No.

Republic of Mauritius
Mauritius Wastewater Management Authority

Republic of Mauritius
Technical Assistance
for
Grand Baie Sewerage Project Phase 1-B

Final Report
Volume1: Main Report

March 2011

Japan International Cooperation Agency (JICA)

NIPPON KOEI CO.,LTD. (NK)

AFD
CR (3)
11-002

Republic of Mauritius
Mauritius Wastewater Management Authority

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Mr. Kenzo OOSHIMA
Senior Vice-President
Japan International Cooperation Agency

Dear Sir,

Letter of Transmittal

We are very pleased to submit herewith the Final Report of ”The Study on Technical Assistance for Grand Baie Sewerage Project Phase 1-B for the Republic of Mauritius”

The Study was carried out by NIPPON KOEI CO., LTD. Under the contract with your Agency for the four-month period from December 2010 to March 2011.

The study is one of technical assistance which aims to promote ODA loan project of detail design and construction smoothly, and to enhance project result through topographic survey and inflow & infiltration mitigation survey. The study proposed main sewer route in accordance with topographic condition, considering number of pumping station and pumping head. Effective wastewater collection in low lying area and customer information, which is required in operation stage, are also proposed. Technical and institutional plan of inflow and infiltration mitigation is provided for sewerage facility management.

Finally, we genuinely wish that the report will be transferred to sewerage system development of Mauritius.

Yours very sincerely,

Yakuro INOUE
Team Leader,
Technical Assistance for Grand Baie Sewerage Project Phase 1-B
for the Republic of Mauritius

Republic of Mauritius
Technical Assistance for Grand Baie Sewerage Project Phase 1-B

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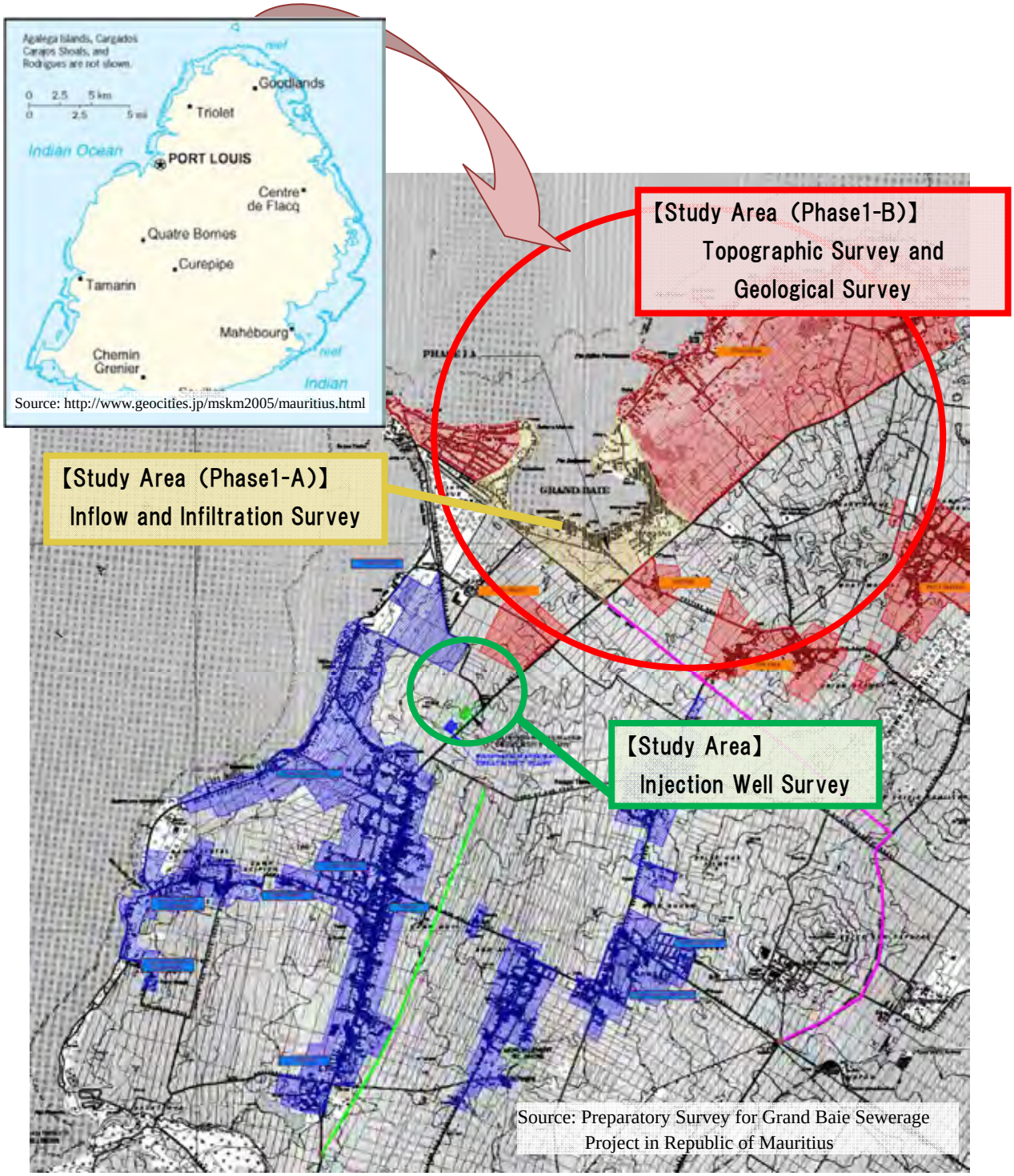
Abbreviations

AFD	Agence Française de Développement
AfDB	African Development Bank
BH	Borehole
C/P	Counter Part
CAD	Computer Aided Design
COD	Chemical Oxygen Demand
CWA	Central Water Authority
DF/R	Draft Final Report
DI	Ductile Iron
EBDR	European Bank of Development and Reconstruction
EIA	Environmental Impact Assessment
F/R	Final Report
F/S	Feasibility Study
GOM	Government of Mauritius
GPS	Global Positioning System
HDPE	High Density Polyethylene
I/I	Inflow and Infiltration
IC/R	Inception Report
MS	Mini Pumping Station, Manhole Type Pumping Station
NEAP1	First National Environmental Action Plan
NSP	National Sewerage Programme
OJT	On The Job Training
ORP	Oxygen Reduction Potential
PE	Polyethylene
PS	Pumping Station
PVC	Polyvinyl chloride
RDA	Road Development Authority
SCADA	Supervisory Control and Data Acquisition
STP	Sewerage Treatment Plant
TBM	Temporary Benchmark
TDS	Total Dissolved Solids
TOR	Terms of Reference
WB	World Bank
WMA	Wastewater Management Authority
WRU	Water Resources Unit
WWTP	Wastewater Treatment Plant

Project Site Map



SUMMARY

1. Objectives of The Survey

The study supports the technical assistance program aiming Grand Baie Wastewater Project to be more efficient. The study aims to conduct the following in advance prior to detailed design:

1) Topographic and geological survey in the area of Sewerage Project Phase 1-B (route survey, individual housing lot survey, and geological survey)

- To collect technical information for further study of detailed design

2) Borehole investigation at wastewater effluent injection

- To collect technical information for further study of detailed design

3) Inflow/Infiltration (I/I) survey at existing sewerage service area of Phase 1-A

- To execute survey and provide technical transfer through seminars
- Proposal on applying I/I mitigation measures on Phase1-B Project

2. Study Result

(1) Topographic Survey

Street survey was executed with sufficient accuracy in order to prevent obstacles for global positioning system (GPS) digital terrain model and electro-optical distance measurement are combined. Street survey smoothly provided, on the beginning stage, contour maps which supplied valuable information to housing lot survey and sewer layout plan. This study was the first to develop contour map for Grand Baie. On housing lot survey, cadastral record and household information were not established, and customer information of Central Water Authority (CWA) and Energy Services Division of the Ministry of Energy and Public Utilities could not identify address and house owners. The study interviewed each household and collected information as described in Table S-2. Since housing lot survey is delicate on privacy, interviews were executed through community awareness of radio and local administration office.

Street and reconnaissance surveys detected topographic information of low-lying area and longitudinal street profile.

Table S-1 Housing Lot Survey Scope

Object	Amount	Scope
Low-Lying Area Housing Lot	1,112 houses (900 planned) 810 at ground level surveyed	・Location of wastewater discharge facilities ・Obstacles of house connection ・Building lay-out ・Elevation
Others	5,626 houses	Sewer route determined by aerial photo (check elevation of house connection) * Detailed design executes housing lot survey
Total	6,738 houses (4,400 houses planned)	

Table S-2 Information Collected from Housing Lot Survey

Collected Information	Survey Team	Purpose of the Information Acquisition
Address	WMA	Basic customer information
Owner	WMA	Basic customer information
Phone Number	WMA	Basic customer information
CWA Account Number	WMA	Basic customer information (For fare collection)
Front Road Proprietary	JICA Study Team	Basic information for detailed design (To check the necessity of wayleave)
Location of Wastewater Discharge Facilities	JICA Study Team	Basic information for detailed design (To decide location of house connection)
Location of Other Utility Service Line	JICA Study Team	Basic information for detailed design (To decide location of house connection)
Length of House Connection	JICA Study Team	Basic information for detailed design (To calculate the amount of construction works)
Elevation of Front Road	JICA Study Team (GPS Survey)	Basic information for detailed design (To decide the pipe depth)
Lowest Elevation in Housing Lot	JICA Study Team (GPS Survey)	Basic information for detailed design (To decide the pipe depth)

Topographic survey contributed to reduce three pumping stations (PS) and manhole type pumping stations (MS) including 25 m pump head as seen on Table S-3.

Sewer layout plan showing sewer line with MS and PS and house connection was provided. House connection is decided through aerial photo, street survey and interviews on housing facilities.

House connection requires drainage pump as for houses in low-lying area, on hollow and at the backside of hills along beaches. Low cost sewer was proposed such as occupying private property, condominial sewerage, and grinder pump units for individual and communal houses.

Topographic survey contributed to the followings:

- Topographic information (contour map, housing map, etc.)
- Sewer layout plan
- Number of pumping stations is reduced from nine to six, and proposal of low cost sewage collection technology
- Customer information (household inventory)

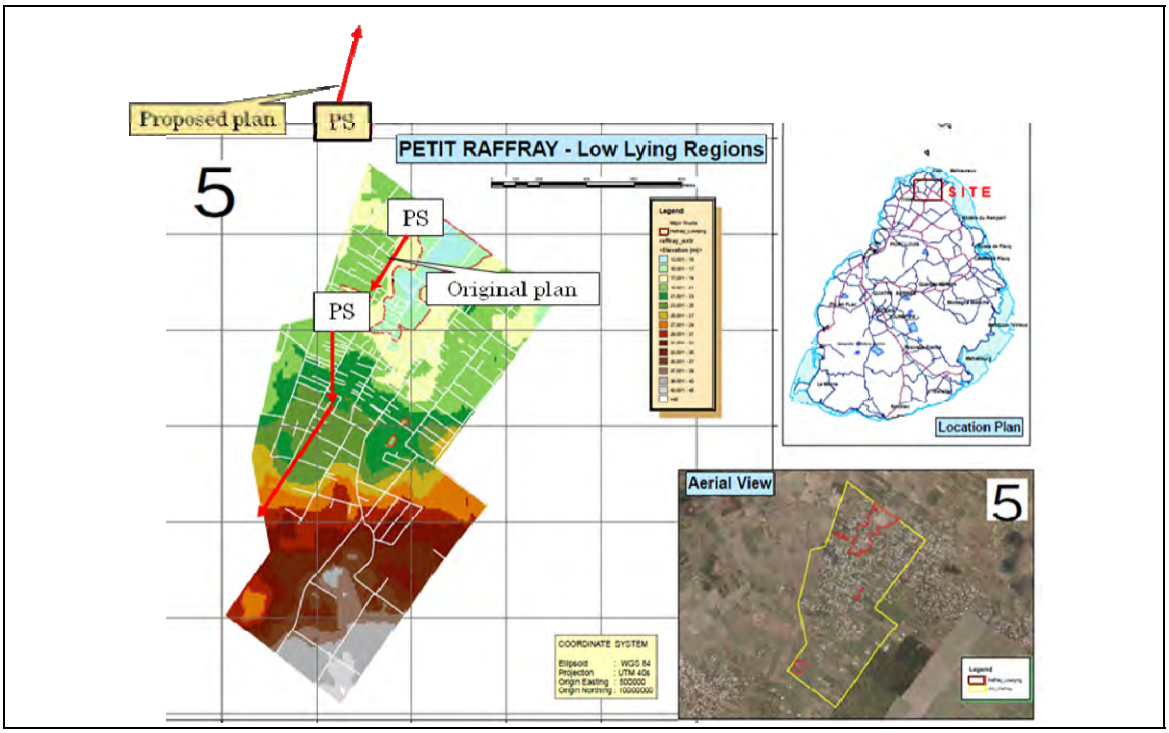


Figure S-1 Sewer Main Route Developed by Contour Map

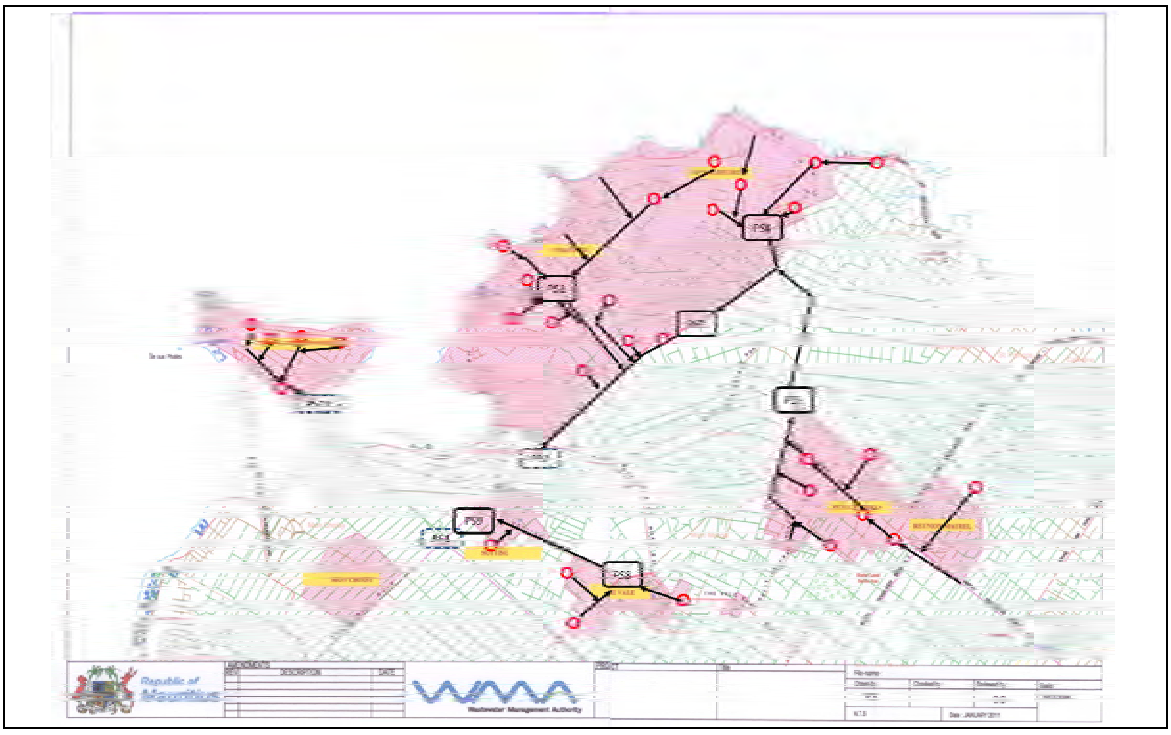


Figure S-2 Sewer Main Route

Table S-3 Pumping Station Plan

Facilities	Original plan 2009	Proposed plan
Pumping station	9	6
Mini station	42	31

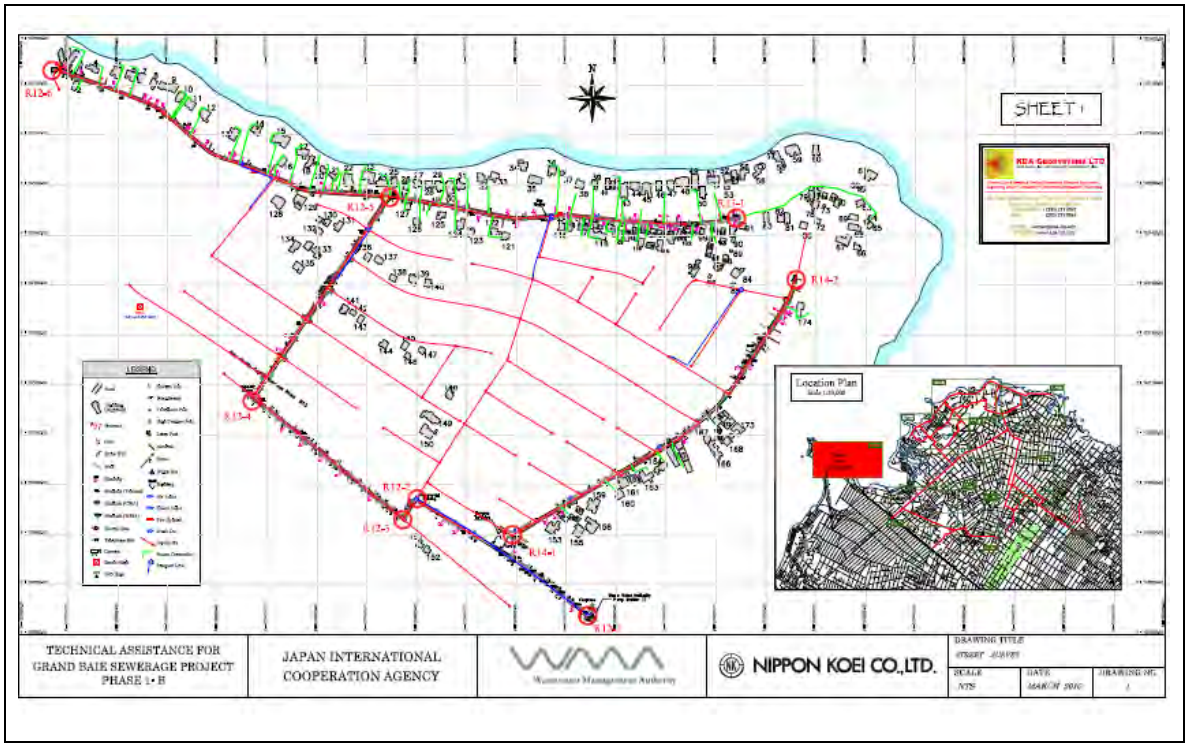


Figure S-3 Sewer Layout Plan

Figure S-4 Example of Sewage Collection in Low-Lying Areas (Condominial Sewer)

Table S-4 House Inventory

Household Inventory Survey

Technical Assitance for Grand Baie Sewerage Project Phase 1-B

		Household Details					Housing lot survey items								Survey Methodology		
Aerial photo reference No.	Hosue reference No.	Village	Address	CWA AC No.	Ownership Name	Telephone	Front Road		Boundary		Housing lot elevation of lowest point	Road elevation	Housing lot higher or lower than, or equal to road	House connection length	Measured in-situ	DTM/ aerial photo	Rejected
							Public	Private	Detected	Not Detected	GL + m	GL + m	cm	m			
1	1	Pts aux Cannoniers			Navneet Akaloo	269 0929	*			*	7.52	7.87	0.35	81	*		
1	2	Pts aux Cannoniers			Soobash Chandra Ramparsad	263 5129	*			*	7.18	7.98	0.80	23	*		
1	3	Pts aux Cannoniers	Island View		Paula Labat	258 0755	*			*	7.00	7.87	0.87	50	*		
1	4	Pts aux Cannoniers	Island View		Paula Labat	259 0755	*			*		7.95		46	*		
1	5	Pts aux Cannoniers			Jean Bernard Tyack	727 0080	*			*	7.52	7.53	0.01	57	*		
1	6A	Pts aux Cannoniers			Jean Francois Adam	727 0080	*			*	7.29	7.11	0.18	73	*		
1	6B	Pts aux Cannoniers			Jean Francois Adam	727 0080	*			*			0.00		*		
1	6C	Pts aux Cannoniers			Jean Francois Adam	727 0080	*			*			0.00		*		
1	7	Pts aux Cannoniers			Frederick Robert		*			*	7.18	7.11	0.07	80	*		
1	8	Pts aux Cannoniers	Coeur Volant		Christine Colin	752 8715	*			*	7.51	6.86	0.65	65	*		
1	9A	Pts aux Cannoniers			Veronique Moufferon	423 6000	*			*	9.66	6.86	2.80	78	*		
1	9B	Pts aux Cannoniers			Noel Raffray	423 6000	*			*			0.00		*		
1	9C	Pts aux Cannoniers			Gilbert Deleplaque	423 6000	*			*			0.00		*		
1	24B	Pts aux Cannoniers			Serge Bathfield/Meur c/o Sunil	910 5122	*			*			0.00		*		
2	25	Pts aux Cannoniers			Bougois		*			*	9.90	11.81	1.91	31	*		
2	26	Pts aux Cannoniers			Alain Paillusseau	263 3845	*			*	10.20	11.67	1.47	27	*		
2	27	Pts aux Cannoniers	23 Coastal Road		Maurice Martin	258 1660	*			*	11.42	11.52	0.10		*		
2	28	Pts aux Cannoniers	24 Coastal Road		Maurice Martin c/o Mme La Grue	931 5065	*			*		12.05			*		
2	29	Pts aux Cannoniers			Roger Koenig c/o Subash	263 5486/261 3197	*			*	10.57	12.31	1.74	56	*		
2	30	Pts aux Cannoniers			Alexis Harel	735 8668	*			*	10.61	11.71	1.10	68	*		
2	31	Pts aux Cannoniers			John Tagg (Jessica)	932 3804	*			*	9.13	11.71	2.58	69	*		

(2) Geological Survey

Columnar joints in lava rocks such as basalt predominate geologically in the project area (Figure S-5). Lava rock layer was detected by geological survey and site reconnaissance in the whole project area. Lava rock layers with vertical and horizontal joints are hard or weathered.

Geological survey detected lava rocks at five pumping station sites excluding one site. Ground water level is also detected deep as sea water level since only two sampled water was obtained.

Lava rocks are jointed, and consists of hard and weathered rocks. Construction work and quarry use crusher. Sewer main is planned along the main road with gravity flow and approximately 1 m difference can be excavated. Small roads are difficult to excavate and drainage pump must be applied. Proposed sewer layout plan displaces adjacent MS considering cost of construction and operation and maintenance (O&M) of MS. Sewer pipe is laid in ground water at an elevation of 2 m. Construction works are intended for drainage pump because of limited ground water inflow through rock joints.

Figure S-5 (Left) Columnar Joints Exposed on Beach Side, (Right) Ball-like Porous Basalt

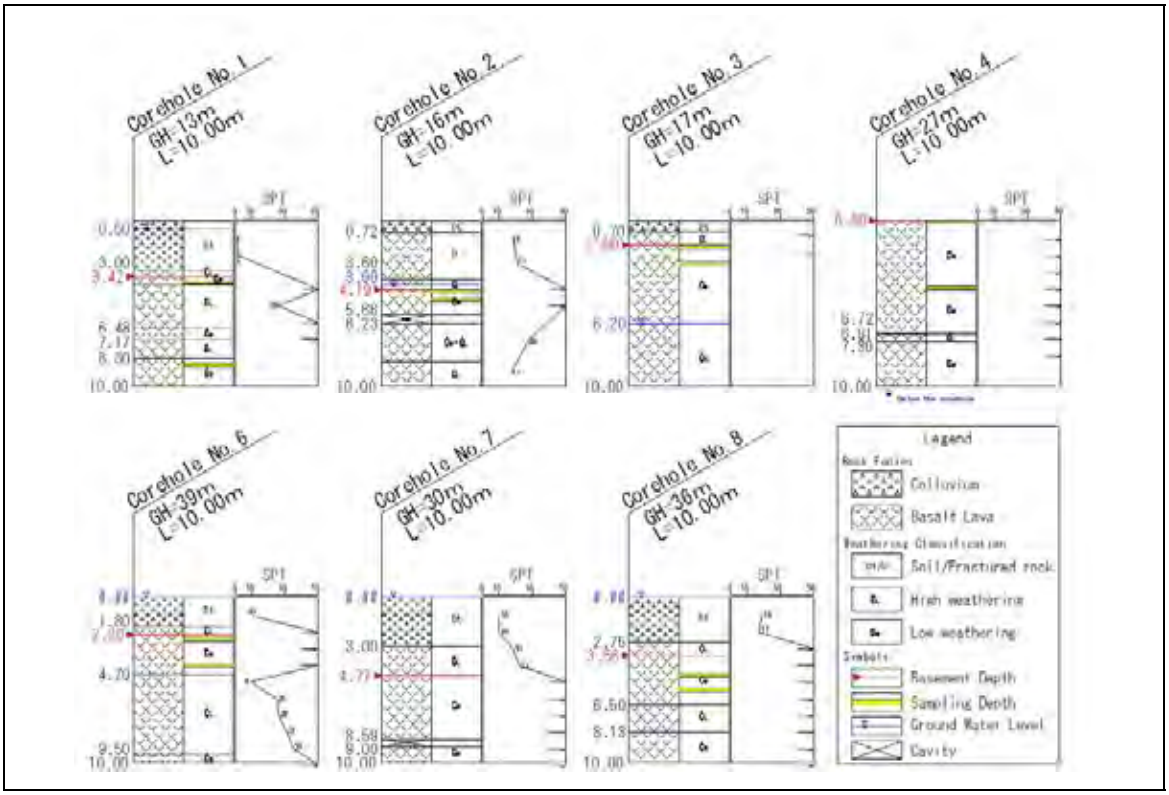


Figure S-6 Summarized Columnar Section

The basalt rocks distributed in the studied area exposed on ground surface or underground up to 3.0 m. Furthermore, fresh basalt is very hard with N-value of more than 50, and an allowable bearing capacity of 700~800 kN/m^2,which is sufficient for the structure's foundation. The proposed pumping station shall be constructed by removing the loose colluvial surface and building a spread foundation on hard basalt rock.

Sewer construction will be affected by hard lava rocks in the whole project area, and the on-going project applies excavation machine for executing open-cut method. Sewer depth shall be decided to compare the cost and maintenance of pumping and open-cut method by

gravity flow, which can be applied with less ground water leakage.

Figure S-7 Construction in Residential Area

(Left: Sewer construction in Quatre Bornes, Right: Housing construction in Grand Baie)

(3) Injection Well Survey

The two existing injection wells operates alternately while one injection well has been abandoned. The study bored additional two injection wells and conducted permeability tests. Since lava tubes were not detected in Grand Baie Region, injection is performed through cracking of lava rocks. Distribution of injection wells are determined considering the lava flow direction in Mont Virer, existing well layout, and candidate sites for future sewerage system expansion. Figure S-8 shows the location of the injection wells.

The first injection well (BH-4) was suspended at 52 m deep because boring facing cavity rock layer and debris of 15 cm cannot be exploited. The second well (BH-5) was amended from 300 mm to 380 mm in diameter.

Pumping tests shown in Figure S-9 detected that transmissivity, measured between 100 and 1,000 mins during the 24 hr pumping tests, in BH-4 and BH-5 are 9,311 $m^{2/}$day ($1.08x10^{-1}$ m^2/s) and 15,372 m^2/day ($1.78x10^{-1}$ m^2/s), respectively as shown in Table S-5.

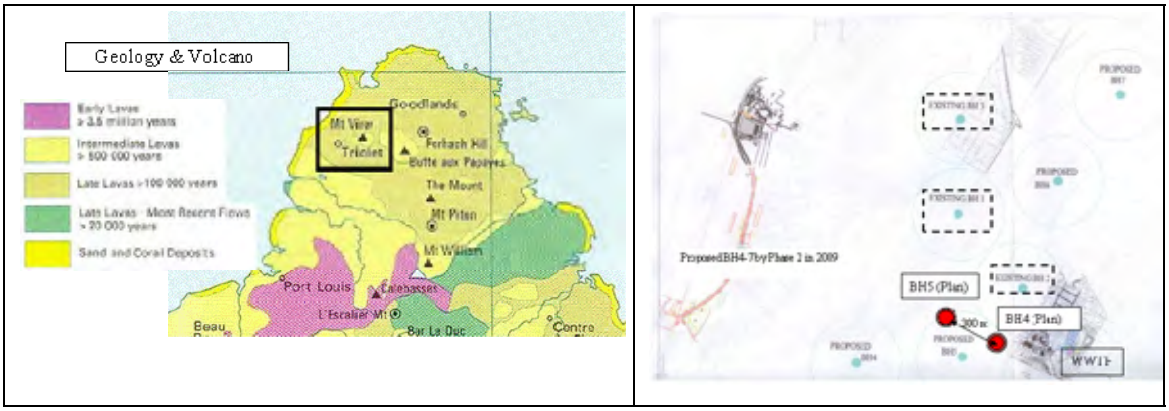


Figure S-8 Location of Injection Well Tests

Figure S-9 Pumping Test (Tentative)

Table S-5 Pumping Test Result

No. Step	Duration of Test (mins)	Q (Yield) m^3/h	s (Drawdown) m	s/Q h/m^2	Q/s m^2/h
BH-4					
1	30	25.5	0.03	0.00118	850.0
2	30	50.2	0.05	0.00100	1,004.0
3	30	75.6	0.10	0.00132	756.0
4	30	106.0	0.16	0.00151	662.5
BH-5					
1	30	69.9	0.03	0.00043	2,330.0
2	30	154.0	0.02	0.00013	7,700.0
3	30	227.7	0.01	0.00004	22,770.0
4	60	363.0	0.09	0.00025	4,033.3

(4) Inflow and Infiltration Mitigation Plan

Inflow rate of the existing Grand Baie sewerage is fluctuating regularly in commercial area and continuous in residential area. However, irregular flow reaches three to four times of that in dry weather as shown in Figure S-10.

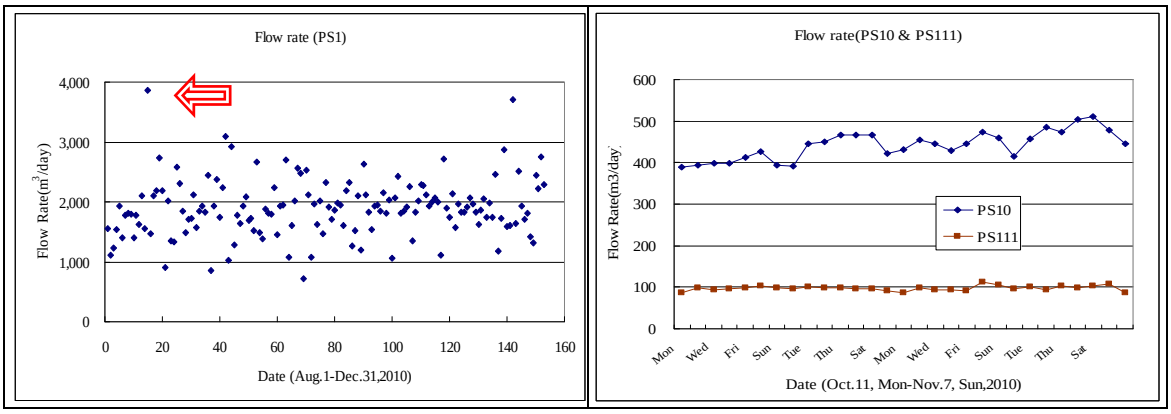


Figure S-10 Daily Wastewater Flow Rate of Pumping Station

I/I mitigation of construction stage in Mauritius applies overall measures such as rubber sealing and PE prefabricated inspection chamber, excavation by manual, pipe bedding of sand and gravel, pressure test, and separation of storm water from wastewater drain, as seen on Figure S-11. The existing sewerage system in Grand Baie may have been conveying inflow from opened manholes and inspection chambers, particularly for grease traps. However, the most inflow was detected to be from residential wastewater which amounts to three to four times of that in dry weather, as seen on Figure S-12.

Therefore, the study proposed a stormwater drainage system that performs infiltration, retention on school ground, and reuse along with comprehensive application of inflow mitigation, sewer materials waterproofing, and careful construction. As for the treatment plant, manual valve diversion chamber will be replaced by an automatic valve to prevent overload at the final sedimentation tank and avoid activated sludge spillage. Replacement of SCADA in Phase 1-B and expansion of treatment plant in Phase 2 are key opportunities for upgrading the inflow mitigation plan (see Table S-5 and Figure S-13).

As for soft measure, the study proposed qualified plumbers which are supposed to be certified engineer, have registration license as plumber and subject to penalties as necessary in conjunction with public-private partnership. This is intended to prevent inferior plumbing works; improve capability in trouble shooting for sewer maintenance; and public relation on sewerage.

Sewer with sand bedding

Pipe with socket & seal ring

Figure S-11 Sewer Construction

Habitual flooding

Inundated house

Opened inspection chamber

Cleansing clogged inspection chamber

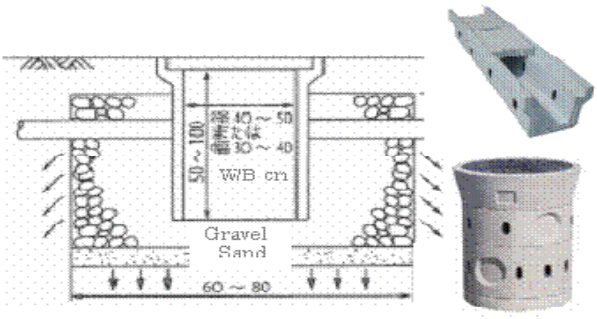
Figure. S-12 Inundation and Inflow

Table S-5 Overall of Inflow and Infiltration Mitigation

O&M of facilities	Retaining in sewer Standby pump operation Bypassing aeration tank	
On-Site Measures	Building sewer repair	Repair of pipe and cover and storm drain separation Disconnection of abandoned septic tank and soak way
	Sanitary sewer repair	Repair of pipe and cover and storm drain separation Disconnection of abandoned sewer
	Storm water drainage	Drainage, infiltration, reuse, and retention
Off-Site Measures	Sewer & pumping station	Expansion of sewer capacity, standby pump operation, Retention reservoir
	Treatment plant	Bypassing aeration tank Sedimentation, coagulation, filtration, etc. Disinfection

Grand Baie government school

Infiltration facility



Stromwater outfall with sedimentation & infilitration (Pointe aux Piments)

Figure S-13 Infiltration and Retaining of Storm Water

3 Conclusion

The study is a technical assistance aiming to promote a smooth ODA loan project of detailed design and construction, and to enhance project result through topographic and I/I mitigation surveys.

The study proposed a main sewer route in accordance with the topographic conditions considering the number of pumping stations and pumping head. Effective wastewater collection in low-lying areas and customer information, which is required during operation, are also proposed. Technical and institutional I/I mitigation plan is provided for sewerage facility management.

Sewerage service requires not only information of customers and facilities, but public relation, such as tariff levies and claims, and trouble shooting on pipe clogging and offensive odor. Information necessary on O&M shall be accumulated on each project stage, and institution is required on urban development project, illicit discharge control and regulation, and design guideline.

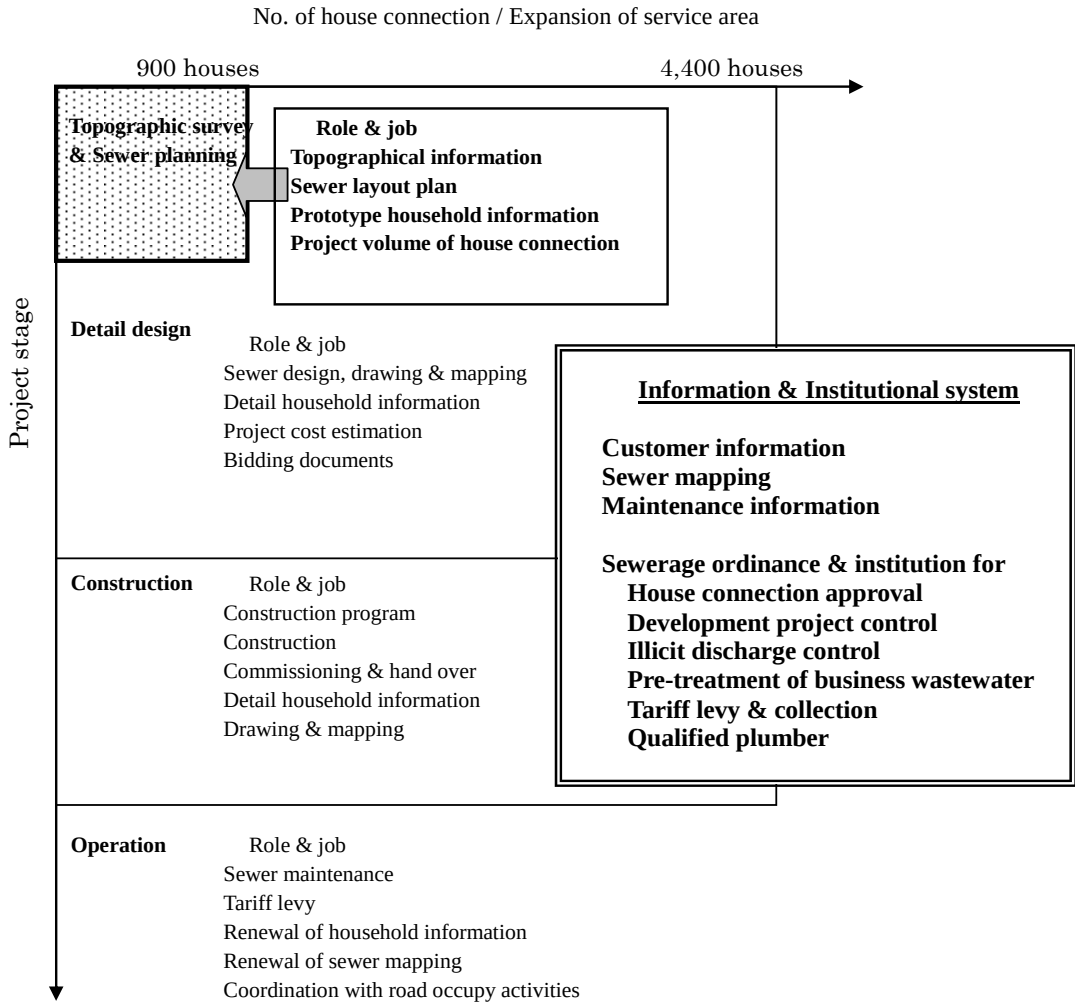


Figure S-14 Roles and Jobs during Survey, Detailed Design and Construction

CHAPTER 1 INTRODUCTION

1.1 Background of The Survey

(1) History and Status of Sewerage System Development in Mauritius

Mauritius has issued NEAP1 on 1988 supported by WB recognizing that environmental prevention and health and welfare of nations are indispensable to sustainable economic development.

GOM provided a sewerage master plan accordant to NEAP1 of summarizing financial policy and operation and management in 20 years supported by AfDB. The Grand Baie Wastewater Project is defined as one of the priority project components of NSP in 10 years.

Sewerage Development Goal of NEAP1

Served population of 50% on 2014 to 80% on 2030

* Sewerage project has actually delayed 40% at present as for targeted goal of 50% in 2014.

(2) Present Status and Plan of Grand Baie Sewerage Development

The Grand Baie Region, where the sewerage project is implemented, is rich in coral reef and sugar cane fields, which respectively serve as a tourist destination and produce products for export, earning overseas money.

GOM has provided a F/S for the Grand Baie Wastewater Project in 1994 supported by AFD of the French government. At present, the sewerage system of the Grand Baie Wastewater Treatment Plant, which consists of pumping stations, sewers, and house connection in Grand Baie Region, were constructed through the Grand Baie Wastewater Project Phase 1-A as shown in Figure 1.3-1. However, only 10% of the population is served, and house connection project is urgent since wastewater from residential and commercial buildings are discharged on ground without any treatment. Discharge of wastewater leads to contamination of coastal and ground waters. The Grand Baie Sewerage Project aims to develop the sewerage service area in order to promote house connections and utilize excess treatment capacity. Phase 1-B costing 8.27 billion yen (Loan Agreement of 7.012 billion yen) was allocated on July 8, 2010, aimed to develop additional house connection of 4.400 s.

Table 1.1-1 Sewerage Project Phase1-A & Phase1-B

		Phase1-A (Existing)	Phase1-B (Plan)
Donor		AFD (France)	JICA(Japan)
Service Area		219 ha	1,268 ha
Projected year (Operation start)		(Dec. 2006)	2016
Served population		4,600 cap. (2007) 5,180 cap. (2030)	22,980 cap. (2007) 25,810 cap. (2030)
Project component	Treatment plant	5,530 m3/day (Retention 2,030 m3/day)	- (Extended in Phase2)
	Injection well	3 wells	2 wells
	Pumping station	13 Pumping station 6 Mini pump station	9 Pumping station 42 Mini pump station
	Sewer	35.5 km (168 m/ha) Gravity :PVC Pressure: HDPE(<250 mm) DI(300 mm<)	94 km (79.7 m/ha) Gravity : 79.2 km Pressure: 13.4 km
	House connection	House hold 1,730 connection Non-domestic 22 connection Total 1,752(Sep. 2009)	4,348 connection
	Others	SCADA	SCADA (replace)

(3) Background of the Project

Technical Assistance of Grand Baie Sewerage Project Phase 1-B (hereinafter referred to as the Study), aims to enhance the project efficiency of Grand Baie Wastewater Project on environmental conservation and public health improvement through facilitating house connections and wastewater treatment service in North Grand Baie Region where households discharge wastewater without treatment.

1.2 Objectives of the Study

The Study supports the technical assistance program for a more efficient Grand Baie Wastewater Project. The study aims to conduct the following prior to detailed design:

1) Topographic and geological survey in the area of Sewerage Project Phase 1-B (route survey, individual housing lot survey, and geological survey)

- To collect technical information for further study of detailed design

2) Borehole investigation at wastewater effluent injection

- To collect technical information for further study of detailed design

3) I/I survey in existing sewerage service area of Phase 1-A

- To execute survey and to provide technical transfer through seminars

- Proposal of applying I/I mitigation measures on Phase1-B Project

1.3 Implementing Organization and Survey Area

(1) Implementing Organization

The implementing organizations for this Study are as follows:

1） Ministry of GOM

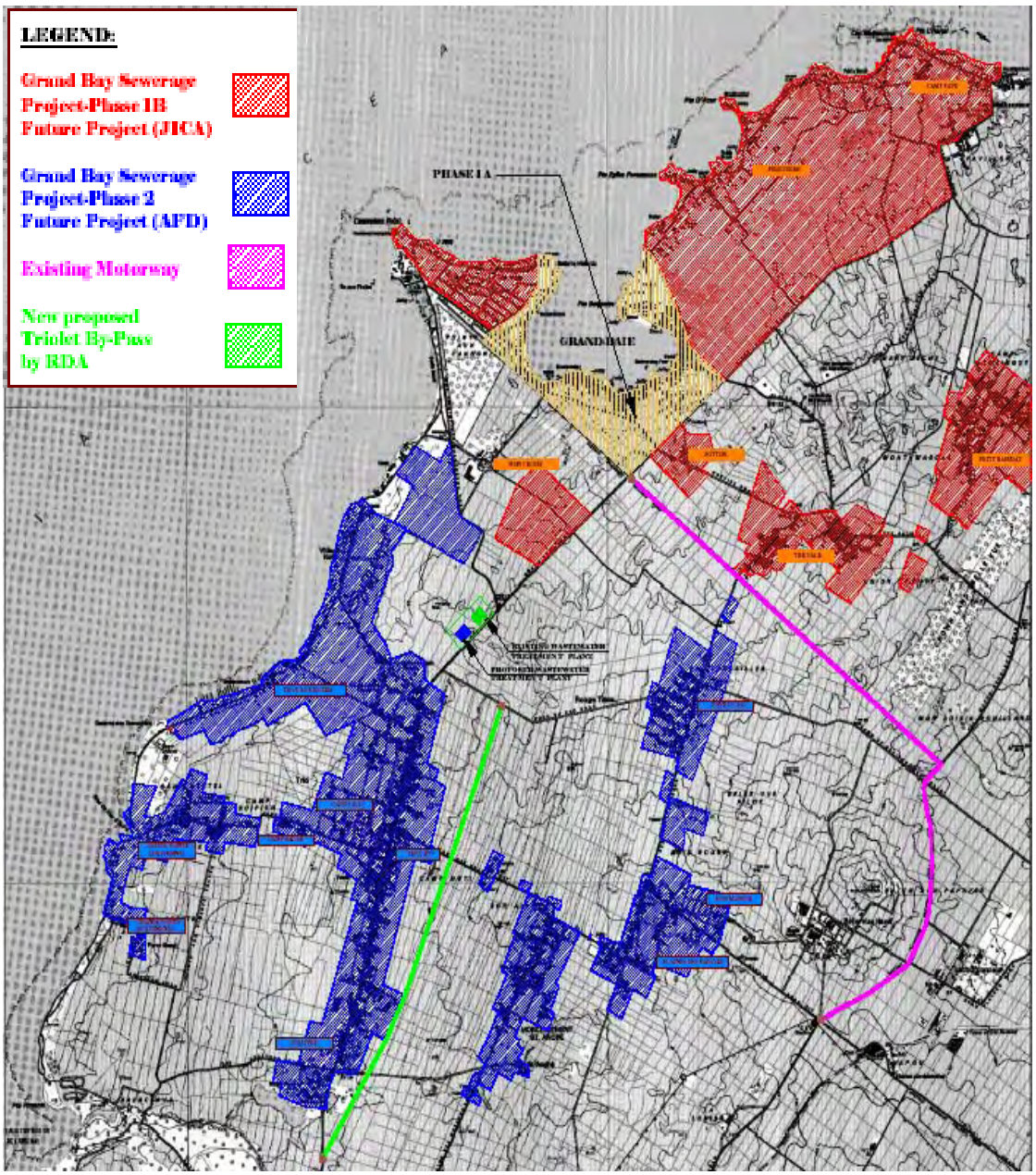
WRU, Ministry of Energy and Public Utilities,

2） Counterpart

WMA, Wastewater Management Authority

(2) Survey Area

The area of the Survey is Grand Baie Region, which is located north of Mauritius, is shown in Figure 1.3-1.



1) Phase 1-A : Existing sewerage Area 【 Brown 】
2) Phase 1-B : Survey Area 【 Red 】
3) Phase 2 : Future Developing Area 【 Blue 】

Figure 1.3-1 Grand Baie Sewerage Project Phase 1-A, Phase 1-B, and Phase 2

1.4 Points to be Noted When Implementing the Survey

(1) Characteristics of Grand Baie Region and Points to Develop the Sewerage System

Characteristics of Grand Baie Region and points to develop sewerage system are described as follows.

1) Typical Geological Condition

Lava rocks appear all over the Project area. Most rocks are buried in shallow earth classified by 1) shallow sandy layer, 2) rocky layer, and 3) rocks.

2) Careful Layout Plan of Pumping Station

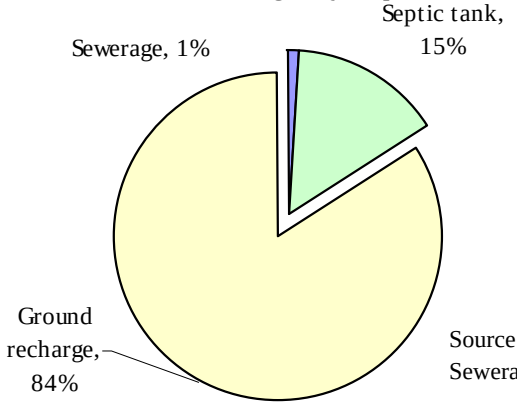
Wastewater collection system applied in the project area consists of gravity and pressurized flows, which are generally adopted in Mauritius. Sewers are laid with some gradient. Lift stations and pressurized flow are adopted where there are deep excavations. The Sewerage Project adopts pumping stations in order to avoid deep excavation.

Furthermore, the location of pumping stations located within private properties should be decided at the earliest since land acquisitions are necessary.

* Layout plan of pumping stations should be reviewed according to route, topographical and geographical surveys since the Preparatory Study of Grand Baie Sewerage Project in Mauritius used 1:2,500 scale maps developed 20 years ago.

3) Low Rate of House Connection

Water closets are available for 93% of households of the Grand Baie Region according to the 2000 National Census, which was before wastewater service operation started. Since 84% of wastewater is discharged into groundwater, as shown in Figure 1.4-1, sewerage development and house connection are urgently required.



Source: Preparatory Survey for Grand Baie Sewerage Project in Republic of Mauritius

Figure 1.4-1 Wastewater Treatment

4) Indispensable Project Component of House Connection

House connection requires design of sewers in private properties, as the house connection project is executed by the public sector. Practical design of house connection requires careful survey of private properties so as not to damage privately owned assets.

5) Huge Amount of Inflow and Infiltration

Wet season flow amounts to 2.2 times of the yearly average of dry-weather flow in spite of a separate sewer system. I/I mitigation measures are required to prevent inundation of pumping stations and provide full capacity of the sewerage system.

Sewerage development plan estimates a design I/I of 10% of domestic and commercial wastewater. Pumping capacity can approve such design I/I, which should reduce the present 1.2 to 0.1 times of the average dry-weather wastewater flow.

(2) Survey Methodology and Points to Develop Sewerage System

The Study includes collection of information on sewer lines, construction methods, construction duration, cost estimation, and safety management. The Study also consists of topographic surveys on route and private housing lot, geographical surveys, and sewer route survey of trunk sewer, local sewer and house connection. Survey methodology and points for sewer design are described in Table 1.4-1.

Table 1.4-1 Points of The Study

Study subject	Study contents	Points to be studied
1) Existing Drawings (Road map, topographic map, Housing lot map)	To collect road maps, which describes road width, principal structures, and houses for sewer plan. Also, to collect aerial photo.	Although current land use map is not available, the water supply sector may provide road and housing lot map. Such map shall be collected through WMA. Data on housing boundaries is important since house connection is implemented by public works. Housing boundary map of water supply sector shall be collected. In case housing boundary data is unavailable, point of sewer house connection will be decided adjacent to water supply connections.
2) Watershed and Project Area condition	Topographic condition and boundary of watershed, drainage route, house distribution, traffic, and drainage of individual house are studied.	Housing lot survey includes hollow place at low land area and ground level elevation in order to decide drainage route. Sufficient land acquisition is required for pumping station.
3) Public Utilities Survey (Existing sewer,	Road layout, pavement material, water supply, electric power supply,	Present information and future plan on pavement material and public utilities are collected from relevant organizations.

underground utilities, channel & drainage)	telecommunication, road facilities (pole, drainage, adjacent building and retaining wall) are surveyed.	Irrigation canals seriously affect sewer planning.
4) Topographic Survey	Plane and longitudinal surveys provide information on public utilities, position of man hole and pole, and irrigation channel.	Route survey of sewer mains and local or secondary sewer of 35 km provides topographic data on plane and longitudinal surveys, and location of principal public utilities. Route survey of main and secondary sewer to houses provides information for sewer design through plane and longitudinal surveys. Information on ground elevation is important to lessen pressurized flow to prevent putrefaction of wastewater.
5) Geological Survey	Geological survey collects information for sewer basement, retaining wall and ancillary works.	Boreholes were made to get information for the design of pumping station whereby wayleave have been obtained from land owners. Route survey of sewer would help get information on the presence of rocks through site reconnaissance along roads.

(3) Point of I/I Measures

1) I/I Situation in Japan

I/I consists of stormwater and unpredictable groundwater flow into sewer, and affects treatment performance and operation costs due to increase of inflow.

I/I is popular in Japanese wastewater treatment plants, and inflows to 50% of treatment plants reach twice of dry weather flow in during storm events. I/I makes it difficult to detect source and rate of flow, and compels serious damage and cost on wastewater management.

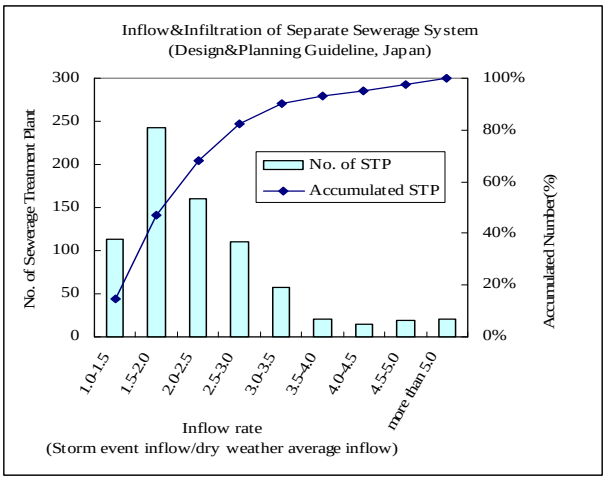


Figure 1.4-2 Change of I/I in Japan

2) I/I Flow Source

I/I of separate sewer during storm events is defined as follows:

Stormwater discharges into sewer through perforated covers of manholes and building sewer lines.

Stormwater also infiltrates through pipes and damaged pipes of sewer when it fills back-filled trenches.

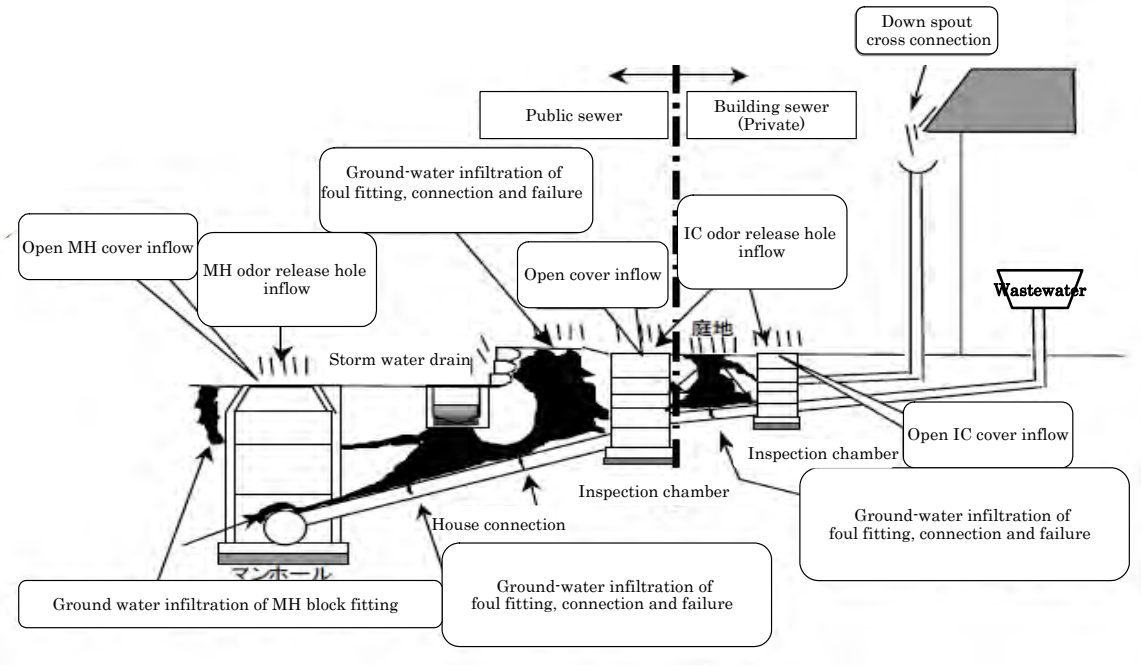


Figure 1.4-3 I/I of Separate Sewer

Surveyed I/I flowrate after stepwise rehabilitation in Japan is reported in Table 1.4-2, which shows I/I of whole facilities of sewer collection system..

Table 1.4-2 Stepwise I/I Rehabilitation

I/I Source	Flow Rate
House Connection and Inspection Chamber (Public)	40 %
Building Sewer (Private)	24 %
Public Sewer (Public)	36%

Source: Kobe City, Japan

3） Points of I/I Measures

I/I measures should be applied comprehensively such as 1) training of plumbers; 2) careful construction and maintenance of sewers; and 3) construction of stormwater drainage system to reduce I/I flow.

However, rehabilitation of private and public sewers can be difficult as these involve higher cost and longer construction period. When I/I issues appear, survey should detect such data on flowrate, water quality and dilution rate, and I/I event frequency. The most rational measure should be applied considering not only capacity of sewer, pump and treatment but also O&M matters and cost-benefit analyses.

CHAPTER 2 STUDY METHODOLOGY

2.1 Study Schedule

Field survey started on December 16, 2010 after the submission of the Draft Inception Report. Result discussed with WMA was reviewed to field survey planning and TOR of the Study contract.

The Draft Final Report was submitted on March 11, 2011 to JICA Madagascar Office. And the conclusion of the Study was reported on March 15, 2011 to the Embassy of Japan. During field survey, progress was reported to JICA Madagascar Office and WMA on February 11, 2011. The Study Team then reported to JICA Headquarters on March 28, 2011 and concluded the Final Report.

Table2.1-1 summarizes the schedule of the Study.

Table 2.1-1 Study Itinerary

Year/Date			Organization	Subject
2010 Dec	9	Thu.	JICA	Contract Inception Report (Draft) submission
	15	Wed.	Study Team	Study Team Departure
	16	Thu.	Study Team	Study Team Arrival in Mauritius
	17	Fri.	WMA	Preliminary Meeting
	18	Sat.	Study Team	Project Site Visit
	19	Sun.	Study Team	Project Site Visit
	20	Mon.	WMA	Kick-off Meeting and Inception Report (Draft) submission
	22	Wed..	Luxconsult Co. Ltd.	Meeting on TOR of Employment Contract
	27	Mon.	Luxconsult Co. Ltd.	Employment Contract
	28	Tue.	WMA	TOR on Topographic Survey
			Study Team	Starting Street Survey
2011 Jan.	7	Fri.	WMA	Final Inception Report Submission Report on Study
	12	Wed.	WRU/WMA	Water Resource Unit Meeting on Core Hole & Borehole Test
	13	Thu.	Mauritius University	Consultation with Dr. Andre Chan Chin on Borehole Test
	14	Fri.	WMA	Sewer Main Route & Pumping Station Layout
	17	Mon.	Study Team	Selection of 900 Low-Lying Houses
	18	Tue.	WMA	Field Meeting on Core Hole Survey
	19	Wed.	WMA	Field Meeting on Borehole Survey

	20	Thu.	Study Team	Team Member Nishikawa left for Japan
	21	Fri.	WMA	Sewer Main Route & Pumping Station Layout
			Study Team	Awarding on Core Hole and Bore Hole Contract
	22	Sat.	Study Team	Nippon Koei Staff Kawahara Arrival
	25	Tue.	Water Research Co.	Meeting on TOR
			WMA	Report on Core Hole &Bore Hole Contract
	27	Thu.	WMA Water Research Co.	Field Meeting on Bore Hole Survey
	28	Fri.	WRU/WMA	Water Resource Unit Meeting on Core Hole & Bore Hole Test
	31	Mon.	WMA	Meeting on Study
Feb.	2	Wed.	WMA	Arrangement on Land Approval
	4	Thu.	WMA	Acceptance of Land Approval of Core Hole Test
	7	Mon.	WMA	Meeting on Study Progress
	10	Thu.	Study Team	Started Core Hole Drilling Field Work
	11	Fri.	JICA/WMA	JICA Madagascar Office Meeting
	14	Mon.	WMA/WRU Mont Choisy Ltd. Co.	Meeting on Land Approval for Bore Hole
	15	Tue.	WMA/ Mont Choisy Ltd. Co.	Borehole Site Meeting
	17	Thu.	RDA/WMA	Site Meeting on Sewer Plan in Classified Road with RDA
	18	Fri.	WMA	Meeting Study Progress
	22	Tue.	Water Research Co.	Starting Borehole Drilling Field Work
	25	Fri.	WMA	Meeting Study Progress
			Water Research Co.	Amendment Meeting on Borehole Contract
Mar.	4	Fri.	WMA	Meeting Study Progress
	11	Fri.	WMA	Draft Final Report Submission
	14	Tue.	JICA Office	Report on Study
	15	Wed.	Japan Embassy	Report on Study
	17 18	Thu. Fri.	Study Team	Departure from Mauritius Arrival in Narita
	23	Wed.	JICA HQ	Draft Final Report Submission
	28	Mon.	JICA HQ	Final Report Submission

2.2 Staffing

The Study collects information on topography, sewer route, geology and underground facilities prior to detailed design for smooth implementation of the Phase1-B Project. The surveys consist of topographic surveys in Phase1-B and wastewater effluent injection wells. I/I survey in Phase1-A area also applies to I/I mitigation measures of Phase1-B.

The Study had several issues such as the broad area and individual housing lot survey in restricted terms. In the organization of team members, the following were considered:

i. Experts with sufficient experience on sewer route planning, topographical survey, and I/I mitigation.

ii. Experts familiar with Japanese ODA projects and can execute surveys effectively.

iii. Experts with sufficient communication skills with government organizations and contractors in Mauritius, and can utilize information and data in English.

iv. Topographic, geological and injection well surveys are contracted to private companies who haveexperiences in Mauritius.

Team members are experts on the following fields:

- Team Leader/Sewer Design Expert: Yakuro Inoue
- Sewer Survey Expert: Takamasa Nishikawa
- Geological survey expert: Naoki Kawahara*

  * Additional Team Member necessary because there are a lot of unexpected works such as getting permission and application procedures on geological and injection well surveys.

Table 2.2-1 shows the assignment schedule of the experts.

Table 2.2-1 Assignment Schedule

	Position	Name	Company	Rank	2010 12	1	2	3	4	MM 計 Mauritius	Japan
Work in Mauritius	Team Leader／Sewerage Design	Yakuro INOUE	Nippon Koei	2	17	31	28	18		3.13	
	Sewer Survey	Takamasa NISHIKAWA	Nippon Koei	3	17	21	20	18		2.53	
	Geological survey	Naoki KAWAHARA	Nippon Koei			11	12			0.77	
									Sub-Total	6.43	
Work in Japan	Team Leader／Sewerage Design	Yakuro INOUE	Nippon Koei	2	6			7			0.43
	Sewer Survey	Takamasa NISHIKAWA	Nippon Koei	3	2		2	2			0.20
	Geological survey	Naoki KAWAHARA	Nippon Koei								
									Sub-Total		0.63
	Report	Submission			ICR			DF/R	F/R		
	Total	Work in Mauritius Work in Japan			Preparation of IC/R	Work in Mauritius		Preparation of DF/R	Preparation of F/R	6.43	0.63 7.06

CHAPTER 3 TOPOGRAPHIC SURVEY

3.1 Street Survey

3.1.1 Methodology of Street Survey (Center Line and Longitudinal Profile)

(1) Essential Requirements

Route survey provides topographic maps for detailed design.

The sewer design expert decided to place sewer lines where route survey has identified street center, longitudinal profile, underground utilities (water supply, telecommunication, etc.), street gutters, and intersections.

Topographic maps are processed into CAD data (1:3000 scale maps is consulted with C/P).

Survey area	Point aux Canonniers, Petit Raffray, The Vale, Pereybere and Cap Malheureux, and Sottise (Approx. 35 km of existing streets)
Survey items	Plane survey : 35 km×20 m, Centerline : 50 m interval, Longitudinal Profile : 35 km、TBM ： 500 m interval

(2) Survey Methodology

The survey is executed using electro-optical distance meter and GPS. The electro-optical distance meter detects phase of waves and transfers them to distance. GPS of digital terrain model (DTM) detects location and elevation of subjects using GPS satellite waves.

Street surveys between villages are executed through GPS to shorten the survey period. The electro-optical distance meter was used for street surveys in villages since GPS cannot be applied due to the presence of big trees.

Total Station

Total station consists of a transit and electro-optical distance meter, and it surveys gradient and distance simultaneously. Surveyed results are digitized on monitor and recorded. Location and elevation of objects are processed in three-dimension.

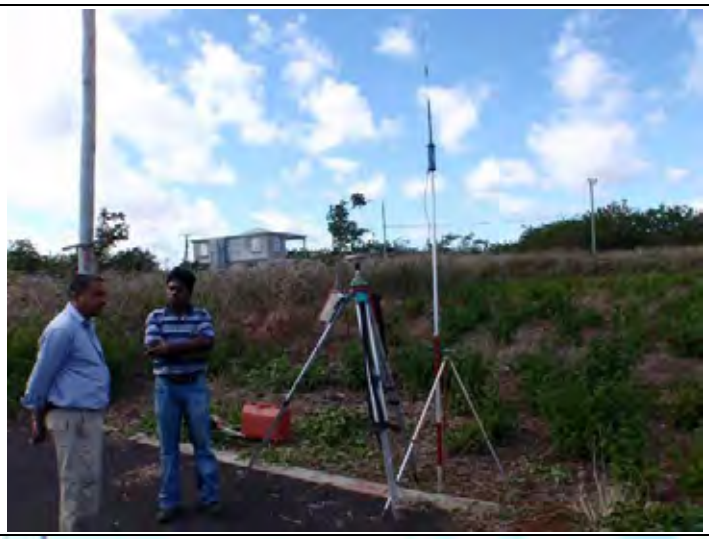
Street Survey (GPS): *GPS Antenna Receiver	
Street Survey (GPS): *GPS Rover in RTK Mode	
Street Survey (Total Station)	

Figure 3.1-1 Survey Situation

3.1.2 Result of Street Survey

(1) Street Survey Route

Street route survey was decided considering the main sewer network plan as shown in Section 3.3. The length of street survey is about 40 km and the route is shown in Figure 3.1-2.

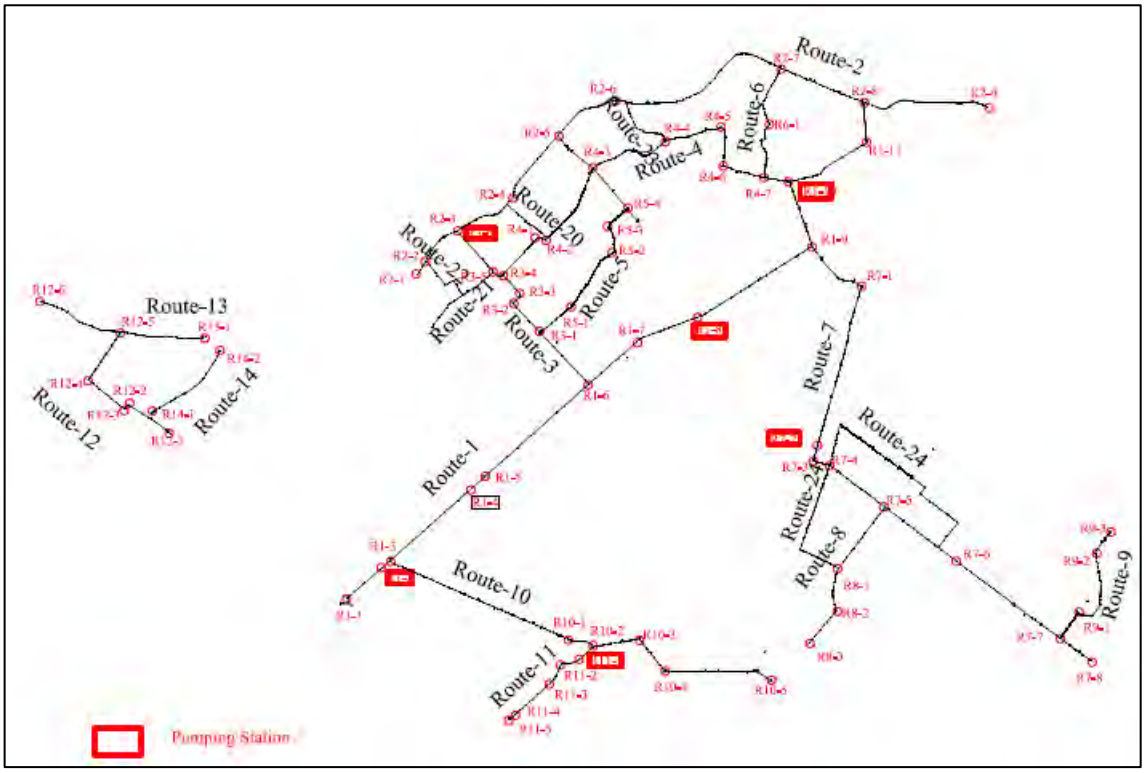


Figure 3.1-2 Street Survey Route

The Study Team set the route number (Route-1 to Route-24) and reference node number (R1-1 to R14-2) to specify the location easily in 2D diagram and longitudinal profiles.

(2) Result of Street Survey

The result of street survey is shown in 2D diagram (1:3000 scale) and longitudinal profile (1:100 vertical scale, 1:1000 horizontal scale). These drawings are attached in the report Volume 2, Report on Topographic Survey.

3.1.3 Application of Surveyed Result

Street survey result is developed into contour maps showing the topographical condition of high and low areas. The direction of the sewer flows and necessity of pumping station were decided by the contour maps as seen in Figure.3.1-3, right.

As for sewer main route, contour maps have provided an alternative sewer main route which bypasses high land and removes two pumping stations, including a 25 m head loss. Site reconnaissance confirmed sewer flow direction and details of alternate pipe route as seen in Figure 3.1-3, left.

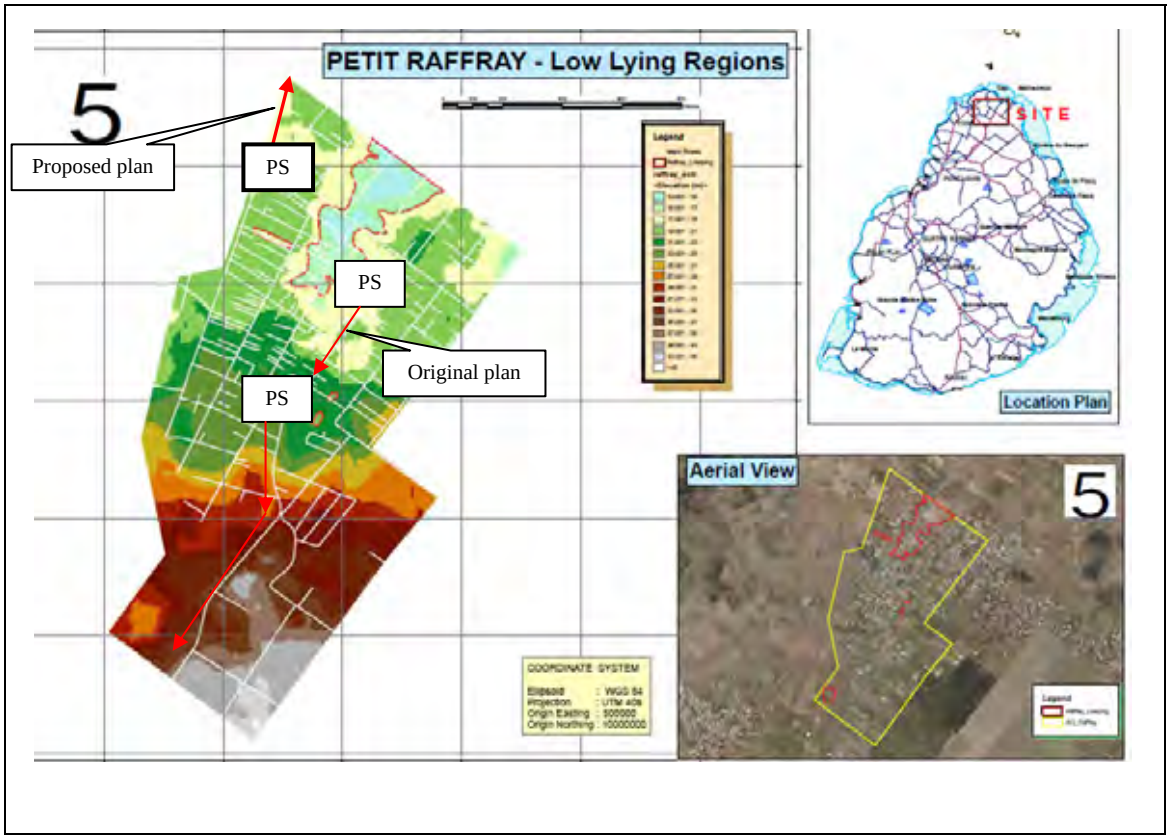


Figure 3.1-3 Low-Lying Area and Sewer Main Alternative in Petit Raffray

Occupying farm land for sewer main, where public roads are located higher than private farm lands, reduces sewer length and MS.

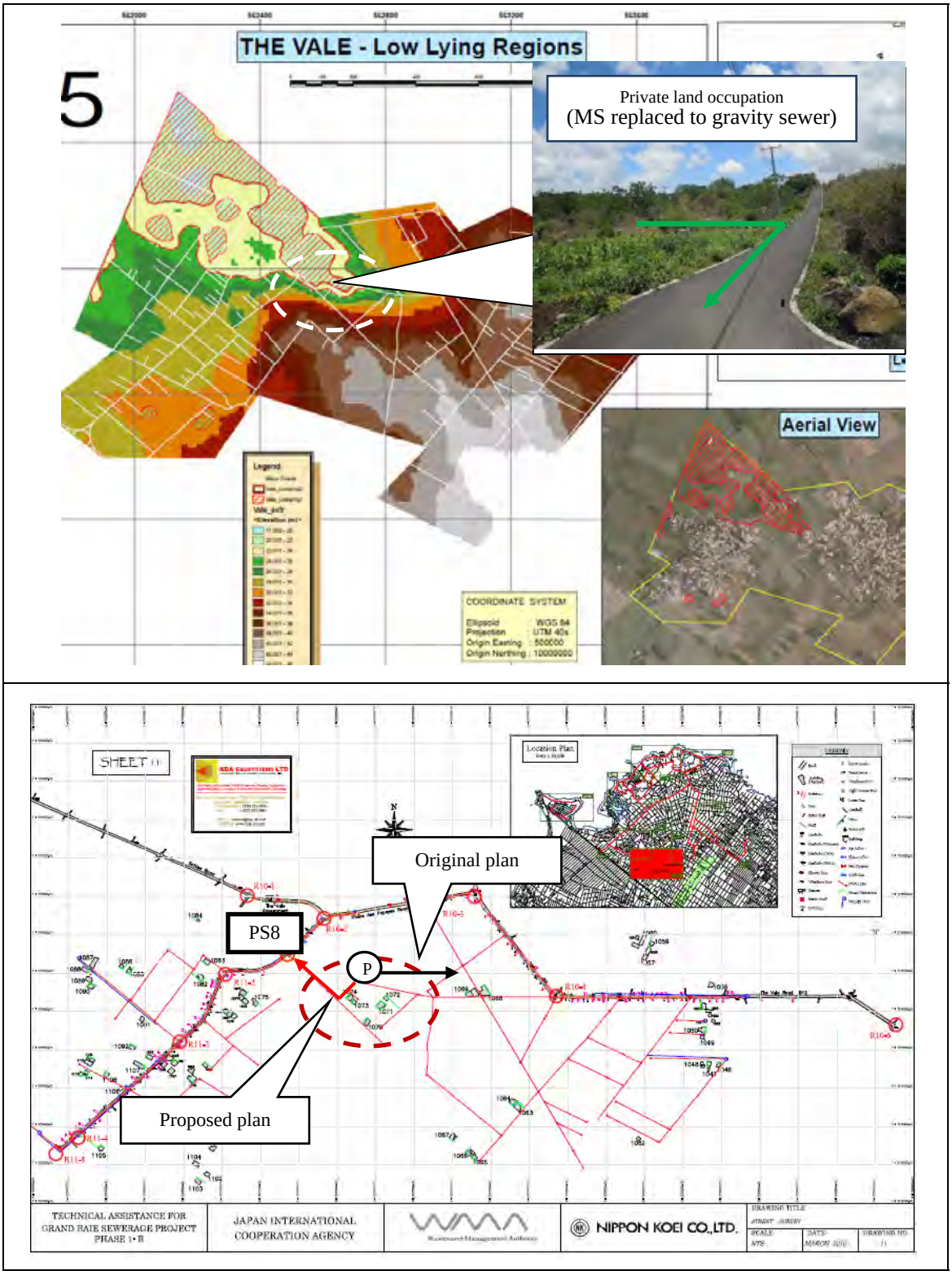


Figure 3.1-4 Sewer Main Occupying Private Property (Farm land) in The Vale

3.2 Housing Lot Survey

3.2.1 Methodology of Housing Lot Survey

(1) Essential Requirements

Plan survey is intended for Phase1-B area excluding Mont Choisy East Development Project, with approximately 4,400 households, and route between individual household and trunk sewers.

Proposed house connections were processed into CAD file.

Survey area	Point aux Canonniers, Petit Raffray, The Vale, Pereybere and Cap Malheureux, and Sottise (Approx. 4,400 households)
Survey items	Street: Plane survey：5 km×20 m; TBM：500 m interval; Longitudinal profile：50 m interval Housing lot: Plane survey： 900 households ＞ Location of wastewater drainage facilities, lowest ground elevation & drain direction 3,500 households＞ Check household lot higher than street, aerial photo detection of sewer line

Table 3.2-1 Housing Lot Survey Scope

Object	Amount	Scope
Low-Lying Area Housing Lot	1,112 houses (900 planned) 810 at ground level surveyed	・Location of wastewater discharge facilities ・Obstacles of house connection ・Building lay-out ・Elevation
Others	5,626 houses	Sewer route determined by aerial photo (check elevation of house connection) * Detail design executes housing lot survey
Total	6,738 houses (4,400 houses planned)	

(2) Survey Methodology

1）Selection of Low-Lying Area Housing Lot (Target of Housing Lot Survey)

Housing land development in the survey area has been progressing rapidly in the recent years. Therefore, there is no permanent road map available for the sewer network plan. At present, the Ministry of Housing and Lands is digitizing road maps

with the aid from Australia.

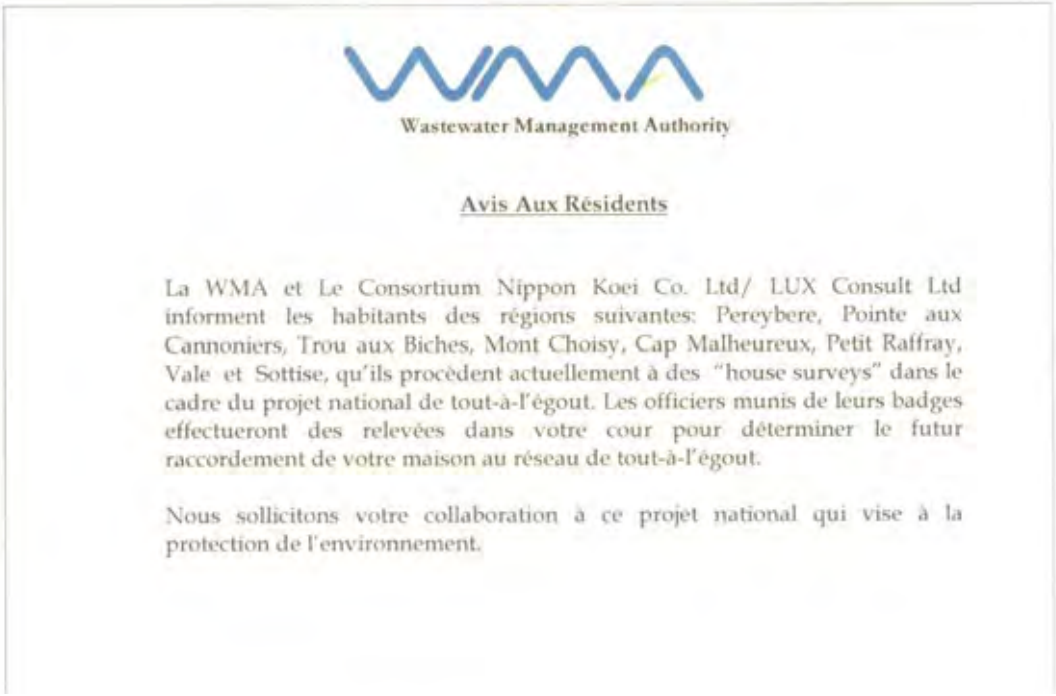
In this Study, the Study Team use aerial photos published by the Ministry of Housing and Lands to detect the housing lot and make sewer network plan. The number of housing lots in the study area, determined by aerial photo, was 6738.

The Study Team picked out low-lying area housing lots enough to make the sewer network plan by the field survey. The number of lots found was 1,112.

The location and shape of the specified households were digitized through CAD from aerial photos and GIS survey results. These information were utilized for the arrangement of results of the housing lot survey and planning of house connection.

2）Request for Cooperation for Survey

Since entering properties is a matter of privacy, the government administration was vital for the execution of this Study. Therefore, WMA issued request letters to the media, particularly to radio stations, and regional councils in advance. WMA staff informed each household with communiqué. Site reconnaissance detected 1,112 houses in low-lying area.



Wastewater Management Authority

Avis Aux Résidents

La WMA et Le Consortium Nippon Koei Co. Ltd/ LUX Consult Ltd informent les habitants des régions suivantes: Pereybere, Pointe aux Cannoniers, Trou aux Biches, Mont Choisy, Cap Malheureux, Petit Raffray, Vale et Sottise, qu'ils procèdent actuellement à des "house surveys" dans le cadre du projet national de tout-à-l'égout. Les officiers munis de leurs badges effectueront des relevées dans votre cour pour déterminer le futur raccordement de votre maison au réseau de tout-à-l'égout.

Nous sollicitons votre collaboration à ce projet national qui vise à la protection de l'environnement.

Figure 3.2-1 Request for Cooperation (Communiqué)

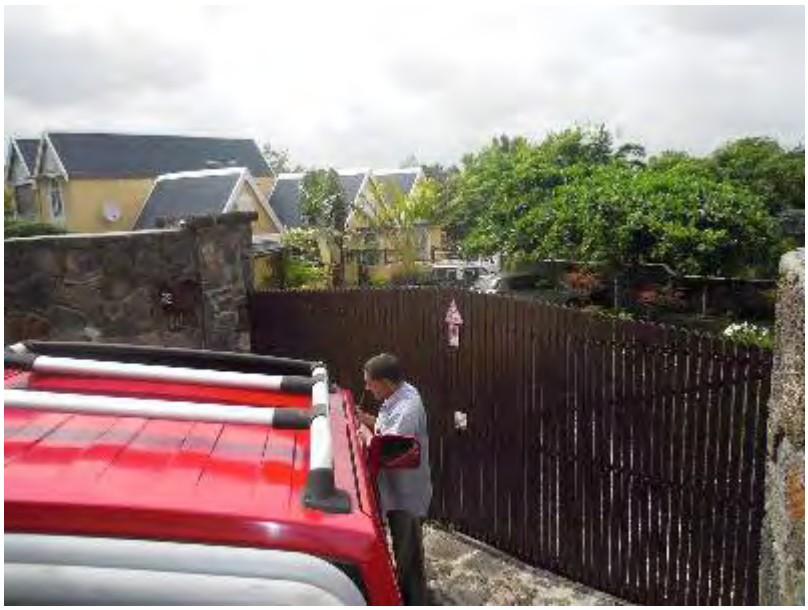


Figure 3.2-2 Household Interview (WMA Staff)

3）Housing Lot Survey

WMA staff and JICA Study Team visited together each 1,112 households to carry out surveys. JICA Study Team used individual housing lot survey form, as seen in Figure 3.2-3, to perform surveys and get as much information as possible, as shown in Table 3.2-2. In addition, the study area involves resorts and a lot of holiday cottages for rent. Therefore, owners and residents are not the same in many cases, and JICA Study Team could not get enough information in that case even with the assistance of WMA staff. In case the residents would not permit to go inside their properties, JICA Study Team will supplement the necessary information based from oral interviews.

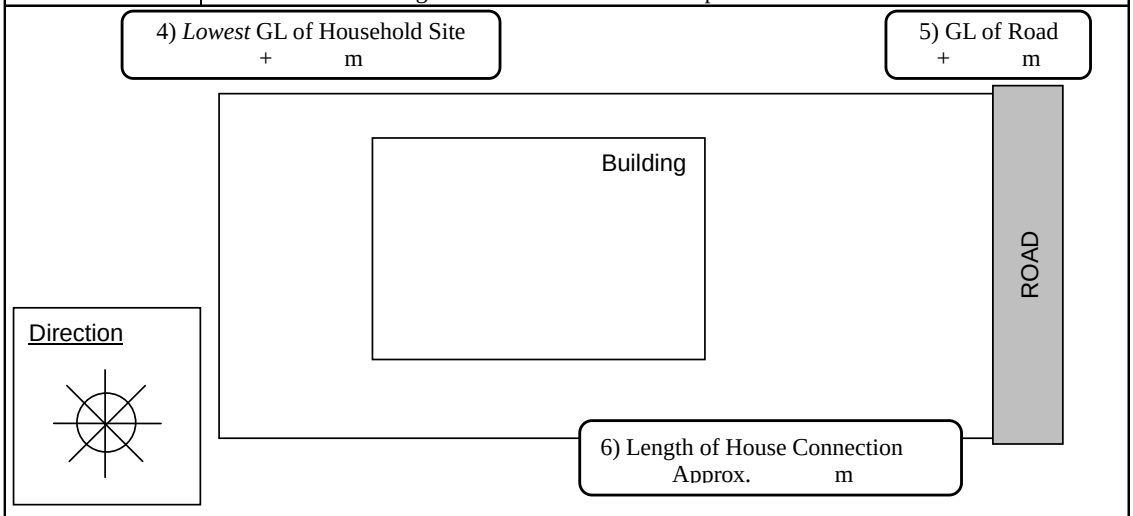
Table 3.2-2 Information Collected from the Housing Lot Survey

Collected Information	Information Receiver	Purpose of the Information Acquisition
Address	WMA	Basic customer information
Owner	WMA	Basic customer information
Phone Number	WMA	Basic customer information
CWA Account Number	WMA	Basic customer information (For fare collection)
Front Road Proprietary	JICA Study Team	Basic information for detail design (To check the necessity of wayleave)
Location of Wastewater Discharge Facilities	JICA Study Team	Basic information for detail design (To decide the location of house connection)
Location of Other Utility Service Line	JICA Study Team	Basic information for detail design (To decide the location of house connection)
Length of House Connection	JICA Study Team	Basic information for detail design (To calculate the amount of construction works)
Elevation of Front Road	JICA Study Team (GPS Survey)	Basic information for detail design (To decide the pipe depth)
Lowest Elevation in Housing Lot	JICA Study Team (GPS Survey)	Basic information for detail design (To decide the pipe depth)

Individual House Lot Survey Form

No/ Map No.	/
Aerial Photo No.	

Survey date			
Address			
Owner			
TEL		CWA Account	
Front Road	☐ Public road ☐ Private		
Survey items	1) Boundary of housing lot ☐ measured in-situ ☐ DTM/aerial photo ☐ not detected		
	2) Location of wastewater discharge facilities (kitchen, bath, toilet and Laundry) ☐ kitchen ☐ bath ☐ laundry ☐ toilet ☐ septic tank/pit latrine		
	3) Location of other utility service lines ☐ water ☐ electricity ☐ telephone line ☐ others( )		
	4) Lowest elevation of ground level (household site) ☐ measured in-situ ☐ DTM	+	m
	5) Elevation of road level	+	m
	6) Length of house connection ☐ measured in-situ ☐ Aerial photo	Approx.	m
	7) Combined or separated of building sewer of wastewater sewer and storm water sewer ☐ No drainage ☐ Combined ☐ Separated		



【Legend】Ⓚ : Kitchen, Ⓑ : Bath, Ⓣ : Toilet, Ⓛ : Laundry, Ⓢ : Septic tank, Ⓟ : Pit latrine

Remarks

Wastewater Management Authority, Gov. of Mauritius
JICA Study Team of Grand Baie Wastewater Project
Address:
Tel:

Figure 3.2-3 **Individual Housing Lot Survey Form**

3.2.2 Result of Housing Survey

(1) Housing Map

Figure 3.2-4 shows an aerial photo of house location and building layout, where low-lying houses are highlighted in pink.

Figure 3.2-4 Housing Map in Point aux Canonniers

(2) Supplementary Street Survey

Accuracy of location and ground elevation for GPS is adjusted through combined street survey and aerial photo. Street survey is for 35 km (40 km including housing lot survey), which is equivalent to 40% of the total sewer length. Distributed housing lot surveys supplemented street survey and collected the overall topographic profile in the project area.

3.2.3 Application of Surveyed Result

The Study Team selected 1,112 houses in low-lying areas and acquired 810 housing lot information. Survey results are applied to the local sewer layout plan. The average length of house connections is 46.9 m. Topographic profile provides a background on the direction of sewer flow and necessity of pump stations. Household information is also useful for customer information during the operation stage. Therefore, a prototype of house inventory is provided, as shown in Table3.2-3.

Since information of housing lot and households is vital for detailed design, construction, and operation stage, survey on the remaining household information will be continued by WMA.

Table 3.2-3 Prototype of House Inventory (1/2)

Summary of housing lot survey

Village	Household Details							Housing lot survey items					
	No. of Total House	No. of low lying house	Address	CWA AC No.	Ownership Name	Ownership Name	Telephone	Front Road		Boundary	Housing lot elevation	House lower than road (average)	House connection length (average)
								Public	Private	Not Detected	house	m	m
Pointe aux Cannonries	1,168	174	43	1	102	79	92	106	0	106	130	1.7	55.7
Pereybere & Cap Malheureux	2,864	623	317	152	329	322	307	296	44	207	409	0.8	48.2
Petit Raffray	1,738	225	100	97	105	122	96	93	11	92	201	1.2	44.5
The Vale	810	67	38	37	42	27	40	32	9	28	55	0.9	38.2
Sottise	158	23	22	10	22	6	17	18	0	0	15	0.2	32.1
Total	6,738	1,112	520	297	600	556	552	545	64	433	810	1.1	46.9

Remarks
(1) No. of total house is counted by aerial photo as one house of cottage type buildings.
(2) Low lying houses are selected by reconnaisance survey and indicated on map.
(3) Figures of Address, CWA AC No., Ownership Name and Telephone are obtained by interviewing.
(4) Ground elevation is surveyed on 810 housing lots.
(5) Closed house and rejected house are detected by GPS and eye view survey.
(6) Remaining household details are contnuously surveyed by WMA.

Table 3.2-3 Prototype of House Inventory (2/2)

Household Inventory Survey

Technical Assitance for Grand Baie Sewerage Project Phase 1-B

Aerial photo reference No.	Hosue reference No.	Household Details: Village	Address	CWA AC No.	Ownership Name	Telephone	Housing lot survey items: Front Road		Boundary		Housing lot elevation of lowest point	Road elevation	Housing lot higher or lower than, or equal to road	House connection length	Survey Methodology: Measured in-situ	DTM/ aerial photo	Rejected
							Public	Private	Detected	Not Detected	GL + m	GL + m	cm	m			
1	1	Pts aux Cannoniers			Navneet Akaloo	269 0929	*			*	7.52	7.87	0.35	81	*		
1	2	Pts aux Cannoniers			Soobash Chandra Ramparsad	263 5129	*			*	7.18	7.98	0.80	23	*		
1	3	Pts aux Cannoniers	Island View		Paula Labat	258 0755	*			*	7.00	7.87	0.87	50	*		
1	4	Pts aux Cannoniers	Island View		Paula Labat	259 0755	*			*		7.95		46	*		
1	5	Pts aux Cannoniers			Jean Bernard Tyack	727 0080	*			*	7.52	7.53	0.01	57	*		
1	6A	Pts aux Cannoniers			Jean Francois Adam	727 0080	*			*	7.29	7.11	0.18	73	*		
1	6B	Pts aux Cannoniers			Jean Francois Adam	727 0080	*			*			0.00		*		
1	6C	Pts aux Cannoniers			Jean Francois Adam	727 0080	*			*			0.00		*		
1	7	Pts aux Cannoniers			Frederick Robert		*			*	7.18	7.11	0.07	80	*		
1	8	Pts aux Cannoniers	Coeur Volant		Christine Colin	752 8715	*			*	7.51	6.86	0.65	65	*		
1	9A	Pts aux Cannoniers			Veronique Moufferon	423 6000	*			*	9.66	6.86	2.80	78	*		
1	9B	Pts aux Cannoniers			Noel Raffray	423 6000	*			*			0.00		*		
1	9C	Pts aux Cannoniers			Gilbert Deleplaque	423 6000	*			*			0.00		*		
1	24B	Pts aux Cannoniers			Serge Bathfield/Meur c/o Sunil	910 5122	*			*			0.00		*		
2	25	Pts aux Cannoniers			Bougois		*			*	9.90	11.81	1.91	31	*		
2	26	Pts aux Cannoniers			Alain Paillusseau	263 3845	*			*	10.20	11.67	1.47	27	*		
2	27	Pts aux Cannoniers	23 Coastal Road		Maurice Martin	258 1660	*			*	11.42	11.52	0.10		*		
2	28	Pts aux Cannoniers	24 Coastal Road		Maurice Martin c/o Mme La Grue	931 5065	*			*		12.05			*		
2	29	Pts aux Cannoniers			Roger Koenig c/o Subash	263 5486/261 3197	*			*	10.57	12.31	1.74	56	*		
2	30	Pts aux Cannoniers			Alexis Harel	735 8668	*			*	10.61	11.71	1.10	68	*		
2	31	Pts aux Cannoniers			John Tagg (Jessica)	932 3804	*			*	9.13	11.71	2.58	69	*		

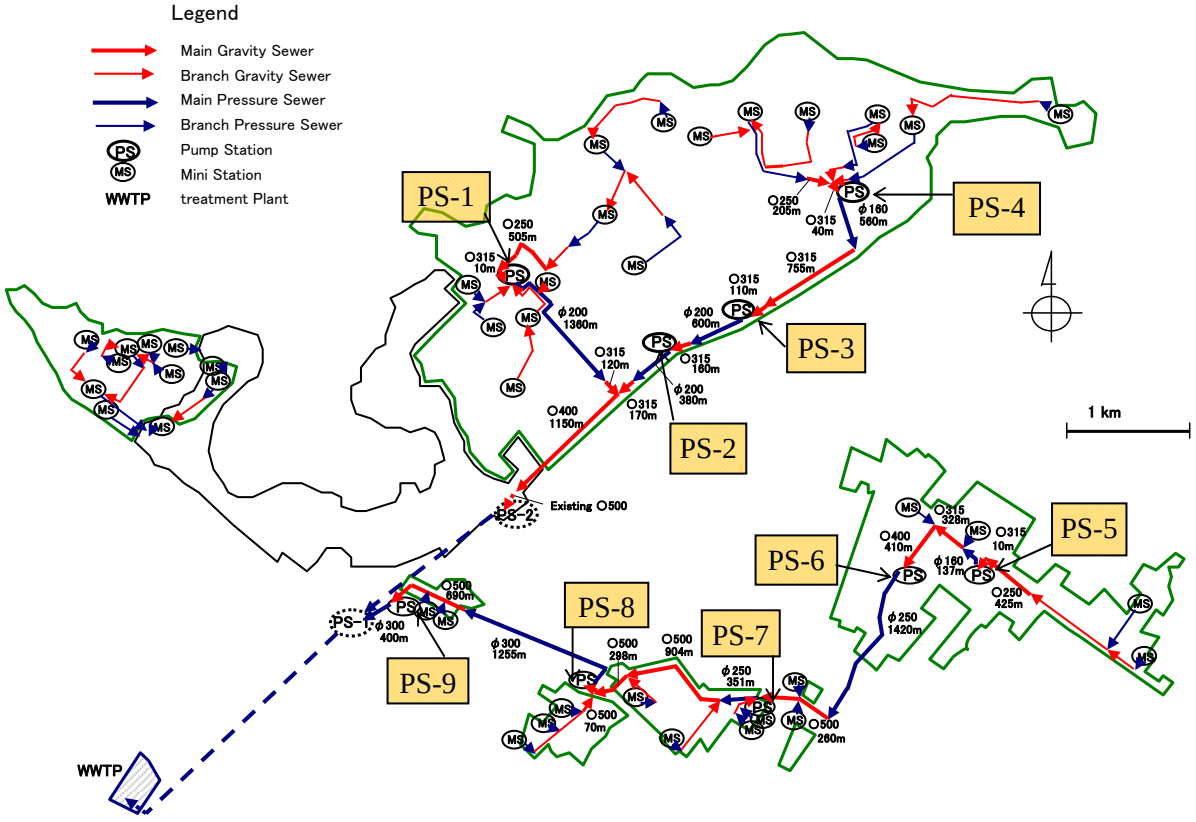
3.3 Sewer Main Route Survey

3.3.1 Issues on the Original Plan

Grand Baie Region is situated on a plain with moderate hills where eruptions and lava flows have created debris. Grand Baie Sewerage Project Phase 1-B plans to develop a sewerage system in five sewerage service areas: Pointe Aux Cannoniers, Pereybere and Cap Malheureux, Petit Raffray, The Vale, and Sottise.

Ground level declines gradually in Petit Raffray and The Vale from south to north and west as shown in the contour map of Figure3.3-2. Pereybere and Cap Malheureux are located above lava rocks along the beach. Scattered low-lying areas where storm water accumulates are called swamp.

The original main sewer route consists of two major sewer routes as shown in Figure 3.3-1. The first sewer route joins the existing Pump Station No. 1 (PS-1) and Petit Raffray through The Vale and Sottise. The second sewer route runs along Motorway B-45 and the coastal road in Pereybere and Cap Malheureux.



Source: Preparatory Survey for Grand Baie Sewerage Project in Republic of Mauritius

Figure 3.3-1 Original Main Sewer Route Plan

Issues on the original plan are as follows;

A) The proposed nine relay pumping stations are considered extensive.
B) Pumping stations are planned on private properties, which require land acquisition.
C) A high pumping head of 25 m above ground elevation difference is required. Wastewater in Petit Raffray is collected in lowest point and pumped up to cross a hill.

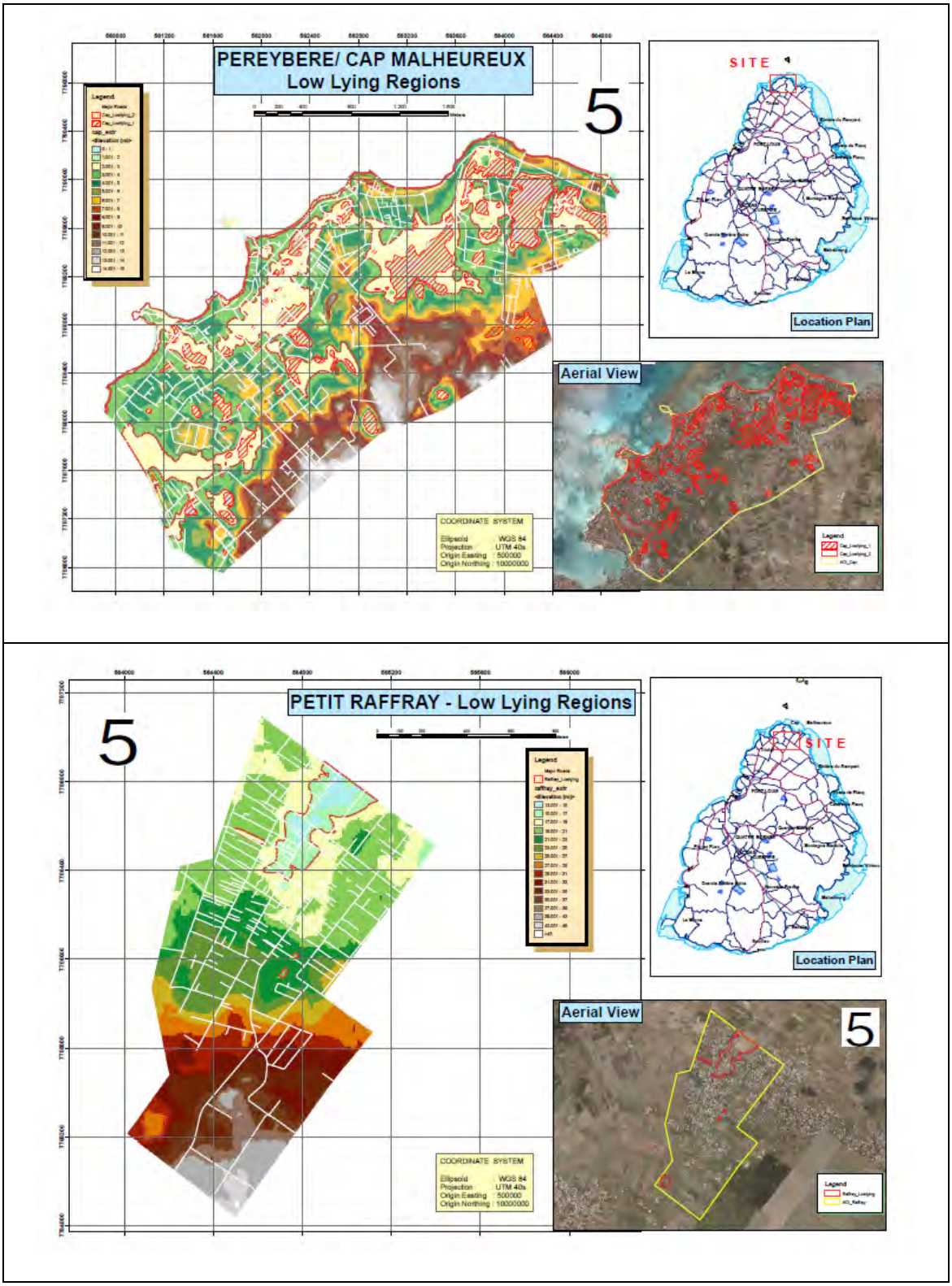


Figure 3.3-2 Contour Map（1/2）

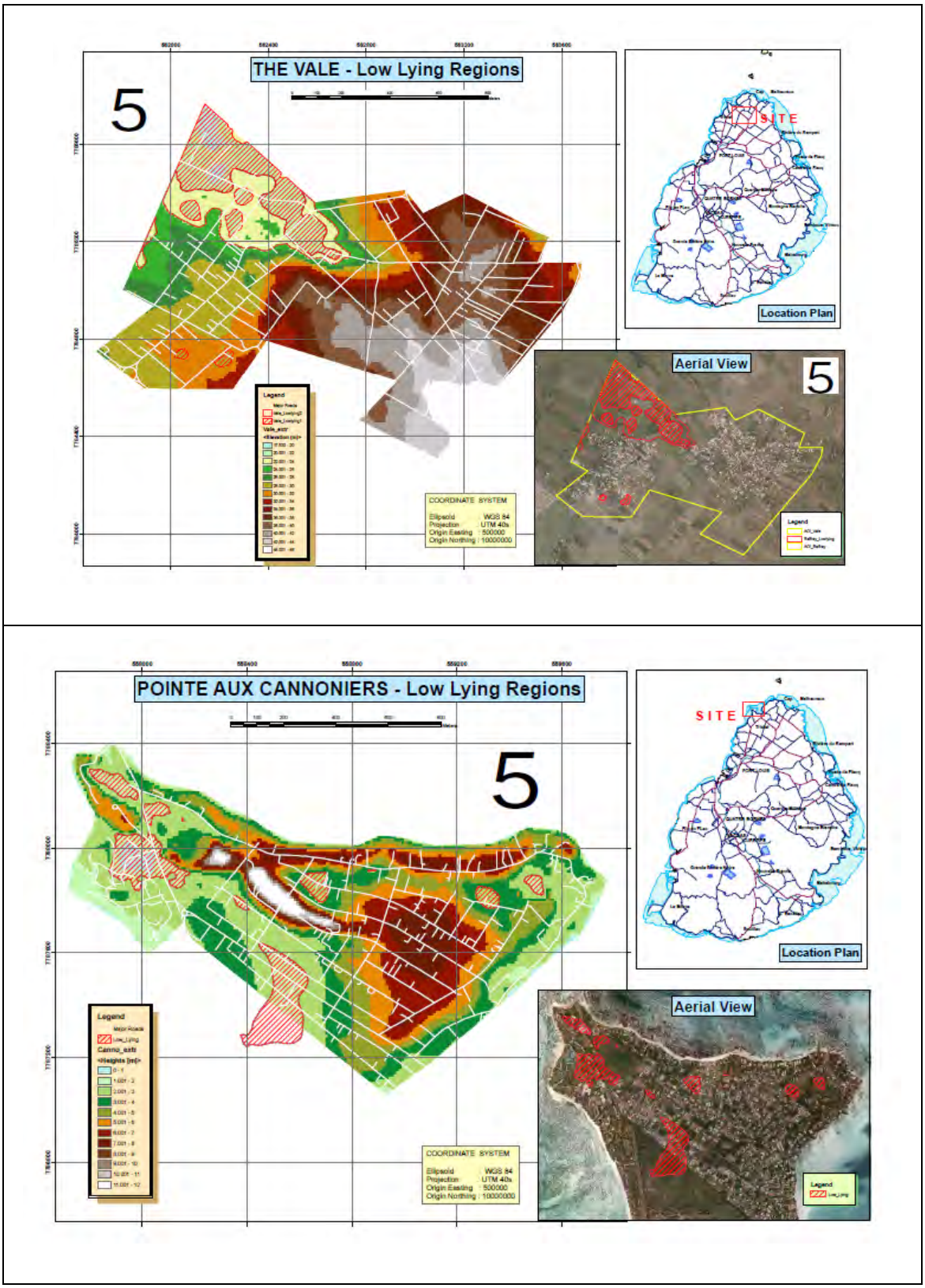


Figure 3.3-2 Contour Map (2/2)

3.3.2 Alternative Plan

The street and housing lot surveys have provided detailed contour maps for ground elevation. The longitudinal survey resulted to an alternative plan of joining Petit Raffray with Pereybere and Cap Malheureux, where ground elevation is lower. As a result, the alternative plan has changed the high pumping head requirement of 25 m into an ordinary state, disregarding two pumping stations, PS-6 and PS-7. PS-7 is replaced by a mini pumping station due to a decrease in flow rate, serving only the east of The Vale Region.

PS-3, which is approximately 500 m from PS-2, transfers wastewater beyond PS-2. PS-2 is replaced to a mini pumping station which collects and lifts only the adjacent wastewater. However, two conveyance pipes are installed.

PS-4 and PS-5 are planned on public property of an existing wastewater treatment plant and football field, respectively. The number of pumping stations is decreased from nine to six, and land acquisition will cover two private properties and two sugar cane farms. Amended pumping location plan avoids delay of project schedule and complicated procedures attributed to land acquisition.

Figure 3.3-3 shows the comparison of the original and proposed plan, while Table 3.3-1 shows the principal advantages of alternative plan.

Wastewater in Flamonds Road area has been reduced from three to one PS due to relocation of the releasing point of the mini pumping station into Motorway B-45. As a result, the housing development area adjacent to the mini pumping station can be served.

Eleven mini pumping stations are planned in the Pointe Aux Cannoires sewerage area. MS-1, which is close to MS-2, can be integrated since the reverse 1 m gradient has been altered to gravity flow and MS-2 has been relocated to the main sewer connection.

Table 3.3-1 Advantages of the Proposed Plan

1	Petit Raffray connects to Pereybere & Cap Malheureux in order to avoid 25 m pump head loss. PS-5 relocated to football field from private lot.
2	PS-7 is replaced to MS due to wastewater in Petit Raffray transferred to Pereybere and Cap Malheureux.
3	PS-2 is replaced to MS as it is near PS 3, which transports wastewater downstream of PS-2.
4	MS in Flamonds Rd transports wastewater to down-stream of PS-1 in order to avoid 3 times pumping. Along with, MS collects new developing housing area on the gravity sewer line.
5	MS collects new developing housing area between existing sewerage area and Phase 1-B area.

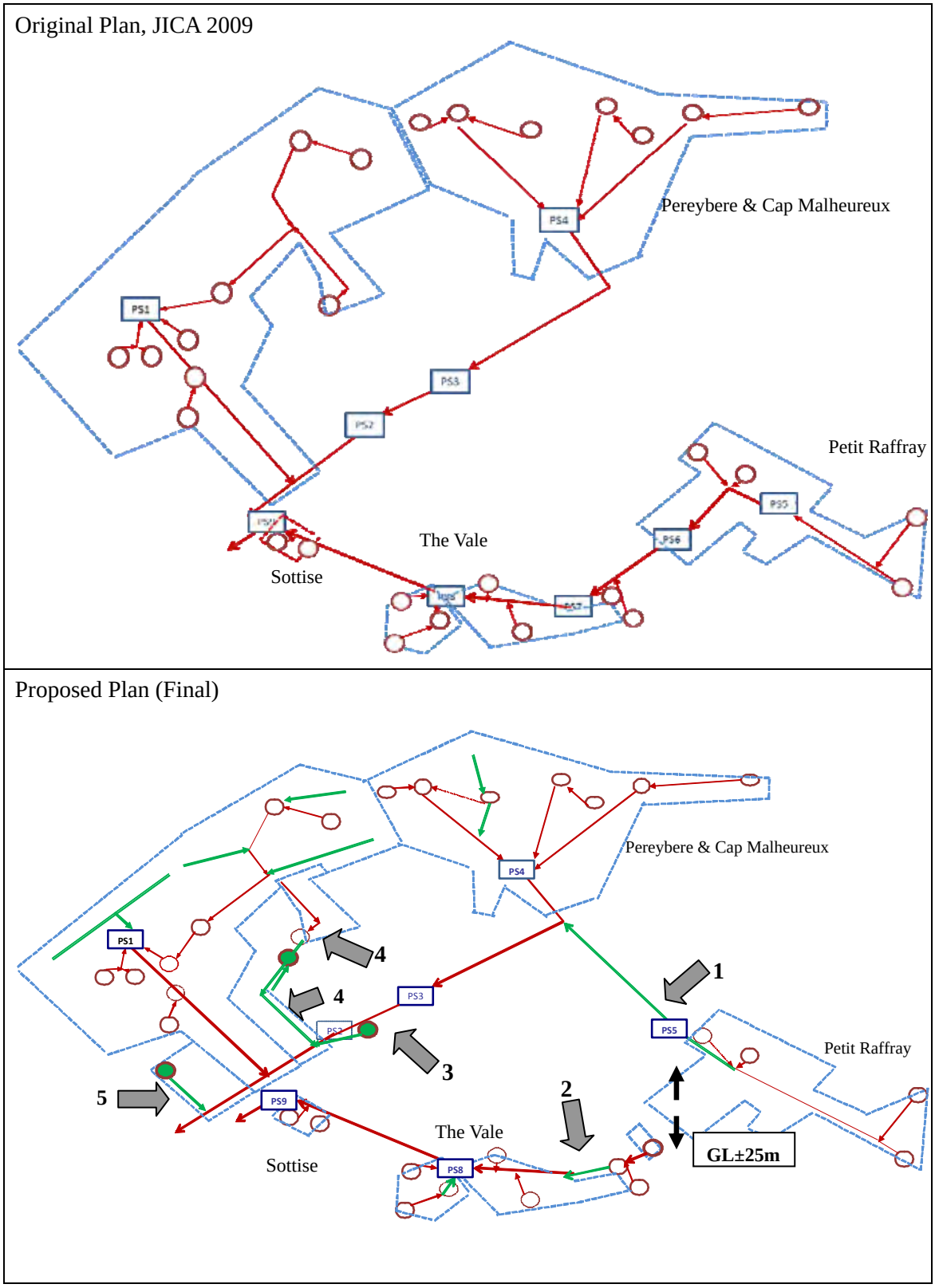


Figure 3.3-3 Alternative Study on Pereybere and Cap Malheureux, Petit Raffray, The Vale and Sottise

3.3.3 The Requirement of Road Development Authority

RDA manages classified roads as shown in Figure 3.3-4. Other public roads are managed by District Council Office.

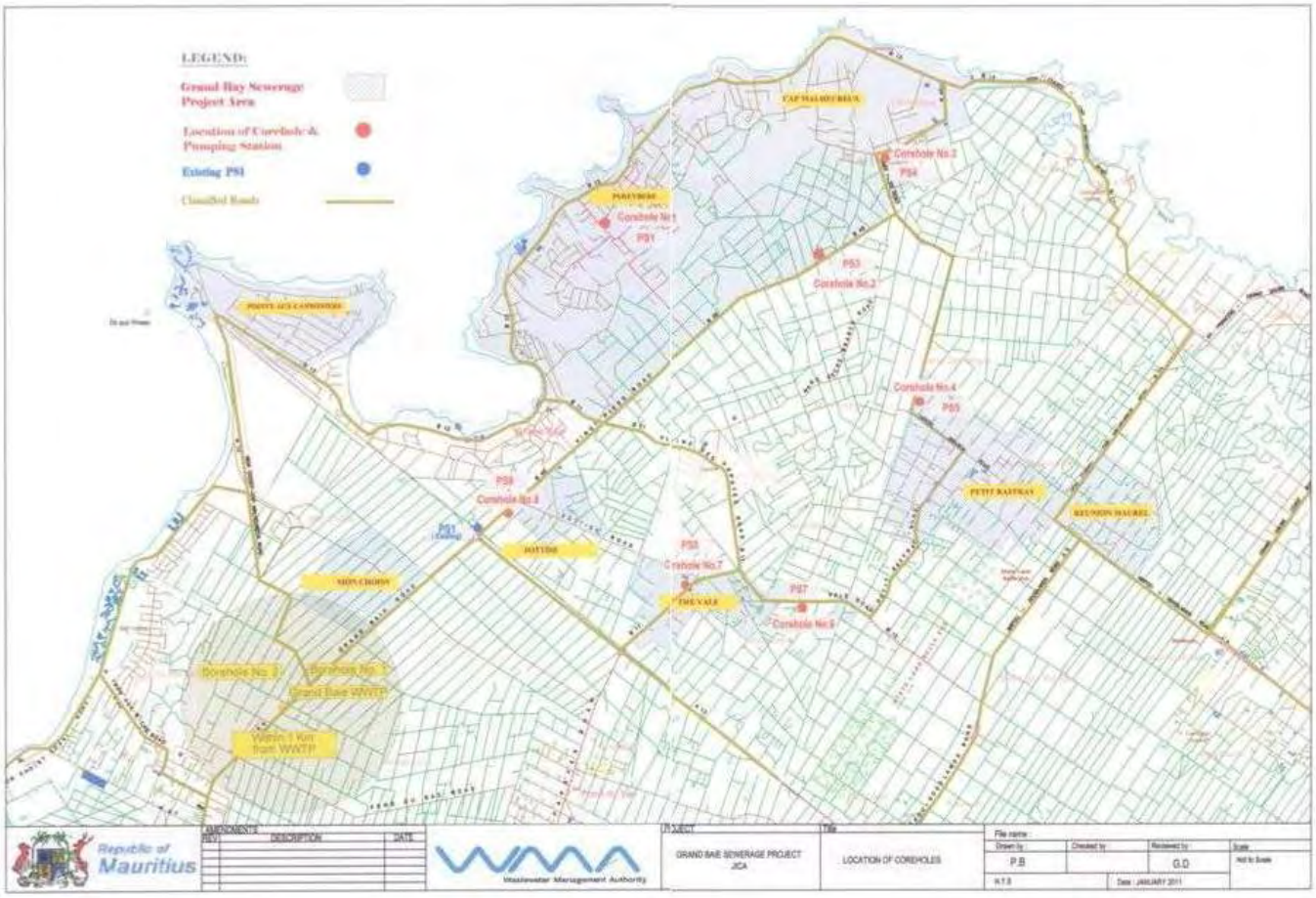


Figure 3.3-4 Classified Road of Road Development Authority

RDA requires road occupation approval at detailed design stage. RDA also requires sufficient sewer depth and concrete work for road crossing and sheath pipe for future urban development project. Longitudinal road occupation principally provides sidewalks and road reserves area because of cost and workability of construction and traffic safety issues due to open manholes. RDA regulates 1.5 m road reserve and 4.5m building setback. Actual roads do not always have a reserve of 1.5 m. At detailed design stage, careful study and consultation are required since CWA and telecommunication occupy road sides.

3.3.4 Conclusion

(1) Rational Main Sewer Planning as Multi-pump Conveyance Sewer

Since Grand Baie Region is situated on a flat plain with moderate hills, the sewer main is 8 km long with multiple pumps. Urban development projects such as commercial and housing projects are ongoing along the main road, therefore, urbanization will progress.

The Study proposes a single pump conveyance sewer for easy valve maintenance. However, multi-pump conveyance sewer is rational for future expansion in order to collect wastewater adjacent to sewer main route.

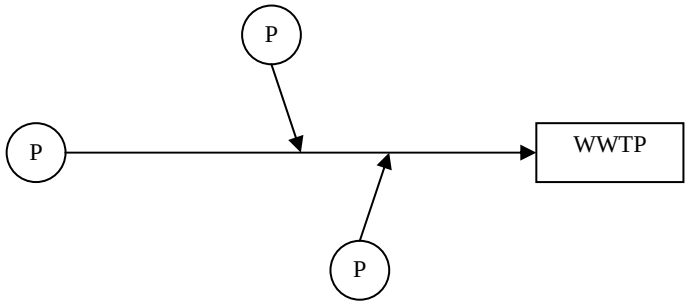


Figure 3.3-5 Multi-Pump Conveyance Sewer

(2) Wastewater Putrefaction and H_2S Measures

Wastewater easily releases H_2S since deposited wastewater putrefies. Since wastewater in pressurized conveyance is conveyed intermittently and deposits in sewer, H_2S corrosion may occur. Concrete and metallic materials in the receiving tank and screen of Grand Baie WWTP may corrode. Concrete on receiving tank wall above water level corrodes. Machinery and concrete of pumping station do not corrode because of ventilation, deodorization, and short pressure conveyance. Since the pressure mains in Phase 1-B and Phase 2 projects are long, H_2S corrosion may progress. Air injection and concrete corrosion measures are effective in lengthening durability and reducing maintenance costs.

WWTP Screen
(Machinery corrosion)

WWTP Receiving Tank
(Concrete corrosion)

Relay Pumping Station
(Fresh machinery & concrete)

Deodorizer
(Activated carbon)

Figure 3.3-6 H_2S Corrosion

3.4 Local Sewer Plan

3.4.1 Sewerage Planning Area

Sewerage area is appropriate for densely populated areas and commercial centers. Existing residential and commercial areas are developed in Grand Baie region. However, balconies for tourists are built and some are isolated from populated area.

Public awareness obtained from interviews during housing lot survey suggests the following:

- According to a male respondent, residents near swamp recognizes sewerage as important infrastructure because groundwater lever rises and wastewater retains during rainy season.
- According to a female respondent, septic tank has not been desludged since stormwater and wastewater easily infiltrate ground.

- From another a female respondent, septic tank releases offensive odor, and sewerage service relieved septic cleansing.
- From another a female respondent, sea water in Grand Baie used to be clean. However water is contaminated at present and sewerage is necessary.

Grand Baie Region has volcanic debris with high permeability, and habitual inundated areas are located only adjacent to swamp. Stormwater drainage systems are facilitated in limited beach areas only. Grey water is discharged without any treatment, and all wastewater including septic tank effluent will contaminate ground water due to rapid urbanization.

For low density area that are susceptible to seawater intrusion, on-site treatment is more appropriate than sewerage. Sewerage area shall be decided considering cost-benefit of off-site and on-site treatment, future land use, public awareness, and national policy.

The Study does not plan sewerage area and on-site treatment area. It also excludes isolated houses in the design as shown in Figure 3.4-1.

Figure 3.4-1 Isolated Houses