survey plan
- Preparing a boat and other items
- Installing the echo sounder and GPS

Checking the weather and sea conditions

Survey Plan

First, the area and the sounding line are decided according to the purpose of the survey. For coastal erosion analysis, the survey covers the littoral cells in the alongshore direction and from the beach up to a 20m depth offshore. Generally, the changes in the coastal profile are greater in the offshore direction than in the alongshore direction. Therefore, the interval of the survey line is dense offshore, such as 20m, and sparse alongshore, such as 200m.

The time and date are determined by considering the weather, tides and waves. It is better to avoid rough weather such as rainy and windy conditions and high waves. If the purpose of the survey is to measure a shallow area, high tide is preferable.

Because the bottom profile is measured from the head of the echo sounder to the bottom, it is necessary to measure the tidal level and the distance from the sea level to the head of the echo sounder. The tidal records can be used to correct the changes in sea level.

Preparation of a boat and other items

The sounding is carried out by fixing the echo sounder to a boat. The size of the boat is determined by the number of persons engaged in the survey, the size of the machine and the battery.

The necessary items are as follows:

- Echo sounder with GPS
- Fixing apparatus for the pickup
- Battery
- Charts or SD card of charts
- Life jackets
- Camera

Installing the echo sounder and GPS

First, install the echo sounder and GPS on the boat and check the water depth by comparing the actual depth and the recorded depth. Also, it is necessary to correlate the actual position and the GPS record. There are several methods to fix the pickup on the boat. If it is not a permanent installation, the pickup will be installed on the outside of the boat.

Checking the weather and sea conditions

Before starting the survey, it is essential to check the weather and sea conditions to ensure accurate and safe measurements.

(3) Echo Sounding

There are several ways to measure the bottom profile. One is to take a parallel course to the coastline and the other is to take a vertical course to the coastline. Usually, a vertical course is taken because it is more efficient and easier to navigate. To check the sounding results, a cross course should be taken. During the survey, the time is recorded for correction of the sea level.

(4) Analysis of Results

The bottom profile is calculated and charts made using software such as Dr. Chart.

The bias of bottom profile measurements comes from the difference in sea level and the setting height of the pickup. Variation comes from the movement of the boat. The purpose of the measurement is to obtain the sediment budget, so the bias should be eliminated. Comparing the measurement results at a fixed bed at different times enables correction of the data.

7-2-5 Beach Monitoring Guidelines

(1) Introduction

The beach monitoring plan is derived from the monitoring aims, the characteristics of the beach and the limited resources of the related organisations. The importance of monitoring has been pointed out in many reports and is understood by the related organisations. However, only limited monitoring was conducted and the results were not applied to the actual management works.

The reason why the monitoring was not conducted continuously is that it did not take into consideration the limited resources such as the capacity of the organisations, limited budget and lack of understanding of how to apply the results to management works. The proposed guidelines concentrate on the important practical points.

It is better to monitor only important beaches. The other beaches will be monitored after several years of experience and the establishment of the system. The proposed method is simple and the cost is affordable. The time interval is twice a year according to the seasonal changes in the waves. For the long-term changes of the beach, satellite data such as Google Earth will be used. In the Seychelles the environmental management plan is evaluated and revised every 10 years. The analysis will be conducted at the time of evaluation to improve the next 10 year plan.

(2) Aims of Beach Monitoring

The aims of beach monitoring are to collect quantitative information for coastal management over a long time span. In the Seychelles the actual aims depend on the beach characteristics and are classified into three items. The first is the long-term beach changes, the second is the seasonal beach changes and the last is the impact of structures on the beach changes.

(3) Monitored Beaches

Long-term loss of sediment can be caused by offshore movement of sediment and sand mining. Essentially, coral reefs act as a source of sediment supply and beaches that are protected by reefs are usually stable. Beaches with a narrow reef or partly protected reef show the possibility of loss of sediment. Such beaches are North East Point, Baie Lazare and Beau Vallon. Flooding sometimes causes offshore sediment movement through a channel which has been formed by fresh water discharge. Baie Lazare is such a beach. The information needed for these beaches is the quantitative total loss of beach material. Long-term observation is necessary because of the dynamic seasonal changes and the limited occurrence of flooding.

The wave climate in the Seychelles has two seasonal changes which are brought by the northeast monsoons and the southeast trade winds. Seasonal variation also causes beach erosion problems in some cases. Temporal erosion and accretion occur even though the total sediment volume does not change. If a beach is eroded, the wave run-up becomes higher and causes flood damage. The beaches classified in this type are North East Point, Beau Vallon and Anse Kerlan in Praslin.

The impacts caused by coastal structures are accretion and erosion at La Passe in La Digue and erosion at Anse Kerlan in Praslin. Also, the outlet at Anse a La Mouche caused accretion on the updrift side of longshore sediment transport. It is said that the vertical wall revetment also caused scouring in front of it.

The beach is stable when it is protected by a wide reef or it is short like a pocket beach. However, at Au Cap the beach is narrow with a wide reef and shows erosion of about 20m since 1967. The beach needs to be monitored to discover the reason for the erosion.

The monitored beaches were selected based on the considerations as stated above and are shown in Table 7-2-1.

Table 7-2-1: Monitored Beaches and Characteristics

Name of Beach	Beach Characteristics	Monitoring Items
Mahe		
North East Point (NEP)	Narrow reef, offshore loss and seasonal changes	Total loss and seasonal changes of sediment volume, wave overtopping on coastal road at high tide
Au Cap (AC)	Wide reef and narrow beach	Total loss of sediment volume and wave overtopping on coastal road
Baie Lazare (BL)	Offshore loss through a channel	Loss of sediment by flooding, beach changes and wave overtopping on coastal road
Praslin		
Anse Kerlan (AK)	Longshore transport (eroded)	Total loss and seasonal changes of sediment, characteristics of longshore transport, impact of groynes and revetments

Name of Beach	Beach Characteristics	Monitoring Items
Grand Anse (GA)	Wide reef and longshore transport (accreted)	Accumulation of sediment related to the erosion at Anse Kerlan
La Digue		
La Passe (LD)	Wide reef and longshore transport	Structural impact around breakwaters and groyne

(4) Monitoring Method

The beach monitoring method is explained in some guidelines by Kairu (2000). The measured section of beach is proposed for each beach as in Table 7-1-2 and is called a transect. The beach profile is measured by hand level and engineering pole. The position can be recorded by GPS. (Kairu, K. and N. Myandwi: Guidelines for the Study of Shoreline Change in the Western Indian Ocean Region, IOC, UNESCO, 2000)

If the beach is short, three transects is enough. The data from both ends give the seasonal changes and the data from the centre give the total changes in the beach. If the beach is long or is not straight, more than three transects is necessary.

Table 7-2-2: Position and Height of Proposed Transect at Each Beach

NEP1	328852.3	9495196.7	2.88	AK4	354071.7	9523517.0	3.61
NEP2	328957.1	9495015.1	3.01	AK5	354113.9	9523326.0	3.97
NEP3	329103.9	9494861.4	2.85	AK6	354166.1	9523136.0	4.30
NEP4	329254.7	9494690.9	2.89	AK7	354166.1	9522925.0	3.66
NEP5	329358.2	9494511.3	2.79	AK8	354164.1	9522769.0	3.06
NEP6	329411.1	9494470.9	2.60	AK9	354296.3	9522616.0	2.88
NEP7	329460.4	9494390.6	2.73	AK10	354454.3	9522466.0	3.09
NEP8	329506.9	9494271.7	2.62	AK11	354602.2	9522324.0	2.76
NEP1B	329581.9	9494095.5	3.19	AK12	354771.1	9522212.0	2.79
AC1	336080.2	9479292.0	1.98	AK13	354927.8	9522064.0	2.79
AC2	335900.6	9479490.0	-0.50	GA1	355515.8	9522018.0	2.24
AC3	335757.4	9479446.0	1.79	GA2	355944.8	9522049.0	1.72
AC4	335981.9	9479630.0	2.17	GA3	356382.0	9522041.0	2.39
AC5	335934.4	9479622.0	1.67	GA4	356628.7	9522012.0	2.11
BL1	370086.8	9519483.3	2.10	GA5	357511.2	9521751.0	2.27
BL2	370037.4	95193978.0	1.94	GA6	357746.6	9521623.0	2.11
BL3	369925.0	9519330.9	1.96	GA7	358022.9	9521283.0	1.71
BL4	369876.6	9519226.7	2.23	LD1	370086.8	9519483.3	2.10
BL5	369822.0	9519058.7	1.59	LD2	370037.4	9519398.0	1.94
BL6	369808.9	9518863.8	2.27	LD3	369925.0	9519330.9	1.96
BL7	369766.5	9518660.2	2.20	LD4	369876.6	9519226.7	2.23
BL8	369750.7	9518454.4	1.94	LD5	369822.0	9519058.7	1.59
AK1	353848.0	9524076.0	2.20	LD6	369808.9	9518863.8	2.27
AK2	353968.5	9523916.0	3.32	LD7	369766.5	9518660.2	2.20
AK3	354045.4	9523714.0	3.03	LD8	369750.7	9518454.4	1.94

7-3 Acquirement of Engineering Knowledge

Through OJT, workshops, seminars and training courses in Japan, the engineering knowledge necessary for project implementation was acquired by the related persons in the Seychelles. They take aerial photographs by helicopter and conduct coastal investigations and flood damage surveys.

7-3-1 Taking of Aerial Photographs

For the measurement of coastal changes, aerial photographs are very useful. Therefore, an explanation of the method and planning according to the guidelines and field training were given to the counterparts. As field training, photographs were taken of Mahe on 7th April and Praslin on 17th June.

7-3-2 Coastal Investigation

Coastal erosion problems can be understood better by field visits than in-room lectures. The condition and causes of erosion at the site in La Passe in La Digue were investigated and explained to the counterparts on 8th April. The erosion at the site was caused by the construction of two breakwaters and heavy accretion in the sheltered area where sand was covered by vegetation, indicating long-time accumulation. Also, it is understood that wave direction on the beach is limited because of Praslin Island in front of the site. Past maps and aerial photographs aid understanding of coastal erosion phenomena.

7-3-3 Flood Damage Survey

(1) Objective

The flood survey was carried out to identify the flood prone area and conditions, as well as the social conditions, for the urban flood management plan in Victoria Town and other flood risk areas.

(2) Targets of the survey

The targets of the survey in Victoria Town are as follows:

- Members of DOE who were assumed to be familiar with the flood situation
- Households, offices, shops and restaurants in the flood prone area

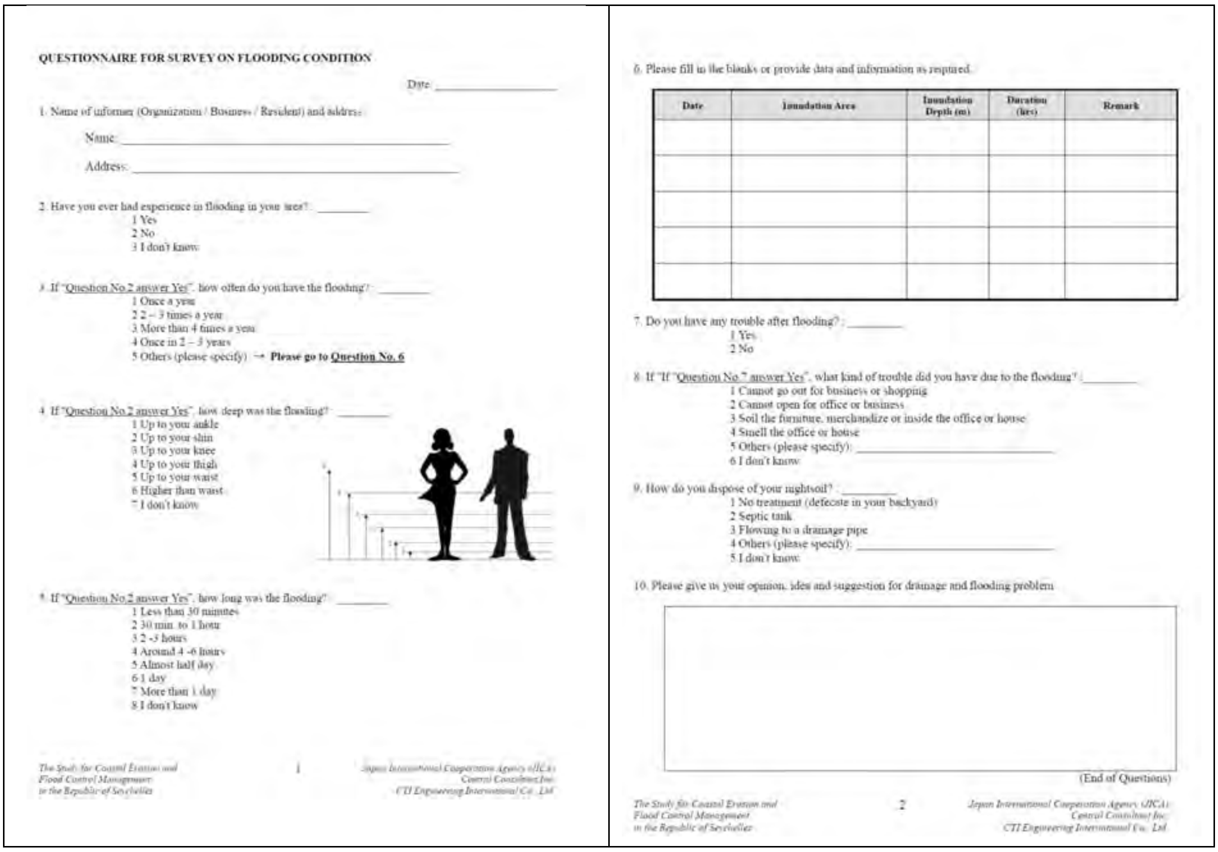
The targets of the survey in other flood risk areas are as follows:

- Persons living in flood prone areas and the surrounding area.

(3) Methodology

The survey in Victoria Town was carried out in two steps. The first step was to review the related reports and to visualise the general flood conditions in the area through interviews with members of DOE who were assumed to be familiar with the flood situation. The questionnaire consisted of the location, degree of damage and priority for improvement.

In the second step, based on the results of the first step, the study team was able to identify the areas where inundation occurred. After identification of the flood prone area, the study team visited each household, office, shop and restaurant in the area and conducted an interview survey to clarify the flood conditions and social conditions for drainage improvement in detail. Furthermore, the study team was able to identify the high priority areas to be improved. The questionnaire to the interviewees contained the questions in Figure 7-3-1.



QUESTIONNAIRE FOR SURVEY ON FLOODING CONDITION

Date: ________________

1. Name of informer (Organization / Business / Resident) and address:

Name: ______________________________

Address: ______________________________

2. Have you ever had experience in flooding in your area? : ________
1 Yes
2 No
3 I don't know

3. If "Question No.2 answer Yes", how often do you have the flooding? : ________
1 Once a year
2 2 – 3 times a year
3 More than 4 times a year
4 Once in 2 – 3 years
5 Others (please specify) → **Please go to Question No. 6**

4. If "Question No.2 answer Yes", how deep was the flooding? : ________
1 Up to your ankle
2 Up to your shin
3 Up to your knee
4 Up to your thigh
5 Up to your waist
6 Higher than waist
7 I don't know

5. If "Question No.2 answer Yes", how long was the flooding? : ________
1 Less than 30 minutes
2 30 min. to 1 hour
3 2 -3 hours
4 Around 4 -6 hours
5 Almost half day
6 1 day
7 More than 1 day
8 I don't know

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6. Please fill in the blanks or provide data and information as required.

Date	Inundation Area	Inundation Depth (m)	Duration (hrs)	Remark

7. Do you have any trouble after flooding? : ________
1 Yes
2 No

8. If "If "Question No.7 answer Yes", what kind of trouble did you have due to the flooding? : ________
1 Cannot go out for business or shopping
2 Cannot open for office or business
3 Soil the furniture, merchandize or inside the office or house
4 Smell the office or house
5 Others (please specify): ______________________
6 I don't know

9. How do you dispose of your nightsoil? : ________
1 No treatment (defecate in your backyard)
2 Septic tank
3 Flowing to a drainage pipe
4 Others (please specify): ______________________
5 I don't know

10. Please give us your opinion, idea and suggestion for drainage and flooding problem

(End of Questions)

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Figure 7-3-1: Questionnaire for Flood Survey

The survey in the other flood risk areas adopted the same questionnaire form and it was carried out by the following procedure. The Study Team and DOE held a meeting with the District Administrator (DA) or Development Board regarding the flood prone area, damage level and frequency of flooding in the district. Then the Study Team asked the DA to arrange an interview survey using the questionnaire. With these survey data, it may be possible to understand the actual flooded area, flood phenomena and damage caused by past floods.

7-3-4 GIS Training

Introduction of the Geographic Information System (GIS) in governmental administrative works is one of the national sustainable development strategies in the Seychelles. With its effectiveness for managing huge amounts of data in a variety of classifications, it is expected to be applied to comprehensive analysis and research implemented by executive authorities such as the environmental policy-making sector. On the other hand, it is crucial to possess and organise adequate data relevant to coastal and inland water areas in order to analyse the coastal erosion and flood management. Therefore, being able to utilise GIS with an enormous amount of environmental data can easily provide persons working in the environmental field with opportunities to determine what is happening or will possibly happen to the environment in the Seychelles. Based on the basic idea mentioned above, GIS training activity was conducted for the staff of DoE as one of the technical transfers in the Study.

(1) Background

The training activities as a part of the technical transfer in the Study are partly integrated with a project developed by the Marine Conservation Society of Seychelles (MCSS) to digitise and quantify part of the EIA application process. Since 2011 the GIS unit of DoE has begun to introduce a versatile database known as PostgreSQL which can harmonise with the open source GIS application known as Quantum GIS (QGIS) in the relevant government sections. The idea is to have a GIS application with easy operation and less economic burden which both the Study Team and government policy can direct to the same solution for managing national environmental and social information.

(2) Objective

The objective of the GIS training is to assist the staff of DoE, especially the Pollution Control Environment Impact Section (PCEI) and Environment Engineering and Wetland Section (EEWS), in storing and managing environmental information for future research as well as making appropriate decisions on EIA Class 2 analytical activities. At the end of the training and with further continuous self-training, the activities will provide the trainees with basic knowledge and techniques in GIS application.

(3) Training Outline

The GIS training started with the general concept of GIS to provide knowledge of the purpose, effectiveness and workability of the application. For the next step, the trainers gave lectures by demonstrating GIS work on the projection screen. The training outline for both PCEI and EEWS is summarised in Table 7-2-1.

Table 7-3-1: Outline of the GIS Training

Training Items	Remarks
(Basic information) • Brief Introduction to GIS/mapping /expectations • Introduction to Quantum GIS – functions, compatibilities • How to install QGIS and how to enter/save data	Verbal
(Introduction of basic functions) • Basic functions (zoom, pan, save, load layers, etc.) • Working with existing layers (symbols, labelling, etc.) • Setting up CRS + options for measurements	Using Computer
(Digitising techniques) • Creating layers (point, line and polygon) by digitising or selection • Creating attribute tables + save	Using Computer
(Analytical techniques) • Modifying polygons (small + large – both cutting and adding) • Save layers when done • Delete record from table • Merge themes • Integrate • Snapping (line + poly) • Creating tables with desired fields/adding columns etc.	Using Computer
(Other technical functions) •Labelling •Creating buffers •Calculating areas (manually and as a function) •Preparation of map before printing	Using Computer
(Applications with GPS) •GPS functionalities •How to collect points (data) on site •Measurements and usage of other media	Field Exercise
(Advanced techniques) • Basic orthophoto interpretation - for mapping • Geo-referencing • DXF to SHP	Using computer/Maps Lectures only for EEWS

Source: DoE and Study Team

Since EEWS will take charge of coastal and wetland management in future, training in advanced techniques for future analytical works was added. Basic orthophoto interpretation and geo-referencing techniques can be applied to aerial photos of the coastal area including wetlands adjacent to the beach taken either by helicopter or plane. And DXF to SHP techniques can be applied to future monitoring activities associated with GIS when ground survey data have to be converted to GIS data. These techniques were previously used by the Study Team in the study on coastal erosion and flood management.

(4) Methodology

The methodology of the GIS training consists of two types, in-room training and field training. The former was basically composed of verbal lectures and demonstrations on the projection screen. The latter was field exercises in GPS in conjunction with GIS application. Two of the major trainings are described in the following. The GIS application used exclusively in the trainings was QGIS and the language of the lectures was English.

(a) In-room training

The in-room training was conducted in the DoE office with a PC and projection screen. The trainees were required to pay attention to the screen while the verbal lectures and demonstrations were going on. After the lectures and demonstrations, the trainers gave the trainees some basic assignments which had been demonstrated previously for individual exercises on their own PCs. After a short time spent on the individual exercises, the trainers began to go around, giving advice and directions on how to complete the given assignment if the trainee had a problem. Before the end of the lecture time, the trainers demonstrated the answers to the assignments on the projection screen. Since the lectures did not require any home assignments or training reports after the training, the trainers encouraged the trainees to continue self-exercises after the lectures.

(b) Field training

The field training was deployed in some open space close to the DoE office. The trainers gave lectures on the basic functions of the GPS and demonstrated how to use the GPS equipment in the field. Because of the shortage of GPS equipment, it was mentioned that the equipment would be available for use after the training. After the field training, the trainers gave lectures on how to utilise the GPX data from GPS in the GIS application by demonstrations in the lecture room. Portable GPS equipment owned by DoE was used for the field training.

7-3-5 Training Results

In the Study the GIS training was held twice according to the schedule in Table 7-3-2.

Table 7-3-2: Schedule of GIS Training

Date	Trainers	Trainees	Location
21st June to 2nd July 2012 (5 days, 15 to 18 hours)	Justine Prosper (DoE) Tomomi Fujita (JICA Study Team)	PCEI 8 to 10 participants	DoE Office in Botanical Garden
5th to 11th July 2012 (6 days, 18 to 20 hours)	Justine Prosper (DoE) Tomomi Fujita (JICA Study Team)	EEWS 8 to 10 participants	DoE Office by English River

Source: Study Team

Photo 7-2-1 In-room Training

Photo 7-2-2 Field Training

Even though it was the first time for the most of the trainees to understand and carry out the GIS application, the trainees began to quickly take in the basic techniques of analytical work after the demonstration. For further progress and continued capacity building in GIS utilisation, it is recommended that the DoE staff carry out some practical exercises in either coastal or inland water areas according to the environmental management and monitoring plan to be developed and get accustomed to utilising the GIS application. In addition to the need for practical works, it will be necessary to facilitate an adequate number of PCs and GPS devices in the near future.

7-3-6 OJT in Downloading from Water Level Gauges

Lectures were given on how to download data from the water level gauges. The download interval should be less than 2 months because of the service life of the battery. The data download procedure is shown below.

(1) Check that the port is a USB serial port with device manager
(2) Connect the computer and the water gauge by the cable
(3) Start up the application software for data extraction
(4) Select the previously checked port (e.g. Com3)
(5) Set the band rate at 38400
(6) Press the button in the sequence "Connect"-> "Get History"-> "Save to File".
(7) Check the battery power on the PC screen

Before downloading it is necessary to check the container in the water level gauge and its supports. Several tools are necessary, namely a personal computer, an RS232 cable with USB converter, two 9-volt batteries and the key for the container.

7-3-7 Training in Levelling

It is important to confirm the vertical interval in the drain design or monitored beach profile. The vertical interval is surveyed with the automatic level imported from Japan for this study.
The level of each point is calculated from the formula as shown in Figure 7-3-2.

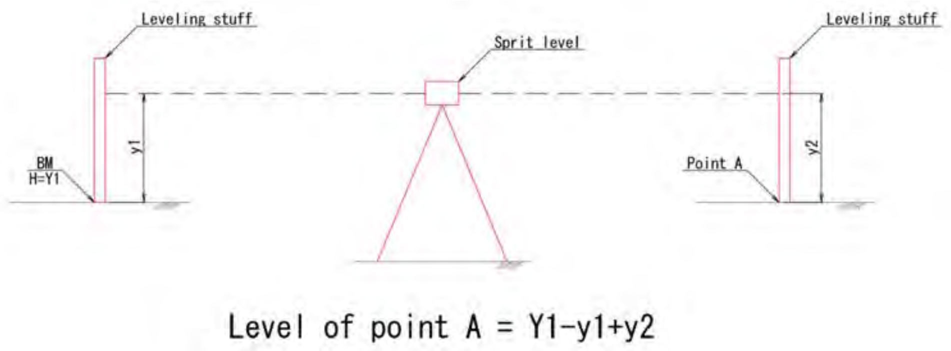

Figure 7-3-2: Height from Levelling

7-3-8 Training in Runoff Analysis

It is important to calculate the discharge volume in the drain design. The formula for the calculation is the rational method as explained in the Stormwater Drainage Design Guidelines. The catchment area is calculated with Quantum GIS.

7-3-9 Lectures in Structural Calculation

Taking the Pointe Larue project as an example, lectures in structural calculation of drains were given. The contents of the lectures are shown below.

- Determination of structural model
- Determination of load type and model
- Calculation of section force
- Calculation of stress intensity

7-4 Seminars, Workshops and Training

7-4-1 Seminars

(1) First Seminar

The first seminar was conducted on 23rd August 2011 at the International Conference Centre in Victoria for the capacity development of the counterpart agencies and other related organisations. The purpose of the seminar is shown below and schedule is shown in Table 7-4-1.

Purpose of the Seminar

- Introduction of the study for coastal erosion and flood control management.
- Introduction of Japan's experience in coastal erosion and countermeasures.
- Sharing of the progress of the study among the counterpart personnel, local government officials, NGOs and related agencies.

Table 7-4-1: First Seminar Programme

Activity	Time	Resource Speaker
Registration	08:45 - 9:00 am	
Opening Programme Welcome Speech	09:00 - 9:10 am	Mr. Didier Dogley, Principal Secretary Ministry of Environment
Overview of the Study	09:10 - 9:30 am	Mr. Hiroshi Hashimoto JICA Expert Team
Coastal Disaster Issues and Solutions	09:30 - 10:30 am	Professor Tomoya Shibayama Associate Dean for International Affairs Waseda University
Break (tea and snack)	10:30 - 10:45 am	
Data Analysis for Rainfall and Sea Level	10:45 - 11:05 am	Mr. Shuichi Mori, JICA Expert Team
Coastal Erosion and Mitigation Measures	11:05 - 11:40 am	Mr. Hiroshi Hashimoto JICA Expert Team
Outline of Flood Management Measures	11:40 am - 12:10 pm	Mr. Shuji Kaku, JICA Expert Team
Closing Remarks	12:10 - 12:20 pm	Mr. Wills Agricole Director General, CESD Ministry of Environment

CESD: Climate and Environment Service Division

There were 33 participants from DOE, EEWS and DRDM of the Ministry of Home Affairs, Energy and Transport, Seychelles National Parks Authority, Landscape and Waste Management Agency, Ministry of Foreign Affairs, UNDP-GEF, secondary schools and public utility corporations. Scenes from the seminar are shown in Photo 7-4-1.

The participants understood the purpose and contents of the project and that economic development sometimes causes coastal disasters from the experience in Japan and other developing countries through the lecture by Professor Shibayama.

Photo 7-4-1: Welcome Speech by DOE-PS and Attendants of the Seminar

(2) Second Seminar

The second seminar was conducted on 9th July 2013 at the International Conference Centre in Victoria for the capacity development of the counterpart agencies and other related organisations. The purpose of the seminar is shown below and schedule is shown in Table 7-4-2.

Purpose of the Seminar

- To explain the results of the Pilot Projects for Coastal Erosion and Flood Management
- Sharing of information and experience of recent flooding between Seychelles and Mauritius.

Table 7-4-2: Second Seminar Programme

Activity	Time	Resource Speaker
Registration	08:45 - 09:00 am	
Opening Programme Welcome Speech	09:00 - 09:10 am	Mr. Wills Agricole, Principal Secretary Ministry of Environment & Energy
Overview of the Study and Pilot Projects at La Digue and North East Point for Coastal Erosion Management	09:10 - 09:40 am	Mr. Hiroshi Hashimoto, JICA Study Team
Pilot Project at Au Cap for Flood Management	09:40 - 10:10 am	Mr. Shuji Kaku, JICA Study Team
Tea Break	10:10 - 10:30 am	
Flood Disaster and Mitigation in Seychelles	10:30 - 11:00am	Mr. Nimhan Senaratne, CAM, DoE Ministry of Environment & Energy (Seychelles)
Coastal Erosion and Management in Mauritius	11:00 - 11:20am	Ms. Nashreen Soogun, ICZM Ministry of Environment & Sustainable Management (Mauritius)
Flood Disaster in Mauritius	11:20 - 11:40am	Mr. Hurrydeo Bholah Ministry of Public Infrastructure (Mauritius)
Discussion	11:40 - 12:00am	
Closing Remarks	12:00 - 12:10 pm	Mr. Alain De Comarmond, Director General, CAAI DoE, Ministry of Environment & Energy (Seychelles)

DOE: Department of Environment, CAAI: Climate Affairs, Adaptation and Information Division, CAM: Coastal Adaptation & Management Section, Seychelles,ICZM: Integrated Coastal Zone Management Division, MoESD, Mauritius

There were 40 participants from the Ministry of Environment and Energy, Seychelles Maritime Safety Authority, Seychelles Port Authority, Civil Engineering Consultancy, District Administration (Au Cap, Glacis, La Digue Cascade, and Anse Etoile), Police, SFA, Eden Island, Ministry of Foreign Affairs, Seychelles Energy Commission and delegations from the Government of Mauritius.

The participants understood not only the contents of the pilot projects in the Seychelles but the problems and measures against coastal erosion and flooding in the Seychelles and Mauritius. The discussion of the flooding which happened this year in both countries provided a good opportunity to improve the mitigation measures.

(3) Third Seminar

The third seminar was held on 7th February in the Seychelles Trading Company (STC) hall in Victoria to develop the capacity of the counterparts and related people. The programme is shown in Table Table 7-4-3. The purpose was to explain the results of the study and pilot projects, to discuss the future direction of coastal conservation and flood management and to publicise the results of the study.

Table 7-4-3: Third Seminar Programme

Activity	Time	Resource Speaker
Registration	08:45 - 09:00 am	
Opening Speech	09:00 - 09:10 am	Mr. Wills Agricole, Principal Secretary Ministry of Environment & Energy
Overview of the Study and Measures for Coastal Erosion Management	09:10 - 09:50 am	Mr. Hiroshi Hashimoto, JICA Study Team
Measures for Flood Management	09:50 - 10:20 am	Mr. Shuji Kaku, JICA Study Team
Tea Break	10:20 - 10:40 am	
Recent Activities of DOE-CAMS related to JICA Study	10:30 - 11:00am	Mr. Nimhan Senaratne, CAMS, DoE Ministry of Environment & Energy
Panel Discussion: • Necessary improvement of coastal and flood management • Future action based on the results of the Study	11:10 - 11:50am	Panellists: Mr. Alain De Comarmond Mr. Nimhan Senaratne Mr. Hiroshi Hashimoto Mr. Shuji Kaku
Closing Remarks	11:50 am - 12:00 noon	Mr. Alain De Comarmond, Director General CAAID, DoE, Ministry of Environment & Energy

DOE: Department of Environment, CAAID: Climate Affairs, Adaptation and Information Division, CAMS: Coastal Adaptation & Management Section

The participants at the third seminar were from the Ministry of Environment and Energy, Seychelles Maritime Safety Authority, Ministry of Land Use and Housing, Ministry of Community Development and Ministry of Foreign Affairs, numbering about 20 because the related people were busy with recovery works from the disasters in January 2013 and 2014. The future direction was discussed based on the study results and the flood disasters in January 2013 and 2014 and the importance of the study was understood.

7-4-2 Workshops

(1) First Workshop

The first workshop was held on 18th May 2011 at the International Conference Centre in Victoria for the capacity development of the counterpart agencies and other related organisations. The purpose of the workshop is shown below and the programme is shown in Table 7-3-3.

Purpose of the Workshop

- Introduction of the Study for Coastal Erosion and Flood Control Management;
- Sharing of knowledge on the existing state of coastal erosion and flood issues among the counterpart personnel, local government officials and related agencies;
- Opportunity to share the knowledge and experience acquired in the Study.

Table 7-4-4: First Workshop Programme on 18th May 2011

Activity	Time	Resource Speaker
Registration	09:15 - 09:30 am	
Opening Programme Welcome Speech	09:30 - 9:45 am	Mr. Didier Dogley Principal Secretary Ministry of Environment
Overview of the Study	09:45 - 10:15 am	Mr. Shuji Kaku, JICA Expert Team
Break (tea, snack and photo taking)	10:15 - 10:35 am	
Existing Issues of Coastal Erosion and Flooding in the Seychelles	10:35 - 11:00am	Ms. Elvina Hoarau Mr. Nimhan Senaratne Mr. Jeanclaude Labrosse Directors of EEWS, EOD
Appreciation of Aerial Photos of the Coastal Area	11:00 - 11:20am	Mr. Tomomi Fujita JICA Expert Team
Present Status of Meteorological Observations (Wind, Rainfall and Tide)	11:20 - 11:40 am	Mr. Selvan Pillay Director of NMS, EOD
Analysis Conception for Natural Conditions	11:40 am - 12:00 noon	Mr. Shuichi Mori JICA Expert Team
Filling in questionnaire	12:00 - 12:15 pm	
Closing Remarks	12:15 - 1:00 pm	Mr. Wills Agricole Director General, CESD Ministry of Environment

EEWS: Environment Engineering and Wetland Section, NMS: National Meteorological Service, CESD: Climate and Environment Service Division

All the counterparts and other concerned agencies were invited to the workshop. There were 28 participants although the presidential election was being held around the same time. The main items discussed in the workshop were the problems and study measures for coastal erosion and flooding. The participants obtained knowledge of new measures.

(2) Second Workshop

The second workshop was held on 25th October 2011 at the DOE for the capacity development of the counterpart agencies and other related organisations. The purpose of the workshop is shown below and the programme is shown in Table 7-4-5.

Purpose of the Workshop

- Discussion of the direction of the coastal conservation plan with related agencies
- Opportunity to share the knowledge and experience acquired in the training in Japan

Table 7-4-5: Second Workshop Programme on 25th October 2011

Activity	Time	Resource Speaker
Registration	09:00 - 09:10 am	
Opening Remarks	09:10 - 09:15 am	Mr Wills Agricole, DOE, DG-CESD
Overview and Progress of the Study	09:15 - 09:30 am	Mr Hiroshi Hashimoto, JICA Expert Team
Existing Coastal Erosion Issues and Mitigation Measures	09:30 - 09:50 am	Mr Hiroshi Hashimoto, JICA Expert Team
Open Discussion on Coastal Erosion Issues and Measures in Each District	09:50 - 10:20 am	
Break	10:20 - 10:35 am	
Report on Training in Japan	10:35 - 11:05 am	Mr. Nimhan Senaratne, Director of EEWS, DoE Mr. Hendrick Figaro
Existing Flood Issues in Victoria Town and Mitigation Measures	11:05 - 11:20 am	Mr. Kazuyoshi Fujimoto, JICA Expert Team
Existing Flood Issues in Other Selected Districts and Flood Management Measures	11:20 - 11:40 am	Mr. Shuji Kaku, JICA Expert Team
Open Discussion on River Drainage and Flood Issues and Measures in Each District	11:40 - 12:15 am	
Closing Remarks (Summarised Comments)	12:15 - 12:30 am	Mr. Wills Agricole, DOE, DG-CESD

EEWS: Environment Engineering and Wetland Section, CESD: Climate and Environment Service Division

There were 29 participants from DOE, EEWS, DRDM of MoEE, Ministry of Land Use and Housing, and District Administrators. The participants discussed coastal erosion and flood problems and understood the present conditions in the Seychelles.

(3) Third Workshop

The third workshop was held on 11th April 2012 at the DOE for the capacity development of the counterpart agencies and other related organisations. The purpose of the workshop is shown below and the programme is shown in Table 7-4-6.

Purpose of the Workshop

- Sharing of Knowledge on Existing State of Coastal Erosion and Flood Issues
- Explanation of the Coastal Conservation Plan and Flood Control Management Plan
- Discussion of Adaptation Measures among the Counterpart Personnel, Members of the National Assembly, Local Government Officials and Related Agencies

Table 7-4-6: Third Workshop Programme on 11th April 2012

Activity	Time	Resource Speaker
Registration	09:00 - 09:10 am	
Opening Remarks	09:15 - 09:30 am	Mr. Nimhan Senaratne, CESD, DOE
Outline of Coastal Conservation Plan and Flood Management Plan	09:30 - 09:50 am	Mr. Hiroshi Hashimoto, JICA Expert Team
Climate Change and Impact on Coastal Areas	09:50 - 10:10 am	Mr. Tsutomu Kurihara, JICA Expert Team
Break	10:10 - 10:30 am	

Activity	Time	Resource Speaker
Coastal Conservation Plan for Priority Coasts and Pilot Projects	10:30 - 11:10 am	Mr. Hiroshi Hashimoto, JICA Expert Team
Flood Management Plan for Priority Areas and Pilot Projects	11:10 - 11:50 am	Mr. Shuji Kaku, JICA Expert Team
Closing Remarks (Summarised Comments)	11:50 - 12:00 noon	Mr. Nimhan Senaratne, CESD, DOE

DOE: Department of Environment, CESD: Climate and Environment Service Division

There were 39 participants from the DOE, Members of the National Assembly, District Administrators, Seychelles Land Transport Agency, LA Digue Development Board, IUCN Mangroves for the Future (MFF) and The Marine Conservation Society of Seychelles.
The participants came from the priority coasts or areas and discussed the problems and measures in each area based on their own experiences.

(4) Fourth Workshop

The fourth workshop was held in the SFA Training Room on 4th July 2013 to explain the purpose and contents of the pilot projects in the four areas to the stakeholders. The programme is shown in Table 7-4-7.

Table 7-4-7: Fourth Workshop Programme on 4th July 2013

Activity	Time	Resource Speaker
Registration	9:00 - 9:15 am	
Opening Programme Welcome Speech	9:15 - 9:30 am	Principal Secretary, Ministry of Environment
Outline of Coastal Conservation Plan and Flood Management Plan	9:30 - 9:50 am	Mr. Hiroshi Hashimoto, JICA Expert Team
Discussion	9:50 - 10:10 am	
Break	10:10 - 10:30 am	
Outline of Pilot Projects	10:30 - 11:10 am	Mr. Junichi Furukawa, JICA Expert Team
Discussion	11:10 - 11:50 am	
Closing Remarks	11:50 - 12:00 noon	Principal Secretary, Ministry of Environment

There were 40 participants from the DOE, District Administrators of the pilot project areas (Anse Etoile, Point Larue, Au Cap, La Digue), Members of the National Assembly, Seychelles Land Transport Agency and La Digue Development Board. They were informed of and discussed the details of the pilot projects.

7-4-3 Training in Japan

Two counterpart persons were assigned to the training courses in Japan in 2011, Mr N. Senaratne and Mr. H. Figaro of the DOE. The aim was to learn appropriate management and design methods related to coastal conservation and flood management, especially from the experience in Japan. The training curriculum is shown in Table 7-4-8.

Table 7-4-8: Curriculum and Schedule of First Training in Japan

Day	Theme	Type	Lecturer
28 Sep.	Briefing / orientation and Courtesy Call	Lecture	JICA and CCI

Day	Theme	Type	Lecturer
29 Sep.	Coastal erosion mitigation measures and design of coastal structures	Lecture	Mr, Hashimoto of CCI
30 Sep.	Coastal erosion and preventive measures on Shizuoka Coast, and Tomoe River comprehensive flood mitigation project	Field visit (Shizuoka Prefecture)	Mr, Hashimoto and Mr, Fujita of CCI
1 Oct.	Coastal erosion mitigation measures on Toban Coast	Field Visit (Toban Coast)	Mr, Hashimoto and Mr, Furukawa of CCI
2 Oct.	Day in Kyoto		
3 Oct.	Coastal erosion and countermeasures	Lecture	Professor Shibayama of Waseda University
4 Oct.	Tsunami disasters and river mouth improvement works on south coast of Miyagi Prefecture	Field visit (Sendai)	Mr. Hashimoto and Mr. Fujita of CCI
5 Oct.	Report writing and discussion		Mr. Fujita of CCI
6 Oct.	Drainage facility design	Lecture	Mr. Fujimoto of CCTI
7 Oct.	Reporting and evaluation Certification		JICA and CCI

CCI: Central Consultant Inc., CCTI: CTI Engineering International Co.

Two counterparts also attended the training course in Japan in 2012, Ms. E. Hoarau and Mr. J. C. Labrosse of DOE. The aim was the same as in 2011. The training curriculum for that year is shown in Table 7-4-9.

Table 7-4-9: Curriculum and Schedule of Second Training in Japan

Day	Theme	Type	Lecturer
5 September (Wednesday)	Briefing / Orientation Courtesy call/ Programme orientation		JICA and CCI
6 September (Thursday)	Japanese experience of coastal erosion and flood mitigation measures	Lecture and discussions	Mr. Hashimoto of CCI
7 September (Friday)	Coastal erosion and prevention measures on Shizuoka Coast and Tomoe River comprehensive flood mitigation project	Field visit	Mr. Hashimoto of CCI Mr. Fujita of CCI
8 September (Saturday)	Coastal erosion and prevention measures on Thoban Coast	Field visit	Mr. Hashimoto of CCI Mr. Furukawa of CCI
9 September (Sunday)	Day in Kyoto		
10 September (Monday)	Coastal erosion and flood management research in Japan	Lecture on and observation of model test	Mr. Kato and Mr. Fukushima of NILIM
11 September (Tuesday)	Tsunami disasters and river mouth improvement works on the south coast of Miyagi Prefecture	Field visit	Mr. Hashimoto of CCI Mr. Fujita of CCI
12 September (Wednesday)	Management of coastal erosion and flooding	Lecture and discussions	Mr. Hashimoto of CCI Mr. Furukawa of CCI
13 September (Thursday)	Report writing and discussions		Mr. Fujita of CCI
14 September (Friday)	Reporting and evaluation; Certification		JICA and CCI

NILIM: National Institute for Land and Infrastructure Management, CCI: Central Consultant Inc.

The trainees mastered the design of structural measures from the lectures and site visits for coastal protection and flood mitigation such as detached breakwaters and detention ponds and identified applicable measures such as water gates and river mouth improvement. Also, they understood the importance of observation and research for further development.

Chapter 8 Recommendation

Chapter 8 Recommendations

8-1 General

The Project was conducted in order to mitigate coastal erosion and flood disaster through the formulation of coastal conservation and flood management plans, execution of three pilot projects and technical transfer. Several recommendations are summarised from the study for realisation of the plans and mitigation of related disasters.

In the Seychelles there are several strategies and plans for the mitigation of coastal erosion and flooding such as the Seychelles Sustainable Development Strategy and Seychelles National Disaster Management Policy. These cover a very wide area and propose many kinds of actions. However, the budget and capacity are limited because of the small resources and population of the small islands. The necessity is to select important points for action according to the Seychelles' local conditions. The proposed recommendations are selected from among many suggestions and concentrate on effective actions. They are summarised in Table 8-1-1. The proposal in the coastal conservation plan and flood management plan is not explained to avoid duplication.

Table 8-1-1: Recommendations

Item	Content
Management Plan	
Background	The coastal conservation plan and flood management plan were formulated to mitigate coastal erosion and flood disasters. The plan contains mainly structural measures for the short and medium term and measures for economic development and climate change for the medium and long term.
Problem	Sometimes the plan has to be revised because fundamental information is limited and future climate change is uncertain.
Recommendation	The plan should be revised at certain intervals with the use of the adaptive management cycle based on monitoring and evaluation by the Ministry of Environment and Energy. In particular, the recovery plan is required for the recent flood disasters. The formulation of a short-term-plan can be improved based on the proposed management plan in the study by the Ministry of Environment and Energy with the cooperation of relevant organisations.
Laws & Organisation	
Background	The construction of structures in the coastal zone and activities on the water area are regulated by the Town Planning Act or the Environment Protection Act. Sand mining is also prohibited.
Problem	No laws and regulations have been established for land use management and setback which are important non-structural measures for future climate change.
Recommendation	Legal and management systems should be established by the Ministry of Land Use and Housing for development where risks exist because of the changing coastal area or lowland. Also, laws should be established for land acquisition if the land is necessary for public facilities for disaster mitigation.
Financial Action	
Background	The budget for flood and drainage management is maintained at about 6 million rupees by CAMS in the Ministry of Environment and Energy for conducting drainage projects and maintenance. For disaster recovery, the works are implemented by donations. The budget for coastal conservation is temporary, such as the support from RECOMAP.
Problem	The channels are not maintained regularly though such action is effective. The budget for disaster recovery relies on temporary donations.

Recommendation	A certain budget amount should be allocated to the Ministry of Environment and Energy for execution of the plan and periodic maintenance. The Ministry of Finance should provide support by securing the budget and reserves for disaster recovery.
EIA	
Background	The law on environmental impact assessment has been established and assessments have been conducted. However, the impacts at Pointe Larue of the airport reclamation and the breakwater construction at La Passe were caused in the past. Improvement of the assessment system is planned by the Ministry of Environment and Energy. In the study some improvements were proposed.
Problem	Structures on dynamically changing beaches or in lowland areas have caused coastal erosion and flooding problems.
Recommendation	EIA should be reinforced in areas at high risk of coastal erosion and flooding. The assessment method should be improved by past examples. The improved plan is included in the SSDS.
Monitoring	
Background	The beach was monitored in past monitoring of limited coasts for limited periods but this has now stopped. The rainfall measurement is mainly daily rainfall. The records of disasters were limited with only articles from newspapers. In the study the baseline for beach monitoring and three rainfall gauges for short duration were prepared. The method of recording disasters was also proposed.
Problem	The information is insufficient for understanding the coastal erosion and studying the mitigation measures. For flooding, the information is not enough for understanding the flooding mechanism and the magnitude of damage. This makes it difficult to plan mitigation measures.
Recommendation	Beach monitoring should be continued at the eroding coasts. Monitoring of the water level should be continued in the wetland and lowland areas. The data give the relationship between the rainfall and flooding and the mitigation measures. Rainfall analysis, runoff analysis and inundation analysis should be carried out using the monitoring data. These activities should be done by the Ministry of Environment and Energy,
Disaster Response	
Background	The district disaster response plan has already been formulated for floods, landslides and tsunamis and distributed by the DRDM. It includes the response process and also warnings. In 2012 a tsunami warning was issued. In 2013 and 2014 flood and landslide disasters were caused in the southeast of Mahe and La Digue.
Problem	Disaster response manuals for flooding, landslides and tsunamis were prepared. However, they are not used because they do not take into account the actual conditions.
Recommendation	Actually disaster responses have been conducted, such as the tsunami warning in 2012 and the disaster response to the flooding in January 2013. From these experiences, the manuals should be improved to make them more effective.
Public Communication	
Background	Public communication was planned in the SSDS (2012-2020) action plan
Problem	Past public communication was not effective because the explanations were too general.
Recommendation	Past experience of disasters should be recorded by school children such as the tsunami in 2004 and January floods in 2013 and 2014. The records will contribute to conveying their experiences to future generations.

8-2 Coastal Conservation Plan and Flood Management Plan

In the Project the coastal conservation plan and the flood management plan were formulated. The coastal conservation plan and the flood management plan were formulated to mitigate coastal erosion and flood disasters. The plan contains mainly structural measures for the short and medium term and the non-structural measures for economic development and climate change in the medium and long term.

The lack of basic information such as records of past disasters makes it difficult to analyse and propose suitable measures in the plan. The impacts caused by climate change in future are also uncertain. The plan is not effective if we cannot forecast future conditions with a certain reliability. The application of adaptive management measures consisting of monitoring of changes, identification of problems, proposal of measures and evaluation of the results is proposed.

The recommendation for the management plan is execution of the plan and also monitoring and accumulation of basic data which will form the basis of the plan. Detailed hydrological observation and monitoring are proposed in the plan. In the Seychelles there are national plans and strategies for disaster mitigation and environmental conservation. The problem is execution of the plans within limited human and financial resources.

In the study the plans were mainly focused on the priority coasts or areas where coastal erosion or flooding is a problem rather than on the whole coastline. It will be effective for realisation of the plan to investigate the causes and measures in each area because the country is small and has no great variety. It is recommended that the experience of one area is applied to other areas which have similar conditions.

Planning and execution of the short-term plan are proposed based on the following policy proposed in the flood management plan for the priority areas because of the recent flood disasters.

Most of the rivers in the country have the capacity to discharge rainwater. The main countermeasures to be applied in the short term are drainage improvement, operation and maintenance (O/M) and non-structural measures. After the completion of the short-term measures and in order to upgrade risk management to the medium scale, river improvements are adopted simultaneously with implementation of O/M and non-structural measures.

Structural measures for drainage and river improvement works will take into consideration available materials, equipment and methods in the Seychelles. Structural measures require proper quality, quantity, safety and schedule control. Moreover, better O/M will contribute to longer structural life and savings in the government budget.

River improvement works in the medium term for river basins and river boundaries must be properly maintained by regulations and the Land Use Act, otherwise there will be fewer options for countermeasures for flood mitigation, leading to grave questions in the future

It should be noted that in the long-term measures, structural measures have limitations because of scale and cost implications. The Government of the Seychelles needs to start sending clear messages and implementing measures based on the SSDS 2012.

The Ministry of Environment and Energy is responsible for this kind of activity. In some cases, the Ministry has conducted evaluation of plans such as the Environmental Management Plan (EMS) and Seychelles Sustainable Development Strategy (SSDS). The coastal conservation plan and flood management plan will also be evaluated at the same time as the evaluation of the SSDS every 10 years.

The coastal zone is the target area of the coastal conservation plan, flood management plan and other upper strategies of those plans. In the SSDS, integrated coastal zone management is planned and executed. ICZM is the second of the 13 strategies. The Ministry of Environment and Energy plans to conduct 9 items with a budget of 280 million rupees as explained in the following. The contents are (1) to review and update the existing ICZM-related policies, laws and regulations, (2) to improve communication, networking and stakeholder involvement, (3) to develop a national ICZM framework for the Seychelles, (4) to strengthen the existing stakeholder network and establish a knowledge platform for coastal zone management, (5) to improve communication, information dissemination and networking, (6) to create greater awareness of changes and risks in the coastal zone and impacts on resources and communities, (7) to make the ICZM even more transparent, (8) to increase human and institutional capacity, and (9) to promote research into coastal changes and human behaviour so as to better plan coastal developments and mitigate natural disasters. Execution of these items by the Ministry of Environment and Energy will contribute to the development of non-structural measures and is recommended.

8-3 Laws and Organisation

The construction of structures in the coastal zone and activities on the water surface are regulated by the Town Planning Act or the Environment Protection Act. Sand mining is also prohibited.

For future climate change, land use regulations and setback are proposed as non-structural measures in the coastal lowland area in the plan. However, suitable laws and regulations have not been established for that purpose.

Laws and a management system should be established for the development of areas where there are risks of changing coastline or lowland flooding. One of the causes of the drainage problems is maintenance and management of the drainage systems and channels because there are many obstructions in the channels such as pipes and cables. Therefore, conservation laws or regulations on river and coastal use are necessary to prevent that kind of obstruction.

Also, laws should be established on land acquisition if the land is necessary for public use. In the January flood in 2013 emergency actions were taken and recovery was carried out. From that experience the preparation of a law on acquisition of land is necessary for that kind of disaster.

The second strategy in the SSDS involves land use, coastal zones and urbanisation. One of the goals is long-term national development and land use management strategies for sustainable land management. The actions are to finalise the land use plans and to ensure that disaster and other risk mitigation is mainstreamed in the land use planning process. The responsible organisation is mainly the Ministry of Land Use and Housing. The recommendation is included in the action. Therefore, execution of the action is strongly anticipated. The related government organisations are the Ministry of Environment and Energy, the Ministry of Social Affairs, Community Development and Sports, the Ministry of Home Affairs and Transport and other related ministries.

Recovery works from the January 2013 flood have been conducted. Ordinary administrative procedures are not appropriate for disasters and related laws and systems have not been established. From this experience, laws for urgent measures for disasters are necessary. The responsible organisation will be the DRDM.

8-4 Financial Action

The budget for flood and drainage management is maintained at about 6 million rupees by CAMS in the Ministry of Environment and Energy which conducts drainage projects and maintenance. For disaster

recovery, the works are implemented by donations. The budget for coastal conservation is temporary, such as support from RECOMAP.
A certain budget amount should be allocated to the Ministry of Environment and Energy for the execution of plans and periodic maintenance. The Ministry of Finance should provide support by securing the budget and reserves for disaster recovery.
The drainage channels are maintained from time to time by desilting activities and they are effective. The channels are blocked if there is no maintenance because of sediment and debris accumulation. The growth of vegetation and trees is very rapid and causes some kind of obstruction to drainage. A certain budget amount should be allocated for channel maintenance.
Disasters are very rare and it is difficult to allocate a certain budget for disaster recovery. However, in the past recovery partly relied on donations. It is better to prepare a certain budget amount reserved for disaster recovery.
Estimation of the maintenance and recovery budget is very difficult because there are few disasters and little basic data. Evaluation of disaster mitigation measures is difficult because the scale of finance is small and the occurrence of disaster is rare. Drainage improvement was carried out after the flood in 2004. The effect of the improvement was not clear in the flood in January 2013. Recently, flooding in Victoria Town seems to have declined due to maintenance by DOE such as desilting activities. Flood damage is also difficult to estimate. The investment in disaster mitigation has to be decided based on the scale of damage. Therefore, it is necessary to make clear the damage and effectiveness of measures related to coastal erosion and flooding. The analysis of the January Flood in 2013 can be used for that purpose.

8-5 Environmental Impact Assessment

The law on environmental impact assessment has been established and assessments have been conducted. However, the impacts of the airport reclamation at Pointe Larue and the breakwater construction at La Passe were caused in the past. Improvement of the assessment system is planned by the Ministry of Environment and Energy. In the study some improvements were proposed.
Structures on dynamically changing beaches or in lowland areas have caused coastal erosion and flooding problems in the past. The construction of breakwaters at La Passe caused erosion on the south coast and accumulation of sand at the anchorage near the jetty. The schools and housing on lowland such as at Pointe Larue and Anse Royale suffered from inundation. At present, EIA is not fully effective to prevent such kinds of impacts. Therefore, improvement of EIA is necessary for the construction of coastal structures, impact on flood discharge by the reclamation of wetland, and impact of flood discharge changes by urban development.
It is recommended that EIA should be reinforced in the areas at high risk of coastal erosion and flooding. The assessment method should be improved by past examples. In the study several proposals are made for the EIA evaluation items. The risk areas can be estimated by the flood risk map which has already been prepared. The capacity in assessment is important and can be developed from past experience as continuous activities. The main related organisation is the DOE in the Ministry of Environment and Energy.

The improvement of environmental impact assessment is also proposed in the SSDS for the DOE with a budget of 40 million rupees to improve the enforcement of environmental legislation. In the action plan, (1) the establishment and implementation of standardised procedures for reporting cases, (2) recruitment and training of enforcement officials, and (3) increased collaboration between enforcement institutions were proposed. The execution of the plan is recommended by the Ministry of Environment and Energy.

8-6 Hydrological Observation and Monitoring

The beaches were monitored in the past from 2003 on limited coasts and this has now stopped since 2009. The rainfall measurement is mainly daily rainfall with hourly observation only at the international airport. The records of disasters were limited to only articles in newspapers. In the study the baseline for beach monitoring and three rainfall gauges for short duration were prepared. The method and format for recording flood disasters were also proposed.

The data on beach profile changes is necessary to understand the erosion condition and to investigate the mitigation measures. The measures are based on the causes and scale of the erosion. For flooding, the rainfall and inundation data and damage information are limited. The flood run-off will be analysed by the rainfall, flood discharge and water level data. In particular, short interval rainfall data is necessary for small river basins and is not available.

It is understood that monitoring is necessary, but action is difficult. Beach monitoring was introduced in the 1980s and lasted only a few years. The problem is how to maintain monitoring in the long term with limited human capacity and budget. One solution is the use of the monitoring results in daily activities.

Beach monitoring is recommended in the proposed methods in the study by the Ministry of Environment and Energy. The method is also proposed in the manuals. CAMS should conduct water level monitoring in the wetland to understand the relationship between rainfall and inundation and to investigate the mitigation measures. The observation of short-term rainfall has been started already by the National Meteorological Services.

Regarding the rainfall and river water level data, three rainfall gauges and four water level gauges were installed in or near Victoria in this study. The correlation between the rainfall data and water level data is analysed to evaluate the usability of the data for flood management. According to the results of data analysis, it seems possible to estimate the river water level from the hourly rainfall data. However, the reliability of the analysis is currently inadequate since the amount of data is insufficient. The reliability of the analysis can be improved by storing data through continuous observation in future.

Missing data and abnormal data should be reduced, so it is recommended to check how the instruments are maintained and the maintenance schedule and to improve them if needed. For instance, when a rainfall event of more than 60mm/h occurs, the gauge datum changes before and after the rainfall.

Disaster reports should be collected by the DRDM through the district administrator. Past records of disasters were not collected. It is necessary to collect the records for improvement of the system.

According to the results of the flood survey in Victoria, the average inundation depth is less than 30cm and the average inundation duration is less than 1 hour, that is, there is not always serious damage from heavy rain. A hydraulic analysis was conducted to determine the design discharge and evaluate the existing drainage system in Victoria. From the results of the analysis, inadequate drains for the 10-year design return period are found as shown in the following figure.

The location of the flood prone areas almost matches the location of the inadequate drains. It is obvious that the main cause of flooding in Victoria Town is the insufficient capacity of the drains. It is recommended to obtain the latest results of aerial topographic surveying in order to conduct more detailed analysis of the inundation area.

Based on the spatial variation of rainfall intensity obtained from the existing rainfall stations, Mahe Island can be divided into three areas: the north, the centre and the south. In this study, the probable rainfalls in these three areas can be estimated by multiplying the following ratios by the rainfall intensity curve created at Seychelles airport station which is the only gauging station where hourly rainfall data are observed.

In future, when a sufficient amount of data has been collected, it is recommended that the reliability of the estimation of rainfall distribution shown above is evaluated by utilising the rainfall data obtained from the newly equipped gauges which are able to observe hourly variations in rainfall, as well as from the existing rainfall stations.

Flood discharge analysis was carried out based on the Stormwater Drainage Design Guidelines. However, there were difficulties in determining the value of some of the coefficients due to lack of basic hydrological data. Therefore, some of the coefficients were estimated based on assumptions utilising past Japanese experience. In future, these coefficients should be reviewed after a sufficient amount of sample data has been collected.

Flood inundation analysis was conducted with HEC-RAS software. Records of previous flood events had not been properly archived by the concerned agencies which made it difficult to verify the developed hydraulic model. In future, flood conditions such as depth and duration and photographs should be properly recorded in order to contribute to better analysis.

It is recommended that the rainfall data be properly recorded and analysed from the point of view of seasonal variations and spatial distribution, and the results be reflected in the Disaster Response Plan which includes the Emergency Response Plan and Standard Operation Procedures. The final goal will be to establish a simple early warning system for each river basin and improve flood risk management for residents.

8-7 Disaster Response

District disaster response plans have already been formulated for floods, landslides and tsunamis and were distributed by the DRDM in 2009. They include the response process and also warnings. In 2012 a tsunami warning was issued. In 2013 and 2014 flood and landslide disasters occurred in the southeast of Mahe and La Digue.

Disaster response manuals for floods, landslides and tsunamis have been prepared. However, they are not used because they do not take into account the actual conditions in the Seychelles. During the execution of the project, there were two examples of disaster response. One was the warning and preparation for the tsunami that occurred in 2012. The warning was issued but not according to the existing manual which is complicated and does not allow for the actual conditions. In the Seychelles the tsunami generating area is far from the islands. It takes 4 to 6 hours from the origin to the Seychelles. Therefore, there is enough time to prepare for evacuation. It is possible to issue warnings in a stepwise manner as the tsunami spreads by monitoring. This procedure is not proposed in the manual.

The manual was prepared for each district. However, the scale of tsunami is large and it is better to respond as a whole country.

The January flood in 2013 in Mahe and in 2014 in La Digue had a scale of several districts. Therefore, for flood response, each island, such as Mahe, Praslin and La Digue, is the appropriate scale. In the manual warnings are issued according to the rainfall in a certain period such as one hour or one day. The January flood was caused by continuous rain over several days resulting in the accumulation of water on low land and increased runoff. Therefore, it is necessary to issue warnings based on the accumulated rainfall over several days. In the manual the district administrator has to make a report within two weeks of the event. However, this is not the actual situation.

From this experience, the manual should be improved to make it more effective based on a study of past experience by DRDM.

8-8 Public Communication

It was planned to improve public communication in the SSDS (2012-2020) action plan. The second strategy in the SSDS involves land use, coastal zones and urbanisation. One of the objectives is the establishment of effective and integrated national coastal zone management. The action plan includes (1) improvement of communication, networking and stakeholder involvement and (2) improvement of communication, information dissemination and networking, and the responsible organisations are the Ministry of Environment and Energy and the Ministry of Land Use and Housing. Public communication is also included.

The problem is that past public communication was not effective because the explanations were too general and not specific and there was no consideration for the actual conditions in the Seychelles.

The government and the Ministry of Environment and Energy are eager to promote public communication using newspapers such as the Nation and TV such as the Seychelles Broadcasting Cooperation (SBC). Disaster communication is important for understanding the situation and taking actions such as evacuation in the event of heavy rain or making preparations in daily life. Personal experience and neighbours' experiences are very important. Usually flooding happens very rarely and it is said that natural disaster strikes when the memory of previous disasters has faded. Therefore, keeping the memory alive is very important especially for younger people. In the Seychelles there have been several opportunities to experience disasters recently. Examples are the tsunami warning in 2012 and January floods in 2013 and 2014. One proposal is for school children to make reports and publish their experiences or hold contests. Recent flooding has been abnormal and it is a very important experience. Activities to mitigate the damage from disasters are proposed herein. The responsible organisation will be the Ministry of Education.

Appendix

MINUTES OF MEETING
ON INCEPTION REPORT FOR THE STUDY
FOR COASTAL EROSION AND FLOOD CONTROL MANAGEMENT
IN THE REPUBLIC OF SEYCHELLES
AGREED UPON BETWEEN THE DEPARTMENT OF ENVIRONMENT,
MINISTRY OF HOME AFFAIRS, ENVIRONMENT, TRANSPORT AND ENERGY
AND THE JAPAN INTERNATIONAL COOPERATION AGENCY

The Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Team on the Study for Coastal Erosion and Flood Control Management in the Republic of Seychelles (hereinafter referred to as " the Study Team" and "the Study") to the Republic of Seychelles (hereinafter referred to as "Seychelles") in order to explain and consult with Seychelles on the contents of an inception report of the Study (hereinafter referred as to "the Inception Report") from February 20 to 23, 2011.

As a result of discussions, both sides agreed to the matters described on the attached sheets.

Victoria, February 22, 2011

Mr. Didier Dogley
Principal Secretary
Department of Environment,
Ministry of Home Affairs, Environment,
Transport and Energy
The Republic of Seychelles

Mr. Hiroshi Hashimoto
Leader,
The Study Team
Japan International Cooperation Agency

Maurice Loustau-Lalanne

Mr. Maurice J. L. Loustau-Lalanne
Ambassador
Principal Secretary
Ministry of Foreign Affairs
The Republic of Seychelles

Witnessed by

Kenji

Mr. Kenji Nagata
Leader
Monitoring Mission,
Japan International Cooperation Agency

Attachment

1. Contents of the Inception Report

The Government of Seychelles (hereinafter referred to as "GOS") agreed and accepted in principle the contents of the Inception Report and the undertakings by GOS for the execution of the Study explained by the Study Team.

Detailed study methods will be adjusted in the course of the Study with mutual cooperation.

2. Steering Committee and Technical Committee

In accordance with Minutes of Meeting on Scope of Work agreed upon between DOE and JICA on 26^{th} June 2010, Seychellois side agreed to set up the Steering Committee chaired by the Principal Secretary of DOE for the smooth implementation of the Study.

Seychellois side also agreed to set up the Technical Committee to support the Steering Committee. The members are shown in **Annex-1**.

Both sides agreed that the Steering Committee Meetings would be conducted at each phase of the Study, as scheduled and shown in **Annex-2**, and the Technical Committee Meetings would be held before the Steering Committee and upon the request of DOE and the Study Team.

3. Counterpart Personnel to the Experts of the Study Team

The Study Team explained that the on-the-job-training will be conducted throughout the Study period and would be a main technical transfer activity.

Seychellois side agreed to provide and nominate the counterpart personnel to the following expertise from relevant organizations in accordance with the Study schedule. The nominated members are shown in **Annex-3**.

- Team Leader
- Coastal Conservation
- Flood Management
- Natural Conditions
- Urban Flood Management
- Survey / GIS
- Public Awareness and Involvement / Environmental and Social Considerations
- Design / Cost Estimation / Supervision

4. Provision of Necessary Materials and Data

Seychellois side explained that aerial photographs for the three main islands will be taken in March 2011 by Ministry of Land Use and Housing and the Study Team could be provided with them.

Seychellois sides also agreed to provide the Study Team with the latest topographic maps with the scale of 1/10,000 and the hydrographic charts made by the British Admiralty as well as the latest and chronicled aerial photographs.

5. Environmental and Social Considerations

The Study will follow both Seychelles laws/regulations and JICA's Environmental and Social Considerations Guidelines.

Seychellois side agreed to go through the procedures for Environmental Impact Assessment (EIA) of both the in-depth studies and pilot projects before implementation of these activities.

6. Seminars and Workshops

Seminars and workshops are to be held in Seychelles during the course of the Study, mainly to raise technical level and managerial skills for the counterpart personnel.

In order to broadly disseminate the knowledge and experience acquired through the Study both sides agreed that NGOs, private sectors and others concerned could also participate in the seminars and workshops. The members from NGOs, private sectors and others concerned would be selected in a neutral and fair manner by DOE.

7. Counterpart Training in Japan

Counterpart training in Japan will be conducted in 2011 and 2012. Two counterparts from Seychellois side will participate in the training each year. The training will be conducted to actually observe and understand the advanced experiences in Japan in terms of measures taken against coastal erosions, and flood management activities and facilities. The details of the training and its application will be suggested by the Study Team.

The Study Team recommended to the Seychellois side to identify the candidates to attend the training. Their application forms should be sent to JICA headquarters by two and a half months before the trip. JICA Kenya Office as well as the Study Team will assist.

8. Other Relevant Issues

8-1. Relevancy of the Study as Adaptation to Climate Change

Both sides confirmed that the Study shall be consistent with National Climate Change Strategy and the updating of the Environment Management Plan of Seychelles (2011-2020) be positioned as a part of the adaptation measures to climate change.

8-2. Collaboration with Other Donors

It will be significant to collaborate with other donors from the point of view of ensuring sustainability of measures resulting from the Study. Both sides agreed to share the information of the Study with other donors and collaborate with them during the Study.

8-3. Office Space

The Study Team confirmed that Seychellois side arranged suitable office space with necessary facilities and equipments including electricity and water supply, telephone line and Internet access, for the Study Team at the time of the commencement of the Study.

8-4. Approval Letter for the Study Team

Seychellois side confirmed that they would issue a letter to facilitate convenient entry of the Study Team to Seychelles.

8-5. Securing of Emergency Contact System

As there are no Japanese Embassy and JICA Regional Office in Seychelles, Seychellois side agreed to ensure that the system of emergency contact with the Study Team was in place to secure safety of the Study Team.

Annex-1 Members of the Steering Committee and the Technical Committee
Annex-2 Schedule and Contents of the Steering Committee Meetings
Annex-3 Member list of Counterparts
Annex-4 List of Attendants

Annex-1

Members of the Steering Committee and the Technical Committee

Steering Committee:

	Organization	Affiliation
Chairperson	Department of Environment, HAETE	Principal Secretary
	Ministry of Foreign Affairs	Principal Secretary
	Ministry of Land Use and Housing	Principal Secretary
	Ministry of Community Development, Youth and Sports	Principal Secretary
	Division of Climate and Environmental Services	Director General
	Divisions of Risk and Disaster Management, HAETE	Director General

Technical Committee:

Organization	Affiliation
Environmental Engineering & Wetland Section , DOE, HAETE	Director
	Head, Wetland and River management Unit
	Head, Coastal Management Unit
	Head, Drainage Unit
	National Coordinator, EMPS
Environment Impact Assessment Section, DOE	Director
National Meteorological Services, DOE	Director
GIS and Information Technology Support Services, MLUH	Director
Divisions of Risk and Disaster Management, HAETE	Director General
Department Community Development, MCDYS	Director
Ministry of Foreign Affairs	Third Secretary

DOE : Department of Environment
EMPS : Environmental Management Plan of Seychelles
HAETE : Ministry of Home Affairs, Environment, Transport and Energy
MCDYS : Ministry of Community Development, Youth and Sports
MLUH : Ministry of Land Use and Housing

Annex-2

Schedule and Contents of the Steering Committee Meetings

No.	Proposed Date	Contents / Objectives
1	21 February 2011	Inception Report
2	September 2011	Progress Report 1
3	February 2012	Interim Report
4	March 2013	Progress Report 2
5	January 2014	Draft Final Report

Member list of Counterparts

Category	Organization
Leader	Director, Environmental Engineering & Wetland Section , DOE
Coastal Conversation	Head, Coastal Management Unit, DOE
Flood Management	Head, Drainage Unit, DOE
Natural Conditions (Hydrological Analysis)	Head, Drainage Unit, DOE
Urban Flood Management	Head, Drainage Unit, DOE
Survey / GIS	Director or staff, GIS and Information Technology Support Services, MLUH
Public Awareness and Involvement / Environmental and Social Considerations	Director or staff, Environment Impact Assessment Section, EMPS, DOE
Design / Cost Estimation / Supervision	• Head, Coastal Management Unit, DOE • Head, Drainage Unit, DOE

DOE : Department of Environment
EMPS : Environmental Management Plan of Seychelles
MLUH : Ministry of Land Use and Housing

Annex-4

List of Attendants

<SEYCHELLOIS SIDE>

Department of Environment, Ministry of Home Affairs, Environment, Transport and Energy
Mr. Joel Morgan (Minister)
Mr. Didier Dogley (Principal Secretary for Department of Environment)
Mr. Phillip Morin (Principal Secretary for Transport and Energy)
Mr. Alain De Comarmond (Director General, Divisions of Risk and Disaster Management)
Mr. Wills Agricole (Director General, Division of Climate and Environmental Services)
Mr. Nimhan Senaratne (Director, Environmental Engineering & Wetland Section)
Mrs. Begum Nageon de Lestang (National Coordinator, Environmental Management Plan of Seychelles)

Ministry of Foreign Affairs
Mr. Maurice J. I. Loustau-Lalance (Ambassador, Principal Secretary)
Mr. Christian Faure (Third Secretary, International Relations Division)

<JAPANESE SIDE>
JICA Monitoring Mission
Mr. Kenji Nagata (Leader, Senior Advisor, Global Environment Department)
Mr. Shinichi Saito (Representative Seychelles, JICA Kenya Office)
Mr. John N. Ngugi, (Senior Programme Officer, JICA Kenya Office)

The Study Team
Mr. Hiroshi Hashimoto (Team Leader / Coastal Conservation Expert)
Mr. Kazuyoshi Fujimoto (Urban Flood Management Expert)

MINUTES OF MEETING
ON
INTERIM REPORT
FOR
THE STUDY
FOR
THE COASTAL EROSION AND FLOOD CONTROL MANAGEMENT
IN
THE REPUBLIC OF SEYCHELLES
AGREED UPON BETWEEN
THE DEPARTMENT OF ENVIRONMENT,
MINISTRY OF ENVIRONMENT AND ENERGY
AND
JICA STUDY TEAM

The third steering committee meeting of the Study for Coastal Erosion and Flood Control Management in the Republic of Seychelles (hereinafter referred to as "the Study") was held on July 3, 2012 with the attendance of the Department of Environment, Ministry of Environment and Energy (hereinafter referred to as "DOE"), the authorities concerned, the Japan International Cooperation Agency (hereinafter referred to as "JICA") and the JICA Study Team (hereinafter referred to as "the Team").

As a result of the discussion on the draft version of the Interim Report (hereinafter referred to as "IT/R") of the Study, both parties have agreed on the matters referred to in the document attached hereto.

Victoria, July 6, 2012

Mr. Flavien Joubert
Acting Principal Secretary,
Department of Environment, Ministry of Environment and Energy
The Republic of Seychelles

Mr. Hiroshi Hashimoto
Team Leader,
JICA Study Team,
Japan International Cooperation Agency,
Japan

Mr. Maurice Loustau-Lalanne
Ambassador,
Principal Secretary,
Ministry of Foreign Affairs,
The Republic of Seychelles

Witnessed by

Mr. Kenji Nagata
Senior Advisor, Global Environment Department,
Japan International Cooperation Agency,
Japan

THE ATTACHED DOCUMENT

1. Components of the Interim Report

DOE agreed and accepted in principle the contents of the draft version of the Interim Report for the management plan and the execution of pilot projects explained by the Team, and pledged commitment to cooperate closely with the Team during the Study.
Detailed methodology shall be adjusted in the course of the Study with mutual cooperation.

2. Other Relevant Issues

2.1 Coastal Conservation and Flood Management Plan
The Team explained that the above stated management plan is formulated with the acceptance that there exists limited information on local coastal erosion and flooding disasters. Therefore it is necessary to monitor and record disasters for evaluation of the plan within a ten year timeframe, after the Study. DOE agrees to take the necessary measures.

2.2 Pilot Projects
The Team and DOE jointly agreed to effectuate the pilot projects at four sites, namely North East Point, Pointe Larue, Au Cap and La Passe.

Duties and Responsibilities of DOE and the Team are as follows;
DOE;
- Shall take joint responsibility for the implementation of all the pilot projects and shall take full responsibility for maintenance of these projects.
- Or other Seychelles organizations shall bear all the expenses such as maintenance, operation and repair costs etc..
- Oversee and monitor the overall process of the pilot projects.
- Provide logistical support for monitoring and technical supervision.
- Facilitate the preparatory works for the pilot projects.
- Ensure regular and timely communication among the relevant parties.
- Facilitate public announcements on the implementation of the pilot project.
- Ensure communication among the relevant parties and related organizations.

The Team;
- Provide funding for the procurement of local contractors to implement the pilot projects.
- Prepare the bidding documents for pilot projects in line with local procurement laws.
- Implement bidding procedure in cooperation with DOE.
- Conclude the contract awarded to contractors for the pilot projects.
- Lead the supervision of the pilot projects.
- Evaluate and validate the progress reports of the construction.

2.3 Technology and Knowledge Transfer
DOE expressed that the training in Japan conducted last year was very useful in both the transfer of Japanese technology to the local counterparts as well as the increased capacity building in the use of the observed components during the course of the training.

The Team informed that the members of the local counterparts for the Project for Capacity Development on Coastal Protection and Rehabilitation in the Republic of Mauritius will be invited to the second seminar which is planned in 2013. DOE agreed to jointly attend the Seminar with the Mauritius counterparts for the exchange of information and knowledge on coastal management.

Annex I

List of Attendants

<SEYCHELLOIS SIDE>

Department of Environment, Ministry of Environment & Energy

Mr. Alain De Comarmond (Director General, Divisions of Risk and Disaster Management)

Mr. Nimhan Senaratne (AG. Director, Environmental Engineering & Wetland Section)

Ministry of Foreign Affairs

Mr. Maurice Loustau-Lalanne (Ambassador, Principal Secretary)

Ms. Melanie Scharpf (Second Secretary, International Relations Division)

Ministry of Land Use and Habitat

Mr. Yves Choppy

Ministry of Community Development, Social Affairs and Sports

Mr. Emmanuel Toussaint

<JAPANESE SIDE>

JICA

Mr. Kenji Nagata (Senior Advisor, Global Environment Department)

Mr. Kazuhisa Katayama (Representative Seychelles, JICA Kenya Office)

Mr. John N. Ngugi, (Senior Programme Officer, JICA Kenya Office)

The Study Team

Mr. Hiroshi Hashimoto (Team Leader / Coastal Conservation Expert)

Mr. Tomomi Fujita (Survey / GIS Expert)

Mr. Yoshiteru Nanri (Public Awareness and Involvement / Environmental and Social Consideration)

Mr. Junichi Furukawa (Design / Cost Estimation / Supervision)

MINUTES OF MEETING
ON
DRAFT FINAL REPORT
FOR
THE STUDY
FOR
THE COASTAL EROSION AND FLOOD CONTROL MANAGEMENT
IN
THE REPUBLIC OF SEYCHELLES
AGREED UPON BETWEEN
THE DEPARTMENT OF ENVIRONMENT,
MINISTRY OF ENVIRONMENT AND ENERGY
AND
JICA STUDY TEAM

The forth steering committee meeting of the Study for Coastal Erosion and Flood Control Management in the Republic of Seychelles (hereinafter referred to as "the Study") was held on February 11, 2014 with the attendance of the Department of Environment, Ministry of Environment and Energy (hereinafter referred to as "DOE"), the authorities concerned, the Japan International Cooperation Agency (hereinafter referred to as "JICA") and the JICA Study Team (hereinafter referred to as "the Team").

As a result of the discussion on the Draft Final Report (hereinafter referred to as "DF/R") of the Study, both parties have agreed on the matters referred to in the document attached hereto.

Victoria, February 13, 2014

Mr. Willis Agricole
Principal Secretary,
Department of Environment, Ministry of Environment and Energy
The Republic of Seychelles

Mr. Hiroshi Hashimoto
Team Leader,
JICA Study Team,
JICA,
Japan

Witnessed by

for
Mr. Maurice Loustau-Lalanne
Principal Secretary,
Ministry of Foreign Affairs,
The Republic of Seychelles

Mr. Hideo Eguchi
Representative,
Japan International Cooperation Agency,
Kenya Office

Annex I

List of Attendants

<SEYCHELLOIS SIDE>

Department of Environment, Ministry of Environment & Energy

Mr. Willis Agricole (Principal Secretary)

Mr. Alain De Comarmond (Director General, Climate Affairs, Adaptation and Information Division)

Ms. Elvina Hoarau (Coastal Coordinator Climate Affaires, Adaptation and Information Division)

Ms. Veronique Baker (Division of Risk and Disaster Management)

Ministry of Foreign Affairs

Mr. Maurice J. I. Loustau-Lalance (Principal Secretary)

Ministry of Finance, Trade & Investment

Ms. Noella Vinda

Ministry of Land Use and Housing

Mr. Michel Laporte

Ministry of Community Development, Social Affairs and Sports

Mr. Daniel Adeline (Director)

<JAPANESE SIDE>

JICA

Mr. Hideo Eguchi (Representative, JICA Kenya Office)

The Study Team

Mr. Hiroshi Hashimoto (Team Leader / Coastal Conservation Expert)

THE ATTACHED DOCUMENT

1. Components of the Draft Final Report

DOE agreed and accepted in principle the contents of the Draft Final Report for the final results explained by the Team, and would submit views and comments from members on the Draft Final Report by the 22nd February 2014 to the Study Team.

2. Other Relevant Issues

2.1 Coastal Conservation and Flood Management Plan
The Team explained that the above stated management plan is formulated with the acceptance that there exist limited information on local coastal erosion and flooding. Therefore it is necessary to monitor and record disasters for evaluation of the plan within a ten year timeframe, after the Study. DOE agrees to take the necessary measures.

2.2 Pilot Projects
The Team explained the results of the pilot projects at three sites, namely North East Point, Au Cap and La Passe, La Digue. The results show that the projects achieved its objectives and have the potential to be applied to the other areas. DOE agreed to continue to monitor the projects in the long-term.

2.3 Technology and Knowledge Transfer
The Team explained the technical transfer activities and expressed its hopes to use guidelines and data base. DOE expressed their gratitude to the Government of Japan and JICA for the positive outputs and capacity built for the staff of the DOE during the term of the study especially the training and experience obtained in Seychelles and in Japan. It was mentioned that the training and knowledge gained is already being applied by the DOE in its activities and functions.

2.4 Equipment Transfer
JICA explained that the equipment used in the Study can be transferred with the request from DOE. DOE expressed the gratitude to the Government of Japan for accepting the proposal and reassured that the equipments will be effectively used and maintained.

2.5 VAT exemption
The Team on behalf of JICA expressed their appreciation to the Government of Seychelles primarily the Ministry of Finance for their good cooperation and understanding in the negotiations on the matter. The Ministry of Finance equally expressed their appreciation of the understanding of JICA during the resolution of the matter.

2.6 Recommendation
The Team explained some recommendations for the realization of the plan by the financial support, implementation of the action plan in the Seychelles Sustainable Development Strategy which includes non-structural measures, and monitoring.

2.7 Statement by JICA Representative
The JICA representative expressed satisfaction on the commitment of the Government of Seychelles during the implementation of the programme and reaffirmed the Government of Japan's commitment to partner with Seychelles in its fight against climate change related issues. JICA called on the DOE to ensure that the outputs and recommendations from the programme is implemented and sustained in the long-term.

2.8 Statement by Principal Secretary of Environment and Energy
The PS reaffirmed the government of Seychelles' commitment to the long-term implementation of the recommendation and sustainability of the different activities.